SMPTE STANDARD

Ruggedized Fiber-Optic Connectors for HDTV and UHDTV SDI

Table of Contents

Approved
January 6, 2017

Foreword

SMPTE (the Society of Motion Picture and Television Engineers) is an internationally recognized standards developing organization. Headquartered and incorporated in the United States of America, SMPTE has members in over 80 countries on six continents. SMPTE's Engineering Documents, including Standards, Recommended Practices, and Engineering Guidelines, are prepared by SMPTE's Technology Committees. Participation in these Committees is open to all with a bona fide interest in their work. SMPTE cooperates closely with other standards-developing organizations, including ISO, IEC and ITU.

SMPTE Engineering Documents are drafted in accordance with the rules given in its Standards Operations Manual.

SMPTE ST 2091-1 was prepared by Technology Committee 32NF.

Intellectual Property

Attention is drawn to the possibility that implementing some of the elements of this document may be subject to patent rights. The holder of such patents is prepared to grant a license to its essential patent claims to an unrestricted number of applicants on a worldwide, non-discriminatory basis and on reasonable terms and conditions (RAND).

Introduction

This section is entirely informative and does not form an integral part of this Engineering Document.

This standard describes an optical connector system based on type LC or type MPO connectors which is targeting two areas of application, fixed installations and mobile use in the field. Therefore two performance classes are introduced. Applications with multiple mating cycles in a rather harsh environment require ruggedized connectivity solutions. The connectors specified in this document provide adequate features to cope with relevant requirements for harsh environments.

1 Scope

This document specifies ruggedized fiber-optic connectors based on standardized fiber-optic connectors, intended for use in HDTV and UHDTV broadcasting and video equipment where robust and reliable solutions are required.

The connectors are intended to be used for optical fiber systems such as defined in SMPTE ST 297-1, SMPTE ST 435-3 and SMPTE ST 2036-3.

This standard defines dimensional requirements related to reference planes of the underlying connector interfaces as standardized in IEC 61754-7 and IEC 61754-20. Furthermore structural and performance requirements are included considering optical and mechanical specifications.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:"

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords, "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword “reserved” indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword “forbidden” indicates “reserved” and in addition indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; Tables shall be next; followed by formal languages; then figures; and then any other language forms.

3 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

SMPTE ST 292-2:2011, Dual 1.5 Gb/s Serial Digital Interface for Stereoscopic Image Transport

SMPTE ST 297-1:2015, Serial Digital Fiber Transmission System for SMPTE ST 259, SMPTE ST 344, SMPTE ST 292-1/2, SMPTE ST 424, SMPTE ST 2081-1 and SMPTE ST 2082-1 Signals

SMPTE ST 372:2011, Dual Link 1.5 Gb/s Digital Interface for 1920 x 1080 and 2048 x 1080 Picture Formats

SMPTE ST 425-3:2015, Image Format and Ancillary Data Mapping for the Dual Link 3 Gb/s Serial Interface

SMPTE ST 425-4:2012, Dual 3 Gb/s Serial Digital Interface for Stereoscopic Image Transport

SMPTE ST 425-5:2015, Image Format and Ancillary Data Mapping for the Quad Link 3 Gb/s Serial Interface

SMPTE ST 425-6:2014, Quad 3 Gb/s Serial Digital Interface for Stereoscopic Image Transport

SMPTE ST 435-3:2012, 10 Gb/s Serial Signal/Data Interface – Part 3: 10.692 Gb/s Optical Fiber Interface

SMPTE ST 2036-3:2015, UItra High Definition Television – Mapping into Single-link or Multi-link 10 Gb/s Serial Signal/Data Interface using 10-bit width container

SMPTE ST 2048-3:2012, 4096 x 2160 Digital Cinematography Production Image Formats FS/709 – Mapping into Multi-link 10 Gb/s Serial Signal/Data Interface

SMPTE ST 2081-11:2016, 2160-line Source Image and Ancillary Data Mapping for Dual-link 6G-SDI

SMPTE ST 2081-12:2016, 4320-line and 2160-line Source Image and Ancillary Data Mapping for Quad-link 6G-SDI

SMPTE ST 2082-11:2016, 4320-line and 2160-line Source Image and Ancillary Data Mapping for Dual-link 12G-SDI

SMPTE ST 2082-12:2016, 4320-line and 2160-line Source Image and Ancillary Data Mapping for Quad-link 12G-SDI

IEC 60512-13-5:2006, Connectors for Electronic Equipment – Tests and Measurements – Part 13-5: Mechanical Operation Tests – Test 13e: Polarizing and Keying Method

IEC 61300-2-2:2009, Fibre Optic Interconnecting Devices and Passive Components – Basic Test and Measurement Procedures - Part 2-2: Tests – Mating Durability

IEC 61300-2-4:1995, Fibre Optic Interconnecting Devices and Passive Components – Basic Test and Measurement Procedures - Part 2-4: Tests – Fibre/Cable Retention

IEC 61300-3-4:2012, Fibre optic interconnecting devices and passive components – Basic Test and Measurement Procedures - Part 3-4: Examinations and Measurements - Attenuation

IEC 61300-3-6:2008, Fibre Optic Interconnecting Devices and Passive Components – Basic Test and Measurement Procedures - Part 3-6: Examinations and Measurements – Return Loss

IEC 61754-7:2008, Fibre Optic Interconnecting Devices and Passive Components – Fibre Optic Connector Interfaces – Part 7: Type MPO Connector Family

IEC 61754-20:2012, Fibre Optic Interconnecting Devices and Passive Components – Fibre Optic Connector Interfaces – Part 20: Type LC Connector Family

4 Terms and Acronyms

4.1 Angled Physical Contact (APC)

The fiber endfaces are polished with an angle of 5° to 15° relative to the axis vertical to minimize possible back reflections.

4.2 Connector

Ruggedized free component of connector system, assembled to multi-fiber patch cords and jacketed cables.

4.3 Multimode (MM) Fiber

Optical fiber with a larger core diameter in which the waves of multiple modes can propagate at the wavelength of interest. Due to its lower bandwidth-distance product this type of fiber is suitable for wideband transmission over short distances only. However it simplifies connections and allows the use of lower-cost light sources in premises applications.

4.4 Physical Contact (PC)

The fiber endfaces are polished with a convex rounded surface to make physical contact in the connector near the fiber core.

4.5 Receptacle

Ruggedized fixed component of connector system, acting as adapter installed in rack- or wall-mounted patch panels to intermate connector terminated fiber cables, or on terminal equipment to provide the interface between active optical devices and cabling circuits

4.6 Single Mode (SM) Fiber

Optical fiber with a small core diameter in which the wave of only one mode can propagate at the wavelength of interest. This type of fiber is particularly suitable for wideband transmission over large distances.

5 Connector System

Three different non-compatible connector systems are being specified:

- DUO: system based on the use of two parallel LC terminated fibers, in terms of a LC duplex connector.

- QUAD: system based on the use of four parallel LC like terminated fibers, in terms of two mirrored LC duplex like connectors.

- MPO: system based on the use of one MPO like coupler terminating up to 12 fibers in a single row or 24 fibers in two rows.

5.1 Structural Requirements

The interconnection system shall consist of a connector to connector arrangement, i.e. connectors shall be installed at both ends of the cable, while the receptacle acts as a feed-through adapter.

Note: In terminal equipment an E/O transmitter, receiver or transceiver, commonly mounted on a printed circuit board, can be connected to the panel mount receptacle by means of a patch or installation cable with connectors of type LC or type MPO respectively.

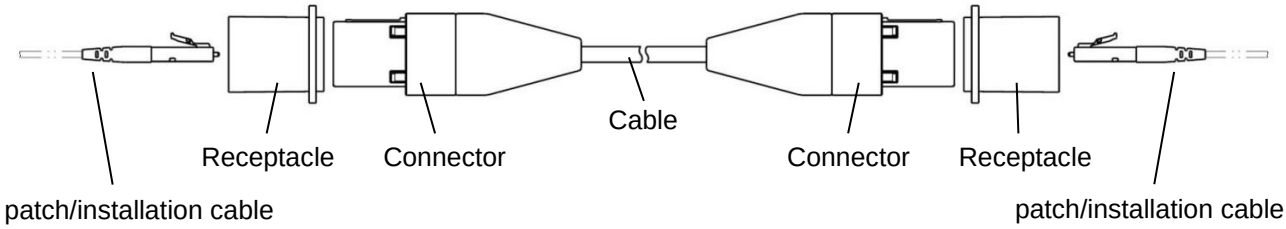

Figure 1 – Elements of the interconnection system

5.2 Types and Classification

In this document the various types are identified as follows:

- DUO connector: shall house two type LC connectors with PC polished fiber ends in a duplex configuration.

- DUO receptacle: shall house one type LC duplex adapter.

- QUAD connector: shall house four 1.25 mm ferrules based on type LC connectors with PC polished fiber ends in a double duplex configuration.

  Note: In a type LC compatible configuration double duplex would mean – one duplex with keys up and one duplex with keys down. Keys are not relevant in this type of connector.

