Abstract
The SPA Physical Interface specifies the mechanical requirements and physical mounting considerations for SPA devices and panels.
Contents

Foreword ............................................................................................................................................... vii

Introduction ............................................................................................................................................ ix

1 Scope ...................................................................................................................................... 1

2 Tailoring ................................................................................................................................... 1

3 Applicable Documents ............................................................................................................. 1

4 Vocabulary .................................................................................................................................. 2

  4.1 Acronyms and Abbreviated Terms ........................................................................................... 2

  4.2 Terms and Definitions .............................................................................................................. 2

5 Mechanical Requirements for SPA Devices ............................................................................. 2

  5.1 Device Mounting ...................................................................................................................... 2

    5.1.1 Mounting Method ..................................................................................................................... 2

    5.1.2 Recommended Fastener Size .................................................................................................. 2

    5.1.3 Mounting Pattern ..................................................................................................................... 3

    5.1.4 Number of Mounting Holes....................................................................................................... 3

    5.1.5 Device Mounting Hole Size and Positional Tolerance ............................................................... 3

    5.1.6 Mounting Fastener Access ....................................................................................................... 4

    5.1.7 Mounting Surface Flatness....................................................................................................... 4

    5.1.8 Mounting Surface Conductivity ................................................................................................. 4

    5.1.9 Mounting Surface Properties .................................................................................................... 4

  5.2 Dynamic Requirements ............................................................................................................ 4

  5.3 Deployables, Actuators, and Moving Mechanical Assemblies ................................................... 4

  5.4 Protective Covers .................................................................................................................... 4

  5.5 Maintainability ........................................................................................................................ 4

  5.6 Reporting of Device Physical Characteristics............................................................................ 5

    5.6.1 Envelope and Mounting ........................................................................................................... 5

    5.6.2 Mass, Center of Gravity, and Inertia Reporting ......................................................................... 5

    5.6.3 Connector Type and Location Reporting .................................................................................. 5

    5.6.4 Field of View Reporting .......................................................................................................... 5

    5.6.5 Special Instructions.................................................................................................................. 5

6 Thermal Requirements for SPA Devices .................................................................................. 6

  6.1 General Thermal Requirements ............................................................................................... 6

    6.1.1 SPA Device Thermal Control Approach .................................................................................... 6

    6.1.2 Thermal Mounting Surfaces ................................................................................................... 6

    6.1.3 Device Thermal Interface Materials ......................................................................................... 6

    6.1.4 Thermal Control External Surface Conductivity ....................................................................... 6
6.1.5 Special Instructions .................................................................................................................. 6
6.2 Reporting of Device Thermal Characteristics ............................................................................ 6
6.2.1 Thermal Design Approach ...................................................................................................... 6
6.2.2 Thermal Dissipation Levels .................................................................................................. 7
6.2.3 Heaters and Heater Control .................................................................................................. 7
7 SPA Interface Connector and Cabling Requirements: Type A Connector ........................................ 7
7.1 Type A: SPA 25-pin Micro-D Power and Data Interface Connector Overview ....................... 7
7.2 25-pin Micro-D SPA Endpoint Connector ................................................................................ 7
7.2.1 SPA Endpoint Connector Type .......................................................................................... 7
7.2.2 SPA Endpoint Connector Gender ...................................................................................... 7
7.2.3 Hot-Plugging ...................................................................................................................... 7
7.2.4 SPA Endpoint Connector Mechanical Mounting Hardware ................................................ 7
7.2.5 SPA Endpoint Connector Pin Assignments ........................................................................ 7
7.3 SpaceWire Endpoint Wiring and Cable Assemblies ................................................................. 9
7.3.1 SpaceWire Cable Assemblies ............................................................................................ 9
7.3.2 SpaceWire Cable Overall Shield Termination .................................................................... 9
7.3.3 SPA Power Bus Wiring ...................................................................................................... 9
7.3.4 SPA Pulse-per-Second Wiring .......................................................................................... 9
7.3.5 SPA Test Bypass Wiring .................................................................................................. 9
7.3.6 SPA Wiring Harness Overall Shielding ............................................................................. 9
8 SPA Interface Connector and Cabling Requirements: Type B Connector ..................................... 10
8.1 Type B: 25-pin Micro-D/Power Connector and 15-pin D-Subminiature 30A Power Connector Overview ........................................................................................................................ 10
8.2 25-pin Micro-D SPA Endpoint Connector ............................................................................... 10
8.2.1 SPA Endpoint Connector Type ........................................................................................ 10
8.2.2 Endpoint Connector Gender ............................................................................................. 10
8.2.3 Hot-Plugging ..................................................................................................................... 10
8.2.4 SPA Endpoint Connector Mechanical Mounting Hardware .............................................. 10
8.2.5 SPA Endpoint Connector Pin Assignments ...................................................................... 10
8.3 15-pin D-Subminiature 30A Power Connector ........................................................................ 12
8.3.1 SPA 30A Power Connector Type ....................................................................................... 12
8.3.2 SPA 30A Power Connector Gender .................................................................................. 12
8.3.3 Hot-Plugging .................................................................................................................... 12
8.3.4 SPA Endpoint Connector Mechanical Mounting Hardware .............................................. 12
8.3.5 SPA Endpoint Connector Pin Assignments ...................................................................... 12
8.4 SPA Endpoint Wiring and Cable Assemblies .......................................................................... 13
8.4.1 SpaceWire Cable Assemblies ......................................................................................... 13
8.4.2 SpaceWire Cable Overall Shield Termination ................................................................. 14
8.4.3 SPA Power Bus Wiring .................................................................................................... 14
8.4.4 SPA Pulse-per-Second Wiring ....................................................................................... 14
8.4.5 SPA Test Bypass Data Wiring ....................................................................................... 14
8.4.6 SPA Wiring Harness Overall Shielding ........................................................................ 14
9 SPA Interface Connector and Cabling Requirements: Type C Connector ......................... 14
  9.1 SPA 15-pin HD Power, Synchronization, and Test and Dual Quadrax High-Speed Serial
      Interface Connectors ........................................................................................................ 14
    9.1.1 SPA Type C Electrical Connector Overview ............................................................... 14
  9.2 15-pin HD SPA Endpoint Power/Data Connector ............................................................ 14
    9.2.1 SPA Endpoint Connector Type .................................................................................. 14
    9.2.2 SPA Endpoint Connector Gender ............................................................................. 14
    9.2.3 Hot-Plugging ............................................................................................................ 15
    9.2.4 SPA Endpoint Dual Quadrax Connector Mechanical Mounting Hardware ................. 15
  9.3 Dual Quadrax High Speed Serial Interface Connectors .................................................. 16
    9.3.1 SPA Endpoint Dual Connector Type ........................................................................ 16
    9.3.2 SPA Endpoint Connector Gender ............................................................................. 16
    9.3.3 Hot-Plugging ............................................................................................................ 16
    9.3.4 SPA Endpoint Dual Connector Mechanical Mounting Hardware ............................. 16
    9.3.5 SPA Endpoint Connector Pin Assignments ................................................................. 16
10 SPA Interface Connector and Cabling Requirements: Type D Connector ..................... 16
  10.1 Type D: 25-pin Micro-D/Power Connector and 15-pin D-Subminiature 50A Power Connector Overview ................................................................. 17
  10.2 25-pin Micro-D SPA Endpoint Connector .................................................................... 17
    10.2.1 SPA Endpoint Connector Type ............................................................................... 17
    10.2.2 Endpoint Connector Gender .................................................................................. 17
    10.2.3 Hot-Plugging ........................................................................................................ 17
    10.2.4 SPA Endpoint Connector Mechanical Mounting Hardware ................................... 17
    10.2.5 SPA Endpoint Connector Pin Assignments .............................................................. 17
  10.3 25-pin D-Subminiature 50A Power Connector ............................................................... 19
    10.3.1 SPA 50A Power Connector Type ............................................................................. 19
    10.3.2 SPA 50A Power Connector Gender ....................................................................... 19
    10.3.3 Hot-Plugging ........................................................................................................ 19
    10.3.4 SPA Endpoint Connector Mechanical Mounting Hardware ................................... 19
    10.3.5 SPA Endpoint Connector Pin Assignments .............................................................. 19
10.4 SPA Endpoint Wiring and Cable Assemblies ................................................................. 21
10.4.1 SpaceWire Cable Assemblies .................................................................................. 21
10.4.2 SpaceWire Cable Overall Shield Termination ......................................................... 21
10.4.3 SPA Power Bus Wiring ........................................................................................... 21
10.4.4 SPA Pulse-per-Second Wiring ............................................................................... 21
10.4.5 SPA Test Bypass Data Wiring ............................................................................... 21
10.4.6 SPA Wiring Harness Overall Shielding ................................................................. 21

