Power SCOE Requirement Specification

CI CODE: 124 4200

UK EXPORT CONTROL RATING : Not Listed
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Power SCOE Requirement Specifications (v1.2).doc
## CONTENTS

1. INTRODUCTION AND SCOPE ..................................................................................................................... 7
   1.1 Introduction ........................................................................................................................................... 7
   1.2 Scope .................................................................................................................................................. 7
   1.3 Summary Description ......................................................................................................................... 7

2. DOCUMENTS .............................................................................................................................................. 12
   2.1 Applicable Documents ....................................................................................................................... 12
   2.2 Standards .......................................................................................................................................... 12
   2.3 Reference Documents ....................................................................................................................... 12

3. POWER SCOE GENERAL REQUIREMENTS ................................................................................................. 13
   3.1 General Design ................................................................................................................................... 13
   3.2 Flight Equipment Safety ..................................................................................................................... 13
   3.3 Operating Modes ............................................................................................................................... 13
   3.4 Missing Equipment's ......................................................................................................................... 14
   3.5 Automatic testing .............................................................................................................................. 14
   3.6 Local Controller ................................................................................................................................ 14
      3.6.1 Graphical Data Plots ................................................................................................................ 15
      3.6.2 Printing ....................................................................................................................................... 15
   3.7 Remote Interface ................................................................................................................................ 15
   3.8 SCOE Protection Facility .................................................................................................................... 16
      3.8.1 Local Mode ............................................................................................................................... 17
      3.8.2 System mode ............................................................................................................................ 17
   3.9 Log and Archive files ......................................................................................................................... 18
   3.10 SCOE Local Controller Login Accounts .......................................................................................... 18
   3.11 Mains Input ....................................................................................................................................... 19
      3.11.1 SCOE Emergency OFF button ............................................................................................ 19
   3.12 Cables and Grounding ...................................................................................................................... 20
   3.13 Protected Test Points ....................................................................................................................... 20
   3.14 CE Marking ....................................................................................................................................... 21

4. UMBILICAL POWER, MONITORING AND LAUNCH SUPPORT .................................................................. 22
   4.1 Umbilical Bus Support ...................................................................................................................... 22
      4.1.1 Bus Support Power Supply ...................................................................................................... 22
      4.1.2 Protection .................................................................................................................................. 23
      4.1.3 Output Stability .......................................................................................................................... 24
      4.1.4 Ripple and Spikes ....................................................................................................................... 24
      4.1.5 Load Regulation ......................................................................................................................... 25
      4.1.6 Isolation ...................................................................................................................................... 25
      4.1.7 Umbilical Bus Support Satellite Interface ............................................................................... 25
   4.2 Battery Relay Interface ....................................................................................................................... 27
      4.2.1 Battery Safety Relay commands ............................................................................................... 27
      4.2.2 Battery Relay Status Monitoring .............................................................................................. 32
   4.3 Umbilical Monitoring Functions ....................................................................................................... 35
      4.3.1 Bus Voltage Monitor .................................................................................................................. 35
      4.3.2 Umbilical Battery Voltage Monitor ......................................................................................... 39
      4.3.3 Umbilical Battery Temperature Monitor ................................................................................. 42
   4.4 Umbilical Support Functions ............................................................................................................ 45
      4.4.1 Separation Strap Status ............................................................................................................. 45
      4.4.2 X-Band TM/TC Bypass ............................................................................................................. 48
   4.5 Launch Support .................................................................................................................................. 50
5. BATTERY SIMULATOR
   5.1 General ................................................................. 51
   5.2 Overvoltage Protection ................................................. 51
   5.3 Battery Charge ............................................................. 52
   5.4 Battery Discharge ......................................................... 52
   5.5 Thermistor Simulation .................................................... 53
   5.6 Heater Simulation .......................................................... 53
   5.7 Terminal Voltage Monitors ............................................. 53
   5.8 Battery Simulator Interface ........................................... 54

6. OFF-LINE BATTERY SUPPORT FUNCTION
   6.1 Charge Function ......................................................... 56
   6.2 Discharge Function ....................................................... 56
   6.3 Monitoring Function ...................................................... 57
      6.3.1 Battery Undervoltage protection .................................. 57
   6.4 Isolation ................................................................. 57
   6.5 Off-line Battery Support Interface ................................. 57

7. MEASUREMENT ERROR AMPLIFIER STIMULI ....................... 60
   7.1 DETAILS are TBD ...................................................... 60

8. THERMAL OVERRIDE UNIT ........................................... 61
   8.1 Thermal Override Unit Interface ................................... 64

9. PYRO LOAD AND MONITOR FUNCTIONS ............................... 67
   9.1 Pyro Initiator Device .................................................. 67
   9.2 Shape Memory Devices ................................................ 68
   9.3 Motor Actuator devices ............................................... 70
   9.4 Pyro Device Interface .................................................. 72

10. SOLAR ARRAY SIMULATOR (SAS) .................................... 75
    10.1 SAS Power Requirements ........................................ 75
    10.2 Protection .............................................................. 76
        10.2.1 Overvoltage ....................................................... 76
        10.2.2 Overcurrent ....................................................... 77
    10.3 Sunlight to Eclipse, Eclipse to Sunlight Transitions ............. 77
    10.4 Ripple and Spikes .................................................... 79
    10.5 Isolation ............................................................. 79
    10.6 SAS Satellite Interface ............................................. 79

11. LOAD TEST RACK ....................................................... 83
    11.1 Electronic load ........................................................ 84
    11.2 Monitoring ............................................................ 85
    11.3 Load Test rack Interface ........................................... 85

12. PSS / PYRO SCOE VALIDATION ..................................... 90
    12.1 SCOE Self Test ....................................................... 90
    12.2 SCOE Validation Cable Interfacing Concept .................... 91

13. VERIFICATION .......................................................... 93

14. PA REQUIREMENTS .................................................... 94
TABLES

Table 4-1: Standard High Power Command Driver Specification ................................................................. 28
Table 4-2: Standard High Power Command Receiver Specification ............................................................ 28
Table 4-3: Relay Status Acquisition Receiver Specification ............................................................................. 32
Table 4-4: Relay Status Acquisition Source Specification .................................................................................. 32
Table 4-5: UBV Interface Data Sheet ................................................................................................................... 35
Table 4-6: EBV Interface Data Sheet ................................................................................................................... 39
Table 4-7: Type 1 (ANY) Receiver Circuit Specification ....................................................................................... 42
Table 4-8: Type 1 (ANY) Source Circuit Specification .......................................................................................... 43
Table 4-9: Relay Status Acquisition Source Specification .................................................................................... 45
Table 9-1: Pyro Activation Device Characteristics ............................................................................................. 67
Table 9-2: Deployment Heating Device Characteristics ....................................................................................... 69
Table 9-3: Motor Actuator Characteristics ........................................................................................................... 71
Table 9-4: SCOE Pyro Device Prime Interface ...................................................................................................... 73
Table 10-1: Solar Array Power Interface ............................................................................................................... 80
Table 11-1: Power Interfaces Summary ................................................................................................................ 86
Table 11-2: Heater Interface Summary ................................................................................................................ 86

FIGURES

Figure 1-1: LISA-Pathfinder EGSE Configuration ................................................................................................. 9
Figure 1-2: Power SCOE general Interfaces ........................................................................................................ 11
Figure 4-1: SCOE Umbilical Bus Support Interface ............................................................................................. 26
Figure 4-2: PCDU Battery Safety Relay configuration ......................................................................................... 27
Figure 4-3: SCOE Battery Safety Relay Command Interface .................................................................................. 31
Figure 4-4: Principle of Relay Status Acquisition .................................................................................................. 33
Figure 4-5: SCOE Battery Safety Relay Status Interface ....................................................................................... 34
Figure 4-6: SCOE Bus Voltage Monitor Interface ............................................................................................... 38
Figure 4-7: SCOE Battery Voltage Monitor Interface ........................................................................................... 41
Figure 4-8: SCOE Battery Temperature Monitor Interface ..................................................................................... 44
Figure 4-9: SCOE Separation Strap Status Interface ............................................................................................ 47
Figure 4-10: SCOE TM/TC Bypass Interface ....................................................................................................... 49
Figure 5-1: Battery Simulator Interface ................................................................................................................ 55
Figure 6-1: SCOE Off-line Battery Support Interface ............................................................................................ 59
Figure 8-1: LISA-Pathfinder Heater and Thermostat circuits (TBC) ................................................................. 62
Figure 8-2: Thermostat Override circuit (suggested) details ................................................................................ 63
Figure 8-3: Thermal Override Unit Prime Interface ............................................................................................ 65
Figure 8-4: Thermal Override Unit Redundant Interface ..................................................................................... 66
Figure 9-1: SCOE Pyro Device Redundant Interface ........................................................................................... 74
Figure 10-1: Satellite orientation during LEOP and apogee raising manoeuvres .............................................. 78
Figure 10-2: SCOE Solar Array Simulator Interface ........................................................................................... 82
Figure 11-1: LCL Characteristic .......................................................................................................................... 83
Figure 11-2: FCL Characteristics ........................................................................................................................ 84
Figure 11-3: Load Test Rack Heater LCL Interface (AIT 6) ................................................................................ 87
Figure 11-4: Load Test LCL AIT 3 and AIT 3A Interface ...................................................................................... 88
Figure 11-5: Load Test LCL AIT 4 and AIT 4A Interface ...................................................................................... 89
Figure 11-6: Load Test FCL AIT 5 Interface ......................................................................................................... 89
Figure 12-1: Validation Interface Cable Connection Concept ................................................................................ 92

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1. INTRODUCTION AND SCOPE

1.1 Introduction

LISA is a co-operative program between ESA and NASA to detect and measure ‘ripples’ in the fabric of space-time to verify tenets of fundamental physics. The program includes two space missions; The LISA-Pathfinder mission, and the LISA mission.

LISA will consist of three spacecraft flying in a quasi-equilateral triangular formation, in a trailing Earth orbit at some 20 deg behind the Earth in a gravitational noise free ‘Halo orbit’ at the Lagrange 1 point. Within each spacecraft, a measurement system consisting of a test mass, associated laser interferometer measurement systems, and electronics will detect and measure low frequency gravitational waves. The test mass is maintained in a drag-free environment, i.e. shielded from spurious external forces, by using low thrust propulsion. This mission is currently in its formulation stage.

LISA-Pathfinder is a precursor mission to LISA that aims to verify most of the challenging technologies necessary for LISA. The mission will last approximately 11 months, of which 6 are expected to be spent in scientific experiments.

1.2 Scope

This document contains the contractually relevant requirements and constraints for the LISA Pathfinder Power SCOE (hereafter known as the SCOE). This includes:

• The performance, design and interface requirements of the SCOE
• The testing and verification requirements
• The product assurance requirements

Requirements within this document are shown in an italic font. Each requirement is preceded by a summary line that contains the following fields, delimited by “/”.

• <Doors Requirement Number> GDI-xyz. This is a unique number, assigned consecutively
• <Created From> Shows parent requirement
• <Test Method> T= Test, A = Analysis, I = Inspection, R = Review of Design.

If tables are considered as part of a requirement they are referenced clearly in the text and inserted after and separated from the requirement table and are managed as free text attached to the identifier requirement.

The trace to the upper level requirements (Upper Links), shall be managed using the following format:

• AAA-NNNN where AAA is a label associated to the upper document and NNNN the requirement identifier of this upper level.

• Or CREATED key word if the requirement has no link with upper level

(This information is only relevant for verification tracing performed within Astrium and consequently maybe ignored by the subcontractor.)

All document elements not presented in the format explained above are not requirements and will not be verified or tracked.

1.3 Summary Description

The LISA-Pathfinder power subsystem consists of three main components, a solar array, a battery module and a single Power Control and Distribution Unit (PCDU).
In order to support the AIT activities on the power subsystem at test bench, system and launch stages of the LISA-Pathfinder project, the SCOE will consist of the following main elements:-

- Umbilical functions
- Solar Array Simulator (SAS)
- Battery Simulator
- Off-line Battery support
- Power Subsystem test support functions

The SCOE will form part of the LISA-Pathfinder EGSE system as shown in Figure 1-1.
The general interfaces between the SCOE and the LISA-Pathfinder power subsystem are shown in Figure 1-2. Further details of the individual interfaces required are contained elsewhere in this specification.

The Battery Isolation Box (BIB) is shown in Figure 1-2 for completeness, it does not form part of the SCOE delivery. The BIB will be fitted to the satellite Offline Battery Support skin connector and utilised to isolate this interface from the live battery. This will ensure hazard free connection and disconnection of the EGSE cables from the battery.
Figure 1-2: Power SCOE general Interfaces
2. DOCUMENTS

The following documents are relevant to this specification. Unless an issue is quoted for a document, then the latest issue shall apply. Any conflict between this specification and those listed below shall be reported to Astrium.

2.1 Applicable Documents

<table>
<thead>
<tr>
<th>Doc. No.</th>
<th>Doc. Type</th>
<th>Description</th>
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<tr>
<td>[AD-1]</td>
<td>S2.ASU.RS.5038</td>
<td>EGSE Overall Requirement Specification</td>
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<td>[AD-2]</td>
<td>S2.ASD.ICD.2001</td>
<td>EGSE Interface Control Document</td>
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<td>[AD-3]</td>
<td>S2.ASU.RS.1005</td>
<td>Product Assurance Requirements for Subcontractors</td>
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2.2 Standards

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<td>[SD-1]</td>
<td>EN 61010</td>
<td>Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use</td>
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<tr>
<td>[SD-2]</td>
<td>EN 61008-1</td>
<td>Electrical accessories- Residual Current operated Circuit Breakers</td>
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<tr>
<td>[SD-3]</td>
<td>EN 60898-1</td>
<td>Circuit Breakers for overcurrent protection</td>
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<td>[SD-4]</td>
<td>EN 60309-2</td>
<td>Plugs, Socket-outlets and Couplers for Industrial Purposes</td>
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<td>[SD-5]</td>
<td>ECSS-E-70.1</td>
<td>Space Engineering - Ground Systems and Operations - Part 1 - Principles and Requirements</td>
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2.3 Reference Documents

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<td>S2.ASU.RS.2019</td>
<td>LISA-Pathfinder PCDU Specification</td>
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<tr>
<td>[RD-2]</td>
<td>S2.ASU.RS.2020</td>
<td>LISA-Pathfinder Battery Specification</td>
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<td>[RD-4]</td>
<td>S2.ASU.TN.5065</td>
<td>EGSE Configurations for MDVE and Satellite AIT</td>
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<td>S2.ASU.LI.1006</td>
<td>LISA-Pathfinder Acronyms, Abbreviations and Terminology</td>
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<tr>
<td>[RD-6]</td>
<td>S2.ASU.RS.2012</td>
<td>LISA-Pathfinder OBC Specification</td>
</tr>
</tbody>
</table>
3. POWER SCOEE GENERAL REQUIREMENTS

3.1 General Design
PS-57/CREATED/T,R
The design, implementation and build of the SCOEE shall be in accordance with the requirements of [AD-1].

