



**SLOVENSKI STANDARD**  
**SIST EN 16603-50-11:2020**

**01-november-2020**

---

**Vesoljska tehnika - SpaceFibre - Zelo hiter serijski vmesnik**

Space engineering - SpaceFibre - Very high-speed serial link

Raumfahrttechnik - SpaceFibre - Serielle Verbindung mit sehr hoher Geschwindigkeit

Ingénierie spatiale - SpaceFibre - Liaison série très haut débit

**Ta slovenski standard je istoveten z: EN 16603-50-11:2020**

[SIST EN 16603-50-11:2020](https://standards.iteh.ai/catalog/standards/sist/d07723aa-534b-4f27-988e-8d40f90ba5c0/sist-en-16603-50-11-2020)

<https://standards.iteh.ai/catalog/standards/sist/d07723aa-534b-4f27-988e-8d40f90ba5c0/sist-en-16603-50-11-2020>

**ICS:**

49.140 Vesoljski sistemi in operacije Space systems and operations

**SIST EN 16603-50-11:2020**

**en,fr,de**

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

[SIST EN 16603-50-11:2020](#)

<https://standards.iteh.ai/catalog/standards/sist/d07723aa-534b-4f27-988e-8d40f90ba5c0/sist-en-16603-50-11-2020>

EUROPEAN STANDARD

EN 16603-50-11

NORME EUROPÉENNE

EUROPÄISCHE NORM

September 2020

ICS 49.140

English version

## Space engineering - SpaceFibre - Very high-speed serial link

Ingénierie spatiale - SpaceFibre - Liaison série très haut débit

Raumfahrttechnik - SpaceFibre - Teil 50-11: Sehr schnelle serielle Schnittstelle

This European Standard was approved by CEN on 3 May 2020.

CEN and CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN and CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN and CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN and CENELEC members are the national standards bodies and national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.



**CEN-CENELEC Management Centre:  
Rue de la Science 23, B-1040 Brussels**

## Table of contents

<b>European Foreword</b> .....	<b>9</b>
<b>1 Scope</b> .....	<b>10</b>
<b>2 Normative references</b> .....	<b>11</b>
<b>3 Terms, definitions and abbreviated terms</b> .....	<b>13</b>
3.1 Terms defined in other standards .....	13
3.2 Terms specific to the present standard .....	13
3.3 Abbreviated terms.....	26
3.4 Conventions.....	29
3.4.1 Numbers.....	29
3.4.2 Multiplication .....	29
3.4.3 Differential signals.....	29
3.4.4 Order of sending bits in symbols.....	29
3.4.5 Graphical representation of packets.....	30
3.4.6 State diagram notation .....	30
3.4.7 UML diagram notation.....	31
3.4.8 D/K notation for 8B/10B characters .....	32
3.5 Nomenclature .....	32
<b>4 Principles</b> .....	<b>34</b>
4.1 SpaceFibre purpose .....	34
4.2 SpaceFibre overview .....	35
<b>5 Requirements</b> .....	<b>37</b>
5.1 Overview .....	37
5.2 Protocol stack and interface architecture .....	37
5.2.1 General.....	37
5.2.2 Network layer .....	39
5.2.3 Data Link layer .....	39
5.2.4 Multi-Lane layer .....	40
5.2.5 Lane layer .....	40
5.2.6 Physical layer.....	41

5.2.7	Management Information Base .....	41
5.3	Formats .....	41
5.3.1	Control words and encoding/decoding .....	41
5.3.2	8B/10B encode/decode .....	42
5.3.3	Lane control words .....	44
5.3.4	Multi-Lane control words .....	51
5.3.5	Data Link control words .....	53
5.3.6	Receive error indication control word (RXERR) .....	62
5.3.7	Characters .....	63
5.3.8	Frames .....	66
5.3.9	Packets .....	70
5.3.10	Control word and frame precedence .....	70
5.3.11	K-code summary .....	73
5.3.12	Control word symbol summary .....	73
5.4	Physical layer .....	74
5.4.1	Physical layer responsibilities .....	74
5.4.2	Serialisation .....	75
5.4.3	Electrical physical layer .....	77
5.4.4	Electrical medium .....	88
5.4.5	Fibre optic physical layer .....	97
5.4.6	Fibre optic medium .....	103
5.5	Lane layer .....	112
5.5.1	Lane layer responsibilities .....	112
5.5.2	Lane initialisation and standby management .....	114
5.5.3	Data signalling rate compensation .....	126
5.5.4	IDLE words .....	126
5.5.5	Parallel loopback .....	127
5.5.6	Symbol synchronisation .....	127
5.5.7	Word synchronisation .....	127
5.5.8	Receive synchronisation state machine .....	129
5.6	Multi-Lane layer .....	131
5.6.1	Multi-Lane layer responsibilities .....	131
5.6.2	Multi-Lane link .....	132
5.6.3	Multi-Lane bypass .....	133
5.6.4	Multi-Lane distribution .....	133
5.6.5	Multi-Lane concentration .....	137
5.6.6	Lane Alignment .....	137