Annex A SPA 15-pin HD Power, Synchronization, and Test and Dual Quadrax High Speed Serial Interface Connectors Part Numbers (Informative) ......................................................... 22

Figures
Figure 1 – Typical SPA device mounting pattern ............................................................. 3
Figure 2 – Pin locations for dual quadrax as mounted .................................................... 17

Tables
Table 1 – SPA Endpoint Data/Power Connector Pin Assignments ................................. 8
Table 2 – SPA Endpoint Power/Data Connector Pin Assignments .................................. 11
Table 3 – SPA Endpoint 30A Power Connector Pin Assignments ................................... 13
Table 4 – SPA Endpoint Power/Data Connector Pin Assignments .................................. 15
Table 5 – SPA Endpoint Dual Quadrax Connector ........................................................... 16
Table 6 – SPA Endpoint Power/Data Connector Pin Assignments .................................. 18
Table 7 – SPA Endpoint 50A Power Connector Pin Assignments ................................... 20
Table A.1 – Part List for Sample High-Speed SPA Data Connector ................................. 22
Foreword
This standard was developed through a partnership of the Air Force Research Laboratory Space Vehicles Directorate, the Air Force Office of Operationally Responsive Space, numerous government contractor teams, independent contractor teams, and academic experts. The Space Plug-and-Play Architecture is a collection of standards developed to facilitate rapid constitution of spacecraft systems using modular components. In order for a SPA system to meet expected performance requirements, the SPA components and spacecraft must conform to a consistent and widely agreed upon grounding approach. This document includes specifications for SPA device and panel mechanical features.

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Introduction

The space plug-and-play avionics (SPA) standards are a collection of documents designed to facilitate rapid constitution of spacecraft systems using modular components. This document details the features for mechanical mounting, thermal control and interface connectors of SPA devices on a SPA-compliant spacecraft.

The standard mechanical interface is a bolted connection to a regularly spaced grid of threaded holes.

The grid spacing and fastener size are specified for a particular SPA standard.

Thermal control of SPA devices is accomplished by the rejection of dissipated power to the mounting surface (conduction) or to the surrounding environment (radiation). The spacecraft provides a conductive interface for the SPA devices, however, the device designer may choose other approaches such as heat rejection to space via radiators.

The SPA electrical connector interface consists of one or more connectors that contain provisions for power, data, a timing synchronization pulse, grounding connections, and (if specified) a Test Bypass (TBP) data interface.

There are two broad categories of requirements specified in this document that must be satisfied for integration of SPA devices. First, specific interface requirements must be met by both SPA devices and the SPA spacecraft, such as mounting hole pattern dimensions. Second, SPA device data must be provided with the item at the time of delivery. This data allows the SPA spacecraft developer to configure the spacecraft for proper integration and operation of the SPA device.
1 Scope

Mechanical, thermal and electrical connector interface requirements are contained in this document. These requirements include details of the mounting hole pattern, fastener clearance-hole sizes and thermal control approaches.

Reporting requirements for mechanical and thermal design data, such as mass, CG, envelope, radiator and heater locations, etc. are described.

This document identifies the significant features of the SPA interface connector(s) and the associated cabling to allow SPA device and cable manufacturers to build systems that interconnect successfully with SPA-enabled spacecraft. The connector type and pin assignments are described, along with definitions of connector gender and mechanical mounting. Requirements are provided for the associated cabling, including details of shielding, shield termination, insulation and cable impedance.

Optional SPA connector interfaces are described in the following sections by type (i.e. Type A, Type B, and so forth).

2 Tailoring

When viewed from the perspective of a specific program or project context, the requirements defined in this Standard may be tailored to match the actual requirements of the particular program or project. Tailoring of requirements shall be undertaken in consultation with the procuring authority where applicable.

NOTE Tailoring is a process by which individual requirements or specifications, standards, and related documents are evaluated and made applicable to a specific program or project by selection, and in some exceptional cases, modification and addition of requirements in the standards.

3 Applicable Documents

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

- AIAA G-133-10-201X SPA System Capabilities
- AIAA S-XXX-201X SPA 28V Power, Grounding, and Bonding
- ECSS-E-50-12C SpaceWire Cabling
- GSFC S311-P-4 Connectors: Electrical, Subminiature, Rack and Panel
- MIL-DTL-24308 Connectors: Electric, Rectangular, Nonenvironmental, Miniature, Polarized Shell, Rack and Panel
- MIL-DTL-83513 Connectors: Electric, Rectangular, Microminiature, Polarized Shell
4 Vocabulary

4.1 Acronyms and Abbreviated Terms

AIAA American Institute of Aeronautics and Astronautics
AWG American Wire Gauge
CG Center of Gravity
IGES Initial Graphics Exchange Specification
MKS Meters, Kilograms, Seconds
SPA Space Plug-and-Play Architecture
STEP Standard for the Exchange of Project Model Data

4.2 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

SPA Application
A software SPA component

SPA Compliant
Adheres to applicable SPA standards

SPA Component
A SPA compliant hardware or software component

SPA Core Component
A SPA component which provides one or more SPA service

SPA Device
A hardware SPA component

5 Mechanical Requirements for SPA Devices

5.1 Device Mounting

SPA devices shall include a set of mounting holes which align to a regularly-spaced grid pattern. The fastener clearance hole diameter and grid spacing are specified in section 5.1.3 of this standard.

In the typical implementation, SPA devices are mounted to the spacecraft structure with fasteners passing through clearance holes located on the device and mating with threaded features on the spacecraft.

5.1.1 Mounting Method

SPA devices shall provide clearance holes to accommodate mounting fasteners.

5.1.2 Recommended Fastener Size

Fastener type, size and material are to be determined by the integrator of the SPA device.
The fastener clearance hole sizes specified herein are intended for ANSI #8 (0.164 in.) or Metric M4 sized fasteners.

5.1.3 Mounting Pattern
The mounting pattern shall be a two-dimensional grid pattern with a typical center-to-center hole spacing of 5.0 cm.

5.1.4 Number of Mounting Holes
The number of mounting holes and overall mounting pattern size shall be determined by the device designer in accordance with the strength requirements for the end-use. However, it is recommended there shall not be less than two mounting holes used for an individual device.

