Glass Optical Fibers for Automotive Ethernet

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IEEE 802.3 Multi-Gigabit Automotive Optical PHYs (OMEGA) Study Group

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Agenda

- Basis for possible future proposal
- Keys to success
- Technical feasibility for automotive environments based on glass, optical multimode fiber (MMF) for aerospace
- Technical feasibility of glass optical fiber (MMF) supporting automotive ethernet data rates based on most recent IEEE 802.3 BASE-SR standards
- Foundation for objective including glass optical fiber meeting automotive requirements
- Summary and future work

Basis for possible future proposal

- Glass fiber (MMF) to achieve data rates >25 Gb/s, 40 m length, four connections
- Polymer coating capable of 125º C
- Protective cable for mechanical and chemical protection

Key Factors for Success

- Meet automotive environmental conditions
  - Temperature: 125º C
  - Mechanical (bending, tensile loading, crush resistance, etc.)
  - Chemical (exposure to oils, salts, etc.)
- Optical budget
  - Standard MMF bandwidth and optical performance: proven capability in telecom and datacom to achieve high-speed data rate
  - Modification of fiber to achieve environmental conditions with little or no impact to optical properties: performance demonstrated in multiple applications (e.g. aerospace)
- Economics
  - Cost-effective system at automotive scale volume

Proven Performance and Reliability In Transportation Fiber Optics in Aerospace

- First used in rigorous military applications – more than 25 years
- Data backbone on F-22, F-16 and F-18 variants, Joint Strike Fighter (JSF)
- Retrofit in various airframe upgrades: C-130 Hercules
- Initial commercial uses in non mission critical applications: e.g. In-Flight Entertainment
- Proven success is generating further commercial implementation

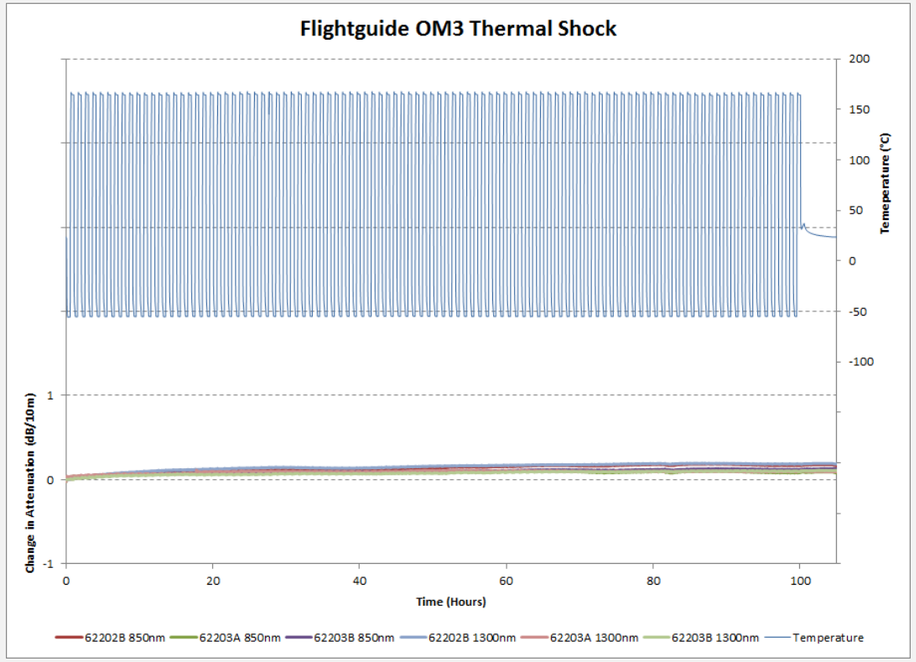
Aerospace Requirements - Similar to Automotive

- High reliability and long lifetime
  - 20+ years
- Wide operating temperature range
  - -55º C to +125º C for commercial aerospace, higher for military
- Tight bends and repeated flexing
  - 9 mm bend radius
- Installation stresses
- Crush/clamping stresses
  - Resistance to microbending losses as well as mechanical damage
- Chemical resistance as a cable
  - Various oils, fuels, fluids, salt spray, etc.
- Flammability
  - FAA, SAE, and OEM specific tests
- Smoke and Toxicity Issues
  - Low Smoke Zero Halogen an issue for applications in passenger areas