**EN 16603-50-11:2020 (E)**

5.6.7	Alignment state diagram .....	141
5.6.8	Asymmetric links .....	144
5.6.9	Initialisation of unidirectional lanes .....	145
5.6.10	Hot redundant lanes .....	146
5.7	Data Link layer .....	149
5.7.1	Data Link layer responsibilities .....	149
5.7.2	Virtual channels .....	151
5.7.3	Flow control .....	153
5.7.4	Medium access controller .....	155
5.7.5	Broadcast flow control .....	163
5.7.6	Framing .....	164
5.7.7	Error recovery .....	177
5.7.8	Data word identification state machine .....	184
5.7.9	Link Reset state machine .....	189
5.7.10	Link reset .....	192
5.8	Network layer .....	194
5.8.1	Network layer responsibilities .....	194
5.8.2	SpaceFibre network .....	195
5.8.3	Virtual networks .....	196
5.8.4	Links .....	199
5.8.5	Packet format .....	199
5.8.6	Sending a packet .....	200
5.8.7	Receiving a packet .....	200
5.8.8	Routing switch .....	201
5.8.9	Packet addressing .....	207
5.8.10	Group adaptive routing .....	209
5.8.11	Packet multicast .....	209
5.8.12	Broadcast messages .....	210
5.8.13	SpaceFibre nodes .....	212
5.8.14	SpaceFibre units .....	213
5.9	Management Information Base .....	214
5.9.1	Management Information Base responsibilities .....	214
5.9.2	Network management .....	214
5.9.3	Configuration parameters .....	215
5.9.4	Status parameters .....	219
<b>6</b>	<b>Service interfaces .....</b>	<b>221</b>
6.1	Overview .....	221

6.2	Network layer service interface .....	221
6.2.1	Network layer services .....	221
6.2.2	Packet Transfer service .....	221
6.2.3	Broadcast message service .....	223
6.3	Data Link layer service interface .....	224
6.3.1	Data Link layer services .....	224
6.3.2	Virtual Channel service .....	224
6.3.3	Broadcast message service .....	225
6.3.4	Schedule synchronisation service .....	226
6.4	Physical layer service interfaces .....	227
6.4.1	Physical layer services .....	227
6.4.2	Transfer symbols service .....	227
6.4.3	Control service .....	228
6.5	Management Information Base service interface .....	230
6.5.1	Management Information Base services .....	230
6.5.2	Link Management service .....	230
<b>Bibliography</b>	<b>..... iTeh STANDARD PREVIEW</b>	<b>232</b>

(standards.iteh.ai)

## Figures

Figure 3-1: Convention for first bit to be sent	29
Figure 3-2: Graphical packet notation	30
Figure 3-3: State diagram style	30
Figure 3-4: UML notation	31
Figure 3-5: D/K notation for 8B/10B characters	32
Figure 4-1: Overview of SpaceFibre protocol stack	35
Figure 5-1: SpaceFibre protocol stack - single-lane	38
Figure 5-2: SpaceFibre protocol stack - multi-lane	39
Figure 5-3: Fills at the end of packets	65
Figure 5-4: Fills at the start and end of a packet	66
Figure 5-5: Data frame format for a single lane	66
Figure 5-6: Idle frame format	67
Figure 5-7: Broadcast frame format	68
Figure 5-8: Interfaces to the Physical layer	75
Figure 5-9: One direction of electrical Physical layer, showing series capacitors, discharge resistors, and different grounds	77
Figure 5-10: Serial output signals	79
Figure 5-11: Serial output test circuit	80