5.1.5 Device Mounting Hole Size and Positional Tolerance
Device mounting features shall be a $\phi 0.478$ cm ($\phi 0.188$ in.) nominal diameter clearance holes.

Device mounting hole diameter tolerance shall be $-0.003 / +0.028$ cm ($-0.001 / +0.011$ in)

Device mounting hole patterns shall maintain a positional tolerance of $\phi 0.025$ cm ($\phi 0.010$ in) at a nominal mounting hole diameter of $\phi 0.188$ in.

The device mounting hole positional tolerance shall be at maximum material condition.

Figure 1 – Typical SPA device mounting pattern. (Primary dimensional units are in centimeters, secondary units are in inches.)
5.1.6 Mounting Fastener Access

The device design shall allow access to mounting fasteners for fastener installation, run-in and application of final torque.

5.1.7 Mounting Surface Flatness

NOTE  The Surface Flatness specification is provided as a recommendation for guidance only and is not a formal requirement.

The device and spacecraft mounting surfaces are recommended to have a flatness of no more than 0.0005 in. per 1.0 in. of linear distance, or 0.008 in., whichever is greater.

EXAMPLE  A device with a 30 cm (11.811 in.) linear dimension of mounting footprint is recommended to be flat within 0.008 in. A device with a 60 cm (23.622 in.) mounting footprint is recommended to be flat within 0.012 in.

5.1.8 Mounting Surface Conductivity

The mounting surfaces shall be electrically conductive such that the device and spacecraft are bonded with a maximum resistance of 2.5mΩ across each faying surface.

5.1.9 Mounting Surface Properties

All metal surfaces shall be passivated, plated, treated, or otherwise finished to provide an inert exposed surface to prevent corrosion. Surface treatments shall not inhibit electrical conductivity as specified in section 5.1.8 of this document.

5.2 Dynamic Requirements

Two cases for SPA device dynamics are provided under this specification:

a) SPA devices shall have no significant modes below 100Hz, or,

b) In cases where a SPA device has significant modes below 100Hz, a structural mathematical model (finite-element model) shall be provided with delivery of the device, sufficiently detailed to allow integration with the spacecraft structural model for prediction of worst-case deformations and stresses. It is recommended that the model shall be supplied in a NASTRAN-compatible format.

5.3 Deployables, Actuators, and Moving Mechanical Assemblies

In order to meet the goals of rapid integration SPA devices shall not employ pyrotechnic or explosive actuators such as initiators. This type of deployment mechanism requires special consideration and clearance on the structure that will increase the complexity of device placement. Non-explosive actuators shall be used for all deployments and actuations, such as shape-memory alloy devices, paraffin actuators, or equivalent.

5.4 Protective Covers

Protective covers shall be provided to preclude entrance of foreign particles to sensitive areas and to preclude damage during handling, assembly, integration, and test. Protective covers not required for on-orbit operation shall be color-coded with a red finish and shall be marked with the words "REMOVE BEFORE FLIGHT".

5.5 Maintainability

All devices shall be designed so that they can be replaced without adjustment.
All devices shall be designed to be installed with standard tools.

All devices shall be designed to be installed and removed from the spacecraft without disassembly of the device.

All mounting bolts, connectors, flight plugs, temporary vacuum seals, and non-flight protective covers shall be readily accessible while the device is mounted on the spacecraft.

5.6 Reporting of Device Physical Characteristics
SPA devices shall be delivered with the following documentation and engineering data

5.6.1 Envelope and Mounting
a) A drawing depicting the overall envelope dimensions shall be provided
b) The device coordinate system and origin shall be shown on the envelope drawing
c) A drawing depicting the mounting hole locations, size and flange thickness shall be provided
d) A solid model of the envelope and mounting details in STEP or IGES format shall be provided.

5.6.2 Mass, Center of Gravity, and Inertia Reporting
Mass properties of SPA devices shall be provided at device delivery.

a) Required: The mass of the device shall be reported to an accuracy of 5% or 0.5 kg (1.1lbm), whichever is less.

b) Recommended: The center of gravity location reported in the device coordinate system to an accuracy of 5 mm (0.2 in.) in any direction

c) Recommended: The inertia tensor, reported in the device coordinate system at the center of mass, shall be reported to an accuracy of 10%. It shall be specified whether the inertia tensor is calculated with a positive or negative integral.

d) Data shall be reported in the MKS system of units (i.e., meters, kilograms, or seconds).

5.6.3 Connector Type and Location Reporting
a) The type and location of all interface connectors shall be depicted on the device envelope drawing or a separate drawing

b) For each connector depicted on the drawing, the location of “Pin 1” shall be shown to identify connector orientation

5.6.4 Field of View Reporting
The boresight, field of view, and field of regard (if applicable) shall be described and provided on a drawing with definition relative to the device coordinate system.

5.6.5 Special Instructions
Special mounting, alignment, installation, integration, or testing requirements shall be identified, if applicable.
6 Thermal Requirements for SPA Devices

6.1 General Thermal Requirements

6.1.1 SPA Device Thermal Control Approach
SPA device thermal dissipations shall be conducted to the spacecraft through the device mounting surface or radiated to the surroundings.

6.1.2 Thermal Mounting Surfaces
a) The spacecraft shall provide a thermally-conductive mounting surface to accommodate a recommended thermal flux of 0.20 W/cm².

b) SPA devices which require thermal isolation from the spacecraft shall be responsible for providing thermal isolation features as an integral part of the SPA device. These may include, but are not limited to, low-conductivity spacers, stand-offs or flexures.

6.1.3 Device Thermal Interface Materials
Devices shall be mounted to the spacecraft without any thermal interface filler (i.e. wet-mounting).

6.1.4 Thermal Control External Surface Conductivity
a) The external surfaces of thermal control materials, including multi-layer insulation (MLI) blankets, radiator surfaces, and thermal control tapes, shall be conductive to dissipate charge build-up. The maximum recommended resistivity is 10K Ω/square.

b) MLI blankets shall be grounded to the device chassis.

6.1.5 Special Instructions
Special requirements for device thermal envelopes, operation modes, and other restrictions shall be provided as applicable.

6.2 Reporting of Device Thermal Characteristics
SPA devices shall be delivered with the following documentation and engineering data related to thermal characteristics to facilitate spacecraft design activities.

6.2.1 Thermal Design Approach
The thermal design approach related to requirements imposed on the spacecraft configuration shall be reported. This includes:

a) SPA device thermal control approach (i.e, mounting surface conduction, radiation to space, radiation to surrounding spacecraft surfaces)

b) Thermal radiator area, location, field-of-view requirements

c) Exterior surface finish descriptions, including emissivity and solar absorptivity

d) The spacecraft integrator may require a device thermal model to be integrated into the overall spacecraft thermal model. This shall be at the discretion of the spacecraft integrator.
6.2.2 Thermal Dissipation Levels
The thermal dissipation of the SPA device in all operational modes shall be reported.

6.2.3 Heaters and Heater Control
The details of internal device heaters shall be reported, including heater power, control set-points, operational modes, and any additional information for incorporation into the spacecraft thermal model.

7 SPA Interface Connector and Cabling Requirements: Type A Connector

7.1 Type A: SPA 25-pin Micro-D Power and Data Interface Connector Overview
The SPA device interface consists of connecting SPA devices to a spacecraft infrastructure. The connection of the SPA devices to the spacecraft is made at SPA endpoint connectors. The direction of power or data flow is referred to as “to SPA device” or “to SPA endpoint” when toward the SPA device, and “to host” when in the opposite direction toward the power source or data router.

