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Road vehicles — General requirements and test methods of in-vehicle optical harnesses for up to 100 Gbit/s communication

Véhicules routiers — Exigences générales et méthodes d'essai des faisceaux optiques embarqués pour les communications jusqu'à 100 Gbit/s

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 32, *Electrical and electronic components and general system aspects*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document contains general requirements and test methods for in-vehicle optical harnesses used for high speed communication. Reliable and robust data communication at high data rates is becoming increasingly crucial for the safe operation of automotive systems. Optical communication using graded index all-silica multimode fibre offers superior bandwidth and immunity to electro-magnetic noise. Optical fibre cables and connectors need equal processability, reliability and robustness against environmental influences to be integrated into the vehicle's wire harness. This document provides a set of test methods and requirements to verify the suitability of optical fibre cables and connectors for in-vehicle harness integration. Optical fibre cables can be used for different data transmission standards, such as Ethernet or other proprietary protocols. This means that some performance related requirements have limits depending on the physical layer they are intended for.

ISO 21111-4 is limited to the use of the 1000BASE-RH physical layer. Thus, the transmission rate is 1 Gbit/s and the communication distance is 15 m maximum with four in-line connections.

The optical harnesses defined in this document may cover any applications at high data rates as well as long distances, regardless of the physical layer (by OSI model). Therefore, this document is applicable for articulated-bus for public transportation and/or large-trailer for logistics.

Road vehicles — General requirements and test methods of in-vehicle optical harnesses for up to 100 Gbit/s communication

1 Scope

This document specifies the performance requirements and test methods for optical harnesses for up to 100 Gbit/s per fibre channel for in-vehicle data communication between electronic devices including in-line connections. The optical harness consists of cables and connectors, including cable to cable (in-line) connectors and electronic device (header) connectors. Safety (electrical safety, protection, fire, etc.) and electromagnetic compatibility (EMC) requirements are outside the scope of this document.

Specific to the optical header connector, only mechanical reference plane (MRP), optical reference plane (ORP) and relevant mechanical dimensions are within the scope of this document.

The optical coupling system inside an optical header connector and the optoelectronic component itself are beyond the scope of this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 16750-3, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 3: Mechanical loads*

ISO 16750-4, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 4: Climatic loads*

ISO 19642-1, *Road vehicles — Automotive cables — Part 1: Vocabulary and design guidelines*

ISO 19642-2, *Road vehicles — Automotive cables — Part 2: Test methods*

ISO 8092-2, *Road vehicles — Connections for on-board electrical wiring harnesses — Part 2: Terminology, test methods and general performance requirements*

ISO 21111-4, *Road vehicles — In-vehicle Ethernet — Part 4: General requirements and test methods of optical gigabit Ethernet components*

IEC 60068-2-60, *Tests — Test Ke: Flowing mixed gas corrosion test*

IEC 60793-1-46, *Optical fibres — Part 1-46: Measurement methods and test procedures — Monitoring of changes in optical transmittance*

IEC 60793-1-47, *Optical fibres — Part 1-47: Measurement methods and test procedures — Macrobending loss*

IEC 60794-1-21, *Optical fibre cables — Part 1-21: Generic specification — Basic optical cable test procedures — Mechanical tests methods*

IEC 60794-1-22, *Optical fibre cables — Part 1-22: Generic specification — Basic optical cable test procedures — Environmental test methods*

IEC 61300-1, *Fibre optic interconnecting devices and passive components — Basic test and measurement procedures — Part 1: General and guidance*

IEC 61300-2-22, *Fibre optic interconnecting devices and passive components — Basic test and measurement procedures — Part 2-22: Tests — Change of temperature*

IEC 61300-3-4, *Fibre optic interconnecting devices and passive components — Basic test and measurement procedures — Part 3-4: Examinations and measurements – Attenuation*

IEC 61300-3-6, *Fibre optic interconnecting devices and passive components — Basic test and measurement procedures — Part 3-6: Examinations and measurements — Return loss*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
buffered optical fibre
optical fibre with an additional layer that surrounds the fibre for the purpose of mechanical insulation and protection from physical damage

3.2
optical header connector
connector which may include an optical transceiver, media dependent interface and socket connector portion that is mated with the cable plug

3.3
optical in-line connector
connector prepared for relaying optical signals, obtained by mating an optical cable plug and an optical cable socket