- QUAD receptacle: shall house two duplex adapters based on type LC, arranged top with keys up and bottom with keys down.

  Note: Keys are not relevant with regard to mating interface.

- MPO connector: shall house a female MPO ferrule with guide holes to accept the alignment pins of the mating connector.

- MPO receptacle: shall house an MPO adapter with a key-up/key-down configuration as shown in Figure 17.

  Note: Key-up/key-down is also referred to as type A configuration enabling connection of the fibers in accordance to polarity Method A as defined in TIA-568-C.0. The use of a key-up/key-down adapter results from the possible use of SM fibers with APC polished endfaces.

Connectors are classified into two performance classes according to the type of use:

- MOBILE: Connector for mobile applications and harsh environment, including enhanced means for cable protection.

- FIXED INSTALLATION: Connector for fixed installations and less demanding environments.

Corresponding differing requirements are defined in Section 7.2.

Figure 2 – Connection setup example: MOBILE vs. FIXED INSTALLATION

5.3 Assignment of SDI Links to Connector Fibers

For single-link and dual-link interfaces such as referred to in SMPTE ST 297-1, SMPTE ST 425-3 or SMPTE ST 2036-3 the link assignments shall be as indicated in Table 1 (DUO assignment), Table 2 (QUAD assignment), or Table 3 or Table 4 (MPO assignment).

For quad-link interfaces such as SMPTE ST 425-5 or SMPTE ST 425-6 the link assignments shall be as indicated in Table 2 (QUAD assignment), or Table 3 or Table 4 (MPO assignment).

For multi-link interfaces such as SMPTE ST 2036-3 or SMPTE ST 2048-3 the link assignments shall be as indicated in Table 2 (QUAD assignment), or Table 3 and Figures 3 and 4, or Table 4 and Figures 5 and 6 respectively for MPO 12 or 24 fiber assignments.

The assignment is referred to the face (front view) of the receptacle.

5.3.1 DUO

Table 1 – DUO link assignments

No. of links	Link Rate	SMPTE SDI Mapping reference Standard	SMPTE SDI Physical Layer reference Standard	SMPTE SDI Optical I/F reference Standard	Output receptacle / Transmitter (TX)[1]		Input receptacle / Receiver (RX)[1]	
					B	A	A	B
Single	143 / 177 / 270 / 360 Mb/s	ST 259	ST 259	ST 297-1	TX	--	RX	--
	540 Mb/s	ST 377	ST 344		TX	--	RX	--
	1.5Gb/s	ST 292-1	ST 292-1		TX	--	RX	--
	3Gb/s	ST 425-1	ST 424		TX	--	RX	--
		ST 425-2	ST 424		TX	--	RX	--
	6Gb/s	ST 2081-10	ST 2081-1		Link 1	--	Link 1	--
	12Gb/s	ST 2082-10	ST 2082-1		Link 1	--	Link 1	--
	10.692Gb/s	ST 435-2	ST 435-3	ST 435-3[2]	TX	--	RX	--
		ST 2036-3	ST 2036-3		Link 1	--	Link 1	--
Dual	1.5Gb/s	ST 292-2	ST 292-1	ST 297-1	Left eye Stream	Right eye Stream	Left eye Stream	Right eye Stream
		ST 372	ST 292-1		Link A	Link B	Link A	Link B
	3Gb/s	ST 425-3	ST 424		Link 1	Link 2	Link 1	Link 2
		ST 425-4	ST 424		Left eye Image Interface	Right eye Image Interface	Left eye Image Interface	Right eye Image Interface
	6Gb/s	ST 2081-11	ST 2081-1		Link 1	Link 2	Link 1	Link 2
	12Gb/s	ST 2082-11	ST 2082-1		Link 1	Link 2	Link 1	Link 2
	10.692Gb/s	ST 2048-3	ST 2048-3	ST 435-3[2]	Link 1	Link 2	Link 1	Link 2
		ST 2036-3	ST 2036-3		Link 1	Link 2	Link 1	Link 2

Notes:

[1] Refer to Figure 10 for definition of B and A.

[2] Single mode fiber interface only.

5.3.2 QUAD

Table 2 – QUAD link assignments

No. of links	Link Rate	SMPTE SDI Mapping reference Standard	SMPTE SDI Physical Layer reference Standard	SMPTE SDI Optical I/F reference Standard	Output receptacle / Transmitter (TX)[1]				Input receptacle / Receiver (RX)[1]			
					B	A	b	a	A	B	a	b
Single	143 / 177 / 270 / 360 Mb/s	ST 259	ST 259	ST 297-1	TX	--			RX	--		
	540 Mb/s	ST 377	ST 344		TX				RX			
	1.5Gb/s	ST 292-1	ST 292-1		TX	--			RX	--		
	3Gb/s	ST 425-1	ST 424		TX	--			RX	--		
		ST 425-2	ST 424		TX	--			RX	--		
	6Gb/s	ST 2081-10	ST 2081-1		Link 1	--			Link 1	--		
	12Gb/s	ST 2082-10	ST 2082-1		Link 1	--			Link 1	--		
	10.692Gb/s	ST 435-2	ST 435-3	ST 435-3[2]	TX	--			RX	--		
		ST 2036-3	ST 2036-3		Link 1	--			Link 1	--		
Dual	1.5Gb/s	ST 292-2	ST 292-1	ST 297-1	Left eye Stream	--	Right eye Stream		Left eye Stream	--	Right eye Stream	
		ST 372	ST 292-1		Link A	--	Link B		Link A	--	Link B	
	3Gb/s	ST 425-3	ST 424		Link 1	--	Link 2		Link 1	--	Link 2	
		ST 425-4	ST 424		Left eye Image Interface	--	Right eye Image Interface		Left eye Image Interface	--	Right eye Image Interface	
	6Gb/s	ST 2081-11	ST 2081-1		Link 1	--	Link 2		Link 1	--	Link 2	
	12Gb/s	ST 2082-11	ST 2082-1		Link 1	--	Link 2		Link 1	--	Link 2	
	10.692Gb/s	ST 2048-3	ST 2048-3	ST 435-3[2]	Link 1	--	Link 2		Link 1	--	Link 2	
		ST 2036-3	ST 2036-3		Link 1	--	Link 2		Link 1	--	Link 2	
Triple	10.692Gb/s	ST 2048-3	ST 2048-3		Link 1	Link 3	Link 2		Link 1	Link 3	Link 2	

Quad	3Gb/s	ST 425-5	ST 424	ST 297-1	Link 1	Link 3	Link 2	Link 4	Link 1	Link 3	Link 2	Link 4
		ST 425-6	ST 424		Link 1	Link 3	Link 2	Link 4	Link 1	Link 3	Link 2	Link 4
	6Gb/s	ST 2081-12	ST2081-1		Link 1	Link 3	Link 2	Link 4	Link 1	Link 3	Link 2	Link 4
	12Gb/s	ST 2082-12	ST 2082-1		Link 1	Link 3	Link 2	Link 4	Link 1	Link 3	Link 2	Link 4
	10.692Gb/s	ST 2048-3	ST 2048-3	ST 435-3(2)	Link 1	Link 3	Link 2	Link 4	Link 1	Link 3	Link 2	Link 4
		ST 2036-3	ST 2036-3		Link 1	Link 3	Link 2	Link 4	Link 1	Link 3	Link 2	Link 4

Notes:

(1) Refer to Figure 14 for definition of B, A, b and a.

(2) Single-mode fiber interface only.

5.3.3 MPO

The fiber position numbers are following the convention as shown in Figure 17, i.e. position 1 left side (top row) with key up.

Table 3 – MPO with 12 fibers, single- to quad-link assignments

					Output receptacle / Transmitter (TX)(1)				**Input receptacle / Receiver (RX)(1)**			
No. of links	**Link Rate**	**SMPTE SDI Mapping reference Standard**	**SMPTE SDI Physical Layer reference Standard**	**SMPTE SDI Optical I/F reference Standard**	**1**	**2**	**3**	**4**	**12**	**11**	**10**	**9**
Single	143 / 177 / 270 / 360 Mb/s	ST 259	ST 259	ST 297-1	TX	--			RX	--		
	540 Mb/s	ST 377	ST 344		TX				RX			