PS-54/CREATED/R
The SCOEE shall consist of the following elements:
- Power / launch Umbilical support
- Umbilical Monitoring Interface
- Solar Array Simulator (SAS)
- Battery Simulator
- Off-line Battery Support
- Measurement Error Amplifier Test Interface
- Thermal Override Unit (TOU)
- Pyro Function
- Load Simulator
- Interface cables (15m from SCOEE to Test interface bracket)

PS-171/CREATED/I,R
All SCOEE front panel indicators and switches shall be clearly marked with their function. This is particularly pertinent for the Emergency OFF switches.

3.2 Flight Equipment Safety
PS-56/CREATED/A,R
The SCOEE design shall ensure the safety of all connected flight hardware, in all SCOEE configurations.

PS-58/CREATED/A,R
No credible failure within the SCOEE shall allow any safety protection incorporated in the SCOEE to be exceeded and endanger the flight hardware. This shall be proven by a FMECA.

3.3 Operating Modes
PS-60/CREATED/T
The SCOEE shall operate in three modes, manual, local, and remote.

The three operational modes are described below:
- Manual mode - the SCOEE stimuli and measurement devices shall be controllable from their front panels without the need for a local or remote controller.
- Local mode - the SCOEE stimuli and measurement devices shall be controllable from the SCOEE local controller, with the stimuli and measurement devices in 'remote mode'.
- Remote mode - the SCOEE stimuli and measurement devices shall be controllable from the core EGSE, via the SCOEE local controller, using C & C messages.

PS-772/CREATED/T
The SCOEE power on default state shall be Local mode operation.
3.4 Missing Equipment's

PS-786/CREATED/T

It shall be possible to power up and operate the SCOE with any of the SCOE equipment's removed (e.g. for calibration or repair).

It is assumed that the SCOE functionality will obviously be reduced according to which equipment's are missing, but this requirement is to ensure that by removing a single equipment from the SCOE, the whole system does not become unusable.

3.5 Automatic testing

PS-63/CREATED/T,R

The SCOE design shall allow for the maximum use of automatic testing techniques.

3.6 Local Controller

PS-65/CREATED/T

The SCOE shall incorporate a local controller with a user HMI.

PS-66/CREATED/T

The local controller shall be capable of controlling all the stimuli and measurement functions of the SCOE with the exception of the mains power switch on and off.

PS-73/CREATED/T

The local controller shall be capable of continually monitoring all the stimuli and measurement functions of the SCOE.

PS-74/CREATED/T

The local controller shall be capable of continually monitoring the operational status of the SCOE including the local / remote status.

PS-67/CREATED/T

The local controller shall be capable of switching the SCOE control from local to remote operation.

PS-68/CREATED/T

The local controller shall be capable of switching the SCOE control from remote to local operation.

PS-69/CREATED/T

At initial SCOE start-up, the local controller shall be able to configure the SCOE hardware and software to a predetermined, default configuration (Hard start-up).

PS-70/CREATED/T

It shall also be possible to start the local controller without any reconfiguration of the SCOE hardware and software (Soft start-up).

PS-71/CREATED/T

The local controller shall interface to the Core EGSE via a Local Area Network

PS-75/CREATED/T

The local controller shall generate and store SCOE status error reports.

PS-76/CREATED/T

The error reports shall be presented to the operator via the local controller HMI.
PS-80/CREATED/T

It shall be possible to define and store different SCOE test configurations on the local controller using unique configuration names.

PS-877/CREATED/T

The test configuration file unique names shall be auto-generated, with the ability to be edited by the user before saving.

PS-876/CREATED/T

The test configuration file auto-generated file names shall contain at least a time / date reference.

PS-81/CREATED/T

It shall be possible to configure the SCOE from previously defined and stored test configurations.

3.6.1 Graphical Data Plots

PS-160/CREATED/T

It shall be possible to generate graphical plots on the user HMI.

PS-161/CREATED/T

It shall be possible to assign any SCOE monitored parameter to a graphical plot.

PS-163/CREATED/T

The graphical plots shall be displayed as 'parameter verses time'.

PS-162/CREATED/T

It shall be possible to assign at least 5 parameters to the same graphical plot.

PS-164/CREATED/T

It shall be possible to configure the time duration of a graphical plot.

PS-168/CREATED/T

Normal operation of the SCOE shall be maintained during parameter plotting.

PS-169/CREATED/T

It shall be possible to store the graphical plots on the local controller using unique file names.

PS-453/CREATED/T

It shall be possible to recall and display previously stored plots on the local controller.

3.6.2 Printing

PS-766/CREATED/T

It shall be possible to print any selected file (e.g. log files, report files etc.) to a network printer (part of the core EGSE).

PS-767/CREATED/T

It shall be possible to print, to a network printer, the contents of the local controller HMI screen at any given point in time ('screen dump').

3.7 Remote Interface

PS-72/CREATED/T

The communication between the SCOE local controller and the Core EGSE shall comply with the requirements of [AD-1] and [AD-2].
PS-83/CREATED/T
All SCOE stimuli and measurement functions, which are controllable by the local controller, shall also be controllable from the remote interface (Core EGSE).

PS-84/CREATED/T
All SCOE parameters which are monitored by the local controller shall also be available for monitoring by the remote interface (Core EGSE).

PS-132/CREATED/T
The parameters to be monitored by the remote interface (Core EGSE) shall be automatically and cyclically sent to the remote interface (Core EGSE) at a time interval of between 1 and 10 seconds, configurable in 1 second increments (the default setting shall be 10 seconds).

PS-154/CREATED/T
It shall be possible to configure the SCOE from the remote interface by selecting a locally stored SCOE configuration set-up.

PS-79/CREATED/T
The SCOE status error reports, generated by the local controller, shall be sent to the Core EGSE.

PS-166/CREATED/T
It shall be possible to retrieve graphical plots stored on the local controller for display on the remote interface.

PS-152/CREATED/T
The switching between SCOE local and remote operation shall in no way interfere with the operational status of the SCOE.

3.8 SCOE Protection Facility
In order to protect both the Satellite and SCOE equipment's from possible damage due to, for example, excessive voltage, current or temperature the SCOE shall incorporate a protection facility. In the event that a predefined limit is exceeded, the protection facility will trigger, resetting and disconnecting the SCOE equipment's from the satellite.

The protection facility will have two distinct modes of operation, system mode and local mode.

All satellite monitored parameters will only trigger the system mode protection, but the SCOE power sources (umbilical supply and SAS) maybe configured to trigger either their local mode protection or the system mode protection.

A trigger of the system mode protection facility will cause a simultaneous disconnection of all the interfaces to the satellite and a reset of all the SCOE equipment's (including those configured for local mode operation).

For a power source that is configured for local mode, a protection trigger will not cause a complete shutdown of the entire SCOE only the equipment which caused the protection trigger will be disconnected and reset, all other SCOE equipment's and interfaces will remain functional.
The protection trigger events may originate from several sources, including satellite monitored parameters, supplied power parameters and SCOE hardware status parameters. Further details of the required protection triggers are contained in subsequent sections of this document.

**PS-90/CREATED/T**

*It shall be possible to configure each SCOE power source to either a local mode or system mode protection facility.*

**PS-127/CREATED/T**

*The protection facility shall only be triggered when a monitored parameter exceeds a predefined limit for >100uS*

**PS-129/CREATED/T**

*It shall be possible to trigger the SCOE Protection Facility from external EGSE elements.*

**PS-130/CREATED/T**

*It shall be possible to send the SCOE Protection Facility trigger signal to external EGSE elements.*

### 3.8.1 Local Mode

**PS-92/CREATED/T**

*If a SCOE power source is configured for local mode protection, then a triggering event issued by that source shall cause a disconnection and reset (to its default state) of only the power source which issued the event.*

**PS-210/Derived from [RD-1] PCDU-185/T**

*In the event of a local mode protection trigger occurrence the associated power source shall be disconnected from the satellite interfaces in <15mS from the instance of the protection facility limit excursion.*

**PS-97/CREATED/T**

*The SCOE shall have a visual indication that a local mode protection event has occurred.*

**PS-116/CREATED/T**

*The SCOE HMI shall indicate that a local mode protection event has occurred.*

**PS-117/CREATED/T**

*The SCOE HMI shall show the source of the local mode protection event.*

**PS-118/CREATED/T**

*It shall be possible to reset the local mode protection event from the SCOE front panel.*

**PS-119/CREATED/T**

*It shall be possible to reset the local mode protection event from the local controller.*

**PS-120/CREATED/T**

*It shall be possible to reset the local mode protection event from the remote interface.*

### 3.8.2 System mode

**PS-91/CREATED/T**

*If a SCOE equipment is configured for system mode protection, then a triggering event issued by an equipment or parameter to the system mode protection facility shall disconnect all SCOE to satellite power interfaces and simultaneously reset all the SCOE power and load equipment's to their default state.*
In the event of a system mode protection trigger occurrence the SCOE to Satellite power interfaces shall be disconnected in <15mS from the instance of the protection facility limit excursion.

It shall be possible to operate the system safety loop from the local controller.

It shall be possible to operate the system safety loop from a rack mounted front panel switch or button, which shall serve as the Satellite power Emergency Off.

The Satellite power Emergency Off switch shall be located on the SCOE front panel at a point which allows easy and unhindered access by a SCOE operator.

The Satellite power Emergency Off switch, once activated, shall lock in the activated position until manually released.

The Satellite power Emergency Off switch shall be protected from inadvertent operation.

The SCOE shall have a visual indication that a system mode protection event has occurred.

The SCOE HMI shall indicate that a system mode protection event has occurred.

The SCOE HMI shall show the source of the system mode protection event.

It shall be possible to reset the system mode protection event from the SCOE front panel.

It shall be possible to reset the system mode protection event from the local controller.

It shall be possible to reset the system mode protection event from the remote interface.

The SCOE shall produce, store and manage log and HK TM archive files as defined in [AD-1] Paragraphs 4.1.3 and 4.1.4.

It shall be possible to retrieve log and archive files, graphical plots and stored test results for display and review on the local controller without interruption to any running SCOE test activities.

The SCOE controller shall have at least two separate login accounts, a user account and an administrator account.
PS-666/CREATED/T
The accounts shall be individually password protected.

PS-667/CREATED/T
The user account shall be used for general operation of the SCOE.

PS-668/CREATED/T
The administrator account shall be used for higher level SCE configuration activities, such as file management (log and configuration, etc.) and data archiving activities, etc.

3.11 Mains Input

PS-141/CREATED/T,R
The SCOE mains supply interface shall comply with the requirements of [AD-1] Paragraph 5.12.

PS-140/CREATED/I
The SCOE shall be supplied with a 10 metre external mains cable.

PS-142/CREATED/T
The SCOE mains cable shall be detachable from the SCOE.

PS-165/CREATED/T
It shall be possible to isolate the mains supply from all SCOE equipment’s with the use of a mains switch.

PS-170/CREATED/R
The mains isolation switch shall be mounted on the SCOE front panel.

3.11.1 SCOE Emergency OFF button

PS-143/CREATED/T
It shall be possible to remove the mains supply to all the SCOE equipment’s by operation of a single SCOE Emergency OFF switch or button.

PS-144/CREATED/I
The SCOE Emergency OFF button shall be located on the SCOE front panel at a position which is easily visible by all personnel.

PS-145/CREATED/I
The location of the SCOE Emergency OFF button shall allow for easy and unhindered access by all personnel.

PS-146/CREATED/I
The SCOE Emergency OFF button shall be red in colour.

PS-147/CREATED/T
The SCOE Emergency Off button, once activated, shall lock in the activated position until manually released.

PS-796/CREATED/I,R
The SCOE Emergency OFF button shall be protected from inadvertent operation.
3.12 Cables and Grounding

PS-151/CREATED/R

The grounding scheme for the SCOE shall comply with the EGSE grounding requirements of [AD-1] paragraph 5.12.

PS-643/CREATED/T,R

All SCOE cable screens shall be terminated to SCOE ground, via the connector shell, at the SCOE rack.

PS-644/CREATED/T,R

All SCOE cable screens shall be terminated on a dedicated pin at the satellite end of the SCOE interface cables.

PS-791/CREATED/I,R

The SCOE shall be delivered with all cables required to interconnect and interface to the SCOE. This shall include all SCOE equipment cables and any rack interconnection cables.

PS-792/CREATED/I,R

The SCOE shall be delivered with the 15m Interface cables as shown in Figure 1-2 and further defined throughout this specification.

PS-645/CREATED/R

All SCOE interface cables shall be manufactured using the most suitable wire for the signal type applied, e.g. twisted screened pair (TSP), RS422 compatible cable, etc.

PS-870/CREATED/I,R

Multiple wires within a cable shall be "lay twisted" between 150mm and 500mm, depending on wire type, in order to form a manageable cable.

PS-868/CREATED/I,R

Each cable shall be indelibly part marked as detailed in [AD-1] Paragraph 5.15.