3.4
system power budget
allocation of available optical power in order to ensure that adequate signal strength is available at the receiver

4 Abbreviated terms

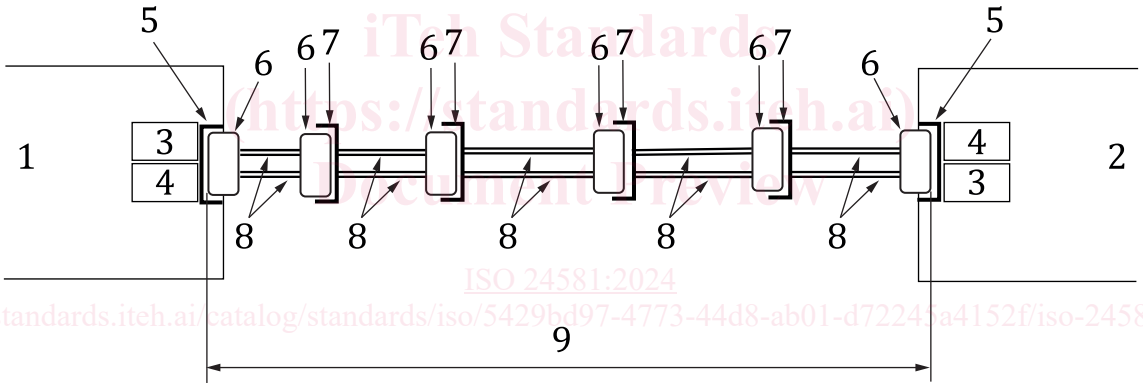
AOP	average optical power
DC	direct current
DUT	device under test
ECU	electronic control unit
FOT	fibre optic transceiver
GI-MMF	graded index – all-silica multimode fibre (excluding GI-POF)
LD	laser diode
MRP	mechanical reference plane

ORP	optical reference plane
PCB	printed circuit board
PD	photodiode
PMD	physical media dependent
TIA	trans impedance amplifier
VCSEL	vertical cavity surface emitting laser

5 Optical channel

5.1 General

The optical channel is composed of all optical elements that guide the optical signal from the light source of the optical transmitter in a first ECU to the photodetector of the optical receiver in a second ECU. The objective of the optical harness is to carry the optical signal between these ECUs with minimum loss and signal distortion. The optical harness may consist of multiple segments of optical fibre cable as defined in 6.3. Each end of a cable segment is terminated by an optical cable plug as defined in 7.3 or an optical cable socket as defined in 7.4. To connect two cable segments, one cable end shall be terminated with a cable plug. The other end that mated with the opposing cable shall be terminated with a cable socket accordingly. The mated combination of a cable plug and a cable socket is referred to as an in-line connection. See Figure 1.



Key

1 ECU-1 or other device-1
2 ECU-2 or other device-2
3 optical transmitter (light source)
4 optical receiver (photodetector)
5 optical header connector
6 optical cable plug
7 optical cable socket
8 optical fibre cable
9 optical channel

Figure 1 — Optical channel connecting ECUs

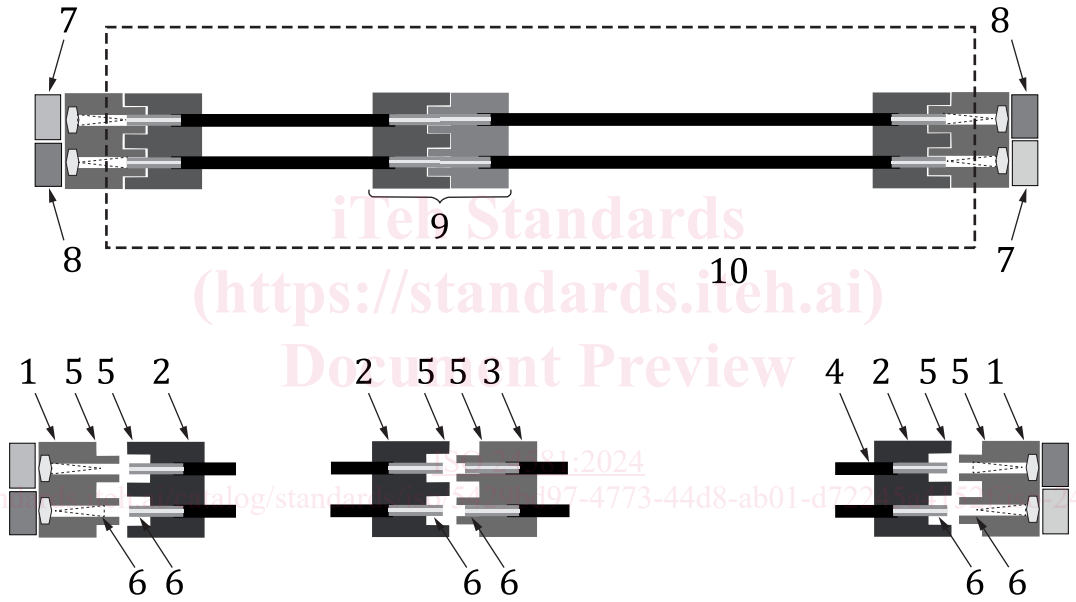
In this document, the mating socket of the ECU (header connector) is only defined with regards to its mechanical and optical mating interface to ensure its mating compatibility with the optical harness. Any optical guiding structures within the ECU or active components of the PMD are beyond the scope of this document.