	1.5Gb/s	ST 292-1	ST 292-1		TX	--			RX	--		
	3Gb/s	ST 425-1	ST 424		TX	--			RX	--		
		ST 425-2	ST 424		TX	--			RX	--		
	6Gb/s	ST 2081-10	ST 2081-1		Link 1	--			Link 1	--		
	12Gb/s	ST 2082-10	ST 2082-1		Link 1	--			Link 1	--		
	10.692Gb/s	ST 435-2	ST 435-3	ST 435-3(2)	TX	--			RX	--		
		ST 2036-3	ST 2036-3		Link 1	--			Link 1	--		
Dual	1.5Gb/s	ST 292-2	ST 292-1	ST 297-1	Left eye Stream	Right eye Stream			Left eye Stream	Right eye Stream		
		ST 372	ST 292-1		Link A	Link B			Link A	Link B		
	3Gb/s	ST 425-3	ST 424		Link 1	Link 2			Link 1	Link 2		
		ST 425-4	ST 424		Left eye Image Interface	Right eye Image Interface			Left eye Image Interface	Right eye Image Interface		
	6Gb/s	ST 2081-11	ST 2081-1		Link 1	Link 2			Link 1	Link 2		
	12Gb/s	ST 2082-11	ST 2082-1		Link 1	Link 2			Link 1	Link 2		
	10.692Gb/s	ST 2048-3	ST 2048-3	ST 435-3(2)	Link 1	Link 2			Link 1	Link 2		
		ST 2036-3	ST 2036-3		Link 1	Link 2			Link 1	Link 2		
Triple	10.692Gb/s	ST 2048-3	ST 2048-3		Link 1	Link 2	Link 3		Link 1	Link 2	Link 3	
Quad	3Gb/s	ST 425-5	ST 424	ST 297-1	Link 1	Link 2	Link 3	Link 4	Link 1	Link 2	Link 3	Link 4
		ST 425-6	ST 424		Link 1	Link 2	Link 3	Link 4	Link 1	Link 2	Link 3	Link 4
	6Gb/s	ST 2081-12	ST2081-1		Link 1	Link 2	Link 3	Link 4	Link 1	Link 2	Link 3	Link 4
	12Gb/s	ST 2082-12	ST 2082-1		Link 1	Link 2	Link 3	Link 4	Link 1	Link 2	Link 3	Link 4
	10.692Gb/s	ST 2048-3	ST 2048-3	ST 435-3(2)	Link 1	Link 2	Link 3	Link 4	Link 1	Link 2	Link 3	Link 4
		ST 2036-3	ST 2036-3		Link 1	Link 2	Link 3	Link 4	Link 1	Link 2	Link 3	Link 4

Notes:

(1) Refer to Figure 17 or Figure 3 for definition of fiber positions numbers 1 to 12.

(2) Single-mode fiber interface only.

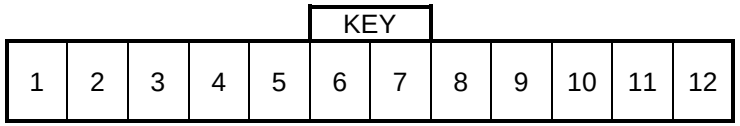

Figure 3 – MPO output receptacle (TX) key-up with 12 fibers, multi-link assignments

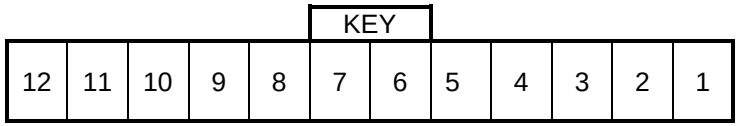

Figure 4 – MPO input receptacle (RX) key-up with 12 fibers, multi-link assignments

Note: Link numbers in Figure 3 correspond to fiber position numbers as identified in Figure 17.

Table 4 – MPO with 24 fibers, single- to quad-link assignments

					Output receptacle / Transmitter (TX)[1]				Input receptacle / Receiver (RX)[1]			
No. of links	**Link Rate**	**SMPTE SDI Mapping reference Standard**	**SMPTE SDI Physical Layer reference Standard**	**SMPTE SDI Optical I/F reference Standard**	**1**	**2**	**3**	**4**	**12**	**11**	**10**	**9**
Single	143 / 177 / 270 / 360 Mb/s	ST 259	ST 259	ST 297-1	TX	--			RX	--		
	540 Mb/s	ST 377	ST 344		TX				RX			
	1.5Gb/s	ST 292-1	ST 292-1		TX	--			RX	--		
	3Gb/s	ST 425-1	ST 424		TX	--			RX	--		
		ST 425-2	ST 424		TX	--			RX	--		

	6Gb/s	ST 2081-10	ST 2081-1		Link 1	--			Link 1	--		
	12Gb/s	ST 2082-10	ST 2082-1		Link 1	--			Link 1	--		
	10.692Gb/s	ST 435-2	ST 435-3	ST 435-3(2)	TX	--			RX	--		
		ST 2036-3	ST 2036-3		Link 1	--			Link 1	--		
Dual	1.5Gb/s	ST 292-2	ST 292-1	ST 297-1	Left eye Stream	Right Eye Stream			Left eye Stream	Right Eye Stream		
		ST 372	ST 292-1		Link A	Link B			Link A	Link B		
	3Gb/s	ST 425-3	ST 424		Link 1	Link 2			Link 1	Link 2		
		ST 425-4	ST 424		Left eye Image Interface	Right Eye Image Interface			Left eye Image Interface	Right Eye Image Interface		
	6Gb/s	ST 2081-11	ST 2081-1		Link 1	Link 2			Link 1	Link 2		
	12Gb/s	ST 2082-11	ST 2082-1		Link 1	Link 2			Link 1	Link 2		
	10.692Gb/s	ST 2048-3	ST 2048-3	ST 435-3(2)	Link 1	Link 2			Link 1	Link 2		
		ST 2036-3	ST 2036-3		Link 1	Link 2			Link 1	Link 2		
Triple	10.692Gb/s	ST 2048-3	ST 2048-3		Link 1	Link 2	Link 3		Link 1	Link 2	Link 3	
Quad	3Gb/s	ST 425-5	ST 424	ST 297-1	Link 1	Link 2	Link 3	Link 4	Link 1	Link 2	Link 3	Link 4
		ST 425-6	ST 424		Link 1	Link 2	Link 3	Link 4	Link 1	Link 2	Link 3	Link 4
	6Gb/s	ST 2081-12	ST2081-1		Link 1	Link 2	Link 3	Link 4	Link 1	Link 2	Link 3	Link 4
	12Gb/s	ST 2082-12	ST 2082-1		Link 1	Link 2	Link 3	Link 4	Link 1	Link 2	Link 3	Link 4
	10.692Gb/s	ST 2048-3	ST 2048-3	ST 435-3(2)	Link 1	Link 2	Link 3	Link 4	Link 1	Link 2	Link 3	Link 4
		ST 2036-3	ST 2036-3		Link 1	Link 2	Link 3	Link 4	Link 1	Link 2	Link 3	Link 4

Notes:

(1) Refer to Figure 17 or Figure 5 for definition of positions 1 to 24.

(2) Single-mode fiber interface only.

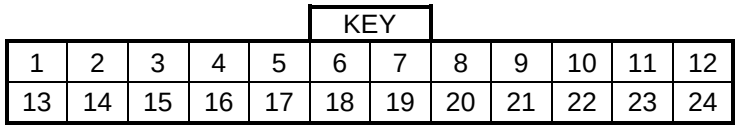

Figure 5 – MPO output receptacle (TX) key-up with 24 fibers, multi-link assignments

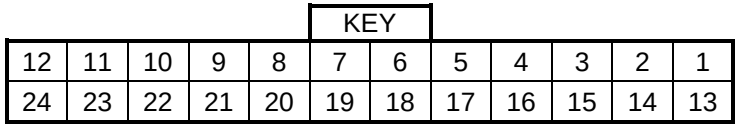

Figure 6 – MPO input receptacle (RX) key-up with 24 fibers, multi-link assignments

Note: Link numbers in Figure 5 correspond to fiber position numbers as identified in Figure 17.

5.4 Mechanical Requirements

5.4.1 Coupling

The mating connector pair shall be mechanically fixed by a push-pull coupling mechanism.

5.4.2 Polarization and Keying

For the purpose of correct alignment and orientation within a connector system and to prevent unintended intermating of different systems adequate mechanical keying means shall be provided as described in Section 6.3.

The proper mechanical keying shall be verified by an appropriate test method as referred to in Section 7.2.

5.4.3 Shutter

Dust and eye protection shall be provided by means of an automatic closing shutter in both mobile connector and receptacle components. The connector for fixed installations need not offer shutter protection, but shall show in the unmated state an easily visible laser warning symbol instead.

5.5 Labeling for Interoperability

Equipment conforming with this standard shall indicate the application (low-power, medium-power or high-power), the polish of the connector, the payload types they support and the wavelength they use in accordance with the Transmitting Unit and Receiving Unit Labeling requirements defined in SMPTE ST 297-1 which have the following format <application>-<polish>-<signal type>-<wavelength>.

In addition to the above requirement, equipment designed in conformance with this standard shall also be labeled to indicate WDM, CWDM or DWDM multiplexing operation, if applicable; and single, dual, quad or MPO connectivity.

Thus, the receptacle related label shall have the format <application>-<polish>-<signal type>-<wavelength>-<multiplex>-<No of links>.