PS-871/CREATED/I,R

The wire type used for the cable construction shall be suitably flexible, at ambient temperature, in order to allow easy 'run out' of the cables between the SCOE and their destinations.

PS-872/CREATED/I,R

The cable construction shall be suitably robust in order to survive the rigours of a full AIV test campaign, involving several SCOE relocations.

3.13 Protected Test Points

PS-774/CREATED/I

Where required, dedicated test points shall be fitted to the SCOE front panel to aid in any monitoring or investigations requiring external test equipment.

PS-775/CREATED/R

All test points shall be protected against inadvertent short circuits by fitting a 10kΩ resistor in both the positive and negative test point lines.

PS-776/CREATED/I

The test points shall be 2mm banana plug type.

PS-777/CREATED/I

The positive and negative test points shall be distinguished by different colours (e.g. red and black).
PS-778/CREATED/I

The test points shall be identified with their signal name.

3.14 CE Marking

PS-769/CREATED/I

The SCOE shall carry a CE mark and be delivered with a relevant CE certificate confirming that it has undergone all required CE testing.
4. UMBILICAL POWER, MONITORING AND LAUNCH SUPPORT

The LISA-Pathfinder power subsystem can be divided into 3 distinct units

- Solar Array
- Battery
- Power Control and Distribution unit (PCDU).

The primary interfaces between the SCOE and the satellite will be via two umbilical cables. These will carry the bus support power, together with the monitored parameters of the onboard Power subsystem.

There will be two separate SCOE interfaces for powering the satellite, the Umbilical bus support and the SAS.

With the satellite powered via the SAS interface and under control of the PCDU, the main bus can be configured for two different voltages. During LEOP and apogee raising manoeuvres the bus voltage will be controlled by the PCDU at 29 +0.4V/-0V. During transfer orbit and while on-station the main bus voltage will be controlled at 28 ± 0.14V.

With the satellite powered via the Umbilical bus support interface, the bus voltage will be that of the Umbilical Bus support power supply, there will be no control of the bus voltage by the PCDU.

4.1 Umbilical Bus Support

The Umbilical Bus support will be a low power interface primarily used to power the main bus prior to closing the Battery Safety relays where the bus voltage must be adjusted to that of the battery voltage before the relays are closed.

4.1.1 Bus Support Power Supply

PS-183/CREATED/T

The Bus Support power supply output shall be adjustable over its full voltage and current range.

PS-194/CREATED/T

The Bus support power supply shall operate in constant voltage mode.

PS-193/Derived from [RD-1] Section 3.9/R

The Bus support power supply shall have a power capability of at least 400W.

PS-189/Derived from [RD-1] PCDU-80/R

The Bus support power supply shall provide a voltage selectable, as a minimum, between 16V and 50V.

PS-190/Derived from [RD-1] Section 3.9/R

The Bus support power supply shall have a current capability of at least 8A for any voltage between 25V and 40V.

PS-195/CREATED/T

It shall be possible to set the voltage of the Bus support power supply with a resolution of 10mV or better.

PS-191/CREATED/T

The actual value of the Bus support power supply voltage, at the satellite end of the SCOE interface cables, shall be within ±0.1% FS or better of the value set, at all load conditions.

PS-199/CREATED/T

The voltage of the Bus support power supply shall be monitored by the SCOE with an accuracy of ±0.1% FS (full scale) or better.
PS-740/CREATED/T

The voltage of the Bus support power supply shall be displayed on the SCOE local controller with a resolution of 10mV or better.

PS-813/CREATED/T

It shall be possible to set the current limit of the Bus support power supply with a resolution of 50mA or better.

PS-202/CREATED/T

The actual value of the Bus support power supply current limit shall be within ±1% FS or better of the value set.

PS-809/CREATED/T

It shall only be possible to set the current limit value of the Bus support power supply from the local controller Administrator account.

PS-203/CREATED/T

The Bus support power supply current limit value shall be displayed by the SCOE local controller with an accuracy of ±1% FS or better.

PS-204/CREATED/T

The current output of the Bus power supply shall be monitored by the SCOE with an accuracy of ±0.25% FS or better.

PS-741/CREATED/T

The current output of the Bus support power supply shall be displayed on the SCOE local controller with a resolution of 10mA or better.

4.1.2 Protection

4.1.2.1 Overvoltage

PS-198/CREATED/T

An overvoltage occurrence on the Bus support power supply output shall be able to trigger the SCOE local protection facility.

PS-201/CREATED/T

An overvoltage occurrence on the Bus support power supply output shall be able to trigger the SCOE system protection facility.

PS-208/CREATED/T

The SCOE protection facility shall be triggered if the Bus support power supply output voltage exceeds a preset value by a maximum of 500mV.

PS-212/CREATED/T

It shall be possible to set the Bus support power supply overvoltage protection between 18V and the power supply maximum voltage.

PS-214/CREATED/T

It shall be possible to set the Bus support power supply overvoltage level with a resolution of 100mV or better.

PS-213/CREATED/T

The actual value of the Bus support power supply overvoltage level shall be within ±1% FS or better of the value set.
4.1.2.2 Overcurrent

PS-376/CREATED/T
An overcurrent occurrence on the Bus support power supply output shall be able to trigger the SCOE local protection facility.

PS-377/CREATED/T
An overcurrent occurrence on the Bus support power supply output shall be able to trigger the SCOE system protection facility.

PS-378/CREATED/T
The SCOE protection facility shall be triggered if the Bus support power supply output current exceeds a preset value by 100mA.

PS-379/CREATED/T
It shall be possible to set the Bus support power supply overcurrent protection between 0.5A and the power supply maximum current.

PS-380/CREATED/T
It shall be possible to set the Bus support power supply overcurrent level with a resolution of 50mA or better.

PS-381/CREATED/T
The actual value of the Bus support power supply overcurrent level shall be within ±1% FS or better of the value set.

PS-382/CREATED/T
The local controller shall display the value of the overcurrent protection.

4.1.3 Output Stability

PS-819/CREATED/T
The Bus support power supply output voltage shall not vary by more than 100mV for an AC mains input variation of ±10%.

PS-820/CREATED/T
The Bus support power supply output current shall not vary by more than 10mA for an AC mains input variation of ±10%.

4.1.4 Ripple and Spikes

PS-822/CREATED/T
The ripple and spikes present on the output of the Bus support power supply shall conform to the requirements of [AD-01] section 5.12.1.

PS-823/CREATED/T
Requirement deleted.

PS-828/CREATED/T
Requirement deleted.

PS-829/CREATED/T
Requirement deleted.
4.1.5 Load Regulation

PS-825/Derived from [RD-1] Section 3.8/T

*The Bus support power supply output voltage, while operating in constant voltage mode, shall vary by <1% FS, after 2ms, for a load change of 4A with a di/dt \( \leq \) 1A/\(\mu\)s.*

PS-826/Derived from [RD-1] Section 3.8/T

*The maximum variation of the Bus support power supply output voltage shall not exceed 4% FS.*

PS-827/CREATED/T

*The Bus support power supply output current, while operating in constant current mode, shall vary by <1% FS for an output voltage transition of \( \pm \) 10 volts.*

4.1.6 Isolation

PS-209/CREATED/T

*It shall be possible to galvanically isolate the Bus support power supply positive and negative lines from the satellite interface.*

PS-215/CREATED/T

*It shall be possible to control the galvanic isolation of the Bus support power supply from SCOE front panel mounted ON / OFF buttons.*

PS-797/CREATED/I,R

*The SCOE front panel ON / OFF buttons shall be protected against inadvertent operation.*

PS-810/Derived from [RD-1] PCDU-182/T

*It shall only be possible to connect the Bus Support power supply to the satellite (switch ON) if the Bus Support power supply voltage is set to >22V.*

4.1.7 Umbilical Bus Support Satellite Interface

The Bus Support interface will be extended from the end of the SCOE interface cable for connection to the satellite Umbilical interface. This extension will vary, depending on the satellite test phase, from a few metres to 200 metres on the launch pad. Details of the expected cabling for the various test phases of LISA-Pathfinder can be found in [RD-4].

PS-280/CREATED/T,A

*The Umbilical bus support power supply shall meet the requirements of section 4.1 with all configurations of SCOE to satellite interface cables.*

PS-217/Derived from [RD-1] PCDU-364/T,I

*The interface between the SCOE and the satellite shall be as shown in Figure 4-1.*

PS-446/CREATED/T

*Cable screens shall be terminated to SCOE ground via the SCOE rack.*
4.2 Battery Relay Interface

The PCDU contains four battery safety relays, connected in a series / parallel configuration to allow the battery to be connected and disconnected from the satellite main bus during AIT activities.

The battery relays will be controlled and monitored by the SCOE via the Umbilical interface.

The PCDU battery safety relay configuration is shown in Figure 4-2.

![Figure 4-2: PCDU Battery Safety Relay configuration](image)

4.2.1 Battery Safety Relay commands

PS-239/Derived from [RD-1] PCDU-350/T

The SCOE shall provide eight High Power On/Off commands (SHP) as follows:-

- Battery Relay 1 CLOSE command
- Battery Relay 1 OPEN command
- Battery Relay 2 CLOSE command
- Battery Relay 2 OPEN command
- Battery Relay 3 CLOSE command
- Battery Relay 3 OPEN command
- Battery Relay 4 CLOSE command
- Battery Relay 4 OPEN command
The SCOE battery relay open and close commands shall conform to the driver circuit specification detailed in the Standard High Power On/Off command data sheet (SHP), Table 4-1.

The receiver circuit for the SHP commands is included in Table 4-2 for reference.
4.2.1.1 CLOSE commands

**PS-241/CREATED/T**

*It shall be possible to individually send the four relay CLOSE commands (from local and remote controllers).*

**PS-243/CREATED/T**

*It shall be possible to send the relay CLOSE commands from discrete front panel switches.*

**PS-798/CREATED/I,R**

*The discrete front panel switches shall be protected from inadvertent operation.*

**PS-244/Derived from [RD-1] PCDU-355/T**

*It shall only be possible to initiate the relay CLOSE commands if the main bus voltage is within ±200mV of the satellite battery voltage.*

**PS-246/CREATED/T**

*The SCOE shall provide an automatic sequence to adjust the Umbilical Bus Support power supply in order to meet the conditions of PS-244. It shall be assumed that the Bus load will be static during the adjustment period.*

**PS-799/Derived from [RD-1] PCDU-182/T**

*The monitored Bus voltage shall be >22V before the automatic sequence shall be able to adjust the Umbilical Bus Support power supply.*

**PS-245/CREATED/T**

*The SCOE shall provide a front panel visual indication that the relay CLOSE commands are available.*

4.2.1.2 OPEN commands

**PS-249/CREATED/T**

*It shall be possible to individually send the four relay OPEN commands (from local and remote controllers).*

**PS-248/CREATED/T**

*It shall be possible to send the relay OPEN commands from discrete front panel switches.*

**PS-800/CREATED/I,R**

*The discrete front panel switches shall be protected from inadvertent operation.*

**PS-250/CREATED/T**

*It shall only be possible to initiate the relay OPEN commands when the SAS interface is disconnected from the satellite.*

**PS-254/CREATED/T**

*It shall only be possible to initiate the relay OPEN commands when the current supplied by the Umbilical Bus Support power supply is less than 6A.*

**PS-251/CREATED/T**

*It shall be possible to initiate the relay OPEN commands when the SCOE is unpowered, utilising a SCOE battery backup. This shall be deemed as the Battery safety relay emergency OPEN commands.*

**PS-255/CREATED/T**

*It shall be possible to initiate the battery safety relay emergency OPEN commands even if the requirements of PS-250 and PS-254 are not satisfied.*
**PS-256/CREATED/R**

It shall only be possible to initiate the battery safety relay emergency OPEN commands from the SCOE front panel switches.

**PS-743/CREATED/T**

The SCOE back up battery shall be sized such to allow all four battery safety relay OPEN commands to be sent at least 3 times without the need for recharging the battery.

**PS-257/CREATED/R**

The SCOE backup battery shall be a rechargeable type.

**PS-258/CREATED/R**

The rechargeable battery shall be maintained by an integral SCOE battery management system.

### 4.2.1.3 Battery Relay Command Satellite Interface

The Battery Relay Command interface will be extended from the end of the SCOE interface cable for connection to the satellite Umbilical interface. This extension will vary, depending on the satellite test phase, from a few metres to 200 metres on the launch pad. Details of the expected cabling for the various test phases of LISA-Pathfinder can be found in [RD-4].

**PS-281/CREATED/T,A**

The Battery Relay commands shall meet all requirements of section 4.2.1 with all configurations of SCOE to satellite interface cables.

**PS-278/Derived from [RD-1] PCDU-351/T,I**

The interface between the SCOE and the satellite shall be as shown in Figure 4-3.

**PS-447/CREATED/T**

Cable screens shall be terminated to SCOE ground via the SCOE rack.
Figure 4-3: SCOE Battery Safety Relay Command Interface
4.2.2 Battery Relay Status Monitoring

PS-260/Derived from [RD-1] PCDU-350/T

The SCOE shall monitor the status of the four battery safety relays:

- Battery Relay 1 Status
- Battery Relay 2 Status
- Battery Relay 3 Status
- Battery Relay 4 Status.

PS-261/Derived from [RD-1] PCDU-773/T

The SCOE Battery Relay Status monitors shall conform to the receiver circuit specification detailed in the Relay Status Acquisition data sheet (RSA), Table 4-3.

