SLOVENSKI STANDARD
SIST EN 16603-50-12:2020

01-junij-2020

Vesoljska tehnika - SpaceWire - Povezave, vozlišča, usmerjevalniki in omrežja

Space engineering - SpaceWire - Links, nodes, routers and networks

Raumfahrttechnik - SpaceWire - Verbindungen, Knoten, Router und Netzwerke

Ingénierie spatiale - SpaceWire - Liens, nœuds, routeurs et réseaux

Ta slovenski standard je istoveten z: **EN 16603-50-12:2020**

ICS:

49.140	Vesoljski sistemi in operacije	Space systems and operations

SIST EN 16603-50-12:2020 **en,fr,de**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 16603-50-12

March 2020

ICS 49.140

English version

Space engineering - SpaceWire - Links, nodes, routers and networks

Ingénierie spatiale - SpaceWire - Liaisons, noeuds, routeurs et réseaux

Raumfahrttechnik - SpaceWire - Verbindungen, Knoten, Router und Netzwerke

This European Standard was approved by CEN on 29 December 2019.

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

European Foreword **7**

1 Scope **8**

2 Normative references **9**

3 Terms, definitions and abbreviated terms **10**

3.1 Terms from other standards 10

3.2 Terms specific to the present standard 10

3.3 Abbreviated terms 20

3.4 Conventions 21

3.4.1 Numbers 21

3.4.2 Differential signals 21

3.4.3 Order of sending bits in symbols 21

3.4.4 Graphical representation of packets 22

3.4.5 State diagram notation 22

3.4.6 UML diagram notation 23

3.5 Nomenclature 24

4 Overview of SpaceWire **25**

4.1 Introduction 25

4.2 SpaceWire Spacecraft Data-Handling Network 25

4.2.1 The Rationale for SpaceWire 25

4.2.2 Example SpaceWire Application 26

4.2.3 How SpaceWire Works 28

5 Requirements **33**

5.1 Overview 33

5.2 Protocol stack and interface architecture 33

5.2.1 Protocol stack 33

5.2.2 Network layer 34

5.2.3 Data Link layer 34

5.2.4 Encoding layer 35

5.2.5 Physical layer 35

5.2.6 Management Information Base 36
5.2.7 Service interfaces 36
5.2.8 SpaceWire Port architecture 36
5.3 Physical layer 37
5.3.1 Introduction 37
5.3.2 Cables 38
5.3.3 Connectors 41
5.3.4 Cable assemblies 45
5.3.5 PCB tracks 50
5.3.6 Line drivers and receivers 51
5.3.7 Data-Strobe skew 59
5.3.8 Physical layer management parameters 62
5.4 Encoding layer 63
5.4.1 Introduction 63
5.4.2 Serialisation and de-serialisation 63
5.4.3 Character and control code encoding 63
5.4.4 Data strobe encoding and decoding 66
5.4.5 First Null 68
5.4.6 Null detection 68
5.4.7 Parity error 69
5.4.8 Disconnect 69
5.4.9 ESC error 69
5.4.10 Data signalling rate 70
5.4.11 Encoding layer management parameters 71
5.5 Data link layer 71
5.5.1 Introduction 71
5.5.2 Data link layer interfaces 71
5.5.3 Data link layer management interface 72
5.5.4 Flow control 73
5.5.5 Flow control errors 74
5.5.6 Sending priority 75
5.5.7 Link initialisation behaviour 75
5.5.8 Link error recovery 80
5.5.9 Accepting broadcast codes for sending 82
5.6 SpaceWire network layer 82
5.6.1 Introduction 82
5.6.2 SpaceWire packets 83

5.6.3 Broadcast codes 83
5.6.4 SpaceWire time-codes 84
5.6.5 SpaceWire distributed interrupts 87
5.6.6 SpaceWire nodes 94
5.6.7 SpaceWire node management parameters 96
5.6.8 SpaceWire routing 96
5.6.9 SpaceWire routing switch management parameters 104
5.6.10 SpaceWire network 104
5.7 SpaceWire management information base 106
5.7.1 Introduction 106
5.7.2 General 106
5.7.3 Physical layer management parameters 106
5.7.4 Encoding layer management parameters 106
5.7.5 Data link layer management parameters 106
5.7.6 Network layer management parameters 106