– In accordance with SMPTE ST 297-1, the element <application> shall have the value:

- H for high-power (long-haul) link applications
- M for medium-power (medium-haul) link applications
- L for low-power (short-haul) link applications

– In accordance with SMPTE ST 297-1, the element <polish> shall have the value:

- PC for Physical Contact (flat polished) Connectors
- SPC for Super Physical Contact (flat polished) Connectors
- UPC for Ultra Physical Contact (flat polished) Connectors
- APC for Angle Physical Contact (angle polished) Connectors

– In accordance with SMPTE ST 297-1, for each supported signal type, the element <signal type> shall have the value:

- A to indicate support of SMPTE ST 259 signals
- B to indicate support of SMPTE ST 344 signals
- C to indicate support of SMPTE ST 292-1 signals
- D to indicate support for SMPTE ST 424 signals
- E to indicate support for SMPTE ST 2081-1 signals

- F to indicate support for SMPTE ST 2082-1 signals
- G Shall be reserved for future use

- and shall additionally support the following values:

- H to indicate support for SMPTE ST 435-3 signals
- J to indicate support for SMPTE ST 2036-3 signals
- K to indicate support for SMPTE ST 2048-3 signals

– The element <wavelength> shall have the value:

- 850 for 850 nm transmitters or receivers
- 1310 for 1310 nm transmitters or receivers
- 1550 for 1550 nm transmitters or receivers
- 850-1310 for receivers supporting 850 nm through 1310 nm
- 1310-1550 for transmitters (WDM) or receivers supporting 1310 nm through 1550 nm

– The element <multiplex> shall have the value:

- W for WDM operation
- CW for CWDM operation
- DW for DWDM operation

– The element <No of links> shall have the value:

- 1 for single link
- 2 for dual link
- 4 for quad link
- MPO‘n’ where ‘n’ shall be in the range 1 through 24

EXAMPLE 1: An angle polished low-power (short-haul) single link transmitter that supports SMPTE ST 259 and SMPTE ST 292-1 signals at an optical wavelength of 1310 nm is labeled L-APC-AC-1310-1.

EXAMPLE 2: An angle polished quad link Receiver that supports SMPTE ST 425-5, SMPTE ST 2081-12 and SMPTE ST 2082-12 signals at an optical wavelength of 1310 nm is labeled APC-DEF-1310-4.

EXAMPLE 3: A PC polished low-power (short-haul) 24 Channel Transmitter that supports multiple SMPTE ST 2081-12 signals at an optical wavelength of 850 nm is labeled L-PC-E-850-MPO24.

Such a label should be clearly visible on the equipment in close proximity to the receptacle to which the information applies. It is also acceptable to include such label information in commercial publications.

Note: The label provides information to the system integrator or installer what connecting cable is required.

5.6 Color Coding Scheme

If, in addition to the requirements of Section 5.5, color coding is deemed necessary for some reasons, the applied colors shall comply with the requirements of this subclause. Indicating colors shall be applied only where they can be easily distinguished and do not lead to false identification or misunderstandings with regard to the application.

5.6.1 Physical identification

For physical identification purpose, with regard to system (number of fibers) and fiber polish, the connector system shall exhibit dedicated colors which shall be easily discernible in the unmated state, as indicated in Table 5.

Table 5 – System color assignment

System	Number of fibers	Color
DUO	2	black
QUAD	4	white
MPO	12	orange
	24	red

Fiber type and polish shall be identified by the following colors assigned to parts visible in the unmated state:

Table 6 – Fiber/Polish color assignment

Fiber type	Color
MM	black
SM	blue
SMA (APC)	green

5.6.2 Data rate / SDI type identification

To recognize and differ between the various data rates and protocols as used in the indicated SDI standards the following color coding scheme shall be used for interoperability of equipment.

The corresponding color coding means shall be possible to being attached by the system installer or user in accordance to the intended application of the connector system.

Table 7 – Protocol color assignment

Interface standard	Data rate / Protocol	Connector/Receptacle Color coding
SMPTE ST 297-1	1.5G-SDI, 3G-SDI, 6G-SDI,… single-/dual-/quad-link	yellow
SMPTE ST 435-3	10G-SDI single-/dual-link and multiple-link	magenta
SMPTE ST 2036-3		

6 Mechanical Interface

6.1 General

The three sets of the connector system - DUO, QUAD and MPO - are characterized by common overall mechanical attributes, like basic housing dimensions, coupling means and shutter mechanisms for dust and eye protection. Each set uses mechanical keys to prevent damage of optical elements from mating with a wrong connector.

All required dimensions to allow proper mating of connector components that are intended to be intermateable and to guarantee specified optical performance are given as referred to in Section 6.2.

Note: Dimensions and positions of electrical contacts of DUO system are specified for intermateability only.

The keying arrangement for each connector type is given as referred to in Section 6.3.

Panel mounting details for receptacles are defined under Section 6.4.

For further dimensional details refer to related standards, i.e. IEC 61754-7 and IEC 61754-20 respectively.

6.2 Mating Interface Drawings and Dimensions

The mating interface dimensions for each connector and receptacle configuration shall be in accordance with Figures 7 to 10 and Tables 11 to 14, Figures 11 to 14 and Tables 15 to 18, and Figures 15 to 18 and Tables 19 to 22, respectively.

6.3 Keying

The connectors and receptacles shall have polarization keys in accordance with Figures 19 and 20 and Tables 23 and 24, Figures 21 and 22 and Tables 25 and 26, and Figures 23 and 24 and Tables 27 and 28, respectively.

6.4 Mounting on panels

Panel apertures and mounting holes for receptacles shall be in accordance with Figure 25 and Table 29.

7 Characteristics

The connector system shall meet the following minimum requirements:

7.1 Optical Specification

Table 8 – Optical performance

Connector system	Fiber interface	Insertion Loss[1]	Return Loss[2]
DUO, QUAD	SM PC / APC	< 0.5 dB	> 50 dB
MPO	SM PC / APC	< 0.75 dB	
DUO, QUAD	MM	< 0.5 dB	> 40 dB
MPO	MM	< 0.75 dB	

[1] Insertion loss measured according IEC 61300-3-4 insertion method B.

[2] Return loss measured according IEC 61300-3-6.

7.2 Mechanical Specification

Requirements according to either performance class MOBILE or FIXED INSTALLATION:

Table 9 – Performance class MOBILE

Connector system	Lifetime[1]	Cable retention force[2]	Polarizing and keying[3]
DUO, QUAD	5000 mating cycles	500 N	60 N
MPO multimode	5000 mating cycles		
MPO single-mode	2500 mating cycles		

Table 10 – Performance class FIXED INSTALLATION

Connector system	Lifetime[1]	Cable retention force[2]	Polarizing and keying[3]
DUO, QUAD	2500 mating cycles	150 N	45 N
MPO multimode	2500 mating cycles		
MPO single-mode	1500 mating cycles		

Footnotes to Tables:

[1] Lifetime measured according IEC 61300-2-2 and IEC 61300-3-4 respectively.

[2] Cable retention force measured according IEC 61300-2-4.

[3] Polarizing and keying measured according IEC 60512-13-5. Applying an unintentional mating force of specified value shall not result in partial insertion or damage likely to impair normal function.

7.3 Environmental Specification

- Temperature range: -40 °C to +75 °C
- Waterproofing: IP65 in mated condition

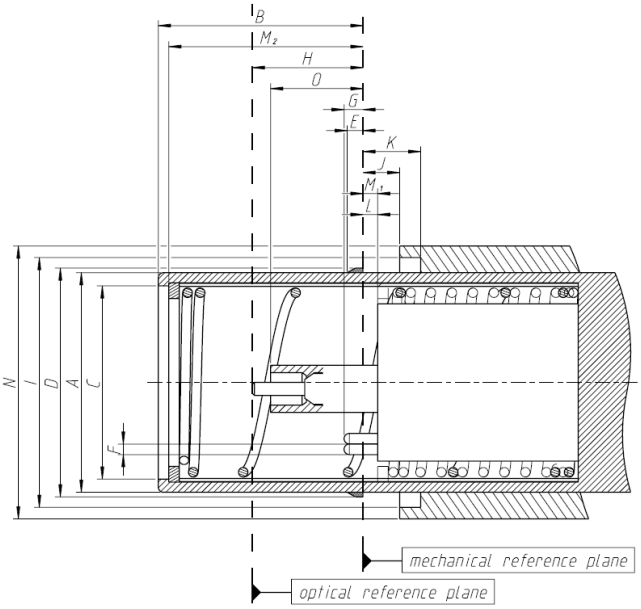

Figure 7 – DUO connector interface – side view

Table 11 – Dimensions of DUO connector interface – side view

Reference	Dimension mm			Description
	Minimum	Nominal	Maximum	
A	–	–	20.93	housing mating diameter
B	19.40	–	19.60	housing depth
C	18.35	–	–	housing front inner diameter
D	–	–	21.80	latch diameter
E	–	–	1.40	latch depth
F	0.98	–	1.00	contact pin diameter
G	2.20	–	2.40	contact pin position
H	10.50	–	10.70	optical to mechanical reference plane [1]
I	23.90	–	–	locking ring inner diameter
J	3.60	–	–	locking ring position
K	5.80	–	–	locking ring position
L	2.50	–	–	adapter position
M_1	2.50	–	–	shutter (insert) rear position [2]
M_2	15.00	–	–	shutter (insert) front position [2]
N	–	–	27.50	locking ring diameter
O	8.70	–	8.90	ferrule holder depth [3]
[1] Dimension H is given for a plug end face when not mated and correlates to dimension B in Figure 1 of IEC 61754-20.				
[2] The shutter must be operated by use of an axial force, the opening force must be more than 7 N. M1 defines the rear position (shutter open) of the shell while M2 defines the front position (shutter closed).				
[3] Dimension O correlates to dimension Q in Figure 3 of IEC 61754-20.				
Note: Dimensions A - M_1 correlate with dimensions A - M_1 of Table 13.				