The Type A SPA interface consists of one connector, the 25-pin Micro-D data and power connector.

7.2 25-pin Micro-D SPA Endpoint Connector

7.2.1 SPA Endpoint Connector Type
The SPA Endpoint connector shall be 25-contact Micro-D connector per MIL-DTL-83513.

7.2.2 SPA Endpoint Connector Gender
The spacecraft or system side of the SPA endpoint connector shall have the “plug” gender installed. The SPA device shall have a “receptacle” gender installed. The definition of “plug” and “receptacle” genders is as specified in MIL-DTL-83513.

7.2.3 Hot-Plugging
The SPA endpoint connectors are not intended for “hot-plugging”. SPA-compliant devices are not required to operate when a SPA endpoint connector is mated while voltage is present on the power pins.

7.2.4 SPA Endpoint Connector Mechanical Mounting Hardware
The SPA endpoint connectors shall be secured with #2-56 jackpost and jackscrew hardware.

7.2.5 SPA Endpoint Connector Pin Assignments
Pin assignments for the SPA endpoint connector shall be as specified in Table 1.
Table 1 – SPA Endpoint Data/Power Connector Pin Assignments

<table>
<thead>
<tr>
<th>Pin Number</th>
<th>Signal</th>
<th>Comments</th>
<th>SPA Device Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SpW Data In +</td>
<td>SpaceWire Data In, Positive</td>
<td>Input</td>
</tr>
<tr>
<td>2</td>
<td>SpW Strobe In +</td>
<td>SpaceWire Strobe In, Positive</td>
<td>Input</td>
</tr>
<tr>
<td>3</td>
<td>SpW Data Out +</td>
<td>SpaceWire Data Out, Positive</td>
<td>Output</td>
</tr>
<tr>
<td>4</td>
<td>SpW Strobe Out +</td>
<td>SpaceWire Strobe Out, Positive</td>
<td>Output</td>
</tr>
<tr>
<td>5</td>
<td>PPS +</td>
<td>Pulse Per Second</td>
<td>N/A</td>
</tr>
<tr>
<td>6</td>
<td>TBP From Host +</td>
<td>Test Bypass Input, Positive</td>
<td>Input</td>
</tr>
<tr>
<td>7</td>
<td>TBP To Host +</td>
<td>Test Bypass Output, Positive</td>
<td>Output</td>
</tr>
<tr>
<td>8</td>
<td>NC (Spare)</td>
<td>No Connect (Spare)</td>
<td>N/A</td>
</tr>
<tr>
<td>9</td>
<td>+28V</td>
<td>+28V Power Bus</td>
<td>N/A</td>
</tr>
<tr>
<td>10</td>
<td>+28V</td>
<td>+28V Power Bus</td>
<td>N/A</td>
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<td>+28V</td>
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<td>+28V</td>
<td>+28V Power Bus</td>
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<tr>
<td>13</td>
<td>Chassis Gnd</td>
<td>Chassis Ground</td>
<td>N/A</td>
</tr>
<tr>
<td>14</td>
<td>SpW Data In -</td>
<td>SpaceWire Data In, Negative</td>
<td>Input</td>
</tr>
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<td>15</td>
<td>SpW Strobe In -</td>
<td>SpaceWire Strobe In, Negative</td>
<td>Input</td>
</tr>
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<td>16</td>
<td>SpW Data Out -</td>
<td>SpaceWire Data Out, Negative</td>
<td>Output</td>
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<td>17</td>
<td>SpW Strobe Out -</td>
<td>SpaceWire Strobe Out, Negative</td>
<td>Output</td>
</tr>
<tr>
<td>18</td>
<td>PPS -</td>
<td>Pulse Per Second</td>
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<tr>
<td>19</td>
<td>TBP From Host -</td>
<td>Test Bypass Input, Positive</td>
<td>Input</td>
</tr>
<tr>
<td>20</td>
<td>TBP To Host -</td>
<td>Test Bypass Output, Positive</td>
<td>Output</td>
</tr>
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<td>21</td>
<td>DGND</td>
<td>SPA device digital ground</td>
<td>N/A</td>
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<td>22</td>
<td>+28V RTN</td>
<td>+28V Power Bus Return</td>
<td>N/A</td>
</tr>
<tr>
<td>23</td>
<td>+28V RTN</td>
<td>+28V Power Bus Return</td>
<td>N/A</td>
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<td>+28V Power Bus Return</td>
<td>N/A</td>
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<td>25</td>
<td>+28V RTN</td>
<td>+28V Power Bus Return</td>
<td>N/A</td>
</tr>
</tbody>
</table>
7.3 **SpaceWire Endpoint Wiring and Cable Assemblies**

### 7.3.1 SpaceWire Cable Assemblies

SpaceWire data cables shall conform to Standard ECSS-E-50-12C for four twisted, shielded pairs. The following deviations are permitted:

a) SpaceWire cables may use 26AWG wire in their construction

b) An outer conductive shield shall enclose the entire SPA cable. The ECSS-E-50-12C specification calls for an outer shield for only the four SpaceWire differential pairs, however, an overall SPA cable shield may be used after consideration of the environment and verification testing approach.

c) The recommended characteristic impedance for SpaceWire differential signal pairs is 100±6Ω. The selection of controlled impedance wire shall be made based on consideration of data rates, environment and specific spacecraft application.

### 7.3.2 SpaceWire Cable Overall Shield Termination

The SpaceWire cable shields shall be connected to chassis.

### 7.3.3 SPA Power Bus Wiring

a) Power bus and power return wiring shall be twisted pairs.

b) Power bus wiring shall be a minimum wire gage of 26AWG

### 7.3.4 SPA Pulse-per-Second Wiring

a) PPS wiring pairs shall be twisted pairs.

b) SPA PPS wiring shall be a minimum wire gage of 26AWG

### 7.3.5 SPA Test Bypass Wiring

a) Test Bypass data differential pairs shall be twisted pairs

b) SPA Test Bypass wiring shall be a minimum wire gage of 26AWG

### 7.3.6 SPA Wiring Harness Overall Shielding

It is recommended that SPA wiring harnesses, including SPA device-to-spacecraft cables, have an overall conductive shield. The overall conductive shield shall be connected to chassis.
8 SPA Interface Connector and Cabling Requirements: Type B Connector

8.1 Type B: 25-pin Micro-D/Power Connector and 15-pin D-Subminiature 30A Power Connector Overview

The SPA device interface consists of connecting SPA devices to a spacecraft infrastructure. The connection of the SPA devices to the spacecraft is made at SPA endpoint connectors. The direction of power or data flow is referred to as “to SPA device” or “to SPA endpoint” when toward the SPA device, and “to host” when in the opposite direction toward the power source or data router.

The Type B SPA interface consists of two connectors, a 25-pin Micro-D Data/Power connector and a 15-pin D-Subminiature 30A Power Interface Connector.

8.2 25-pin Micro-D SPA Endpoint Connector

8.2.1 SPA Endpoint Connector Type

The SPA endpoint data/power connector shall be a 25-contact Micro-D connector per MIL-DTL-83513.

8.2.2 Endpoint Connector Gender

The spacecraft or system side of the SPA endpoint connector shall have the “plug” gender installed. The SPA device shall have a “receptacle” gender installed. The definition of “plug” and “receptacle” genders is as specified in MIL-DTL-83513.