6 Service interfaces 107
6.1 Network layer service interface 107
6.1.1 Packet service interface 107
6.1.2 Time-code service interface 108
6.1.3 Distributed interrupt service interface 109
6.2 Data link layer service interface 111
6.2.1 N-Char service interface 111
6.2.2 Broadcast code service interface 113
6.3 Encoding layer service interface 114
6.3.1 Encoding service interface 114
6.3.2 Decoding service interface 115
6.4 Physical layer service interface 117
6.4.1 Line transmit service interface 117
6.4.2 Line receive service interface 118
6.5 Management information base service interface 119
6.5.1 Set parameter service interface 119
6.5.2 Get parameter service interface 119

Annex A (informative) Technical Changes 121

Bibliography 123

Figures

Figure 3-1: Convention for first bit to be sent 21
Figure 3-2: Graphical packet notation 22
Figure 3-3: State diagram style 22
Figure 3-4: UML notation 23
Figure 4-1: Example SpaceWire Architecture without redundancy 27
Figure 4-2: SpaceWire Packet Format 29
Figure 4-3: Path Addressing 31
Figure 4-4 Logical Addressing 32
Figure 5-1: SpaceWire protocol stack 34
Figure 5-2: SpaceWire port architecture 37
Figure 5-3: SpaceWire connector contact identification 44
Figure 5-4: SpaceWire cable assembly Type A 47
Figure 5-5: SpaceWire cable assembly Type AL 49
Figure 5-6: SpaceWire LVDS 53
Figure 5-7: LVDS line driver output signals 54
Figure 5-8: LVDS line driver differential output signal 56
Figure 5-9: Physical layer components 59
Figure 5-10: Skew and jitter 62
Figure 5-11: Data character encoding 64
Figure 5-12: Control character encoding 65
Figure 5-13: Null control code encoding 65
Figure 5-14: Broadcast code encoding 66
Figure 5-15: Parity coverage 66
Figure 5-16: Data-Strobe (DS) encoding 67
Figure 5-17: Data and strobe signals for first Null 68
Figure 5-18: Null detection sequence 69
Figure 5-19: Link initialisation behaviour 76
Figure 5-20: Link error recovery behaviour 81
Figure 5-21: SpaceWire packet format 83
Figure 5-22: Specialisations and relationships of a SpaceWire broadcast code 84
Figure 5-23 Network layer time-code 85
Figure 5-24: Network layer interrupt 88
Figure 5-25: Network layer interrupt acknowledgement code 89
Figure 5-26: Components and specialisations of a SpaceWire node 95
Figure 5-27: Components of a SpaceWire routing switch 97
Figure 5-28: Components of a SpaceWire network 105

Tables

Table 5-1: Constants for a SpW cable using 28 AWG differential pairs 39
Table 5-2: Insertion loss values 28AWG SpW cable.....40
Table 5-3: Constants for a SpaceWire cable using 26 AWG differential pairs.....40
Table 5-4: Insertion loss values for 26 AWG SpaceWire cable.....40
Table 5-5: Cable PSNEXT specification 41
Table 5-6: Cable PSELFEXT specification 41
Table 5-7: Connector contact identification.....43
Table 5-8: Cable assembly Type A signal wire connections 47
Table 5-9: Cable assembly Type AL signal wire connections 49
Table 5-10 Example calculation of maximum bit rate.....61
Table 5-11: Address function.....99

European Foreword

This document (EN 16603-50-12:2020) has been prepared by Technical Committee CEN-CENELEC/TC 5 “Space”, the secretariat of which is held by DIN.

This standard (EN 16603-50-12:2020) originates from ECSS-E-ST-50-12C Rev.1.