Thermal testing of Avionics Cable – Shock & Cycling at -55º C to +165º C

Thermal Shock

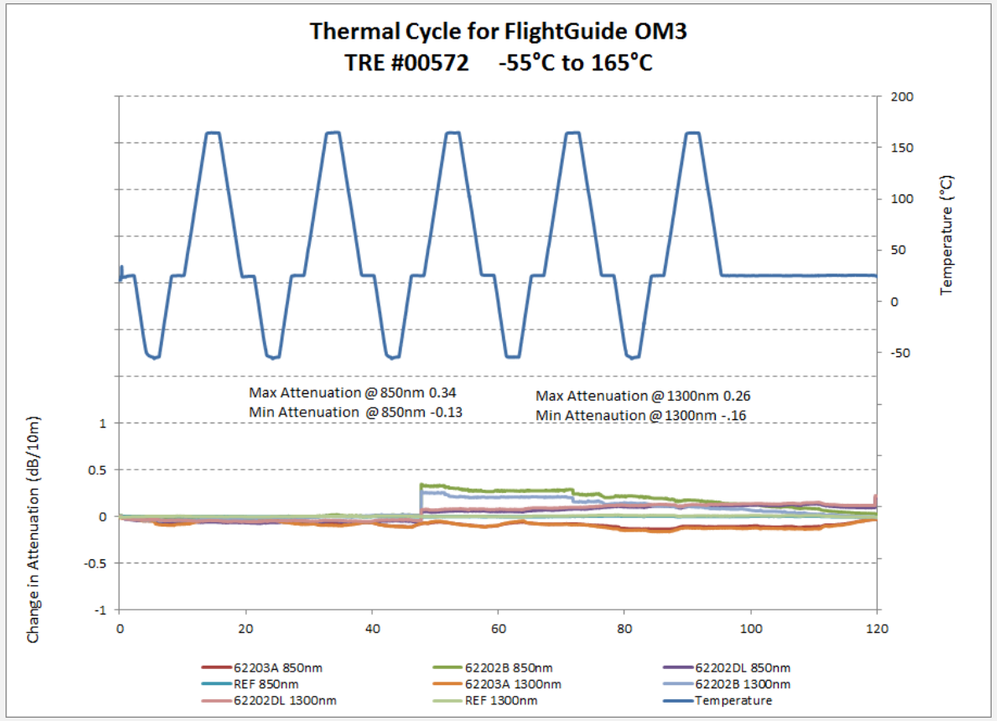
This test was performed in accordance with FOTP-3. The temperature extremes were -55°C to +165°C. One hundred cycles were performed with a 0.5 hour dwell at each temperature extreme. The sample lengths were 10 meters. Optical performance was monitored at both 850nm and 1300nm. Max attenuation change <0.20 dB



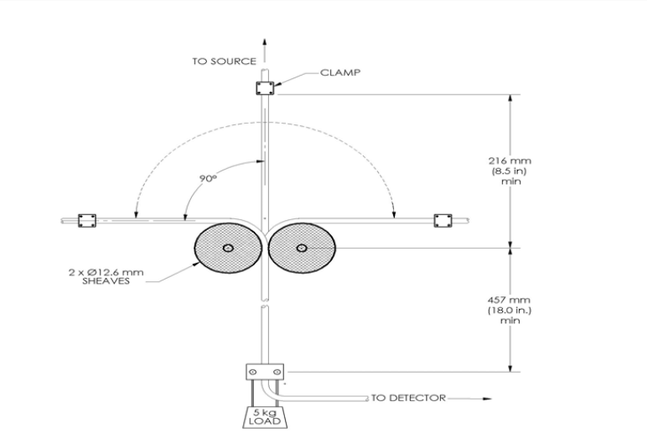
Permanent Change in Attenuation (dB/10m) after Test					
62202B 850nm	62203A 850nm	62203B 850nm	62202B 1300nm	62203A 1300nm	62203B 1300nm
0.17	**0.09**	**0.13**	**0.19**	**0.09**	**0.11**