8.2.3 Hot-Plugging

The SPA endpoint connectors are not intended for “hot-plugging”. SPA-compliant devices are not required to operate when a SPA endpoint connector is mated while voltage is present on the power pins.

8.2.4 SPA Endpoint Connector Mechanical Mounting Hardware

The SPA endpoint connectors shall be secured with #2-56 jackpost and jackscrew hardware.

8.2.5 SPA Endpoint Connector Pin Assignments

Pin assignments for the SPA endpoint power/data connector shall be as specified in Table 2.
Table 2 – SPA Endpoint Power/Date Connector Pin Assignments

<table>
<thead>
<tr>
<th>Pin Number</th>
<th>Signal</th>
<th>Comments</th>
<th>SPA Device Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SpW Data In +</td>
<td>SpaceWire Data In, Positive</td>
<td>Input</td>
</tr>
<tr>
<td>2</td>
<td>SpW Strobe In +</td>
<td>SpaceWire Strobe In, Positive</td>
<td>Input</td>
</tr>
<tr>
<td>3</td>
<td>SpW Data Out +</td>
<td>SpaceWire Data Out, Positive</td>
<td>Output</td>
</tr>
<tr>
<td>4</td>
<td>SpW Strobe Out +</td>
<td>SpaceWire Strobe Out, Positive</td>
<td>Output</td>
</tr>
<tr>
<td>5</td>
<td>PPS +</td>
<td>Pulse Per Second</td>
<td>N/A</td>
</tr>
<tr>
<td>6</td>
<td>TBP From Host +</td>
<td>Test Bypass Input, Positive</td>
<td>Input</td>
</tr>
<tr>
<td>7</td>
<td>TBP To Host +</td>
<td>Test Bypass Output, Positive</td>
<td>Output</td>
</tr>
<tr>
<td>8</td>
<td>NC</td>
<td>No Connect</td>
<td>N/A</td>
</tr>
<tr>
<td>9</td>
<td>+28V</td>
<td>+28V Power Bus</td>
<td>N/A</td>
</tr>
<tr>
<td>10</td>
<td>+28V</td>
<td>+28V Power Bus</td>
<td>N/A</td>
</tr>
<tr>
<td>11</td>
<td>+28V</td>
<td>+28V Power Bus</td>
<td>N/A</td>
</tr>
<tr>
<td>12</td>
<td>+28V</td>
<td>+28V Power Bus</td>
<td>N/A</td>
</tr>
<tr>
<td>13</td>
<td>Chassis Gnd</td>
<td>Chassis Ground</td>
<td>N/A</td>
</tr>
<tr>
<td>14</td>
<td>SpW Data In -</td>
<td>SpaceWire Data In, Negative</td>
<td>Input</td>
</tr>
<tr>
<td>15</td>
<td>SpW Strobe In -</td>
<td>SpaceWire Strobe In, Negative</td>
<td>Input</td>
</tr>
<tr>
<td>16</td>
<td>SpW Data Out -</td>
<td>SpaceWire Data Out, Negative</td>
<td>Output</td>
</tr>
<tr>
<td>17</td>
<td>SpW Strobe Out -</td>
<td>SpaceWire Strobe Out, Negative</td>
<td>Output</td>
</tr>
<tr>
<td>18</td>
<td>PPS -</td>
<td>Pulse Per Second</td>
<td>N/A</td>
</tr>
<tr>
<td>19</td>
<td>TBP From Host -</td>
<td>Test Bypass Input, Positive</td>
<td>Input</td>
</tr>
<tr>
<td>20</td>
<td>TBP To Host -</td>
<td>Test Bypass Output, Positive</td>
<td>Output</td>
</tr>
<tr>
<td>21</td>
<td>DGND</td>
<td>SPA device digital ground</td>
<td>N/A</td>
</tr>
<tr>
<td>22</td>
<td>+28V RTN</td>
<td>+28V Power Bus Return</td>
<td>N/A</td>
</tr>
<tr>
<td>23</td>
<td>+28V RTN</td>
<td>+28V Power Bus Return</td>
<td>N/A</td>
</tr>
<tr>
<td>24</td>
<td>+28V RTN</td>
<td>+28V Power Bus Return</td>
<td>N/A</td>
</tr>
<tr>
<td>25</td>
<td>+28V RTN</td>
<td>+28V Power Bus Return</td>
<td>N/A</td>
</tr>
</tbody>
</table>
8.3 15-pin D-Subminiature 30A Power Connector

8.3.1 SPA 30A Power Connector Type
The SPA endpoint 30A power connector shall be a 15-contact D-Subminiature connector per MIL-DTL-24308 or GSFC S311. The SPA Type B 30A power connector is intended for a maximum current rating of 30A.

8.3.2 SPA 30A Power Connector Gender
The spacecraft or system side of the SPA endpoint connector shall have the "socket" gender installed. The SPA device shall have a "pin" gender installed. The definition of "socket" and "pin" genders is as specified in MIL-DTL-24308 or GSFC S311.

8.3.3 Hot-Plugging
The SPA endpoint connectors are not intended for "hot-plugging". SPA-compliant devices are not required to operate when a SPA endpoint connector is mated while voltage is present on the power pins.

8.3.4 SPA Endpoint Connector Mechanical Mounting Hardware
The SPA endpoint connectors shall be secured with #4-40 jackpost and jackscrew hardware.

8.3.5 SPA Endpoint Connector Pin Assignments
Pin assignments for the SPA endpoint 30A power connector shall be as specified in Table 3.
### Table 3 – SPA Endpoint 30A Power Connector Pin Assignments

<table>
<thead>
<tr>
<th>Pin Number</th>
<th>Signal</th>
<th>Comments</th>
<th>SPA Device Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+28V 30A Power</td>
<td>+28V 30A Power Service</td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td>+28V 30A Power</td>
<td>+28V 30A Power Service</td>
<td>N/A</td>
</tr>
<tr>
<td>3</td>
<td>+28V 30A Power</td>
<td>+28V 30A Power Service</td>
<td>N/A</td>
</tr>
<tr>
<td>4</td>
<td>+28V 30A Power</td>
<td>+28V 30A Power Service</td>
<td>N/A</td>
</tr>
<tr>
<td>5</td>
<td>+28V 30A Power</td>
<td>+28V 30A Power Service</td>
<td>N/A</td>
</tr>
<tr>
<td>6</td>
<td>+28V 30A Power</td>
<td>+28V 30A Power Service</td>
<td>N/A</td>
</tr>
<tr>
<td>7</td>
<td>+28V 30A Power</td>
<td>+28V 30A Power Service</td>
<td>N/A</td>
</tr>
<tr>
<td>8</td>
<td>NC</td>
<td>No Connect</td>
<td>N/A</td>
</tr>
<tr>
<td>9</td>
<td>+28V 30A Power RTN</td>
<td>+28V 30A Power Service Return</td>
<td>N/A</td>
</tr>
<tr>
<td>10</td>
<td>+28V 30A Power RTN</td>
<td>+28V 30A Power Service Return</td>
<td>N/A</td>
</tr>
<tr>
<td>11</td>
<td>+28V 30A Power RTN</td>
<td>+28V 30A Power Service Return</td>
<td>N/A</td>
</tr>
<tr>
<td>12</td>
<td>+28V 30A Power RTN</td>
<td>+28V 30A Power Service Return</td>
<td>N/A</td>
</tr>
<tr>
<td>13</td>
<td>+28V 30A Power RTN</td>
<td>+28V 30A Power Service Return</td>
<td>N/A</td>
</tr>
<tr>
<td>14</td>
<td>+28V 30A Power RTN</td>
<td>+28V 30A Power Service Return</td>
<td>N/A</td>
</tr>
<tr>
<td>15</td>
<td>+28V 30A Power RTN</td>
<td>+28V 30A Power Service Return</td>
<td>N/A</td>
</tr>
</tbody>
</table>