**EN 16603-50-11:2020 (E)**

Figure 5-12: Serial eye pattern mask.....	80
Figure 5-13: Serial input signals .....	86
Figure 5-14: Type-A electrical flight cable assembly.....	89
Figure 5-15: Type-A electrical flight connector saver .....	90
Figure 5-16: Type-C electrical EGSE cable assembly .....	93
Figure 5-17: Type-C electrical EGSE to flight adaptor cable assembly .....	94
Figure 5-18: One direction of fibre optic Physical layer, showing fibre optic transmitter, receiver, connectors and cable.....	97
Figure 5-19: One direction of active optical cable type of fibre optic Physical layer.....	97
Figure 5-20: Electro-optical eye pattern for 1 Gbit/s to 5 Gbit/s transmitters .....	99
Figure 5-21: Electro-optical eye pattern for 1 Gbit/s to 10 Gbit/s transmitters .....	100
Figure 5-22: SpaceFibre lane comprising two Type-A fibre optic flight cable assemblies, one for each direction.....	105
Figure 5-23: Type-B fibre optic flight cable assembly with one lane.....	107
Figure 5-24: Type-B fibre optic flight cable assembly with several lanes .....	108
Figure 5-25: Type-B fibre optic flight cable assembly for an asymmetric link .....	108
Figure 5-26: Type-C flight active optical cable assembly .....	111
Figure 5-27: Interfaces to the Lane layer for a single lane link.....	113
Figure 5-28: Interfaces to the Lane layer for a multi-lane link.....	114
Figure 5-29: Lane initialisation state machine.....	115
Figure 5-30: Receive synchronisation state machine.....	129
Figure 5-31: Interfaces to Multi-Lane layer.....	132
Figure 5-32: Multi-Lane link with different number of lanes at each end .....	133
Figure 5-33: Words forming a row across a multi-lane link .....	134
Figure 5-34: Spreading data across a multi-lane link .....	135
Figure 5-35: PAD control words in a multi-lane link .....	135
Figure 5-36: Row alignment across a multi-lane link.....	140
Figure 5-37: Alignment state machine .....	141
Figure 5-38: Multi-Lane link incorporating some unidirectional lanes.....	144
Figure 5-39: Interfaces to the Data Link layer for a single lane link.....	150
Figure 5-40: Interfaces to the Data Link layer for a multi-lane link .....	150
Figure 5-41: Scrambler / de-scrambler .....	165
Figure 5-42: Example of scrambling of a short data frame.....	166
Figure 5-43: Effect of scrambling on an idle frame.....	167
Figure 5-44: Examples of CRC calculation for a short data frame .....	172
Figure 5-45: Illustration of bit ordering during 16-bit CRC calculation .....	172
Figure 5-46: Examples of CRC calculation for a broadcast frame and FCT .....	175
Figure 5-47: Illustration of bit ordering during 8-bit CRC calculation .....	176



Figure 5-48: Receive Error state machine .....	182
Figure 5-49: Data Word Identification state machine .....	185
Figure 5-50: Link Reset state machine .....	190
Figure 5-51: Interfaces to the Network layer .....	194
Figure 5-52: Components of a SpaceFibre network.....	195
Figure 5-53: Relationships of a SpaceFibre virtual network .....	197
Figure 5-54: SpaceFibre packet format .....	199
Figure 5-55: Components of a SpaceFibre routing switch .....	202
Figure 5-56: Components and specialisations of a SpaceFibre node .....	212
Figure 5-57: Components and specialisations of a SpaceFibre unit .....	214

## Tables

Table 5-1: 5B/6B encoding .....	43
Table 5-2: 3B/4B encoding .....	44
Table 5-3: Lane control words .....	44
Table 5-4: Multi-Lane control words.....	51
Table 5-5: Data framing control words.....	53
Table 5-6: Flow control word .....	58
Table 5-7: Error recovery control words.....	60
Table 5-8: Receive error indication control word.....	63
Table 5-9: SpaceFibre N-Char Symbols.....	64
Table 5-10: Fill control character symbol .....	64
Table 5-11: Meaning of K-codes.....	73
Table 5-12: Meaning of control word symbols .....	73
Table 5-13: Serial output interface.....	77
Table 5-14: Serial eye pattern mask intervals 1 Gbit/s to 3,125 Gbit/s.....	81
Table 5-15: Serial eye pattern mask intervals above 3,125 Gbit/s to 6,25 Gbit/s .....	81
Table 5-16: Coefficient $\alpha$ for different values of BER .....	82
Table 5-17: Driver and receiver characteristics 1 Gbit/s to 3,125 Gbit/s.....	83
Table 5-18: Driver and receiver characteristics above 3,125 Gbit/s to 6,25 Gbit/s .....	84
Table 5-19: Serial input interface .....	85
Table 5-20: Type-A electrical flight cable assembly connector contact terminations .....	89
Table 5-21: Type-A electrical flight connector saver connector contact terminations .....	89
Table 5-22: Type-B electrical flight cable assembly connector contact terminations .....	92
Table 5-23: Type-C electrical EGSE cable assembly connector contact terminations .....	93
Table 5-24: Type-C electrical EGSE to flight adaptor cable assembly connector contact terminations .....	94
Table 5-25: Type-D electrical EGSE cable assembly connector contact terminations .....	96