The optical header connector is defined in 7.2. It shall follow the mechanical interface definitions of a socket connector to mate with an optical cable plug of a specified connector family. The optical path within the ECU and thus inside a header connector is not part of this document. The optical channel consists of optical fibre cables based on GI-MMF defined in Clause 6 and cable connectors defined in Clause 7 without any active (optoelectronic) power consuming sub-component.

5.2 Optical harness

The optical harness consists of one or more segments of optical fibre cable with optical cable plugs and/or optical cable sockets attached. The mated connection of two segments by a cable plug and a socket is referred to as an in-line connection. See Figure 2. The dashed line in Figure 2 encloses the optical harness and the housing parts of the header connector that are defined in this document. The total attenuation of the optical harness is also affected by the layout shape (bending and number of in-line connections) mounted on the vehicle. It shall not exceed the sum of the system power budget and system margin of the optical transceiver of the communication system. Optical harness design guidelines are provided in Annex B.

The length and number of segments allowed depend on each communication system specification (e.g. ISO/IEC/IEEE 8802-3). Additionally, when constructing a multi-giga optical Ethernet as specified in IEEE802.3cz:2023, the modal noise penalty listed in Annex D shall be satisfied.



Key

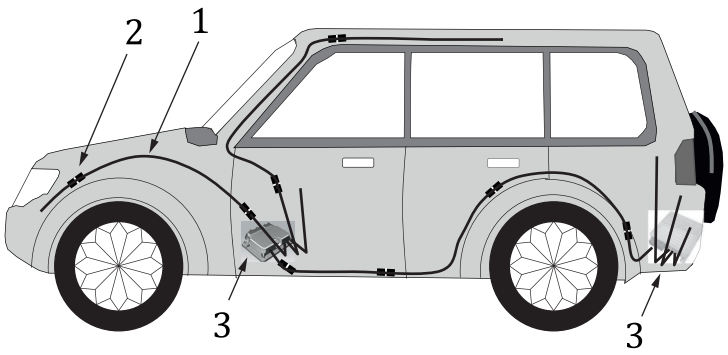
1 header connector housing
2 cable plug
3 cable socket
4 optical fibre cable
5 MRP
6 ORP
7 optical transmitter (light source)
8 optical receiver (photodetector)
9 optical in-line connection
10 optical harness

Figure 2 — Optical harness and relation between connectors

5.3 Optical harness application examples

Since the route of the long optical harness may correspond to the vicinity of the ceiling or the exposed part of the vehicle, various qualification tests shown in Clauses 6 to 9 of this document shall be required.