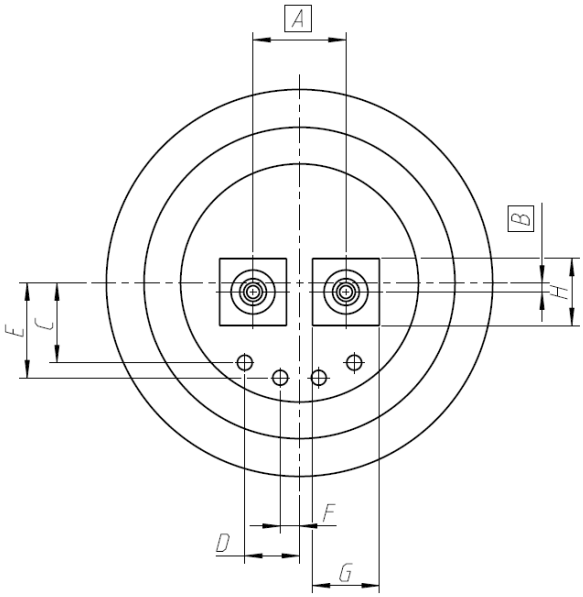

Figure 8 – DUO connector interface – front view

Table 12 – Dimensions of DUO connector interface – front view

Reference	Dimension mm			Description
	Minimum	Nominal	Maximum	
A	–	6.25	–	optical contact basic dimension [1]
B	–	0.61	–	optical contact basic dimension, offset
C	5.35	–	5.37	electrical contact position
D	3.67	–	3.69	electrical contact position
E	6.36	–	6.38	electrical contact position
F	1.29	–	1.31	electrical contact position
G	4.42	–	4.52	ferrule holder dimension [1]
H	4.42	–	4.52	ferrule holder dimension [1]
[1] According to IEC 61754-20.				
Note: Dimensions A - F correlate with dimensions A - F of Table 14.				

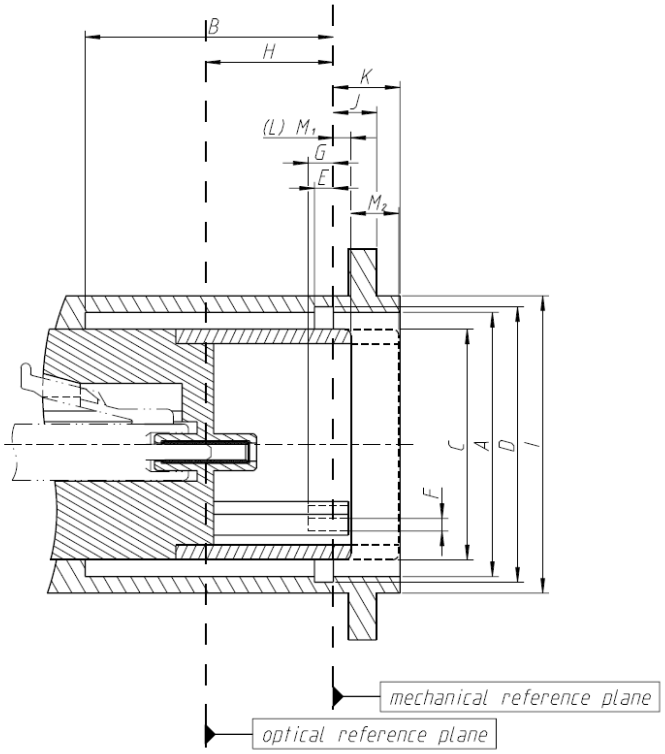

Figure 9 – DUO receptacle interface – side view

Table 13 – Dimensions of DUO receptacle interface – side view

Reference	Dimension mm			Description
	Minimum	Nominal	Maximum	
A	20.97	–	–	housing mating diameter
B	20.00	–	–	housing depth
C	–	–	18.20	shutter (insert) diameter
D	21.85	–	–	locking groove diameter
E	1.50	–	–	locking groove depth
F	–	1.00	–	electrical contact inside diameter [2]
G	3.00	–	–	electrical contact depth
H	10.10	–	10.20	optical to mechanical reference plane
I	–	–	23.70	Flange front diameter
J	–	–	2.75	flange depth
K	–	–	5.30	housing depth
(L) M_1	–	–	1.70	shutter (insert) rear position [1]
M_2	–	3.90	–	shutter (insert) stroke [1]
[1] The shutter must be operated by use of an axial force, the opening force must be less than 5 N. M1 defines the rear position (shutter open) of the shell while M2 defines the front position (shutter closed). The shutter shall contain a two way opening system activated by axial force on the inner shell as well as by inserting the LC connector shaped ferrule holder of the connector (Tables 12 and 11).				
[2] Sleeve pre-load to be adjusted with dimension F of Table 11.				
Note: Dimensions A - M_1 correlate with dimensions A - M_1 of Table 11.				

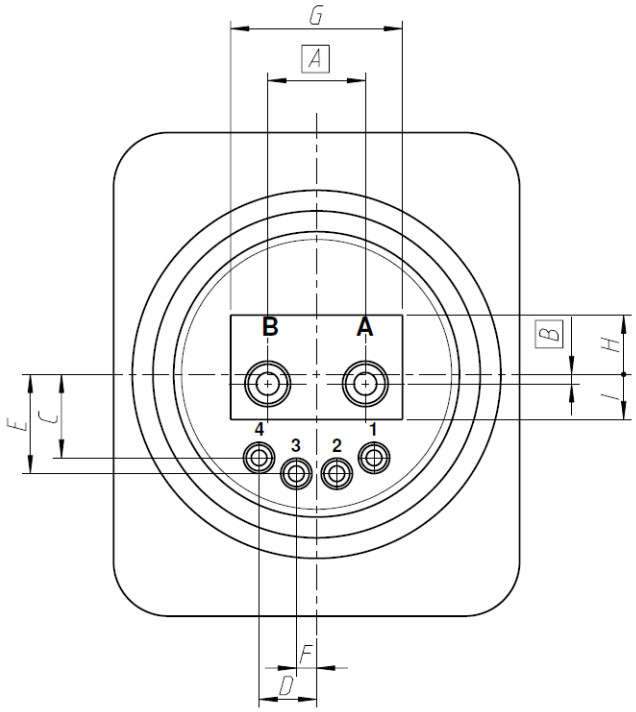

Figure 10 – DUO receptacle interface – front view

Table 14 – Dimensions of DUO receptacle interface – front view

Reference	Dimension mm			Description
	Minimum	Nominal	Maximum	
A	–	6.25	–	optical contact basic dimension [1]
B	–	0.61	–	optical contact basic dimension, offset
C	5.35	–	5.37	electrical contact position
D	3.67	–	3.69	electrical contact position
E	6.36	–	6.38	electrical contact position
F	1.29	–	1.31	electrical contact position
G	11.00	–	–	shutter (insert) dimension
H	3.80	–	–	shutter (insert) dimension
I	2.90	–	–	shutter (insert) dimension
[1] According to IEC 61754-20.				
Note: Dimensions A - F correlate with dimensions A - F of Table 12.				

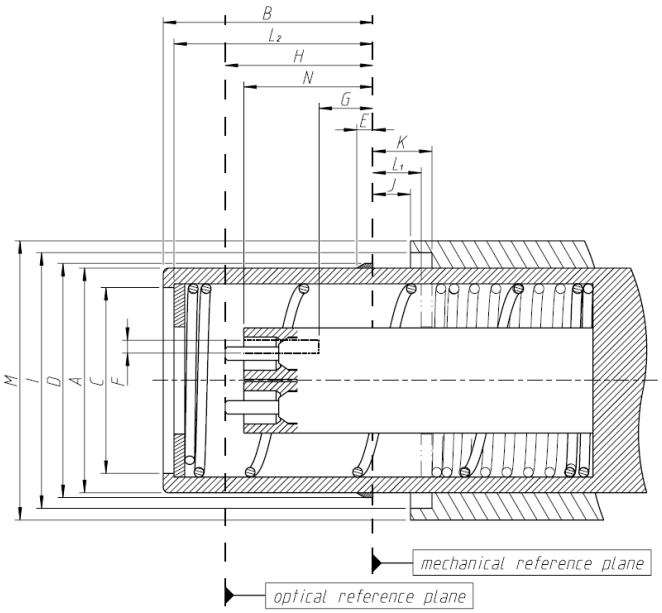

Figure 11 – QUAD connector interface – side view

Table 15 – Dimensions of QUAD connector interface – side view

Reference	Dimension mm			Description
	Minimum	Nominal	Maximum	
A	–	–	20.93	housing mating diameter
B	19.40	–	19.60	housing depth
C	17.40	–	–	housing front inner diameter
D	–	–	21.80	latch diameter
E	–	–	1.40	latch depth
F	1.20	–	1.25	guide hole diameter
G	5.00	–	–	guide hole depth
H	13.85	–	14.05	optical to mechanical reference plane [1]
I	23.90	–	–	locking ring inner diameter
J	3.60	–	–	locking ring position
K	5.80	–	–	locking ring position
L_1	5.00	–	–	shutter (insert) rear position [2]
L_2	15.00	–	–	shutter (insert) front position [2]
M	-	–	27.50	locking ring diameter
N	12.05	–	12.25	ferrule holder depth [3]
[1] Dimension H is given for a plug end face when not mated and correlates to dimension B in Figure 1 of IEC 61754-20.				
[2] The shutter must be operated by use of an axial force, the opening force must be more than 7 N. L1 defines the rear position (shutter open) of the shell while M2 defines the front position (shutter closed).				
[3] Dimension N correlates to dimension Q in Figure 3 of IEC 61754-20.				
Note: Dimensions A - L_1 correlate with dimensions A - L_1 of Table 17.				