**EN 16603-50-11:2020 (E)**

Table 5-26: Electro-optical characteristics for 1 Gbit/s to 5 Gbit/s transmitters .....	100
Table 5-27: Electro-optical characteristics for 1 Gbit/s to 10 Gbit/s transmitters .....	101
Table 5-28: Electro-optical characteristics for 1 Gbit/s to 5 Gbit/s receivers.....	102
Table 5-29: Electro-optical characteristics for 1 Gbit/s to 10 Gbit/s receivers.....	103
Table 5-30: Connection of SpaceFibre lane using Type-A flight fibre optic cable assemblies .....	105
Table 5-31: Type-B flight fibre optic cable assembly connector contact terminations for each SpaceFibre lane .....	107
Table 5-32: Type-C flight active optical cable connector terminations for each SpaceFibre lane .....	109
Table 5-33: Type-C flight active optical cable assembly connector contact terminations for each SpaceFibre lane .....	110
Table 5-34: Precedence for different qualities of service .....	158
Table 5-35: Routing switch addresses.....	204
Table 5-36: SpaceFibre configuration parameters .....	216
Table 5-37: SpaceFibre status parameters.....	219

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

[SIST EN 16603-50-11:2020](https://standards.iteh.ai/catalog/standards/sist/d07723aa-534b-4f27-988e-8d40f90ba5c0/sist-en-16603-50-11-2020)

<https://standards.iteh.ai/catalog/standards/sist/d07723aa-534b-4f27-988e-8d40f90ba5c0/sist-en-16603-50-11-2020>

## European Foreword

---

This document (EN 16603-50-11:2020) has been prepared by Technical Committee CEN-CENELEC/TC 5 "Space", the secretariat of which is held by DIN.

This document (EN 16603-50-11:2020) originates from ECSS-E-ST-50-11C.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2021, and conflicting national standards shall be withdrawn at the latest by March 2021.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a standardization request given to CEN by the European Commission and the European Free Trade Association.

This document has been developed to cover specifically space systems and has therefore precedence over any EN covering the same scope but with a wider domain of applicability (e.g. aerospace).

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

# 1

## Scope

---

SpaceFibre is a very high-speed serial link and network technology, designed specifically for use on board spacecraft. SpaceFibre is able to operate over fibre-optic and electrical cable and supports data rates of up to 5 Gbit/s (6,25 Gbit/s data signalling rate). It complements the capabilities of the widely used SpaceWire on-board networking standard: improving the data rate by a factor of 10, reducing the cable mass and providing galvanic isolation. Multi-laning improves the data rate further to well over 20 Gbit/s.

SpaceFibre provides a coherent quality of service mechanism able to support bandwidth reserved, scheduled and priority-based qualities of service. It substantially improves the fault detection, isolation and recovery (FDIR) capability compared to SpaceWire.

SpaceFibre aims to support high data-rate payloads, for example synthetic aperture radar and hyper-spectral optical instruments. It provides robust, long distance communications for launcher applications and supports avionics applications with deterministic delivery constraints through the use of virtual channels. SpaceFibre enables a common on-board infrastructure to be used across many different mission applications resulting in cost reduction and design reusability. SpaceFibre uses a packet format which is the same as SpaceWire enabling simple connection between existing SpaceWire equipment and high-speed SpaceFibre links and networks. Applications developed for SpaceWire can be readily transferred to SpaceFibre.

The SpaceFibre standard specifies the interfaces to the user application and to the physical medium. Intermediate interfaces between protocol layers are also specified. The functions that a SpaceFibre interface has to implement are specified. Connector and cable characteristics for SpaceFibre optical and copper implementations are also specified.

This standard may be tailored for the specific characteristics and constraints of a space project in conformance with ECSS-S-ST-00.