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 September 2020, and conflicting national standards shall be withdrawn at the latest by September 2020.

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

SpaceWire technology has grown from the needs of spacecraft on-board data handling applications. This Standard provides a formal basis for the exploitation of SpaceWire in a wide range of future on-board processing systems.

One of the principal aims of SpaceWire is the support of equipment compatibility and reuse at both the component and subsystem levels. In principle a data-handling system developed for an optical instrument, for example, can be used for a radar instrument by unplugging the optical sensor and plugging in the radar one. Processing units, mass-memory units and down-link telemetry systems developed for one mission can be readily used on another mission, reducing the cost of development, improving reliability and most importantly increasing the amount of scientific work that can be achieved within a limited budget.

Integration and test of complex on-board systems is also supported by SpaceWire with ground support equipment plugging directly into the on-board data-handling system. Monitoring and testing can be carried out with a seamless interface into the on-board system.

SpaceWire is the result of the efforts of many individuals within the European Space Agency, European Space Industry and academia.

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 16602-70-08	ECSS-Q-ST-70-08	Space product assurance - Manual soldering of high-reliability electrical connections
EN 16602-70-26	ECSS-Q-ST-70-26	Space product assurance - Crimping of high-reliability electrical connections
	ESCC 3401	Connectors, electrical, non-filtered circular and rectangular, ESCC Generic Specification no. 3401, Issue 5, March 2018
	ESCC 3401/029:2017	Connectors, Electrical, Rectangular, Microminiature, based on type MDMA, ECSS Detail Specification no. 3401/029, Issue 15, November 2017.
	ESCC 3401/077:2016	Connectors, Electrical, Rectangular, Microminiature, Removable Crimp Contacts, based on type MDMA, ECSS Detail Specification no. 3401/077, Issue 7, April 2016.
	ESCC 3902/003:2014	Cable, “SpaceWire”, Round, Quad using Symmetric Cables, Flexible, –200 to +180 °C, Detail Specification no. 3902/003, Issue 4, November 2014.
	ESCC 3902/004:2014	Cable, Low Mass, “SpaceWire”, Round, Quad using Symmetric Cables, Flexible, –100 to +150 °C, Detail Specification no. 3902/004, Issue 1, October 2014.
	MIL-DTL-17J:2014	Military Specification: Cables, Radio, Frequency, Flexible and Semirigid, General Specification for, 10th February 2014.
	TIA-644-A:2012	TIA-644-A, Electrical Characteristics of Low Voltage Differential Signalling (LVDS) Interface Circuits, Revision A, Reaffirmed 12/07/12, Telecommunications Industry Association, 2012.

3 Terms, definitions and abbreviated terms

3.1 Terms from other standards

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

The UML diagrams of Figure 5-22, Figure 5-26, Figure 5-27 and Figure 5-28 in clause 5.6 illustrate the relationships between various terms used within this standard.

3.2.1 allocated output port

output port that a **packet** is routed through

3.2.2 after 6,4 µs

delay of 6,4 µs (nominal) measured from when a state is entered

3.2.3 after 12,8 µs

delay of 12,8 µs (nominal) measured from when a state is entered

3.2.4 AutoStart

management parameter set by hardware or software which when asserted allows an enabled **SpaceWire port** to start the SpaceWire **link** only when a **Null** is received

3.2.5 bit error rate

ratio of the number of bits received in error to the total number of bits sent across a link

3.2.6 broadcast code

time-code or **distributed interrupt code**

3.2.7 broadcast code identifier

two-bit code that identifies the type of **broadcast code**: 0b00 identifies a **time-code** and 0b10 identifies a **distributed interrupt code**

3.2.8 byte

eight bits

3.2.9 cargo

some information for transfer from a **source** to a **destination** which is encapsulated in a **packet**

3.2.10 character

control character or **data character**

3.2.11 coding

act of translating a set of bits into another set of bits which are more appropriate for transmitting across a medium

3.2.12 configuration port

port in a **routing switch** or **node** that gives access to a **configuration node**