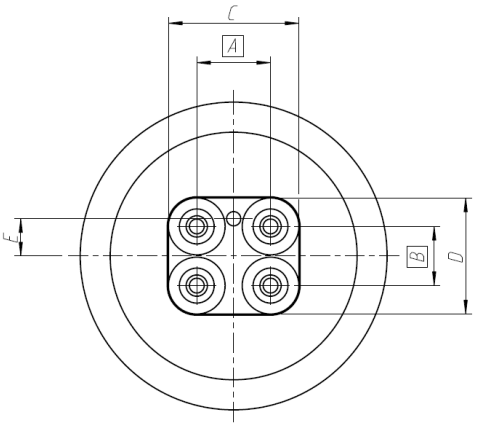

Figure 12 – QUAD connector interface – front view

Table 16 – Dimensions of QUAD connector interface – front view

Reference	Dimension mm			Description
	Minimum	Nominal	Maximum	
A	–	6.25	–	optical contact basic dimension [1]
B	–	5.00	–	optical contact basic dimension
C	–	–	11.05	ferrule holder dimension
D		–	9.80	ferrule holder dimension
E	3.14	–	3.16	guide pin position
[1] According to IEC 61754-20.				
Note: Dimensions A - E correlate with dimensions A - E of Table 18.				

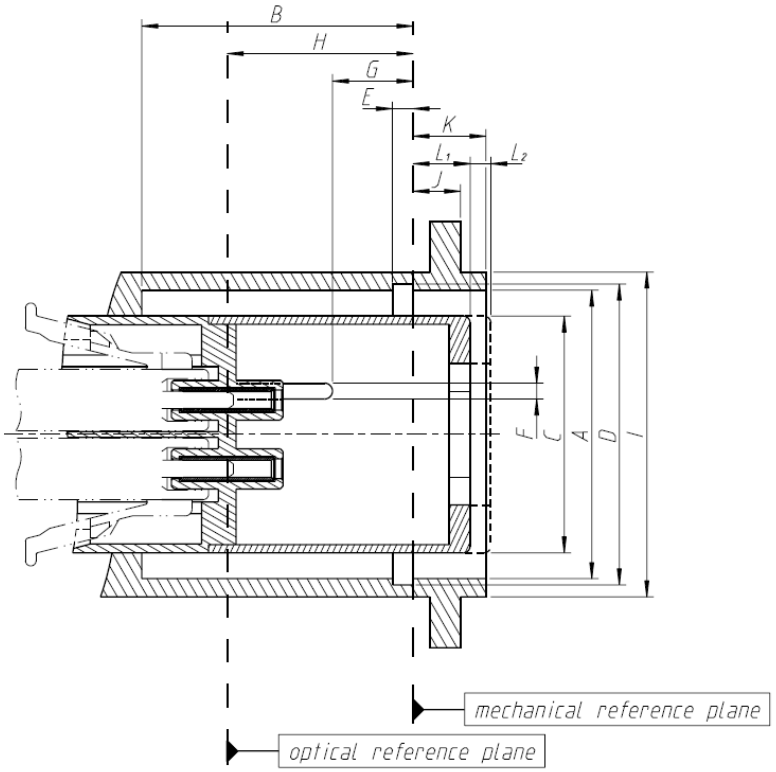

Figure 13 – QUAD receptacle interface – side view

Table 17 – Dimensions of QUAD receptacle interface – side view

Reference	Dimension mm			Description
	Minimum	Nominal	Maximum	
A	20.97	–	–	housing mating diameter
B	20.00	–	–	housing depth
C	–	–	17.20	shutter (insert) diameter
D	21.85	–	–	locking groove diameter
E	1.50	–	–	locking groove depth
F	1.10	–	1.18	guide pin diameter
G	5.80	–	6.00	guide pin length
H	13.45	–	13.55	optical to mechanical reference plane
I	–	–	23.70	flange front diameter
J	–	–	2.75	flange depth
K	–	–	5.30	housing depth
L_1	–	–	5.00	shutter (insert) rear position [1]
L_2	–	1.50	–	shutter (insert) stroke [1]
[1] The shutter must be operated by use of an axial force, the opening force must be less than 5 N. L1 defines the rear position (shutter open) of the shell while L2 defines the front position (shutter closed).				
Note: Dimensions A - L_1 correlate with dimensions A - L_1 of Table 15.				

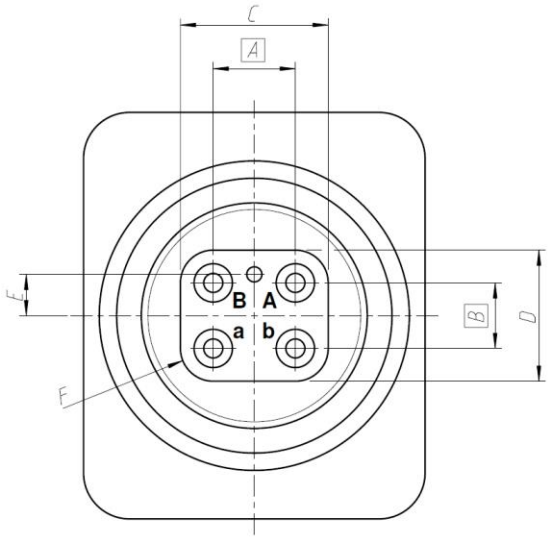

Figure 14 – QUAD receptacle interface – front view

Table 18 – Dimensions of QUAD receptacle interface – front view

Reference	Dimension mm			Description
	Minimum	Nominal	Maximum	
A	–	6.25	–	optical contact basic dimension [1]
B	–	5.00	–	optical contact basic dimension
C	11.25	–	–	shutter (insert) dimension
D	10.00	–	–	shutter (insert) dimension
E	3.14	–	3.16	guide hole position
F	–	–	2.50	shutter (insert) dimension, radius
[1] According to IEC 61754-20.				
Note: Dimensions A - E correlate with dimensions A - E of Table 16.				

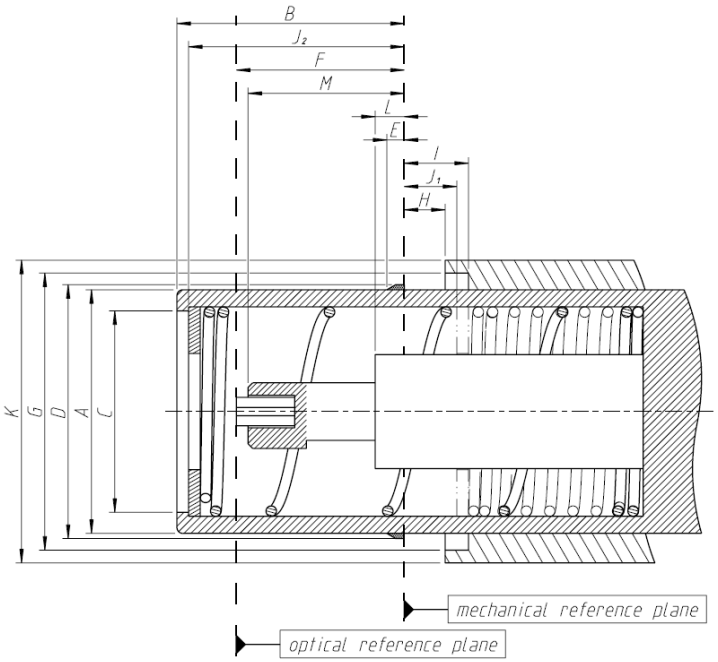

Figure 15 – MPO connector interface – side view

Table 19 – Dimensions of MPO connector interface – side view

Reference	Dimension mm			Description
	Minimum	Nominal	Maximum	
A	–	–	20.93	housing mating diameter
B	19.40	–	19.60	housing depth
C	17.40	–	-	housing front inner diameter
D	–	–	21.80	latch diameter
E	–	–	1.40	latch depth
F	15.15	–	15.55	optical to mechanical reference plane [1]
G	23.90	–	–	locking ring inner diameter
H	3.60	–	–	locking ring position
I	5.80	–	–	locking ring position
J_1	5.00	–	–	insert rear position [2]
J_2	15.00	–	–	insert front position [2]
K	–	–	27.50	locking ring diameter
L	–	–	3.60	holder depth
M	14.25	–	14.45	ferrule holder depth [3]
[1] Dimension F is given for a plug end face when not mated and correlates to dimension I in Figure 2 of IEC 61754-7.				
[2] The shutter must be operated by use of an axial force, the opening force must be more than 7 N. J1 defines the rear position (shutter open) of the shell while J2 defines the front position (shutter closed).				
[3] Dimension M correlates to dimension J in Figure 2 of IEC 61754-7.				
Note: Dimensions A - J_1 correlate with dimensions A - J_1 of Table 21.				

