

**Table of contents**

---

- European foreword.....7**
- Introduction.....8**
- 1 Scope.....9**
- 2 Normative references ..... 10**
- 3 Terms, definitions and abbreviated terms..... 12**
  - 3.1 Terms from other standards..... 12
  - 3.2 Terms specific to the present standard ..... 12
  - 3.3 Abbreviated terms..... 16
  - 3.4 Bit numbering convention ..... 17
  - 3.5 Nomenclature ..... 17
- 4 Overview of the standard and principles..... 19**
  - 4.1 Document organization ..... 19
  - 4.2 Relationship of CAN Bus Network to existing Architectures ..... 19
  - 4.3 CANbus network..... 20
  - 4.4 Physical layer ..... 21
  - 4.5 Communication model ..... 21
  - 4.6 CANopen higher layer protocol ..... 21
  - 4.7 Time distribution ..... 23
    - 4.7.1 Overview ..... 23
    - 4.7.2 SYNC message and protocol ..... 24
    - 4.7.3 Bit timing ..... 24
  - 4.8 Redundancy management and monitoring ..... 24
    - 4.8.1 Overview ..... 24
    - 4.8.2 Node Monitoring via Node-Guarding or Heartbeat Messages ..... 25
    - 4.8.3 Bus monitoring and reconfiguration management ..... 26
  - 4.9 Connectors and pin assignments..... 27
  - 4.10 Minimal protocol set..... 27
- 5 Physical layer..... 28**
  - 5.1 Topology..... 28

5.1.1	Physical topology .....	28
5.1.2	Maximum bus length and drop length.....	30
5.1.3	Number of network devices.....	30
5.2	Medium.....	31
5.2.1	Cable requirements.....	31
5.2.2	Connectors .....	32
5.3	Transceiver characteristics .....	32
5.3.1	General.....	32
5.3.2	ISO 11898-2:2003 transceiver electrical characteristics .....	33
5.3.3	Resistance to electrical CAN Network faults.....	33
5.3.4	Transceiver isolation .....	38
5.3.5	Physical layer implementation based on RS-485 transceivers .....	38
5.3.6	Detailed implementation for RS-485 transceiver .....	39
5.4	Bit timing.....	39
5.4.1	Bit rate 1 Mbps.....	39
5.4.2	Other bit rates .....	39
5.4.3	Bit timing .....	39
5.5	Electromagnetic compatibility (EMC) .....	40
5.6	Data link layer.....	40
5.6.1	ISO 11898 compliance.....	40
5.6.2	Fault confinement .....	40
<b>6</b>	<b>CANopen higher layer protocol.....</b>	<b>42</b>
6.1	Service data objects .....	42
6.2	Process data objects .....	42
6.3	Synchronisation object.....	42
6.4	Emergency object.....	43
6.5	Network management objects.....	43
6.5.1	Module control services .....	43
6.5.2	Error control services .....	43
6.5.3	Bootup service .....	43
6.5.4	Node state diagram.....	43
6.6	Electronic data sheets .....	44
6.7	Device and application profiles .....	44
6.8	Object dictionary.....	45
6.9	Synchronous communications .....	45
6.10	COB-ID and NODE-ID assignment.....	45
<b>7</b>	<b>Time distribution .....</b>	<b>47</b>

7.1	Time objects .....	47
7.1.1	Time code formats .....	47
7.1.2	Spacecraft elapsed time objects.....	48
7.1.3	Spacecraft universal time coordinated objects .....	48
7.2	Time distribution and synchronization protocols.....	49
7.2.1	General .....	49
7.2.2	Time distribution protocol .....	49
7.2.3	High-resolution time distribution protocol.....	50
<b>8</b>	<b>Redundancy management .....</b>	<b>52</b>
8.1	General.....	52
8.2	Node internal bus redundancy architectures .....	52
8.2.1	General .....	52
8.2.2	Parallel bus access architecture.....	52
8.2.3	Selective bus access architecture .....	52
8.3	Bus monitoring and reconfiguration management.....	53
8.3.1	Bus redundancy management parameters.....	53
8.3.2	Start-up procedure .....	56
8.3.3	Bus monitoring protocol .....	57
<b>9</b>	<b>Minimal implementation of the CANopen protocol for highly asymmetrical control applications .....</b>	<b>60</b>
9.1	COB-ID assignment.....	60
9.2	Object dictionary .....	60
9.3	Minimal set CANopen Objects .....	60
9.4	Minimal Set Protocol.....	61
9.4.1	Definitions .....	61
9.4.2	Use of data bytes in application layer .....	62
9.4.3	Minimal Set Protocol data transmission.....	63
9.4.4	PDO transmit triggered by telemetry request.....	64
9.4.5	PDO mapping .....	64
9.4.6	Network management objects .....	65
9.4.7	Special function objects .....	65
9.4.8	Communication error object .....	66
9.4.9	NMT error control objects.....	66
9.4.10	Miscellaneous authorized objects.....	66
9.5	Free COB-ID.....	70
<b>10</b>	<b>Connectors and pin assignments .....</b>	<b>73</b>