### 8.4 SPA Endpoint Wiring and Cable Assemblies

#### 8.4.1 SpaceWire Cable Assemblies

SpaceWire data cables shall conform to Standard ECSS-E-50-12C for four twisted, shielded pairs. The following deviations are permitted:

a) SpaceWire cables may use 26AWG wire in their construction.

b) An outer conductive shield shall enclose the entire SPA cable. The ECSS-E-50-12C specification calls for an outer shield for only the four SpaceWire differential pairs, however, an overall SPA cable shield may be used after consideration of the environment and verification testing.

c) The recommended characteristic impedance for SpaceWire differential signal pairs is $100\pm6 \Omega$. The selection of controlled impedance wire shall be made based on consideration of data rates, environment and specific spacecraft application.
8.4.2 **SpaceWire Cable Overall Shield Termination**

The SpaceWire cable shields shall be connected to chassis.

8.4.3 **SPA Power Bus Wiring**

a) Power bus and power return wiring shall be twisted pairs

b) Power bus wiring shall be a minimum wire gage of 26AWG

8.4.4 **SPA Pulse-per-Second Wiring**

a) PPS wiring pairs shall be twisted pairs

b) SPA PPS wiring shall be a minimum wire gage of 26AWG

8.4.5 **SPA Test Bypass Data Wiring**

a) Test Bypass data differential pairs shall be twisted pairs

b) SPA Test Bypass wiring shall be a minimum wire gage of 26AWG

8.4.6 **SPA Wiring Harness Overall Shielding**

It is recommended that SPA wiring harnesses, including SPA device-to-spacecraft cables, have an overall conductive shield. The overall conductive shield shall be connected to chassis.

9 **SPA Interface Connector and Cabling Requirements: Type C Connector**

9.1 **SPA 15-pin HD Power, Synchronization, and Test and Dual Quadrax High-Speed Serial Interface Connectors**

9.1.1 **SPA Type C Electrical Connector Overview**

The SPA device interface consists of connecting SPA devices to a spacecraft infrastructure. The connection of the SPA devices to the spacecraft is made at SPA endpoint connectors. The direction of power or data flow is referred to as “to SPA device” or “to SPA endpoint” when toward the SPA device, and “to host” when in the opposite direction toward the power source or data router.

The Type C SPA interface consists of two connectors, a 15-pin HD Power Synchronization and Test connector and a dual quadrax high speed data connector, to allow connection of high speed differential primary and redundant signals.

9.2 **15-pin HD SPA Endpoint Power/Data Connector**

9.2.1 **SPA Endpoint Connector Type**

The SPA endpoint data/power connector shall be a standard 15-contact D-sub connector per MIL-DTL-24308.

9.2.2 **SPA Endpoint Connector Gender**

The spacecraft or system side of the SPA endpoint connector shall have the “plug” gender installed. The SPA device shall have a “receptacle” gender installed. The definition of “plug” and “receptacle” genders is as specified in MIL-DTL-24308.
9.2.3 Hot-Plugging

The SPA endpoint connectors are not intended for “hot-plugging”. SPA-compliant devices are not required to operate when a SPA endpoint connector is mated while voltage is present on the power pins.

9.2.4 SPA Endpoint Dual Quadrax Connector Mechanical Mounting Hardware

The SPA endpoint connectors shall be secured with #2-56 jackpost and jackscrew hardware.

9.2.5 SPA Endpoint Dual Quadrax Connector Pin Assignments

Pin assignments for the SPA endpoint power/data connector shall be as specified in Table 4.

Table 4 – SPA Endpoint Power/Data Connector Pin Assignments

<table>
<thead>
<tr>
<th>Pin Number</th>
<th>Signal</th>
<th>Comments</th>
<th>SPA Device Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TBP From Host +</td>
<td>Test Bypass Input, Positive</td>
<td>Input</td>
</tr>
<tr>
<td>2</td>
<td>TBP From Host -</td>
<td>Test Bypass Input, Negative</td>
<td>Input</td>
</tr>
<tr>
<td>3</td>
<td>PPS +</td>
<td>Pulse Per Second</td>
<td>N/A</td>
</tr>
<tr>
<td>4</td>
<td>+28V RTN</td>
<td>+28V Power Bus Return</td>
<td>N/A</td>
</tr>
<tr>
<td>5</td>
<td>+28V</td>
<td>+28V Power Bus</td>
<td>N/A</td>
</tr>
<tr>
<td>6</td>
<td>TBP To Host +</td>
<td>Test Bypass Output, Positive</td>
<td>Output</td>
</tr>
<tr>
<td>7</td>
<td>TBP To Host -</td>
<td>Test Bypass Output, Negative</td>
<td>Output</td>
</tr>
<tr>
<td>8</td>
<td>PPS -</td>
<td>Pulse Per Second</td>
<td>N/A</td>
</tr>
<tr>
<td>9</td>
<td>+28V RTN</td>
<td>+28V Power Bus Return</td>
<td>N/A</td>
</tr>
<tr>
<td>10</td>
<td>+28V</td>
<td>+28V Power Bus</td>
<td>N/A</td>
</tr>
<tr>
<td>11</td>
<td>NC</td>
<td>No Connect</td>
<td>N/A</td>
</tr>
<tr>
<td>12</td>
<td>Chassis Gnd</td>
<td>Chassis Ground</td>
<td>N/A</td>
</tr>
<tr>
<td>13</td>
<td>DGND</td>
<td>SPA device digital ground</td>
<td>N/A</td>
</tr>
<tr>
<td>14</td>
<td>+28V RTN</td>
<td>+28V Power Bus Return</td>
<td>N/A</td>
</tr>
<tr>
<td>15</td>
<td>+28V</td>
<td>+28V Power Bus</td>
<td>N/A</td>
</tr>
</tbody>
</table>
9.3 Dual Quadrax High Speed Serial Interface Connectors

9.3.1 SPA Endpoint Dual Connector Type
The SPA endpoint high speed serial interface connector shall be a pair of quadrax cables, connected to the system with a dual-quadrax cable socket.

9.3.2 SPA Endpoint Connector Gender
The spacecraft or system side of the SPA endpoint connector shall have the “socket” gender installed. The SPA device shall have a “pin” gender installed. The definition of “socket” and “pin” genders is as specified in MIL-DTL-24308.

9.3.3 Hot-Plugging
The SPA endpoint connectors are not intended for “hot-plugging”. SPA-compliant devices are not required to operate when a SPA endpoint connector is mated while voltage is present on the power pins.

9.3.4 SPA Endpoint Dual Connector Mechanical Mounting Hardware
The SPA endpoint connectors shall be secured with #4-40 jackpost and jackscrew hardware.

9.3.5 SPA Endpoint Connector Pin Assignments
Pin assignments for the SPA endpoint dual quadrax high speed serial connector shall be as specified in Table 5.