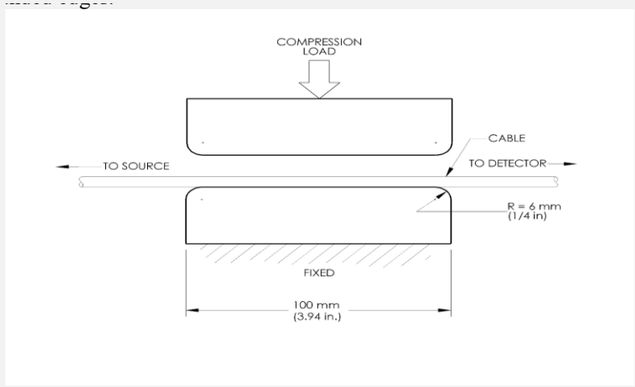
Thermal Cycling

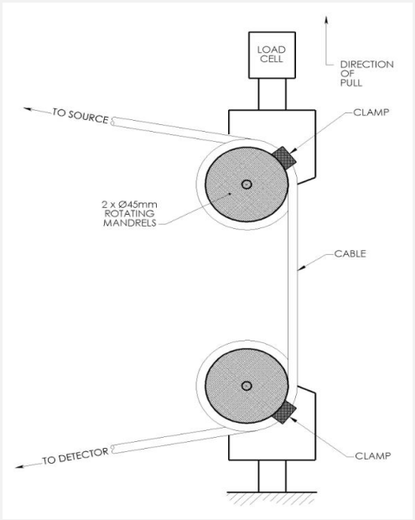
This test was performed in accordance with FOTP-3. The temperature extremes were -55°C to +165°C for a total of 5 cycles. The dwell time at ambient and each temperature extreme was 1 hour. The sample lengths were 10 meters. Optical performance was monitored at both 850nm and 1300nm. Max attenuation change <0.35 dB



Avionic Fiber Optic Qualification – Selected Mechanical Tests at 850 & 1300 nm







- Cyclic Flex
  - 10k cycles
  - Max attenuation change <0.4 dB
- Compression
  - Max load reached 4500 lbs
  - Max attenuation change <0.15 dB
- Tensile loading and bending
  - Max load to 600N, 45 mm diameter
  - Max attenuation change <0.05 dB

Recent IEEE 802.3 BASE-SR reaches for OM3

- IEEE Std 802.3bs-2017:
  - 25 Gb/s electrical and optical lanes, 25GBaud NRZ
  - 400G-SR16: 70 m reach on OM3
- IEEE Std 802.3cd-2018:
  - 50 Gb/s electrical and optical lanes, 25GBaud PAM4
  - 50G-SR, 100G-SR2, 200G-SR4: 70 m reach on OM3
- IEEE P802.3cm Task Force:
  - 50 Gb/s electrical and optical lanes, 25GBaud PAM4
  - 400G-SR8, 400G-SR4.2 (2 wavelengths): 70 m reach on OM3
- As detailed in perezaranda_OMEGA_01b_0919 , BASE-SR optical fibers with OM3 specifications should be able to meet automotive ethernet data rates of ≥ 25 Gb/s for 40 m, 4 connections

Summary and Future Work

- The extensive use of glass optical fiber (MMF) in challenging aerospace environment forms foundation for technical feasibility for glass optical fibers for automotive environments
- BASE-SR – 25 Gb/s and 50 Gb/s lanes – foundation for technical feasibility for automotive data rates and reaches, and for objectives based on glass optical fibers
- Are the OEM requirements for temperature:
  - AEC-Q100
    - Grade 2: Ta = -40ºC — 105ºC or
    - Grade 1: Ta = -40ºC — 125ºC?
  - Technical feasilbity for glass optical fibers at Grade 1 or 2 possible from multiple fiber companies, but economic feasiblity may be impacted by temperature requirment.
- Future work:
  - Technical feasiblity for glass optical fibers based on environmental and link performace testing per automotive requirements
  - Economic feasiblity for glass optical fibers as part of complete cable harness/link solution.

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