10.1 Overview .....	73
10.2 Naming convention .....	73
10.3 Circular connectors.....	73
10.3.1 MIL-C D38999 configuration B: Dual CAN Network.....	73
10.3.2 MIL-C D38999 configuration D: Single CAN Network.....	74
10.4 Sub-miniature D connectors (9-pin D-sub).....	75
10.5 Sub-miniature D connectors (9-pin D-sub) – RS-485 .....	76
<b>11 CANopen standard applicability matrix.....</b>	<b>77</b>
11.1 Introduction.....	77
<b>Annex A (informative) Electrical connectivity.....</b>	<b>88</b>
A.1 Transceivers .....	88
A.1.2 Detailed implementation for RS-485 transceiver .....	88
A.2 Example Implementation of a RS-485 physical layer .....	90
A.3 CAN Network Bus termination .....	93
A.4 Bus management and redundancy .....	93
A.4.1 Selective bus access architecture .....	93
A.4.2 Parallel bus access architecture.....	94
<b>Bibliography.....</b>	<b>95</b>
<b>Figures</b>	
Figure 3-1: Bit numbering convention .....	17
Figure 4-1: Relationship between ISO layering, ISO 11898, CiA 301 and ECSS CAN standard definitions .....	20
Figure 4-2: Example of minimal implementation topology.....	21
Figure 4-3: Format of heartbeat message.....	26
Figure 5-1: Linear multi-drop topology .....	28
Figure 5-2: Daisy chain topology. ....	29
Figure 7-1: Format for objects containing the SCET .....	48
Figure 7-2: Format for objects containing the Spacecraft UTC .....	49
Figure 8-1: Node start up procedure.....	56
Figure 8-2: Bus monitoring logic.....	58
Figure 8-3: Slave bus selection process, toggling mechanism.....	59
Figure 9-1: Unconfirmed Command exchange overview (example with PDO1).....	61
Figure 9-2: Telemetry request exchange overview (example with PDO2).....	62
Figure 10-1: Illustration of a 9-pin D-Sub connector.....	75
Figure A-1 : Principle of Isolated CAN Operation.....	88
Figure A-2 : RS-485 CAN physical interface for OBC/Bus Master .....	90

Figure A-3 : RS-485 CAN physical interface for nodes using single connector for redundant buses .....	91
Figure A-4 : RS-485 CAN physical interface nodes using dual connector for redundant buses .....	91
Figure A-5 : Split (left) and standard (right) Termination schemes.....	93
Figure A-6 : Selective bus access architecture .....	94
Figure A-7 : Parallel bus access architecture.....	94

## Tables

Table 5-1: CAN levels in ISO 11898-2:2003 .....	33
Table 5-2 – CAN failure modes and recommended FDIR actions.....	36
Table 8-1: BUS redundancy management parameters for slaves.....	54
Table 8-2: BUS redundancy management parameters for master .....	55
Table 9-1: Peer-to-Peer objects of the minimal set .....	61
Table 9-2: Broadcast objects of the minimal set .....	61
Table 9-3: PDO Communication Object description:.....	63
Table 9-4: PDO Communication Entry Description: .....	63
Table 9-5 PDO Communication Object description:.....	64
Table 9-6: PDO Communication Entry Description: .....	64
Table 9-7 : SYNC Message Object description:.....	65
Table 9-8: SYNC Message Entry Description: .....	65
Table 9-9 SYNC used with NMT master Object description:.....	66
Table 9-10 SYNC used with NMT master Entry Description: .....	66
Table 9-11: CANopen Object dictionary Data Types .....	67
Table 9-12: Authorized and Forbidden Object Dictionary Entries of the Communication profile .....	68
Table 9-13 : COB ID -Predefined connection set.....	71
Table 10-1 : Signal terminology .....	73
Table 10-2: Pin function for MIL-C D38999 configuration B .....	74
Table 10-3: Pin function for MIL-C D38999 configuration D .....	74
Table 10-4: Pin function for sub D-type with CAN Network.....	75
Table 10-5: Pin function for sub D-type with RS-485 CAN Network.....	76
Table 11-1: DiA 301 (former CIA DS301) applicability matrix.....	78
Table A-1 : Logic Table, RS-485 Driver implementation .....	92
Table A-2 : Logic Table, RS-485 Receiver implementation.....	92
Table A-3 : Component item values.....	92