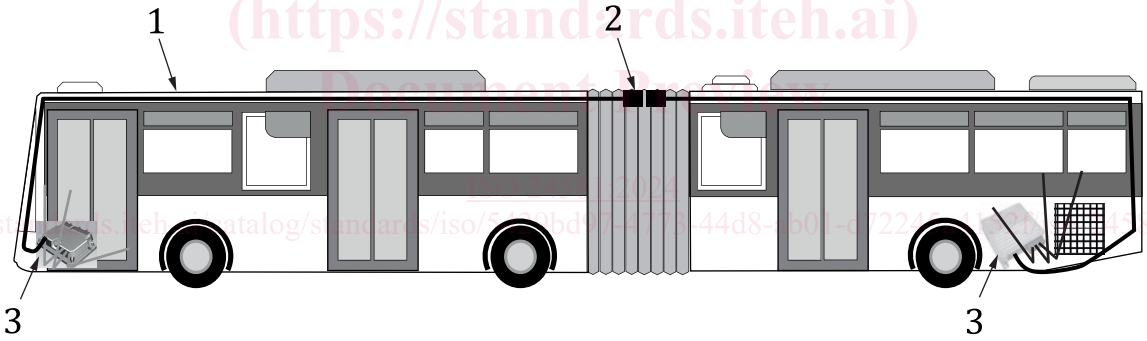
The optical harness is applicable to the engine compartment harness (see Figure 3), the roof harness (see Figure 4) and the exposure harness (see Figure 5). These harnesses should conform to individually specified temperature ranges.



Key

1 engine compartment harness
2 in-line connection
3 backbone ECU

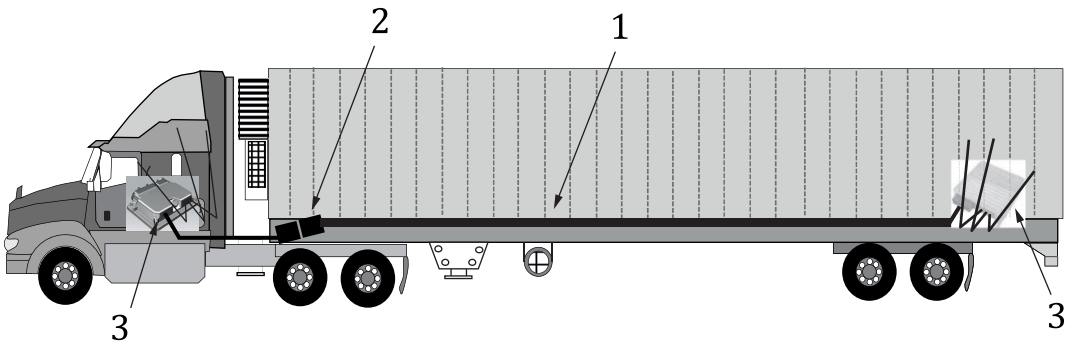
Figure 3 — Optical harness application example for the passenger car



Key

1 roof harness
2 in-line connection
3 backbone ECU

Figure 4 — Optical harness application example for the articulated bus



Key

1 exposure harness
2 in-line connection
3 backbone ECU

Figure 5 — Optical harness application example for the trailer

6 Optical fibre and optical fibre cable

6.1 General

Optical fibres with appropriate bandwidth characteristics at the wavelength of the selected PMD shall be implemented as the optical harnesses according to this document and used for communication with the specified data rates. IEC 60793-2-10 defines different subcategories of GI-MMF. Cables used in an automotive harness shall protect the optical fibre from environmental loads during shipment, storage, processing, installation into the vehicle and during a vehicle's operation. As a wire harness is typically deeply woven through a vehicle's body, it needs to last the entire lifetime of a vehicle. In many in-vehicle applications, the optical fibre cable shares the same installation space or even the same harness as other general wires for electrical functions. Thus, the optical fibre cable should to be able to withstand the same environmental loads such as temperature, humidity, chemicals, shock, vibration, bending, abrasion and pull and sheer forces as electrical cables intended for the same installation space.

6.2 Optical fibre

6.2.1 GI-MMF

IEC 60793-2-10 defines the dimensional requirements of optical fibre types with their core and cladding properties. See Figure 6. Optical fibres of subcategory A1-OM3 and A1-OM4 are defined for link length and signal bandwidth suitable to the requirements of the applications this document is targeting.

All optical cables specified in this document shall conform to subcategories A1-OM3 or A1-OM4 as specified in IEC 60793-2-10 and have an operating temperature range of up to +125 °C.

6.2.2 Buffered optical fibre structure

GI-MMF 50 µm is commercially available to cable manufacturers as a pre-product. For processability reasons, the all-silica fibre is protected by a primary coating applied during the fibre manufacturing process. Typical primary coatings have an outer diameter of 250 µm. Other coating diameters and/or additional coating layers may be applied depending on the application and cable requirements. Figure 6 shows an example of a typical GI-MMF buffered optical fibre structure.