3.2.13 configuration node

type of **node** whose purpose is to configure the **routing switch** or **node** that it is part of

3.2.14 control character

ESC, FCT, EOP or EEP **character** that is used to pass control information across a **link**

3.2.15 control code

sequence of an ESC followed by an FCT forming a **Null** which is used to keep a **link** active, or a sequence of an **ESC character** followed by a **data character** forming a **broadcast code** which is used to broadcast **time-codes** and **distributed interrupt codes** over a **SpaceWire network**

3.2.16 control symbol

control character encoded in 4-bits for transfer across a **link**

3.2.17 data character

character that is used to pass 8 bits of data across a **link**

3.2.18 data link layer

protocol layer which is responsible for the initialisation of a SpaceWire **link**, for transferring **packets** and **broadcast codes** over the **link** and for recovery from errors on the **link**

3.2.19 data rate

rate at which the application data is transferred across a **link**

3.2.20 data signalling rate

rate at which the bits constituting **control** and **data symbols** are transferred across a **link**

3.2.21 data-strobe

sequence of data bits and bit clock encoded into two signals, one containing the data bit sequence (data) and the other changing state whenever the data bit sequence does not (strobe)

3.2.22 data symbol

data character encoded in 10 bits for transfer across a **link**

3.2.23 decoding

act of translating an encoded set of bits back into the original set of bits prior to encoding

3.2.24 de-serialisation

transformation of a serial bit stream into a sequence of **control** or **data symbols**

3.2.25 destination

end-point that a **packet** is being sent to

3.2.26 destination address

route, described by a **path address**, to be taken by a **packet** in moving from **source** to **destination** or an identifier, in the form of a **logical address**, specifying the **destination**

3.2.27 destination node

node that is the **destination** of one or more **SpaceWire packets**

3.2.28 disconnect

indication from a **receiver** that there has been no edge on the data or strobe signals for the past 850 ns (nominal) indicating that the **link** is disconnected

3.2.29 distributed interrupt

interrupt that is distributed to all or many **nodes** on the **network**

3.2.30 distributed interrupt code

broadcast code used to distribute interrupts over a **SpaceWire network** which is either an **interrupt code** or an **interrupt acknowledgement code**

3.2.31 driver

electronic circuit that transmits signals across a particular transmission medium

3.2.32 driver ground

ground at the 0V pin or pins of the **driver** differential outputs

NOTE If the driver has one 0V for signals such as TTL or CMOS, and a separate 0V for the differential outputs, the driver ground is the 0V for the differential outputs. The driver ground is a ground plane or planes which provide

controlled impedance for the driver's differential pairs.

3.2.33 encoding layer

protocol layer which is responsible for the encoding of **characters** into **symbols**, **symbol** serialisation, data-strobe encoding of the serial bit stream, data-strobe decoding, **symbol** de-serialisation and decoding of **symbols** into **characters**

3.2.34 end of packet marker

control character which indicates the end of a **packet**

3.2.35 end-point

interface between the **network** and a **host system** providing a single **port** into the **network**

3.2.36 error recovery scheme

method for handling errors detected within a SpaceWire **link**

3.2.37 ESC

control character which is followed by another **control character** or **data character** to form a **control code**

3.2.38 ESC error

invalid **ESC** sequence, formed from an **ESC** followed immediately by an EOP, EEP, or ESC

3.2.39 FIFO port

port that has a FIFO interface rather than a **SpaceWire interface**

3.2.40 fall time

time during which a falling signal voltage is within the range of 80 % to 20 % of the difference between the two steady state values

3.2.41 first Null

initial **Null** received without a parity error when the link state machine is not in the ErrorReset state

3.2.42 flow control token

control character used to manage the flow of data across a **link**, and being exchanged for eight **N-Chars**

3.2.43 gotBC

sometime after the first **Null** was received, a **broadcast code** has been received without a parity error

3.2.44 gotFCT

sometime after the first **Null** was received, an FCT has been received without a parity error