PS-263/Derived from [RD-1] PCDU-773/T,R

<table>
<thead>
<tr>
<th>INTERFACE DATA SHEET</th>
<th>Page 2 / 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Req</td>
<td>Receiver Circuit Specification</td>
</tr>
<tr>
<td>-8</td>
<td>Circuit type: Single ended with pull-up resistor</td>
</tr>
<tr>
<td>-9</td>
<td>Transfer: DC coupled</td>
</tr>
<tr>
<td>-10</td>
<td>Input voltage threshold (1): 1.4 to 3.3V</td>
</tr>
<tr>
<td>-11</td>
<td>Output voltage: 3.7 to 5.5V via series resistor</td>
</tr>
<tr>
<td>-12</td>
<td>Output current: 0.5 to 1.0 mA (for switch resistance 0 to 50 Ohm)</td>
</tr>
<tr>
<td>-13</td>
<td>Fault voltage emission: -16 V to +16 V (through 1.5 KOhm)</td>
</tr>
<tr>
<td>-14</td>
<td>Fault voltage tolerance: -3 V to +14 V</td>
</tr>
</tbody>
</table>

Harness Specification

-15 Wiring Type: Twisted Pair (TP) R

Notes: (1) The receiver shall detect a closed switch for any switch resistance in the range 0 to 50 Ohm. The receiver shall detect an open switch for any resistance greater than 1 MOhm.

Fault Voltages shall be verified by Worst Case Analysis.

Table 4-3: Relay Status Acquisition Receiver Specification:

The driver circuit for the RSA is included in Table 4-4 for reference.

<table>
<thead>
<tr>
<th>INTERFACE DATA SHEET</th>
<th>Page 1 / 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Req</td>
<td>Driver Circuit Specification</td>
</tr>
<tr>
<td>-1</td>
<td>Circuit type: Relay contact (floating) or optocoupler</td>
</tr>
<tr>
<td>-2</td>
<td>Transfer: DC coupled</td>
</tr>
<tr>
<td>-3</td>
<td>Closed Status: Relay: Resistance ≤ 50 Ohm Optocoupler: voltage level &lt; 1.0 V</td>
</tr>
<tr>
<td>-4</td>
<td>Open Status: Resistance ≥ 1 MOhm</td>
</tr>
<tr>
<td>-5</td>
<td>Current capability: ≥ 10 mA</td>
</tr>
<tr>
<td>-6</td>
<td>Fault voltage tolerance: -16.5 V to +16.5 V</td>
</tr>
<tr>
<td>-7</td>
<td>Fault voltage emission: Not applicable</td>
</tr>
</tbody>
</table>

Table 4-4: Relay Status Acquisition Source Specification:
The principle of the Relay Status Acquisition is shown in Figure 4-4.

![Figure 4-4: Principle of Relay Status Acquisition](image)

The status of the battery safety relays shall be shown by discrete indications on the SCOE front panel.

4.2.2.1 Battery Safety Relay Status Satellite Interface

The Battery Relay Status interface will be extended from the end of the SCOE interface cable for connection to the satellite Umbilical interface. This extension will vary, depending on the satellite test phase, from a few metres to 200 metres on the launch pad. Details of the expected cabling for the various test phases of LISA-Pathfinder can be found in [RD-4].

PS-286/CREATED/T,A

*The Battery Relay status monitoring shall meet the requirements of section 4.2.2 with all configurations of SCOE to satellite interface cables.*

PS-287/Derived from [RD-1] PCDU-351/T,I

*The interface between the SCOE and the satellite shall be as shown in Figure 4-5.*

PS-448/CREATED/T

*Cable screens shall be terminated to SCOE ground via the SCOE rack.*
Figure 4-5: SCOE Battery Safety Relay Status Interface
4.3 Umbilical Monitoring Functions

Several power subsystem on-board parameters will be monitored by the SCOE. These are detailed in the following sections.

4.3.1 Bus Voltage Monitor

There will be two main bus voltage monitors, Bus Volt Monitor 1 and Bus Volt Monitor 2.

The two Bus voltage monitors will measure the same on-board voltage, but maybe utilised for different functions at the SCOE.

PS-299/ Derived from [RD-1] PCDU-85/T

*The SCOE Bus voltage monitors shall conform to the receiver circuit specification detailed in the Umbilical Bus Voltage data sheet (UBV), Table 4-5*

### INTERFACE DATA SHEET

<table>
<thead>
<tr>
<th>Req.</th>
<th>Source Circuit Specification</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Circuit Type:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sunlight regulated bus voltage via 10kOhm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td>Transfer:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>AC coupled with a bandwidth up to 10kHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>Output Voltage:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0V to +32V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-5</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Req.</th>
<th>Receiver Circuit Specification</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-7</td>
<td>Circuit Type:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Differential receiver (tbc)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-8</td>
<td>Transfer:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>AC coupled with a bandwidth up to 10kHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-9</td>
<td>Acquisition Range:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0V to +40V (tbc)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-10</td>
<td>Absolute Accuracy:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>≤ 0.05% FSR (tbc)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-11</td>
<td>Fault Voltage Emission:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; 29.4V (tbc)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Harness Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>-12 Wiring Type (1):</td>
</tr>
<tr>
<td>Twisted pairs, AWG-tbd (TP-tbd)</td>
</tr>
<tr>
<td>Double insulated</td>
</tr>
</tbody>
</table>

| Notes: |
| (1) TBD Lines, minimum gauge shall be AWG-tbd |

*Table 4-5: UBV Interface Data Sheet*

The transmitter (source) circuit for the UBV is included in Table 4-5 for reference.

**PS-295/CREATED/T**

*The Bus voltage shall be monitored by the SCOE with an accuracy of ±0.05% FS or better.*

**PS-296/CREATED/T**

*The Bus voltage shall be displayed by the SCOE with a resolution of 10mV or better.*

**PS-297/CREATED/T**

*The bus voltage shall be displayed on the SCOE front panel using a numerical display with digits of 2.5cms or greater in height.*

**PS-745/CREATED/T**

*It shall be possible to maintain the front panel display of the Bus voltage when the SCOE is unpowereed by utilising a SCOE battery backup.*
PS-749/CREATED/R

The SCOE backup battery shall be a rechargeable type.

PS-748/CREATED/T

The backup battery shall be sized such to allow the bus voltage to be displayed for a minimum of 30 minutes without the need for recharging the battery.

PS-750/CREATED/R

The rechargeable battery shall be maintained by an integral SCOE battery management system.

PS-814/CREATED/T,R

This backup battery shall be separate from the Battery Relay OPEN command backup battery (PS-251) unless a single backup battery is sized to satisfy both requirements PS-743 and PS-748 as serial activities (i.e. support Bus voltage display for at least 30 minutes and then issue battery OPEN commands at least 3 times).

PS-303/CREATED/T

The Bus voltage monitor shall illuminate a high visibility, flashing red SCOE indicator when the Bus voltage exceeds 20V, providing a visual indication that the satellite is powered.

PS-305/CREATED/T

The 'Satellite powered' flashing indicator shall be mounted on the SCOE in such a way that it is visible from any angle.

PS-801/CREATED/I,R

The 'Satellite powered' flashing indicator shall be removable from the SCOE for location at a remote position.

PS-802/CREATED/I,R

It shall be possible to extend the connection of the 'Satellite powered' flashing indicator for up to 30m from the SCOE rack.

PS-751/CREATED/T

It is not required to illuminate the 'Satellite powered' flashing indicator from the Bus voltage monitor backup battery.

PS-310/CREATED/T

The bus voltage, from the two bus voltage monitors, shall be available on protected test points.

PS-311/CREATED/T

The bus voltage monitors shall be utilised within the SCOE in such a way as to be evident if either monitor fails.

4.3.1.1 Bus Voltage Monitor Protection

PS-306/CREATED/T

The Bus voltage monitor shall be able to trigger the SCOE system mode protection facility in the event of a bus overvoltage occurrence.

PS-307/CREATED/T

It shall be possible to set the bus overvoltage trigger point, as a minimum, between 25V and 45V.

PS-309/CREATED/T

It shall be possible to set the bus overvoltage trigger point with a resolution of 100mV or better.
PS-308/CREATED/T

The actual bus overvoltage trigger point shall be within ±0.5% FS or better of the value set.

4.3.1.2 Bus Voltage Monitor Satellite Interface
The Bus Voltage Monitor interface will be extended from the end of the SCOE interface cable for connection to the satellite Umbilical interface. This extension will vary, depending on the satellite test phase, from a few metres to 200 metres on the launch pad. Details of the expected cabling for the various test phases of LISA-Pathfinder can be found in [RD-4].

PS-315/CREATED/T,A

The Bus Voltage monitoring shall meet all requirements of section 4.3.1 with all configurations of SCOE to satellite interface cables.

PS-316/Derived from [RD-1] PCDU-364/T,I

The interface between the SCOE and the satellite shall be as shown in Figure 4-6.

PS-449/CREATED/T

Cable screens shall be terminated to SCOE ground via the SCOE rack.
Figure 4-6: SCOE Bus Voltage Monitor Interface
4.3.2 Umbilical Battery Voltage Monitor

There will be two battery voltage monitors, the Umbilical Battery Voltage Monitor and the AIT Battery Voltage Monitor.

The umbilical battery voltage monitor will be the primary indication of the battery voltage for AIT and launch activities, while the AIT battery voltage monitor will be utilised, via a satellite skin connector, when carrying out off-line battery conditioning activities (charging/discharging).

The AIT battery voltage monitor will be detailed later in this specification.

PS-321/Derived from [RD-1] PCDU-167/T

The SCOE umbilical battery voltage monitor shall conform to the receiver circuit specification detailed in the EGSE Battery Voltage data sheet (EBV), Table 4-6

PS-322/Created/T

<table>
<thead>
<tr>
<th>INTERFACE DATA SHEET</th>
<th>Page 1/1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Req. Source Circuit Specification</td>
<td>Ver. Iss.</td>
</tr>
<tr>
<td>-1 Circuit Type:</td>
<td>Battery bus voltage via 10kOhm</td>
</tr>
<tr>
<td>-2 Transfer:</td>
<td>DC coupled</td>
</tr>
<tr>
<td>-3 Output Voltage:</td>
<td>0V to +32V</td>
</tr>
<tr>
<td>-4</td>
<td></td>
</tr>
<tr>
<td>-5</td>
<td></td>
</tr>
</tbody>
</table>

| Req. Receiver Circuit Specification | Ver. Iss. |
| -7 Circuit Type: | Differential receiver (tbc) |
| -8 Transfer: | DC coupled |
| -9 Acquisition Range: | 0V to +40V (tbc) |
| -10 Absolute Accuracy: | ≤ 0.1% FSR (tbc) |
| -11 Fault Voltage Emission: | < 29.4V (tbc) |

Harness Specification

-12 Wiring Type (1): Twisted pairs, AWG-tbd (TP-tbd) Double insulated

Notes:
(1) TBD Lines, minimum gauge shall be AWG-tbd.

Table 4-6: EBV Interface Data Sheet

The transmitter (source) circuit for the EBV is included in Table 4-6 for reference.

PS-325/Created/T

The battery voltage shall be monitored by the SCOE with an accuracy of ±0.1% FS or better.

PS-326/Created/T

The battery voltage shall be displayed by the SCOE with a resolution of 10mV or better.

PS-327/Created/T

The battery voltage shall be displayed on the SCOE front panel using a numerical display with digits of 2.5cms or greater in height.

PS-330/Created/T

The battery voltage shall be available on front panel protected test points.
4.3.2.1 Umbilical Battery Voltage Monitor Protection

PS-334/CREATED/T

The battery voltage monitor shall be able to trigger the SCOE system mode protection facility in the event of a battery overvoltage occurrence.

PS-335/CREATED/T

It shall be possible to set the battery overvoltage trigger point, as a minimum, between 25V and 35V.

PS-336/CREATED/T

It shall be possible to set the battery overvoltage trigger point with a resolution of 100mV or better.

PS-337/CREATED/T

The actual battery overvoltage trigger point shall be within $\pm 0.5\%$ FS or better of the value set.

PS-338/CREATED/T

The battery voltage monitor shall provide a warning on the local controller if the battery voltage falls below 23V.

4.3.2.2 Umbilical Battery Voltage Monitor Satellite Interface

The Umbilical Battery Voltage Monitor interface will be extended from the end of the SCOE interface cable for connection to the satellite Umbilical interface. This extension will vary, depending on the satellite test phase, from a few metres to 200 metres on the launch pad. Details of the expected cabling for the various test phases of LISA-Pathfinder can be found in [RD-4].

PS-340/CREATED/T,A

The Battery Voltage monitoring shall meet all requirements of section 4.3.2 with all configurations of SCOE to satellite interface cables.

PS-341/Derived from [RD-1] PCDU-364/T,I

The interface between the SCOE and the satellite shall be as shown in Figure 4-7.

PS-742/CREATED/T

Cable screens shall be terminated to SCOE ground via the SCOE rack.
Figure 4-7: SCOE Battery Voltage Monitor Interface
4.3.3 Umbilical Battery Temperature Monitor

There will be two battery temperature monitors, the Umbilical Battery Temperature Monitor and the AIT Battery Temperature Monitor.

The umbilical battery temperature monitor will be the primary indication of the battery temperature for AIT and launch activities, while the AIT battery temperature monitor will be utilised, via a satellite skin connector, when carrying out off-line battery conditioning activities (charging/discharging).

The AIT battery temperature monitor will be detailed later in this specification.


The SCOE umbilical battery temperature monitor shall conform to the receiver circuit specification detailed in the Temperature Acquisition Type 1 - YSI-44907/44908 data sheet (ANY), Table 4-7


---

**INTERFACE DATA SHEET**

<table>
<thead>
<tr>
<th>Req</th>
<th>Receiver Circuit Specification</th>
<th>IF-Code:</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-6</td>
<td>Circuit Type</td>
<td>Conditioning circuitry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-7</td>
<td>Transfer</td>
<td>DC coupled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-8</td>
<td>Resolution</td>
<td>at least 0.2 K / LSB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-9</td>
<td>Measurement Range</td>
<td>-50°C to +70°C (equivalent to 441.3 KOhm to 1990 Ohm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-10</td>
<td>Stability</td>
<td>+/- 1 K (-50 to +70 deg C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-11</td>
<td>Measurement current</td>
<td>≤ 700 µA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-12</td>
<td>Measurement chain accuracy</td>
<td>better than +/- 5 K between -50°C to -5°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(uncalibrated channels)</td>
<td>better than +/- 4 K between -5°C to 70°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-13</td>
<td>Measurement chain accuracy</td>
<td>better than +/- 3 K between -50°C to -5°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(calibrated channels)</td>
<td>better than +/- 2 K between -5°C to 70°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-14</td>
<td>Acquisition rate</td>
<td>consecutive and different acquisitions every 128 µsec with full performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-15</td>
<td>Receiver bandwidth</td>
<td>50Hz to 1500Hz @ 3dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-16</td>
<td>Fault voltage tolerance</td>
<td>-14V to +14V</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>-17</td>
<td>Fault voltage emission</td>
<td>-16 V to +16 V (through 1.5 KOhms)</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Harness Specification</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-18</td>
<td>Wiring Type</td>
<td>Twisted Shielded Pair (TSP)</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>-19</td>
<td>Shielding</td>
<td>Shield at backshell on driver and receiver side</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Notes:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fault Voltages shall be verified by Worst Case Analysis.