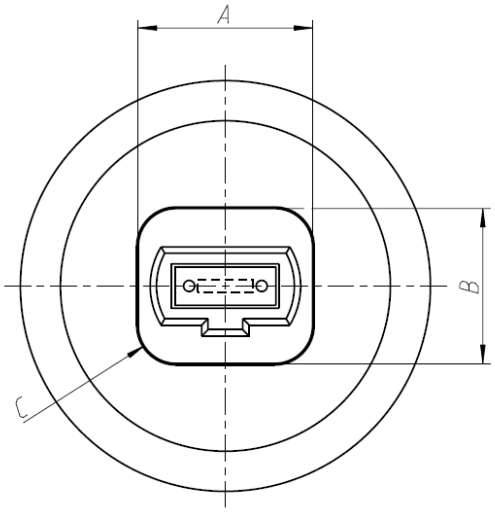

Figure 16 – MPO connector interface – front view

Table 20 – Dimensions of MPO connector interface – front view

Reference	Dimension mm			Description
	Minimum	Nominal	Maximum	
A	–	–	11.05	ferrule holder dimension
B	–	–	9.80	ferrule holder dimension
C	2.40	–	–	ferrule holder dimension, radius
Note: Dimensions A - C correlate with dimensions A - C of Table 22.				

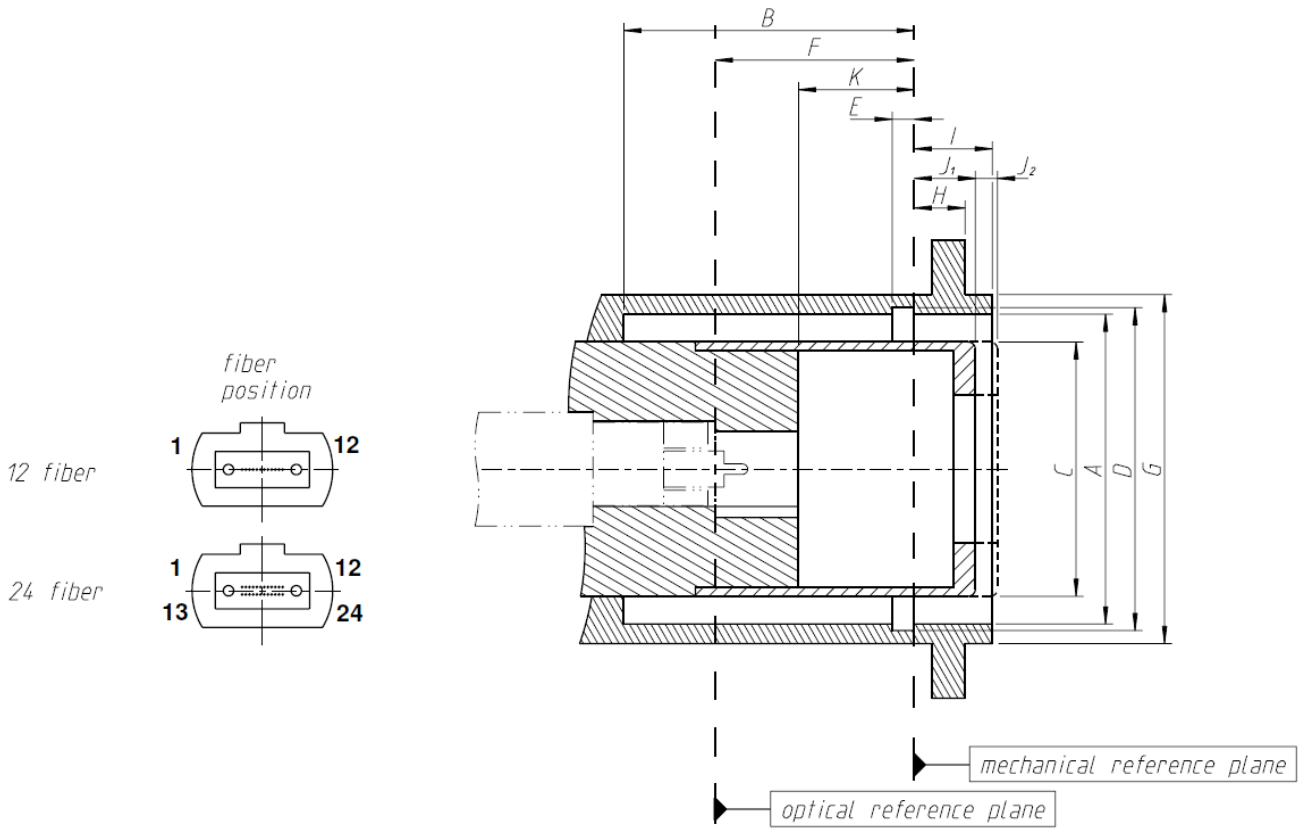

Figure 17 – MPO receptacle interface – side view

Table 21 – Dimensions of MPO receptacle interface – side view

Reference	Dimension mm			Description
	Minimum	Nominal	Maximum	
A	20.97	–	–	housing mating diameter
B	20.00	–	–	housing depth
C	-	–	17.20	shutter (insert) diameter
D	21.85	–	–	locking groove diameter
E	1.50	–	–	locking groove depth
F	14.55	–	14.75	optical to mechanical reference plane
G	–	–	23.70	flange front diameter
H	–	–	2.75	flange depth
I	–	–	5.30	housing depth
J_1	–	–	5.00	shutter (insert) rear position [1]
J_2	–	1.50	–	shutter (insert) stroke [1]
K	4.00	–	–	insert depth
[1] The shutter must be operated by use of an axial force, the opening force must be less than 5 N. J1 defines the rear position (shutter open) of the shell while J2 defines the front position (shutter closed).				
Note: Dimensions A - J_1 correlate with dimensions A - J_1 of Table 19.				

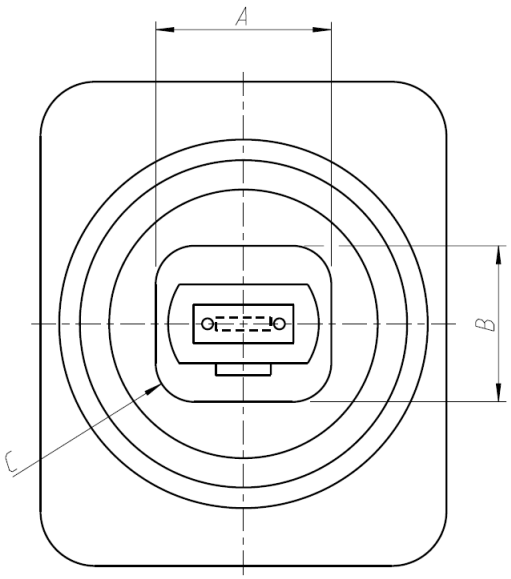

Figure 18 – MPO receptacle interface – front view

Table 22 – Dimensions of MPO receptacle interface – front view

Reference	Dimension mm			Description
	Minimum	Nominal	Maximum	
A	11.25	–	–	shutter (insert) dimension
B	10.00	–	–	shutter (insert) dimension
C	–-	–	2.50	shutter (insert) dimension, radius
Note: Dimensions A - C correlate with dimensions A - C of Table 20.				