Table 5 – SPA Endpoint Dual Quadrax Connector

<table>
<thead>
<tr>
<th>Pin Number</th>
<th>Signal</th>
<th>Comments</th>
<th>SPA Device Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Primary Signal, Tx +</td>
<td>Differential Data from Endpoint to Host</td>
<td>Output</td>
</tr>
<tr>
<td>2</td>
<td>Primary Signal, Rx +</td>
<td>Differential Data from Host to Endpoint</td>
<td>Input</td>
</tr>
<tr>
<td>3</td>
<td>Primary Signal, Tx -</td>
<td>Differential Data from Endpoint to Host</td>
<td>Output</td>
</tr>
<tr>
<td>4</td>
<td>Primary Signal, Rx -</td>
<td>Differential Data from Host to Endpoint</td>
<td>Input</td>
</tr>
<tr>
<td>5</td>
<td>Redundant Signal, Tx +</td>
<td>Differential Data from Endpoint to Host</td>
<td>Output</td>
</tr>
<tr>
<td>6</td>
<td>Redundant Signal, Rx +</td>
<td>Differential Data from Host to Endpoint</td>
<td>Input</td>
</tr>
<tr>
<td>7</td>
<td>Redundant Signal, Tx -</td>
<td>Differential Data from Endpoint to Host</td>
<td>Output</td>
</tr>
<tr>
<td>8</td>
<td>Redundant Signal, Rx -</td>
<td>Differential Data from Host to Endpoint</td>
<td>Input</td>
</tr>
</tbody>
</table>
10 SPA Interface Connector and Cabling Requirements: Type D Connector

10.1 Type D: 25-pin Micro-D/Power Connector and 15-pin D-Subminiature 50A Power Connector Overview

The SPA device interface consists of connecting SPA devices to a spacecraft infrastructure. The connection of the SPA devices to the spacecraft is made at SPA endpoint connectors. The direction of power or data flow is referred to as “to SPA device” or “to SPA endpoint” when toward the SPA device, and “to host” when in the opposite direction toward the power source or data router.

The Type D SPA interface consists of two connectors, a 25-pin Micro-D Data/Power connector and a 25-pin D-Subminiature 50A Power Interface Connector.

10.2 25-pin Micro-D SPA Endpoint Connector

10.2.1 SPA Endpoint Connector Type

The SPA endpoint data/power connector shall be a 25-contact Micro-D connector per MIL-DTL-83513.

10.2.2 Endpoint Connector Gender

The spacecraft or system side of the SPA endpoint connector shall have the “plug” gender installed. The SPA device shall have a “receptacle” gender installed. The definition of “plug” and “receptacle” genders is as specified in MIL-DTL-83513.

10.2.3 Hot-Plugging

The SPA endpoint connectors are not intended for “hot-plugging”. SPA-compliant devices are not required to operate when a SPA endpoint connector is mated while voltage is present on the power pins.

10.2.4 SPA Endpoint Connector Mechanical Mounting Hardware

The SPA endpoint connectors shall be secured with #2-56 jackpost and jackscrew hardware.

10.2.5 SPA Endpoint Connector Pin Assignments

Pin assignments for the SPA endpoint power/data connector shall be as specified in Table 6.
Table 6 – SPA Endpoint Power/Data Connector Pin Assignments

<table>
<thead>
<tr>
<th>Pin Number</th>
<th>Signal</th>
<th>Comments</th>
<th>SPA Device Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SpW Data In +</td>
<td>SpaceWire Data In, Positive</td>
<td>Input</td>
</tr>
<tr>
<td>2</td>
<td>SpW Strobe In+</td>
<td>SpaceWire Strobe In, Positive</td>
<td>Input</td>
</tr>
<tr>
<td>3</td>
<td>SpW Data Out +</td>
<td>SpaceWire Data Out, Positive</td>
<td>Output</td>
</tr>
<tr>
<td>4</td>
<td>SpW Strobe Out +</td>
<td>SpaceWire Strobe Out, Positive</td>
<td>Output</td>
</tr>
<tr>
<td>5</td>
<td>PPS +</td>
<td>Pulse Per Second</td>
<td>N/A</td>
</tr>
<tr>
<td>6</td>
<td>TBP From Host +</td>
<td>Test Bypass Input, Positive</td>
<td>Input</td>
</tr>
<tr>
<td>7</td>
<td>TBP To Host +</td>
<td>Test Bypass Output, Positive</td>
<td>Output</td>
</tr>
<tr>
<td>8</td>
<td>NC</td>
<td>No Connect</td>
<td>N/A</td>
</tr>
<tr>
<td>9</td>
<td>+28V</td>
<td>+28V Power Bus</td>
<td>N/A</td>
</tr>
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<td>10</td>
<td>+28V</td>
<td>+28V Power Bus</td>
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<td>+28V</td>
<td>+28V Power Bus</td>
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<td>+28V</td>
<td>+28V Power Bus</td>
<td>N/A</td>
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<tr>
<td>13</td>
<td>Chassis Gnd</td>
<td>Chassis Ground</td>
<td>N/A</td>
</tr>
<tr>
<td>14</td>
<td>SpW Data In -</td>
<td>SpaceWire Data In, Negative</td>
<td>Input</td>
</tr>
<tr>
<td>15</td>
<td>SpW Strobe In -</td>
<td>SpaceWire Strobe In, Negative</td>
<td>Input</td>
</tr>
<tr>
<td>16</td>
<td>SpW Data Out -</td>
<td>SpaceWire Data Out, Negative</td>
<td>Output</td>
</tr>
<tr>
<td>17</td>
<td>SpW Strobe Out -</td>
<td>SpaceWire Strobe Out, Negative</td>
<td>Output</td>
</tr>
<tr>
<td>18</td>
<td>PPS -</td>
<td>Pulse Per Second</td>
<td>N/A</td>
</tr>
<tr>
<td>19</td>
<td>TBP From Host -</td>
<td>Test Bypass Input, Positive</td>
<td>Input</td>
</tr>
<tr>
<td>20</td>
<td>TBP To Host -</td>
<td>Test Bypass Output, Positive</td>
<td>Output</td>
</tr>
<tr>
<td>21</td>
<td>DGND</td>
<td>SPA device digital ground</td>
<td>N/A</td>
</tr>
<tr>
<td>22</td>
<td>+28V RTN</td>
<td>+28V Power Bus Return</td>
<td>N/A</td>
</tr>
<tr>
<td>23</td>
<td>+28V RTN</td>
<td>+28V Power Bus Return</td>
<td>N/A</td>
</tr>
<tr>
<td>24</td>
<td>+28V RTN</td>
<td>+28V Power Bus Return</td>
<td>N/A</td>
</tr>
<tr>
<td>25</td>
<td>+28V RTN</td>
<td>+28V Power Bus Return</td>
<td>N/A</td>
</tr>
</tbody>
</table>
10.3 25-pin D-Subminiature 50A Power Connector

10.3.1 SPA 50A Power Connector Type
The SPA endpoint 50A power connector shall be a 15-contact D-Subminiature connector per MIL-DTL-24308 or GSFC S311. The SPA Type B 50A power connector is intended for a maximum current rating of 30A.

10.3.2 SPA 50A Power Connector Gender
The spacecraft or system side of the SPA endpoint connector shall have the “socket” gender installed. The SPA device shall have a “pin” gender installed. The definition of “socket” and “pin” genders is as specified in MIL-DTL-24308 or GSFC S311.