**Table 4-7: Type 1 (ANY) Receiver Circuit Specification**

The transmitter circuit for the (ANY) is included in Table 4-8 for reference.
**Table 4-8: Type 1 (ANY) Source Circuit Specification**

**PS-372/CREATED/T**  
The SCOE shall display the battery temperature in degrees centigrade.

**PS-354/CREATED/T**  
The battery temperature shall be monitored by the SCOE with an accuracy of ±1°C or better over the temperature range 10 to 30°C.

**PS-805/CREATED/T**  
The battery temperature shall be monitored by the SCOE with an accuracy of ±3°C or better for monitored values outside the range 10 to 30°C.

**PS-355/CREATED/T**  
The battery temperature shall be displayed with a resolution of 0.1°C or better.

### 4.3.3.1 Umbilical Battery Temperature Monitor Interface

The Umbilical Battery Temperature Monitor interface will be extended from the end of the SCOE interface cable for connection to the satellite Umbilical interface. This extension will vary, depending on the satellite test phase, from a few metres to 200 metres on the launch pad. Details of the expected cabling for the various test phases of LISA-Pathfinder can be found in [RD-4].

**PS-367/CREATED/T,A**  
The Battery Temperature monitoring shall meet all requirements of section 4.3.3 with all configurations of SCOE to satellite interface cables.

**PS-368/Derived from [RD-1] PCDU-364/T,I**  
The interface between the SCOE and the satellite shall be as shown in Figure 4-8.

**PS-752/CREATED/T**  
Cable screens shall be terminated to SCOE ground via the SCOE rack.
Figure 4-8: SCOE Battery Temperature Monitor Interface
4.4 Umbilical Support Functions

There are two test support functions which are carried out via the satellite Umbilical interface. The Separation strap status and the TM/TC On Board Computer bypass interface.

4.4.1 Separation Strap Status

The SCOE will provide a simulation of the separation straps which are normally located in the launch vehicle adapter. These launch vehicle adapter straps provide a link between two pins of each Umbilical connector, which are monitored by the OBC and used to indicate when the satellite has separated from the launch vehicle.

There will be two separation strap interfaces, A and B, between the SCOE and the OBC. Interface A will be via Umbilical 1 and interface B will be via Umbilical 2.

PS-388/Derived from [RD-6] OBC-399/T

*The SCOE separation strap interface shall conform to the Relay Status Acquisition (RSA) driver circuit specification as detailed in Table 4-9.*

PS-389/Derived from [RD-6] OBC-1109/T,R

<table>
<thead>
<tr>
<th>IF Designation:</th>
<th>Relay Status Acquisition</th>
<th>IF-Code:</th>
<th>RSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Req</td>
<td>Driver Circuit Specification</td>
<td>Ver.</td>
<td>Iss.</td>
</tr>
<tr>
<td>-1</td>
<td>Circuit type: Relay contact (floating) or optocoupler</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td>Transfer DC coupled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>Closed Status: Relay: Resistance ≤ 50 Ohm Optocoupler: voltage level &lt; 1.0 V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td>Open Status: Resistance ≥ 1 MOhm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-5</td>
<td>Current capability: ≥ 10 mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-6</td>
<td>Fault voltage tolerance: -16.5 V to +16.5 V</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>-7</td>
<td>Fault voltage emission: Not applicable</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4-9: Relay Status Acquisition Source Specification:

The RSA receiver data sheet and typical circuit are shown, for information, in Table 4-3 and Figure 4-4.

PS-390/Derived from [RD-6] OBC-399/T

*There shall be two separation strap interfaces simulated within the SCOE.*

PS-391/CREATED/T

*It shall be possible to change the state of both separation straps simultaneously.*

PS-392/CREATED/T

*It shall be possible to change the state of each separation strap independently from the other.*

PS-393/CREATED/T

*The separation straps shall have a default closed status (i.e. at SCOE power up).*

PS-753/CREATED/T

*The 'separated' or 'not separated' status of the SCOE separation straps shall be displayed on the local controller.*

PS-754/CREATED/T

*The local controller HMI shall use a coloured indication to aid the operator identification of the separation strap status (e.g. green - 'not separated', red - 'separated').*
4.4.1.1 Separation Strap Status Interface

The Separation strap status interface will be extended from the end of the SCOE interface cable for connection to the satellite Umbilical interface. This extension will vary, depending on the satellite test phase, from a few metres to 16 metres during thermal vacuum. The Separation strap simulations are not used when the satellite is mounted on the launch vehicle. Details of the expected cabling for the various test phases of LISA-Pathfinder can be found in [RD-4].

PS-397/CREATED/T,A

*The Separation Strap Status shall meet all requirements of section 4.4.1 with all configurations, except the launch pad, of SCOE to satellite interface cables.*

PS-398/Derived from [RD-6] OBC-441/T,I

*The interface between the SCOE and the satellite shall be as shown in Figure 4-9.*

PS-755/CREATED/T

*Cable screens shall be terminated to SCOE ground via the SCOE rack.*
Figure 4-9: SCOE Separation Strap Status Interface
4.4.2 X-Band TM/TC Bypass

The SCOE will not be required to provide any form of processing for the TM/TC bypass signals. It is used purely to route the signals from the EGSE TM/TC Front End Equipment to the umbilical interface of the satellite.

PS-402/CREATED/T

The SCOE shall provide an electrical interface between Umbilical 1 and 2 and a rear panel mounted TM/TC FEE interface connector.

4.4.2.1 X-Band TM/TC Bypass Interface

PS-404/Derived from [RD-6] OBC-223/T,I

The SCOE shall provide the TM/TC Bypass interface as shown in Figure 4-10.

PS-756/CREATED/T

The resistance between each pin on the TM/TC bypass connector and its corresponding pin at the satellite end of the 15 metre SCOE interface cables shall be <2\(\Omega\).

PS-873/CREATED/R

The TM/TC Bypass to Power SCOE cable, shown in Figure 4-10, shall be provided with the SCOE.

PS-874/CREATED/I,R

The TM/TC Bypass to Power SCOE cable shall be manufactured in accordance with the pertinent details contained in [AD-2].
Figure 4-10: SCOE TM/TC Bypass Interface
4.5 Launch Support

During the launch support activities, when the satellite is mounted on the launch vehicle, it will be necessary to position the SCOE in the launch site block house or under table room. These facilities have difficult access requirements making installation of the SCOE difficult.

**PS-516/CREATED/R**

The SCOE shall be able to support the following functions during launch:

- Umbilical Bus support
- Battery relay Interface
- Umbilical monitoring
- TM/TC Bypass interface

All other SCOE functions are not required for launch support.

**PS-514/CREATED/A,R**

The SCOE design shall be such that the functions required for launch support shall be housed in a rack (Umbilical rack) with a maximum weight of 75Kgs.

**PS-625/CREATED/I,R**

The SCOE design shall be such that the maximum height of the launch support functions rack (Umbilical rack) shall be 1.25 metres.
5. BATTERY SIMULATOR

The Battery Simulator will be required to simulate, as close as practicable, the LISA-Pathfinder flight battery, which will be a Lithium-ion 30 to 36Ahr, 29V unit.

5.1 General

PS-891/Derived from [RD-1] PCDU-174/T

The Battery Simulator shall be capable of simulating the following functions

- The charge and discharge functionality of a 29V 30-36 Ahr lithium-ion battery
- Battery thermistors
- Battery heaters

PS-927/CREATED/T

The Battery Simulator shall be controlled from the SCOE local controller.

PS-928/CREATED/T

The Battery Simulator will require to be located close to the satellite, therefore all interfaces between the Battery Simulator and the SCOE controller and other SCOE racks shall be 15m, or more.

PS-901/CREATED/T

The Battery Simulator shall be able to seamlessly transfer from charge to discharge mode and vice versa without the need for user intervention.

PS-892/Derived from [RD-2] Section 3.1.2/T

It shall be possible to set the Battery Simulator terminal voltage, as a minimum, between 18V and 30V.

PS-906/CREATED/T

It shall be possible to change the Battery Simulator terminal voltage during charging and discharging activities without interruption to the charging or discharging functions.

PS-897/CREATED/T

It shall be possible to set the Battery Simulator terminal voltage with a resolution of 10mV or better.

PS-893/CREATED/T

The actual value of the Battery Simulator terminal voltage, at the satellite end of the Battery Simulator interface cables, shall be within ±0.2% FS or better of the value set, under all steady state load or charge conditions.

PS-896/CREATED/T

The value of the Battery Simulator terminal voltage shall be displayed on the SCOE local controller with a resolution of 10mV, or better.

PS-898/CREATED/T

The value of the Battery Simulator terminal voltage shall be monitored by the SCOE with an accuracy of ±0.1% FS, or better.

5.2 Overvoltage Protection

PS-936/Derived from [RD-2] Section 3.1.2/T

It shall be possible to set the Battery Terminal overvoltage protection between 18V and 30V.

PS-937/CREATED/T

It shall be possible to set the Battery Terminal overvoltage level with a resolution of 100mV or better.
PS-938/CREATED/T

The actual value of the Battery Terminal overvoltage level shall be within ±1% FS or better of the value set.

PS-935/CREATED/T

The SCOE protection facility shall be triggered if the Battery terminal voltage exceeds a preset value by a maximum of 250mV, but should never be able to exceed 30V.

PS-933/CREATED/T

An overvoltage occurrence on the Battery terminal voltage shall be able to trigger the SCOE local protection facility.

PS-934/CREATED/T

An overvoltage occurrence on the Battery terminal voltage shall be able to trigger the SCOE system protection facility.

PS-939/CREATED/T

The local controller shall display the value of the overvoltage protection.

5.3 Battery Charge

PS-887/Derived from [RD-2] Batt-73/T

The Battery Simulator shall be capable of simulating the Lithium-ion taper charge functionality.

Note - it is not necessary to simulate the change in battery terminal voltage as a function of battery state-of-charge. It is sufficient for the Battery Simulator to present a constant voltage load to the satellite bus.

PS-888/Derived from [RD-2] Batt-70/T

The Battery Simulator shall be capable of sinking at least 20A from the satellite bus.

PS-894/CREATED/T

The value of the Battery Simulator charge current shall be displayed on the SCOE local controller with a resolution of 100mA, or better.

PS-895/CREATED/T

The Battery Simulator charge current shall be monitored by the SCOE with an accuracy of ±0.1% FS or better.

5.4 Battery Discharge

PS-900/Derived from [RD-1] PCDU-174/T

The Battery Simulator shall be capable of sourcing at least 20A to the satellite bus.

PS-902/CREATED/T

The value of the Battery Simulator discharge current shall be displayed on the SCOE local controller with a resolution of 100mA, or better.

PS-903/CREATED/T

The Battery Simulator discharge current shall be monitored by the SCOE with an accuracy of ±0.1% FS or better.
5.5 Thermistor Simulation

PS-908/Derived from [RD-2] Batt-127/T

The Battery Simulator shall simulate three battery thermistors of type ‘ANY’, details of which are shown in Table 4-8:

- One prime temperature monitor to the OBC
- One redundant temperature monitor to the OBC
- One Umbilical temperature monitor to the EGSE

PS-916/Derived from [RD-2] Batt-270/T

It shall be possible to individually adjust the value of the Battery Simulator thermistors in order to simulate temperature values between 5°C and 25°C, as a minimum.

Note - it is acceptable to have a manual adjustment of the thermistors at the Battery Simulator front panel, if necessary.

PS-917/CREATED/T

It shall be possible to adjust the value of the Battery Simulator thermistors with a resolution of 0.5°C, or better.

PS-925/CREATED/T

The set temperature value of each thermistor shall be individually displayed on the SCOE local controller with a resolution of 0.1°C, or better.

5.6 Heater Simulation

PS-911/Derived from [RD-1] PCDU-248/T

The Battery Simulator shall provide two simulated heaters (prime and redundant).

PS-915/CREATED/T

The heaters may be simulated by suitable static, low inductance, resistors of 175Ω ±1%, 5W.

5.7 Terminal Voltage Monitors

PS-913/Derived from [RD-2] Batt-271/T

The Battery Simulator shall provide three Battery terminal voltage monitors:

- One prime voltage monitor to the OBC
- One redundant voltage monitor to the OBC
- One Umbilical voltage monitor to the EGSE

PS-914/Derived from [RD-2] Batt-129/R

Each voltage monitor shall be individually protected by a 10kΩ ±1% resistor to simulate the flight battery monitoring interface.
5.8 Battery Simulator Interface

The Battery Simulator will connect directly to the on-board flight battery harness and will be situated in close proximity to the satellite.

**PS-920/Derived from [RD-2] Batt-66/T,A**

The input DC resistance of the Battery simulator, including the 3m interface cables, shall be $20 \text{m}\Omega < R < 60 \text{m}\Omega$

**PS-924/Derived from [RD-2] Batt-67/T,A**

The AC input resistance of the Battery Simulator shall be:

- lower than $190 \text{ m}\Omega$ for a frequency of up to 2 kHz
- lower than $750 \text{ m}\Omega$ for $2 \text{kHz} < f < 10 \text{ kHz}$

This shall include the effects of any power supply and load control loops in the Battery Simulator.


The interface between the Battery Simulator and the satellite shall be as shown in Figure 5-1. The exact details of this interface are not presently known and will only be defined after the battery supplier selection.

