

SMPTE STANDARD

Ruggedized Fiber-Optic
Connectors for HDTV
and UHDTV SDI



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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, Ultra 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.

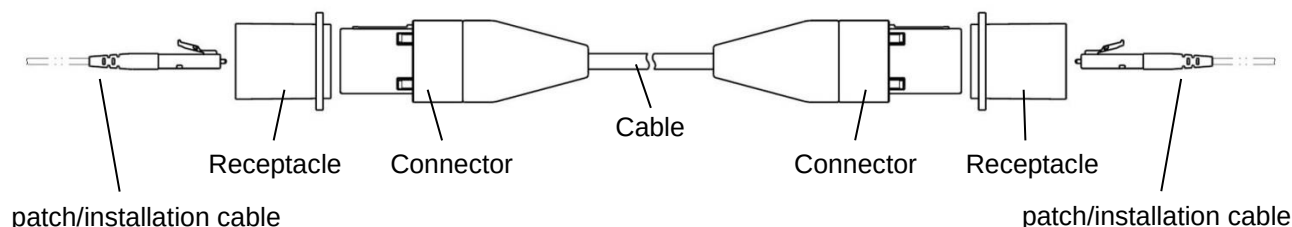


Figure 1 – Elements of the interconnection system

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

					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	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

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⁾			
					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	ST 2081-1		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.

KEY											
1	2	3	4	5	6	7	8	9	10	11	12

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

KEY											
12	11	10	9	8	7	6	5	4	3	2	1

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

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⁾			
					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	--		