

## Table of contents

---

|                                                   |           |
|---------------------------------------------------|-----------|
| <b>European Foreword</b>                          | <b>7</b>  |
| <b>1 Scope</b>                                    | <b>8</b>  |
| <b>2 Normative references</b>                     | <b>9</b>  |
| <b>3 Terms, definitions and abbreviated terms</b> | <b>10</b> |
| 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        |
| <b>4 Overview of SpaceWire</b>                    | <b>25</b> |
| 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        |
| <b>5 Requirements</b>                             | <b>33</b> |
| 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        |
| <b>6</b>       | <b>Service interfaces .....</b>                      | <b>107</b> |
| 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        |
| <b>Annex A</b> | <b>(informative) Technical Changes.....</b>          | <b>121</b> |

|                          |            |
|--------------------------|------------|
| <b>Bibliography.....</b> | <b>123</b> |
|--------------------------|------------|

## 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 |