**PS-941/CREATED/R**

Precautions shall be taken to maintain the integrity of any flight standard connectors fitted to the Battery Simulator Interface cables. This shall be achieved by ensuring that the Battery Simulator Interface cables are only mated to flight standard connectors during Battery Simulator development and test activities.

**PS-929/CREATED/R**

The Battery Simulator Interface cables shall exit the Battery Simulator rack as close as possible to the top of the rack (on the rear). This is to allow for the interface cables to be as short as possible and still allow connection to the satellite battery harness in all satellite orientations.

**PS-922/CREATED/T**

Cable screens shall be terminated to SCOE ground via the Battery Simulator rack.
Figure 5-1: Battery Simulator Interface
6. OFF-LINE BATTERY SUPPORT FUNCTION

The LISA-Pathfinder battery will be a Lithium-ion 30 to 36Ahr, 29V unit that will be connected to and disconnected from the satellite main Bus using Battery Safety Relays under the control of the PCDU.

Normal battery charging and discharging activities will be done from the main Bus, while the spacecraft is powered, but activities such as charging a battery with 'zero state of charge', discharging and capacity measurements will be done off-line, with the spacecraft unpowered.

In order to carry out these off-line battery activities, a dedicated battery interface will be required between the SCOE and a satellite skin connector.

6.1 Charge Function

It is acceptable to use the Bus support power supply to carry out the battery charge function, as bus support and off-line battery charging will be exclusive activities. For the purposes of clarity the power supply will be known as the Battery Charge power supply when used to support the off-line battery charge function.


The requirements of sections 4.1.1 and 4.1.2 shall be applicable to the battery charge power supply.

PS-412/Created/T

If utilising the Bus support power supply, the SCOE shall distinguish between the displayed parameters of the power supply when supporting either the Bus support function or the battery charge function (e.g. the power supply current limit parameter when in bus support will be 'current limit', but in off-line battery charge will be 'charge current').

6.2 Discharge Function

It is acceptable to use the electronic load specified in section 10, where the general requirements of section 10.1 will apply. Requirements specific to the battery discharge are detailed below.

PS-414/Created/T

It shall be possible to connect an adjustable constant current load in place of the battery charge supply to enable battery discharge activities.

PS-804/Created/T,R

The requirements of section 10.1 shall apply to the battery discharge constant current load.

PS-415/Derived from [RD-2] Batt-71/T

The load current shall be adjustable between 0.1A and 20A as a minimum.

PS-418/Created/T

It shall be possible to set the value of the constant current load with a resolution of ±10mA or better.

PS-417/Created/T

The actual value of the constant current load shall be within ±0.5% FS or better of the value set.

PS-419/Created/T

The SCOE shall display the value of the load current with an accuracy of ±0.25% or better.

PS-420/Created/T

The SCOE shall display the value of the load current with a resolution of 10mA or better.

PS-421/Created/T

The SCOE shall calculate and display the battery capacity in Ahrs by recording the value of the load current over time.
6.3 Monitoring Function

The Battery voltage and temperature will be available for monitoring by the SCOE during the off-line battery activities. These will be connected to a satellite skin connector directly from dedicated test connectors on the battery.

**PS-425/CREATED/T**

*The requirements of section 4.3.2 shall be applicable when monitoring the battery voltage.*

**PS-426/CREATED/T**

*The requirements of section 4.3.3 shall be applicable when monitoring the battery temperature.*

**PS-427/CREATED/T**

*The requirements of section 4.3.2.1 shall be applicable for battery voltage protection.*

6.3.1 Battery Undervoltage protection

**PS-428/Derived from [RD-2] Batt-43/T**

*It shall be possible to set a battery under voltage protection trip point.*

**PS-434/CREATED/T**

*The under voltage protection shall only be available when in battery discharge mode.*

**PS-429/CREATED/T**

*The battery voltage monitor shall be able to trigger the SCOE system mode protection facility in the event of a battery undervoltage occurrence.*

**PS-430/Derived from [RD-2] Batt-53/T**

*It shall be possible to set the battery undervoltage trigger point, as a minimum, between 18V and 25V.*

**PS-432/CREATED/T**

*It shall be possible to set the battery undervoltage trigger point with a resolution of 100mV or better.*

**PS-431/CREATED/T**

*The actual value of the battery undervoltage trigger point shall be within ±0.5% FS or better of the value set.*

6.4 Isolation

**PS-437/CREATED/T**

*It shall be possible to galvanically isolate the Battery charge power supply positive and negative lines from the off-line battery support interface.*

**PS-440/CREATED/T**

*It shall be possible to galvanically isolate the constant current load positive and negative lines from the off-line battery support interface.*

6.5 Off-line Battery Support Interface

The Battery charge interface will be extended from the end of the SCOE interface cable for connection to the satellite skin connector, this extension will <2 metres in length. The off-line battery activities will only be conducted during 'standard' test phases, i.e. not during thermal vacuum, launch etc. Details of the expected cabling for the various test phases of LISA-Pathfinder can be found in [RD-4].

**PS-443/CREATED/T,A**

*The Battery Charge interface shall meet all requirements of section 5. with all required configurations of SCOE to satellite interface cables.*

The interface between the SCOE and the satellite shall be as shown in Figure 6-1.

PS-757/CREATED/T

Cable screens shall be terminated to SCOE ground via the SCOE rack.
Figure 6-1: SCOE Off-line Battery Support Interface
7. MEASUREMENT ERROR AMPLIFIER STIMULI

The LISA-Pathfinder main bus voltage is controlled by a majority voting measurement error amplifier system. In order to verify that each control loop is functioning, pairs of MEA's must be disabled in turn to leave one controlling loop, which can then be verified as functioning.

The interface required to disable the pairs of MEA's will be provided by the SCOE.

7.1 DETAILS are TBD.

The MEA testing scheme is dependant on the PCDU supplier, so details will only be available when a supplier has been chosen.
8. THERMAL OVERRIDE UNIT

The Thermal Override Unit (TOU) is used to ‘force’ heaters to their on state by overriding their individual control thermostats. The functionality of the heater circuit is primarily verified by the measurement of the heater current.

The preliminary details of the LISA-Pathfinder heater circuits and thermostats are shown in Figure 8-1, for information (TBC).
Figure 8-1: LISA-Pathfinder Heater and Thermostat circuits (TBC)
**PS-630/Derived from [RD-2] PCDU-T**

The SCOE shall provide individual override switches for each satellite thermostat. Further details of a suggested interface is shown in Figure 8-2.

![Figure 8-2: Thermostat Override circuit (suggested) details](image)

**PS-632/CREATED/T**

*It shall be possible to control each SCOE override switch independently from all other override switches.*

**PS-633/Derived from [RD-1] PCDU-250/T**

*The current through each override switch (the heater current) shall be monitored by the SCOE with an accuracy of 1% FS or better (Full Scale should be taken as 1.5A for each thermostat circuit).*

**PS-634/CREATED/T**

*The current through each override switch shall be displayed on the SCOE local controller with a resolution of 10mA or better.*
The status of all the override switch positions shall be easily identified on the SCOE local controller. This should ideally be achieved with the use of a synoptic picture (mimic), together with coloured indications for the ON/OFF state of the override switches.

The maximum resistance (loop) of the override switch circuits when measured from the satellite end of the 15 metre SCOE interface cables shall be $<3\Omega$.

8.1 Thermal Override Unit Interface

The Thermal Override Unit interface will be extended from the end of the SCOE interface cables for connection to the satellite skin connectors. This extension will vary, depending on the satellite test phase, from a few metres to 16 metres during thermal vacuum. The Thermal Override Unit is not used when the satellite is mounted on the launch vehicle. Details of the expected cabling for the various test phases of LISA-Pathfinder can be found in [RD-4].

The Thermal Override Unit interface shall meet all requirements of section 7 with all required configurations of SCOE to satellite interface cables.

The interface between the SCOE and the satellite shall be as shown in Figure 8-3 (Prime) and Figure 8-4 (Redundant).

Cable screens shall be terminated to SCOE ground via the SCOE rack.
Figure 8-3: Thermal Override Unit Prime Interface
Figure 8-4: Thermal Override Unit Redundant Interface
9. PYRO LOAD AND MONITOR FUNCTIONS

LISA-Pathfinder will utilise several mechanical actuators / release mechanisms, of different types, to carry out mechanical operations during its transfer orbit. The SCOE will need to provide representative loads and monitoring facilities to enable testing of the PCDU actuator interfaces.

The three types of actuators will be:
· Pyro Initiator device
· Shape Memory Alloys or equivalent heating devices (TBC)
· Electric motor (TBC)

The SCOE will interface to the PCDU pyro interface via satellite skin connectors.

9.1 Pyro Initiator Device

PS-461/Derived from [RD-1] PCDU-278/T

The SCOE Pyro interface shall provide individual loads for 32 Pyro Initiator devices (16 nominal and 16 redundant).

PS-463/Derived from [RD-1] PCDU-279/T

The Pyro loads shall comply with the Pyro Interface data sheet (PYR) receiver circuit specification shown in Table 9-1.

PS-462/Derived from [RD-1] PCDU-280/T,R

<table>
<thead>
<tr>
<th>Req</th>
<th>Source Circuit Specification</th>
<th>IF-Code:</th>
<th>Ver. Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Firing Pulse Duration: (24 ± 2)ms</td>
<td>Pyro Interface</td>
<td>PYR</td>
</tr>
<tr>
<td>-2</td>
<td>Repetition Rate: &gt; 100ms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>Firing Current: 4.5A &lt; I_{firing} &lt; 6.0A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td>Grounding Resistor: 1MOhm to structure ground</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Req</th>
<th>Receiver Circuit Specification</th>
<th>Ver. Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-5</td>
<td>Max No-Fire Current: 1A for 5 minutes</td>
<td></td>
</tr>
<tr>
<td>-6</td>
<td>All Fire Current: 4.0A within 20msec</td>
<td></td>
</tr>
<tr>
<td>-7</td>
<td>Input Resistance: R_{i} &lt; 1.3Ohm</td>
<td></td>
</tr>
<tr>
<td>-8</td>
<td>Isolation Resistance: &gt; 2MOhm at 250±5% VDC for &gt; 15s</td>
<td></td>
</tr>
</tbody>
</table>

Harass Specification

| -9  | Wiring Type: Twisted Shielded Pair (TSP) |
| -10 | Antistatic Resistor: 300Ohm < R_{AS} < 3900Ohm |

Notes:
1. Applicable for maximum drive/sink current of 200µA
2. Between filaments and EED-case before firing
3. Implemented in the pyro harness (between Squib and Safe/Arm plug)

Fault Voltages shall be verified by Worst Case Analysis.

Table 9-1: Pyro Activation Device Characteristics

The Pyro Interface Source circuit specification is included for information.

PS-509/CREATED/T

The SCOE pyro loads shall be designed to present the worst case load to the pyro source circuits.
PS-465/CREATED/T,R
The SCOE shall measure the voltage developed across the pyro initiator loads at such a point as to minimise any measurement errors due to rack cable/harness resistance.

PS-466/CREATED/T
The pyro load voltage shall be measured with an accuracy of ±1% of FS.

PS-467/CREATED/T
The SCOE shall calculate the value of the pyro load current for display by the local controller.

PS-469/CREATED/T
The pyro load current shall be displayed with a resolution of 100mA.

PS-470/CREATED/T
The SCOE shall measure the duration of the pyro fire current through the pyro load resistor.

PS-471/CREATED/T
The pyro load current duration shall be measured with an accuracy of ±1% of FS.

PS-472/CREATED/T
The pyro load current duration shall be displayed with a resolution of 100uS.

PS-473/CREATED/T
In addition to the numerical display of the pyro fire pulse characteristics, the local controller shall display the 32 pyro channels with a coloured GO/NOGO status displayed as follows:-

- measured current <=1A - NONE
- measured current 1A < I <3.9A - RED
- measured current >= 4A and duration <22mS - RED
- measured current >= 4A and duration 22mS < T <26mS - GREEN
- measured current >= 4A and duration >26mS - RED
- measured current >= 6A - RED

PS-474/CREATED/T
It shall be possible for the SCOE to simultaneously monitor and display all 32 pyro load channel currents, the 4 shape memory device load channel currents and the 4 Motor Actuator device load channel currents.

This is to monitor for spurious pulses on all channels while one channel is being fired.

PS-491/CREATED/T
All monitored parameters associated with the pyro fire pulses shall be stored in easily retrievable archive files.

PS-779/CREATED/T
All pyro channels shall be individually available on front or rear panel protected test points.

9.2 Shape Memory Devices

PS-477/Derived from [RD-1] PCDU-282/T
The SCOE pyro interface shall provide individual loads for four Shape Memory devices.
The Shape Memory device loads shall comply with the Shape Memory Device data sheet (SMD) receiver circuit specification shown in Table 9-2.

<table>
<thead>
<tr>
<th>INTERFACE DATA SHEET</th>
<th>Page 1 / 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source Circuit Specification</strong></td>
<td></td>
</tr>
<tr>
<td>Actuation Pulse Duration:</td>
<td>Commandable between 40mS / 80sec</td>
</tr>
<tr>
<td>Repetition Rate:</td>
<td>N/A</td>
</tr>
<tr>
<td>Actuation Current:</td>
<td>2.0A &lt; I_{actuate} &lt; 5.0A</td>
</tr>
<tr>
<td>Grounding Resistor:</td>
<td>TBD</td>
</tr>
<tr>
<td><strong>Receiver Circuit Specification</strong></td>
<td>Ver. Iss.</td>
</tr>
<tr>
<td>Max No-Actuation Current:</td>
<td>TBD</td>
</tr>
<tr>
<td>Actuation Current:</td>
<td>2.0A &lt; I_{actuate} &lt; 5.0A within 40mS / 80sec</td>
</tr>
<tr>
<td>Input Resistance:</td>
<td>4.1 &lt; R_i &lt; 9 ohm</td>
</tr>
<tr>
<td>Isolation Resistance:</td>
<td>TBD</td>
</tr>
<tr>
<td><strong>Harness Specification</strong></td>
<td></td>
</tr>
<tr>
<td>Wiring Type:</td>
<td>Twisted Shielded Pair (TSP)</td>
</tr>
<tr>
<td>Antistatic Resistor:</td>
<td>TBD</td>
</tr>
</tbody>
</table>

Table 9-2: Deployment Heating Device Characteristics

The Shape Memory Device source circuit specification is included for information.