## 2

## Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revision of any of these publications do not apply. However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the more recent editions of the normative documents indicated below. For undated references, the latest edition of the publication referred to applies.

EN reference	Reference in text	Title
EN 16601-00-01	ECSS-S-ST-00-01	ECSS system - Glossary of terms
EN 16603-50-52	ECSS-E-ST-50-52	Space engineering - SpaceWire – Remote memory access protocol
EN 16602-70-02	ECSS-Q-ST-70-02	Space product assurance - Thermal vacuum outgassing test for the screening of space materials
EN 16602-70-21	ECSS-Q-ST-70-21	Space product assurance - Flammability testing for the screening of space materials
EN 16602-70-29	ECSS-Q-ST-70-29	Space product assurance - Determination of offgassing products from materials and assembled articles to be used in a manned space vehicle crew compartment
	ESCC 2263420:2017	Evaluation Test programme for optical fibre cable assemblies, ESCC Basic Specification, issue 1, June 2017
	ESCC 3401/090:2018	High Data Rate Connectors Savers, Plugs based on type AxoMach, ESCC Detail Specification, issue 1, 2018
	ESCC 3409:2018	High Data Rate Cable Assemblies, ESCC Generic Specification, issue 1, 2018
	ESCC 3409/001:2018	High Data Rate Harnesses based on type AxoMach, ESCC Detail Specification, issue 1, 2018
	ESCC 3420:2017	Optical Fibre Cable Assemblies with Single Fibre Ferrules, ESCC Generic Specification, issue 1, June 2017
	ESCC 3420/001:2017	Optical Fibre Cable Assemblies with Single Fibre Ferrules, ESCC Detail Specification, issue 1, June 2017

## EN 16603-50-11:2020 (E)

EN reference	Reference in text	Title
	IEC 60793-2-10:2015	Optical fibres - Part 2-10: Product specifications - Sectional specification for category A1 multimode fibres, IEC, 2015
	IEC 61754-5:2005	Fibre optic connector interfaces - Part 5: Type MT connector family, IEC, 2005
	IEC 61755-3-31:2015	Fibre optic interconnecting devices and passive components - Connector optical interfaces - Part 3-31: Connector parameters of non-dispersion shifted single mode physically contacting fibres - Angled polyphenylene sulphide rectangular ferrules
	IEC 61755-3-32:2015	Fibre optic interconnecting devices and passive components - Connector optical interfaces - Part 3-32: Connector parameters of non-dispersion shifted single mode physically contacting fibres - Angled thermoset epoxy rectangular ferrules
	IEEE 802.3:2012	IEEE Standard for Ethernet, IEEE Standards Association, 28 December 2012
	MIL-PRF-49291, Revision D, Amendment 1, 20 November 2014	Performance Specification, Fiber, Optical, (Metric) General Specification
	Serial ATA Revision 3.0:2009	Serial ATA Revision 3.0, clause 6.6.1, Serial ATA International Organization, June 2, 2009, Gold Revision

STANDARD PREVIEW  
(standards.iteh.ai)  
SIST EN 16603-50-11:2020  
<https://standards.iteh.ai/catalog/standards/sist/d07723aa-534b-4f27-988e-8d40f90ba5c0/sist-en-16603-50-11-2020>

## 3

## Terms, definitions and abbreviated terms

---

### 3.1 Terms defined in other standards

- a. For the purpose of this Standard, the terms and definitions from ECSS-S-ST-00-01 apply.

### 3.2 Terms specific to the present standard

#### 3.2.1 active lane

**unidirectional lane** or **bi-directional lane** which is in the Active state

#### 3.2.2 asymmetric link

**multi-lane link** that includes one or more **unidirectional lanes**

#### 3.2.3 available bandwidth

number of **data words** or **control words** sent since the **bandwidth credit** was last updated

#### 3.2.4 bandwidth credit

amount of **link bandwidth** that a **virtual channel** has accumulated

#### 3.2.5 bandwidth credit limit

maximum amount of positive or negative **bandwidth credit** that a **virtual channel** is allowed to accumulate

#### 3.2.6 bandwidth utilisation

measure of how much bandwidth allocated to a **virtual channel** has been used recently, allowing for loss of measured use of bandwidth when either the positive or negative **bandwidth credit limit** is reached

#### 3.2.7 bi-directional lane

**active lane** or **inactive lane** which has the TX\_EN and RX\_EN configuration bits asserted at both ends of the **link**, so that when active it can send information in both directions of the **link**