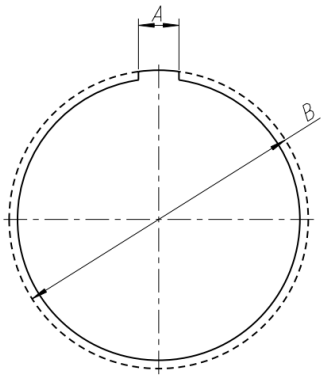

Figure 19 – DUO connector keying

Table 23 – Dimensions of DUO connector keying

Reference	Dimension mm			Description
	Minimum	Nominal	Maximum	
A	–	–	3.00	key dimension
B	–	–	22.19	key dimension, diameter

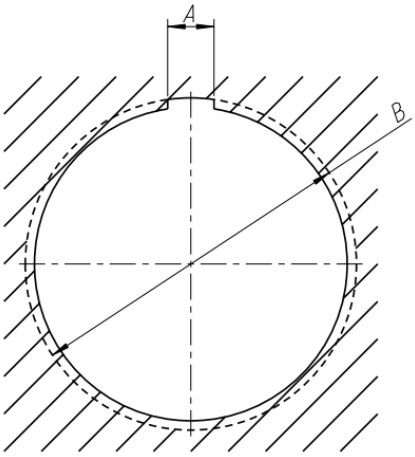

Figure 20 – DUO receptacle keying

Table 24 – Dimensions of DUO receptacle keying

Reference	Dimension mm			Description
	Minimum	Nominal	Maximum	
A	3.15	–	–	key dimension
B	22.20	–	–	key dimension, diameter

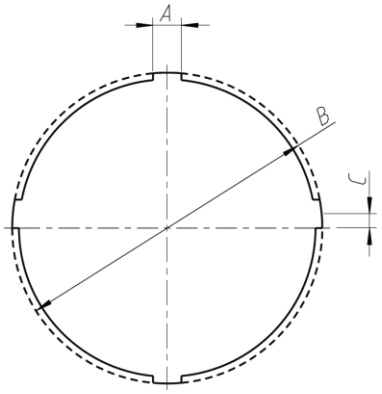

Figure 21 – QUAD connector keying

Table 25 – Dimensions of QUAD connector keying

Reference	Dimension mm			Description
	Minimum	Nominal	Maximum	
A	–	–	2.00	key dimension, for all 4 keys
B	–	–	21.90	key dimension, diameter
C	–	1.00	–	side key position

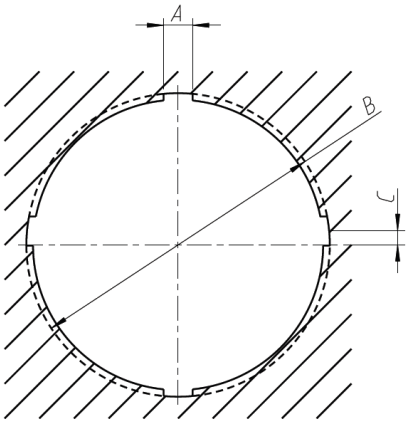

Figure 22 – QUAD receptacle keying

Table 26 – Dimensions of QUAD receptacle keying

Reference	Dimension mm			Description
	Minimum	Nominal	Maximum	
A	2.15	–	–	key dimension, for all 4 keys
B	22.15	–	–	key dimension, diameter
C	–	1.00	–	side key position

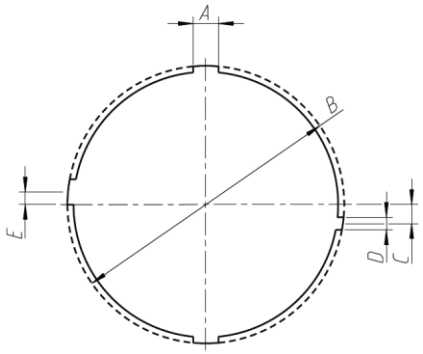

Figure 23 – MPO connector keying

Table 27 – Dimensions of MPO connector keying

Reference	Dimension mm			Description
	Minimum	Nominal	Maximum	
A	–	–	2.00	key dimension, for 3 of 4 keys
B	–	–	21.90	key dimension, diameter
C	–	1.50	–	side key position
D	–	–	1.00	side key dimension
E	–	1.00	–	side key position

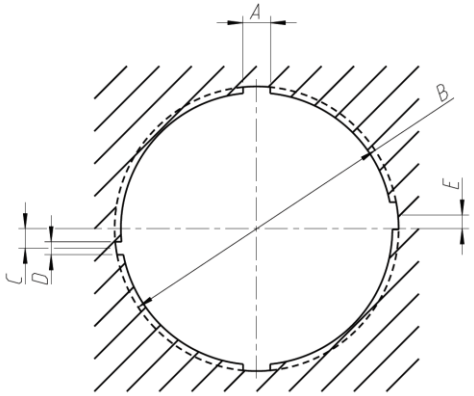

Figure 24 – MPO receptacle keying

Table 28 – Dimensions of MPO receptacle keying

Reference	Dimension mm			Description
	Minimum	Nominal	Maximum	
A	2.15	–	–	key dimension, for 3 of 4 keys
B	22.15	–	–	key dimension, diameter
C	–	1.50	–	side key position
D	1.15	–	–	side key dimension
E	–	1.00	–	side key position

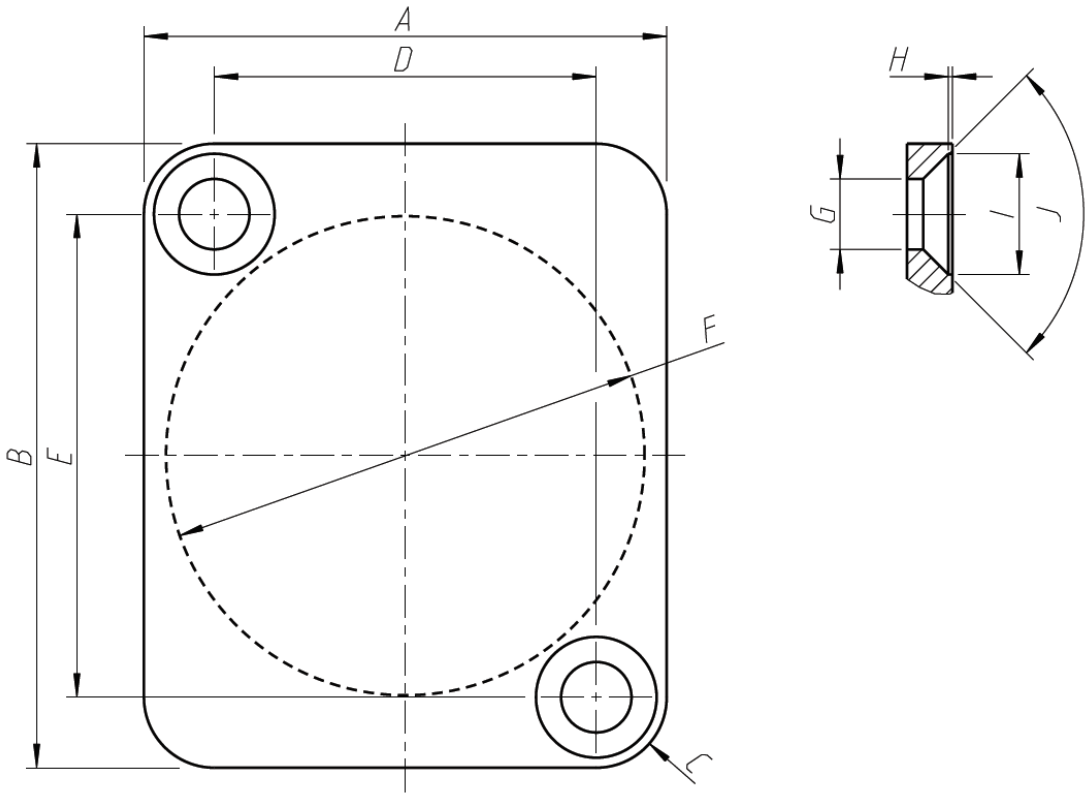

Figure 25 – D-size Flange

Table 29 – Dimensions of D-size Flange

Reference	Dimension mm			Description
	Minimum	Nominal	Maximum	
A	25.80	–	26.00	flange dimension, width
B	30.80	–	31.00	flange dimension, height
C	–	3.50	–	flange dimension, radius
D	18.90	–	19.10	mounting hole position
E	23.90	–	24.10	mounting hole position
F	23.80	–	–	panel cut-out
G	3.50	–	–	mounting hole dimension, diameter
H	–	0.20	–	mounting hole dimension
I	6.00	–	–	mounting hole countersink dimension
J	–	90°	–	mounting hole countersink dimension, angle
Note: Use M3 countersunk screw.				

Annex A Laser safety information (Informative)

Visible and invisible radiation from laser diodes and LEDs used in optical fiber communications systems is considered to be a safe application of laser technology. Light output is entirely confined to the core of the interconnected fiber, and does not leak through the cladding and outer sheath. If the pigtail of an active light source is disconnected, damage to the eye is remotely possible under the most unlikely possibility that a person would look directly into the fiber at close range for an extended period of time.

Publications of the U.S. Government Food and Drug Administration's Center for Devices and Radiological Health, ANSI, and IEC provide guidance on practices to be followed in working with optical fiber communications systems. They also contain information on labeling requirements for modules containing a laser/LED light source coupled to the outside via a pigtail or optical connector. Users are further encouraged to check any local regulations that may exist.

Bibliography (Informative)

ANSI/TIA-568-C.0-2009, Telecommunications Industry Association Standard, Generic Telecommunications Cabling for Customer Premises

IEC 61300-1:2011, Fibre Optic Interconnecting Devices and Passive Components — Basic Test and Measurement Procedures – Part 1: General and Guidance

IEC 61753-1:2007, Fibre Optic Interconnecting Devices and Passive Components Performance Standard — Part 1: General and Guidance for Performance Standards

ISO/IEC 11801:2011, Information Technology — Generic Cabling for Customer Premises

TIA-604-5-E-2015, Telecommunications Industry Association Standard, FOCIS 5, Fiber Optic Connector Intermateability Standard, Type MPO