The SCOE Shape Memory device loads shall be designed to present the worst case load to the device source circuits.

The SCOE shall measure the voltage developed across the shape memory device loads at such a point as to minimise any measurement errors due to rack cable/harness resistance.

The shape memory device load voltage shall be measured with an accuracy of ±1% of FS.

The SCOE shall calculate the value of the shape memory device load current for display by the local controller.

The shape memory device load current shall be displayed with a resolution of 100mA.

The SCOE shall measure the duration of the shape memory device fire current through the load.

The shape memory device load current duration shall be measured with an accuracy of ±1% of FS.

The shape memory device load current duration shall be displayed with a resolution of 100uS.
In addition to the numerical display of the shape memory device drive pulse characteristics, the local controller shall display the 4 shape memory device channels with a coloured GO/NOGO status displayed as follows:-

- measured current $\leq$ TBD - NONE
- measured current TBD $<$ I $<$ 1.9A - RED
- measured current 2A $<$ I $<$ 5A - GREEN
- measured current $>$ 5A - RED

It shall be possible for the SCOE to simultaneously monitor and display the 4 shape memory device load channel currents, the 32 pyro load channel currents and the 4 Motor Actuator device load channel currents.

This is to monitor for spurious drive pulses on all channels while one channel is being stimulated.

All monitored parameters associated with the shape memory devices shall be stored in easily retrievable archive files.

All shape memory device channels shall be individually available on front or rear panel protected test points.

9.3 Motor Actuator devices

The SCOE pyro interface shall provide individual loads for four Motor Actuator devices.

The Motor Actuator device loads shall comply with the Motor Drive Device Interface data sheet (MDD) receiver circuit specification shown in Table 9-3.
### INTERFACE DATA SHEET

<table>
<thead>
<tr>
<th>IF Designation:</th>
<th>Motor Drive Device Interface</th>
<th>IF-Code:</th>
<th>MDD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source Circuit Specification</strong> Ver. Iss.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actuation Pulse Duration:</td>
<td>Commandable to maximum 2 sec</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repetition Rate:</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actuation Current:</td>
<td>$0.3A &lt; I_{actuate} &lt; 1.0A$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grounding Resistor:</td>
<td>TBD</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Receiver Circuit Specification</strong> Ver. Iss.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max No-Actuation Current:</td>
<td>TBD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actuation Current:</td>
<td>1.0A within 2sec</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Resistance:</td>
<td>$2.0 &lt; R_i &lt; 20$ ohm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isolation Resistance:</td>
<td>TBD</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Harness Specification</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wiring Type:</td>
<td>Twisted Shielded Pair (TSP)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antistatic Resistor:</td>
<td>TBD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 9-3: Motor Actuator Characteristics

The Motor Actuator Device source circuit specification is included for information.

**PS-511/CREATED/T**

The SCOE Motor Actuator device loads shall be designed to present the worst case load to the device source circuits.

**PS-498/CREATED/T,R**

The SCOE shall measure the voltage developed across the Motor Actuator device loads at such a point as to minimise any measurement errors due to rack cable/harness resistance.

**PS-499/CREATED/T**

The Motor Actuator device load voltage shall be measured with an accuracy of ±1% of FS.

**PS-500/CREATED/T**

The SCOE shall calculate the value of the Motor Actuator device load current for display by the local controller.

**PS-501/CREATED/T**

The Motor Actuator device load current shall be displayed with a resolution of 100mA.

**PS-502/CREATED/T**

The SCOE shall measure the duration of the Motor Actuator device fire current through the load.

**PS-503/CREATED/T**

The Motor Actuator device load current duration shall be measured with an accuracy of ±1% of FS.

**PS-504/CREATED/T**

The Motor Actuator device load current duration shall be displayed with a resolution of 100uS.
In addition to the numerical display of the Motor Actuator device drive pulse characteristics, the local controller shall display the 4 Motor Actuator device channels with a coloured GO/NOGO status displayed as follows:-

- measured current \(\leq \text{TBD}\) - NONE
- measured current \(\text{TBD} < I < 0.3\text{A}\) - RED
- measured current \(0.3\text{A} < I < 1.0\text{A}\) - GREEN
- measured current \(\geq 1\text{A}\) - RED

It shall be possible for the SCOE to simultaneously monitor and display the 4 Motor Actuator device load channel currents, the 32 pyro load channel currents and the 4 shape memory device load channel currents.

This is to monitor for spurious drive pulses on all channels while one channel is being stimulated.

All monitored parameters associated with the Motor Actuator devices shall be stored in easily retrievable archive files.

All motor actuator device channels shall be individually available on front or rear panel protected test points.

9.4 Pyro Device Interface

The Pyro Device interface will be extended from the end of the SCOE interface cable for connection to the satellite skin connector. This extension will vary, depending on the satellite test phase, from a few metres to 16 metres during thermal vacuum. The Pyro Device loads are not used when the satellite is mounted on the launch vehicle. Details of the expected cabling for the various test phases of LISA-Pathfinder can be found in [RD-4].

The Pyro Device interface shall meet all requirements of section 8 with all required configurations of SCOE to satellite interface cables.

The interface between the SCOE and the satellite shall be as shown in Table 9-4 and Figure 9-1.

Cable screens shall be terminated to SCOE ground via the SCOE rack.
Table 9-4: SCOE Pyro Device Prime Interface

<table>
<thead>
<tr>
<th>Pyro Prime Interface</th>
<th>Pyro Prime Interface</th>
</tr>
</thead>
</table>

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Figure 9-1: SCOE Pyro Device Redundant Interface
10. SOLAR ARRAY SIMULATOR (SAS)

LISA-Pathfinder consists of a single Solar Array utilising cells based on GaAs technology. The solar array will be configured into (a maximum of) 6 equal array 'sections' consisting of 8 strings of \( \leq 24 \) cells, giving a total of 48 strings.

The power generated by the array is regulated by the PCDU utilising Maximum Power Point Transfer (MPPT) controlled step-down regulator dc-dc convertors.

The SAS will be utilised to support the AIT electrical satellite tests by simulating the solar array.

The SAS is required to simulate the individual array sections (current sources) which will be capable of providing the full spacecraft array parameters, together with the simulation of the solar array dynamic performance.

The full spacecraft load for LISA-Pathfinder is a maximum of 700W. The SAS will interface to the PCDU via a dedicated satellite skin connector which will interface to a specific PCDU SAS connector.

10.1 SAS Power Requirements

PS-830/Derived from [RD-3] SA-71/T

The SAS shall be capable of simulating 6 individual array sections (SAS section) (TBC).

PS-529/Derived from [RD-1] PCDU-148/T

Each SAS section shall have the capability to provide an open circuit voltage (Voc) of at least 0 to 81V (TBC).

PS-530/Derived from [RD-1] PCDU-148/T

Each SAS section shall have the capability to provide a short circuit current (Isc) of at least 5A.

PS-531/Derived from [RD-1] PCDU-87/T

The SAS shall have the capability to provide at least 700W (TBC).

PS-831/CREATED/T

It shall be possible to set the Voc for each SAS section independently.

PS-832/CREATED/T

It shall be possible to set the Isc for each SAS section independently.

PS-534/CREATED/T

It shall be possible to set each SAS section Voc with a resolution of 50mV or better.

PS-533/CREATED/T

The actual value of each SAS section Voc output shall be within \( \pm 0.5\% \) FS or better of the value set.

PS-535/CREATED/T

Each SAS section output voltage shall be independently displayed by the SCOE local controller with an accuracy of \( \pm 0.5\% \) FS or better.

PS-541/CREATED/T

Each SAS section output voltage shall be displayed by the SCOE local controller with a resolution of 50mV or better.

PS-564/CREATED/T

It shall be possible to set each SAS section Isc with a resolution of 10mA or better.

PS-536/CREATED/T

The actual value of each SAS section Isc output shall be within \( \pm 0.5\% \) FS or better of the value set.
Each SAS section output current value shall be displayed by the SCOE local controller with an accuracy of ±0.5% FS or better.

Each SAS section output current value shall be displayed by the SCOE local controller with a resolution of 10mA or better.

The total current output from the SAS shall be displayed by the SCOE local controller with an accuracy of ±0.5% FS or better.

The SAS total current output shall be displayed by the SCOE local controller with a resolution of 10mA or better.

The power on default state of each SAS section shall set the Voc and Isc at 0V and 0A respectively.

10.2 Protection

Overvoltage and overcurrent protection facilities are required on each SAS section output to protect the satellite PCDU input in the event of a SAS equipment anomaly.

10.2.1 Overvoltage

An overvoltage occurrence on a SAS section output shall be able to trigger the SCOE local protection facility.

An overvoltage occurrence on a SAS section output shall be able to trigger the SCOE system protection facility.

The SCOE protection facility shall be triggered if a SAS section output voltage exceeds a preset value by a maximum of 1V.

It shall be possible to set the overvoltage protection value for each SAS section independently.

It shall be possible to set each SAS section overvoltage protection between 20V and 65V.

It shall be possible to set each SAS section overvoltage level with a resolution of 500mV or better.

The actual value of each SAS section overvoltage level shall be within ±1% FS or better of the value set.

The local controller shall display the set values of all the SAS section overvoltage protections.
10.2.2 Overcurrent

**PS-557/CREATED/T**

An overcurrent occurrence on a SAS section output shall be able to trigger the SCOE local protection facility.

**PS-558/CREATED/T**

An overcurrent occurrence on a SAS section output shall be able to trigger the SCOE system protection facility.

**PS-559/CREATED/T**

The SCOE protection facility shall be triggered if a SAS section output current exceeds a preset value by a maximum of 100mA.

**PS-836/CREATED/T**

It shall be possible to set the overcurrent protection value for each SAS section independently.

**PS-560/CREATED/T**

It shall be possible to set each SAS section overcurrent protection between 0.1A and 5A.

**PS-562/CREATED/T**

It shall be possible to set each SAS section overcurrent level with a resolution of 10mA or better.

**PS-561/CREATED/T**

The actual value of each SAS section overcurrent level shall be within ±1% FS or better of the value set.

**PS-563/CREATED/T**

The local controller shall display the set values of all the SAS section overcurrent protections.

10.3 Sunlight to Eclipse, Eclipse to Sunlight Transitions

It is only expected to have sunlight to eclipse and eclipse to sunlight transitions during the Leop and apogee raising manoeuvres. During transfer and while on-station the array will be continually sun pointing.

There will be two distinct transition duration’s, one during a non-burn orbit of approximately 10 seconds and the second during a burn orbit of approximately 2 minutes.

The orientation of LISA-Pathfinder during the two orbits is shown in Figure 10-1.
Each SAS section shall be capable of simulating sunlight to eclipse and eclipse to sunlight transitions. The SAS sections shall perform a controlled ramp of the Voc between the programmed Voc value and zero volts (sunlight to eclipse) and from zero volts to the programmed Voc value (eclipse to sunlight). The ramp shall follow a profile defined by $\sin(\pi/2(1+t/\Delta t))$ where $0<t<\Delta t$.

The sunlight to eclipse transition time ($\Delta t$) shall be programmable, as a minimum, between 1 second and 5 minutes.

The eclipse to sunlight transition time ($\Delta t$) shall be programmable, as a minimum, between 1 second and 5 minutes.

For transition times between 1 and 60 seconds, it shall be possible to set the time with a resolution of 0.1 seconds or better.

For transition times greater than 60 seconds, it shall be possible to set the time with a resolution of 0.5 seconds or better.

For transition times between 1 and 60 seconds the actual value of the transition time shall be within ±0.165% FS, or better, of the time set (FS shall be taken as 60 seconds).

For transition times greater than 60 seconds the actual value of the transition time shall be within ±0.165% FS, or better, of the time set (FS shall be taken as 5 minutes).
All SAS sections shall simultaneously track the sunlight to eclipse or eclipse to sunlight transition profile.

It shall be possible to stop a sunlight to eclipse or eclipse to sunlight transition at any point during its execution.

It shall be possible to restart a stopped sunlight to eclipse or eclipse to sunlight transition.

10.4 Ripple and Spikes

The ripple and spikes present on the output of the SAS sections shall conform to the requirements of [AD-01] section 5.12.1.

Requirement deleted.

Requirement deleted.

Requirement deleted.

10.5 Isolation

It shall be possible to galvanically isolate each SAS section output positive and negative lines from the satellite interface.

It shall be possible to control the galvanic isolation of the SAS section outputs from SCOE front panel mounted ON / OFF buttons.

The ON / OFF front panel switches shall be protected from inadvertent operation.

Although each SAS section should be individually isolated from the satellite, it is not required for the isolation method of each section to be controlled independently.

10.6 SAS Satellite Interface

The SAS section interface will be extended from the end of the SCOE interface cable for connection to the satellite skin connector. This extension will vary, depending on the satellite test phase, from a few metres to 16 metres during the Thermal vacuum testing. The SAS is not used when the satellite is mounted on the launch vehicle. Details of the expected cabling for the various test phases of LISA-Pathfinder can be found in [RD-4].

The SAS shall meet all requirements of section 9 with all required configurations of SCOE to satellite interface cables.
PS-575/Derived from [RD-1] PCDU-151/T,A

The effective electrical parameters for each SAS section interface shall conform to the Solar Array Power Interface (PSA) Driver circuit specification shown in Table 10-1.

These parameters shall include the total cable parameters for all the cable configurations required to support the LISA-Pathfinder AIT campaign.

Where direct measurements of the cable parameters cannot be performed, suitable analysis shall be provided to show conformance with this requirement.