10.3.3 Hot-Plugging
The SPA endpoint connectors are not intended for “hot-plugging”. SPA-compliant devices are not required to operate when a SPA endpoint connector is mated while voltage is present on the power pins.

10.3.4 SPA Endpoint Connector Mechanical Mounting Hardware
The SPA endpoint connectors shall be secured with #4-40 jackpost and jackscrew hardware.

10.3.5 SPA Endpoint Connector Pin Assignments
Pin assignments for the SPA endpoint 50A power connector shall be as specified in Table 7.
Table 7 – SPA Endpoint 50A Power Connector Pin Assignments

<table>
<thead>
<tr>
<th>Pin Number</th>
<th>Signal</th>
<th>Comments</th>
<th>SPA Device Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+28V 50A Power</td>
<td>+28V 50A Power Service</td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td>+28V 50A Power</td>
<td>+28V 50A Power Service</td>
<td>N/A</td>
</tr>
<tr>
<td>3</td>
<td>+28V 50A Power</td>
<td>+28V 50A Power Service</td>
<td>N/A</td>
</tr>
<tr>
<td>4</td>
<td>+28V 50A Power</td>
<td>+28V 50A Power Service</td>
<td>N/A</td>
</tr>
<tr>
<td>5</td>
<td>+28V 50A Power</td>
<td>+28V 50A Power Service</td>
<td>N/A</td>
</tr>
<tr>
<td>6</td>
<td>+28V 50A Power</td>
<td>+28V 50A Power Service</td>
<td>N/A</td>
</tr>
<tr>
<td>7</td>
<td>+28V 50A Power</td>
<td>+28V 50A Power Service</td>
<td>N/A</td>
</tr>
<tr>
<td>8</td>
<td>+28V 50A Power</td>
<td>+28V 50A Power Service</td>
<td>N/A</td>
</tr>
<tr>
<td>9</td>
<td>+28V 50A Power</td>
<td>+28V 50A Power Service</td>
<td>N/A</td>
</tr>
<tr>
<td>10</td>
<td>+28V 50A Power</td>
<td>+28V 50A Power Service</td>
<td>N/A</td>
</tr>
<tr>
<td>11</td>
<td>+28V 50A Power</td>
<td>+28V 50A Power Service</td>
<td>N/A</td>
</tr>
<tr>
<td>12</td>
<td>+28V 50A Power</td>
<td>+28V 50A Power Service</td>
<td>N/A</td>
</tr>
<tr>
<td>13</td>
<td>NC</td>
<td>No Connect</td>
<td>N/A</td>
</tr>
<tr>
<td>14</td>
<td>+28V 50A Power RTN</td>
<td>+28V 50A Power Service Return</td>
<td>N/A</td>
</tr>
<tr>
<td>15</td>
<td>+28V 50A Power RTN</td>
<td>+28V 50A Power Service Return</td>
<td>N/A</td>
</tr>
<tr>
<td>16</td>
<td>+28V 50A Power RTN</td>
<td>+28V 50A Power Service Return</td>
<td>N/A</td>
</tr>
<tr>
<td>17</td>
<td>+28V 50A Power RTN</td>
<td>+28V 50A Power Service Return</td>
<td>N/A</td>
</tr>
<tr>
<td>18</td>
<td>+28V 50A Power RTN</td>
<td>+28V 50A Power Service Return</td>
<td>N/A</td>
</tr>
<tr>
<td>19</td>
<td>+28V 50A Power RTN</td>
<td>+28V 50A Power Service Return</td>
<td>N/A</td>
</tr>
<tr>
<td>20</td>
<td>+28V 50A Power RTN</td>
<td>+28V High Power Service Return</td>
<td>N/A</td>
</tr>
<tr>
<td>21</td>
<td>+28V 50A Power RTN</td>
<td>+28V High Power Service Return</td>
<td>N/A</td>
</tr>
<tr>
<td>22</td>
<td>+28V 50A Power RTN</td>
<td>+28V High Power Service Return</td>
<td>N/A</td>
</tr>
<tr>
<td>23</td>
<td>+28V 50A Power RTN</td>
<td>+28V High Power Service Return</td>
<td>N/A</td>
</tr>
<tr>
<td>24</td>
<td>+28V 50A Power RTN</td>
<td>+28V High Power Service Return</td>
<td>N/A</td>
</tr>
<tr>
<td>25</td>
<td>+28V 50A Power RTN</td>
<td>+28V High Power Service Return</td>
<td>N/A</td>
</tr>
</tbody>
</table>
10.4 SPA Endpoint Wiring and Cable Assemblies

10.4.1 SpaceWire Cable Assemblies
SpaceWire data cables shall conform to Standard ECSS-E-50-12C for four twisted, shielded pairs. The following deviations are permitted:

a) SpaceWire cables may use 26AWG wire in their construction

b) An outer conductive shield shall enclose the entire SPA cable. The ECSS-E-50-12C specification calls for an outer shield for only the four SpaceWire differential pairs, however, an overall SPA cable shield may be used after consideration of the environment and verification testing.

c) The recommended characteristic impedance for SpaceWire differential signal pairs is 100±Ω. The selection of controlled impedance wire shall be made based on consideration of data rates, environment and specific spacecraft application.

10.4.2 SpaceWire Cable Overall Shield Termination
The SpaceWire cable shields shall be connected to chassis.

10.4.3 SPA Power Bus Wiring
a) Power bus and power return wiring shall be twisted pairs

b) Power bus wiring shall be a minimum wire gage of 26AWG

10.4.4 SPA Pulse-per-Second Wiring
a) PPS wiring pairs shall be twisted pairs

b) SPA PPS wiring shall be a minimum wire gage of 26AWG

10.4.5 SPA Test Bypass Data Wiring
a) Test Bypass data differential pairs shall be twisted pairs

b) SPA Test Bypass wiring shall be a minimum wire gage of 26AWG

10.4.6 SPA Wiring Harness Overall Shielding
It is recommended that SPA wiring harnesses, including SPA device-to-spacecraft cables, have an overall conductive shield. The overall conductive shield shall be connected to chassis.
Annex A  SPA 15-pin HD Power, Synchronization, and Test and Dual Quadrax High-Speed Serial Interface Connectors Part Numbers (Informative)

This annex lists the part numbers used for a sample implementation of the high-speed SPA endpoint interface. It is provided for the reader’s reference.

Table A.1 – Part List for Sample High-Speed SPA Data Connector

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sabritec Rugged D-Sub Connector (Pin)</td>
<td>RDC-1-N-1-2-P-RA (Pin, Right-Angle)</td>
</tr>
<tr>
<td>4</td>
<td>Size 9 Quadrax Pin Contact, 100 ohm (2 needed for primary and redundant)</td>
<td>019235-8000</td>
</tr>
<tr>
<td>2</td>
<td>Sabritec Rugged D-Sub Connector (Socket)</td>
<td>RDC-1-N-1-2-S-RA (Socket, Right-Angle)</td>
</tr>
<tr>
<td>5</td>
<td>Size 9 Quadrax Socket Contact, 100 ohm (2 needed for primary and redundant)</td>
<td>019135-8000</td>
</tr>
<tr>
<td>3</td>
<td>Sabritec Quad D-Sub Receptacle Cable Mount 2 Contact Cable Mount</td>
<td>012800-3002</td>
</tr>
<tr>
<td>6</td>
<td>100 Ohm Ethernet AWG 24 Quad Cable (Sabritec)</td>
<td>540-1183-000</td>
</tr>
</tbody>
</table>