PS-878/Derived from [RD-1] PCDU-151/T,A

Each SAS section output shall incorporate an easily adjustable matching network in order to allow the section effective capacitance and inductance to be set as close as possible to the actual solar array parameters.

PS-579/Derived from [RD-3] SA-71/T,A

<table>
<thead>
<tr>
<th>INTERFACE DATA SHEET</th>
<th>Page 1 / 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>IF Designation:</td>
<td>Solar Array Power Interface</td>
</tr>
<tr>
<td>IF-Code:</td>
<td>PSA</td>
</tr>
<tr>
<td>Req Driver Circuit Specification</td>
<td>Ver. Iss.</td>
</tr>
<tr>
<td>-1 Circuit type:</td>
<td>Solar Array (6 sections in total).</td>
</tr>
<tr>
<td>-2 Section Output Current:</td>
<td>TBD per section, best case BOL condition.</td>
</tr>
<tr>
<td>-3 Interface Voltage Range:</td>
<td>0V to 65V (TBC)</td>
</tr>
<tr>
<td>-4 Section Effective Capacitance C_e (1):</td>
<td>Adjustable between 10(\mu)F and 23(\mu)F (TBC)</td>
</tr>
<tr>
<td>-5 Section Effective Inductance L_s (1):</td>
<td>Adjustable between 4(\mu)H and 8(\mu)H (TBC)</td>
</tr>
<tr>
<td>-6 Section Wiring Resistance R (1):</td>
<td>&lt; 300m(\Omega) (TBC)</td>
</tr>
<tr>
<td>-7 Fault Voltage Emission:</td>
<td>0V to 65V (TBC)</td>
</tr>
<tr>
<td>-8 Fault Voltage Tolerance:</td>
<td>0V to 65V (TBC)</td>
</tr>
</tbody>
</table>

Req Receiver Circuit Specification | Ver. Iss.
| -9 Bus Voltage Range: | 0V to 65V at PCDU input (TBC) |
| -10 Ground Reference: | Power Bus Return |
| -11 Unregulated power bus filter: | TBC |
| -12 Ripple & Transients: | Specified in GDIR |
| -13 Voltage Drop inside PCDU: | Specified in GDIR |
| -14 Power Quality: | Specified in GDIR |
| -15 Fault Voltage Emission: | 0V to 65V (TBC) |
| -16 Fault Voltage Tolerance: | 0V to 65V (TBC) |

Harness Specification
| Wiring Type (2): | Twisted Pairs, AWG-20 (TP-20) |

R

Notes:
(1): The PCDU supplier shall assume the following electrical parameters for SA interface characteristics:

![Diagram of solar array interface parameters]

(2): TBD pairs, from Solar Array IF to PCDU, minimum gauge shall be AWG-20.

Table 10-1: Solar Array Power Interface
The PSA receiver circuit specification is included for information.

**PS-572/Derived from [RD-1] PCDU-151/T,I**

*The interface between the SCOE and the satellite shall be as shown in Figure 10-2.*

**PS-573/CREATED/T**

*Cable screens shall be terminated to SCOE ground via the SCOE rack.*
Figure 10-2: SCOE Solar Array Simulator Interface
11. LOAD TEST RACK

The load test rack will be utilised, primarily, to verify the shutdown functionality of the LCL and FCL trips. It will perform this function by applying a suitable load to the LCL/FCL output and therefore cause an overcurrent (trip) condition.

The load test rack will also be utilised for off-line battery discharge activities. In addition it maybe used during the LISA-Pathfinder AIT activities as a 'general test load'.

The LCL/FCL's will be tested individually via connections to satellite skin connectors. The SCOE will need to provide an automatic facility to connect the LCL/FCL to be tested to the electronic load.

The definition of a LCL is:- a commandable solid state switch, which after switch on and in case of any overload on the output shall provide current limiting capability for a definite time. If the overcurrent condition exceeds this definite time, the outlet shall autonomously switch off.

The characteristic of a typical LCL are shown in Figure 11-1 where $l_{\text{lim}}$ is dependant on the LCL class and $t_{\text{tripp-off}}$ is between 8 and 15ms (TBC).

![Figure 11-1: LCL Characteristic](image)

The definition of an FCL is:- a non-commandable solid state switch, which provides current limiting capability for an indefinite time in case of any overload on the output. The limiting current reduces (folds back) to a value that can be sustained thermally.

The outlet cannot be switched off.

The characteristics of a typical FCL are shown in Figure 11-2 where $l_{\text{lim}}$ is dependant on the FCL class and $T_r$ is $<$10 $\mu$s.
11.1 Electronic load

The load test rack shall provide an adjustable electronic load to enable testing of the LCL/FCL PCDU outputs.
The electronic load shall be configurable for constant current, constant voltage and constant resistance modes of operation.

The electronic load shall have a load capability of at least 400W.

The electronic load shall have a current capability of at least 40A.

The electronic load shall have a voltage capability of at least 50V.

It shall be possible to set the electronic load current with a resolution of 10mA or better.

The actual value of the electronic load current shall be within ±0.25% FS or better of the value set.

It shall be possible to set the electronic load voltage with a resolution of 10mV or better.

The actual value of the electronic load voltage shall be within ±0.25% FS or better of the value set.

The SCOE shall monitor the current drawn by the electronic load with an accuracy of ±0.2% FS or better.

The monitored electronic load current shall be displayed on the SCOE local controller with a resolution of 1mA or better.

The SCOE shall monitor the voltage across the electronic load with an accuracy of ±0.5% FS or better.

The monitored electronic load voltage shall be displayed on the SCOE local controller with a resolution of 10mV or better.

It shall be possible to monitor the FCL and LCL trip characteristics (as shown in Figure 11-1 and Figure 11-2) on the SCOE local controller with the aid of graphical plots.

The input to the electronic load shall be available on SCOE front or rear panel protected test points. It is not necessary to have individual test points for each individual LCL/FCL input.

It shall be possible to individually connect a LCL or FCL output to the electronic load with the use of a suitable multiplexer.
No single point multiplexer failure shall allow the interconnection of any FCL/LCL satellite output with another.

The connection and disconnection of the LCL or FCL output to the electronic load shall be done under control from the SCOE local controller.

The LCL’s and FCL’s that will require connection to the load test rack are shown, for reference, in Table 11-1.

<table>
<thead>
<tr>
<th>LCL Type</th>
<th>Current</th>
<th>Number Off</th>
<th>Spares</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCA</td>
<td>1A</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>LCB</td>
<td>2A</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>LCC</td>
<td>3A</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>LCD</td>
<td>5A</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>LCE</td>
<td>6A</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>LCF</td>
<td>7A</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>40</strong></td>
<td><strong>7</strong></td>
</tr>
<tr>
<td>FCA</td>
<td>2A</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>FCB</td>
<td>3A</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>4</strong></td>
<td><strong>2</strong></td>
</tr>
</tbody>
</table>

Table 11-1: Power Interfaces Summary.

In addition, the LCL’s shown in Table 11-2 (which are used to supply the heater circuits on the satellite) will also require connection to the load test rack.

<table>
<thead>
<tr>
<th>LCL Type</th>
<th>Current</th>
<th>Number Off</th>
<th>Spares</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCA</td>
<td>4.5A</td>
<td>18</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 11-2: Heater Interface Summary

In addition to the LCL/FCL test interface the load test rack shall provide an interface for the Off-line Battery discharge function specified in section 5.2.

The load test rack shall also provide a 'non specific' input to allow general test access to the electronic load, if required.

This maybe provided by a specific (isolated) connection to the load rack or by using the LCL/FCL test interface together with the ability to select multiple multiplexer inputs simultaneously.

The LCL/FCL test interface will be extended from the end of the Load Test Rack interface cables for connection to the satellite skin connectors, this extension will <2 metres in length. The Load Test Rack activities will only be conducted during 'standard' test phases, i.e. not during thermal vacuum, launch, etc.. Details of the expected cabling for the various test phases of LISA-Pathfinder can be found in [RD-4].

The Load Test Rack interface shall meet all requirements of section 10 with all required configurations of Load rack to satellite interface cables.
The interfaces between the Load Test Rack and the satellite shall be as shown in Figure 11-3, Figure 11-4, Figure 11-5 and Figure 11-6.

Cable screens shall be terminated inside the rack to SCOE ground.

Figure 11-3: Load Test Rack Heater LCL Interface (AIT 6)
Figure 11-4: Load Test LCL AIT 3 and AIT 3A Interface
Figure 11-5: Load Test LCL AIT 4 and AIT 4A Interface

Figure 11-6: Load Test FCL AIT 5 Interface
12. PSS / PYRO SCOIE VALIDATION

The SCOIE equipment's, functions and interfaces will require validating whenever the SCOIE is relocated to a new test location. This can be a long and inefficient process, which involves the use of external test equipment and test aids.

It can be much more efficient if the SCOIE can perform an automated (or semi-automated) 'self validation'. Much of the test equipment required to carry out a validation is integral, by design, to the SCOIE e.g. power supplies can be used to check monitor inputs, etc.

PS-650/CREATED/T
The SCOIE shall be able to perform a self validation under control of the local controller. It is not required to have remote control over the Validation function.

PS-651/CREATED/T
In order to validate the SCOIE interface cables, as well as the SCOIE functions, it shall be possible to connect the satellite end of the these cables back into the SCOIE.

PS-673/CREATED/T,R
The SCOIE validation tests shall be implemented such that there is minimal intervention by an operator during the validation activities.

PS-652/CREATED/R
Wherever possible any specific test aids required to verify a SCOIE function shall be built into the SCOIE rack.

PS-674/CREATED/R
SCOIE racks shall be interconnected with validation specific cables, if required.

PS-675/CREATED/T
The SCOIE validation shall be implemented in such a way as to ensure that the Umbilical functions can be fully validated without reliance on any other SCOIE equipment's.

PS-676/CREATED/T
Any external test equipment required for validation shall be controlled and monitored by the SCOIE local controller.

PS-656/CREATED/T
The SCOIE shall record the results taken during a validation in a specific validation log.

PS-657/CREATED/T
The results of a validation test shall be presented in a report format that will enable easy interpretation of the validation results.

PS-811/CREATED/T
The validation and Self test results shall only record a pass with a verified response. A 'no response' from a test or equipment shall be recorded as a failure.

12.1 SCOIE Self Test

In order to verify the operational status of the SCOIE equipment's and functions, a self test facility will be required. This will not be used to verify any cable interfaces and will largely consist of the SCOIE equipment's internal self test routines (e.g. for power supplies, etc.) together with the SCOIE protection functionality, etc.

PS-653/CREATED/T
It shall be possible to initiate a SCOIE self test at any time to report the operational status of the SCOIE equipment's and functions.
**PS-659/CREATED/T**

It shall be possible to carry out a SCOE self test with all SCOE interfaces connected to the satellite, without stimulating any of the interfaces.

**PS-660/CREATED/T**

Any SCOE equipment failure found during a self test shall be reported on the SCOE local controller.

**PS-661/CREATED/T**

The result of a self test shall be visible on the local controller at all times.

**PS-662/CREATED/T**

It shall be possible to continue to use the SCOE, following a self test failure, if the failure is verified by the SCOE system administrator.

**PS-663/CREATED/T**

It shall be possible to initiate a SCOE self test from the remote interface.

### 12.2 SCOE Validation Cable Interfacing Concept

Interfaces will be required on the SCOE racks to allow the SCOE interface cables to be connected back into the rack. This is only required for the contractor supplied interface cables. Any additional extension cables, for thermal vacuum, etc. will be verified separately.

The interface cable connection concept is shown in Figure 12-1.
Figure 12-1: Validation Interface Cable Connection Concept
13. VERIFICATION

PS-678/CREATED/A

The SCOE will be subject to full verification testing to prove compliance to the requirements detailed in this specification.

PS-679/CREATED/A

The verification tests shall be written by the SCOE contractor with final approval by Astrium.

PS-680/CREATED/A

The verification tests shall be performed by the SCOE contractor, at the contractor premises and witnessed, if deemed necessary, by Astrium.
14. PA REQUIREMENTS
PS-682/CREATED/A

The Product Assurance requirements for the SCOE shall be in accordance with the requirements of [AD-3].
Modified Objects

In the following table modifications to the Object Text attribute are shown using red line markup. For other attributes the new value and the old value are shown in separate columns.

The codes used in the object type (OT) column are: Rq = Requirement, Inf = Information, Hd = Heading, Ah = Applicability Matrix Heading, Ar = Applicability Matrix Requirement

<table>
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<td>Object</td>
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<td>Power / Pyro SCOE General Requirements</td>
<td>Power / Pyro SCOE General Requirements</td>
</tr>
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<td>Heading</td>
<td></td>
<td>LISA is a co-operative program between ESA and NASA to detect and measure 'ripples' in the fabric of space-time to verify tenets of fundamental physics. The program includes two space missions; The LISA-Pathfinder mission due to launch in 2009, and the LISA mission, due to launch, nominally, in 2013. LISA will consist of three spacecraft flying in a quasi-equilateral triangular formation, in a trailing Earth orbit at some 20 deg behind the Earth in a gravitational noise free 'Halo orbit' at the Lagrange 1 point. Within each spacecraft, a measurement system consisting of a test mass, associated laser interferometer measurement systems, and electronics will detect and measure low frequency gravitational waves. The test mass is maintained in a drag-free environment, i.e. shielded from spurious external forces, by using low thrust propulsion. This mission is currently in its formulation stage. LISA-Pathfinder is a precursor mission to LISA that aims to verify most of the challenging technologies necessary for LISA. The mission will last approximately 11 months, of which 6 are expected to be spent in scientific experiments.</td>
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<tr>
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<td>This document contains the contractually relevant requirements and constraints for the LISA Pathfinder Power /Pyro SCOE (hereafter known as the SCOE). This includes:</td>
<td></td>
</tr>
<tr>
<td>section 1.1</td>
<td>Text</td>
<td></td>
<td>In order to support the AIT activities on the power subsystem at test bench, system and launch stages of the LISA-Pathfinder project, the SCOE will consist of the following main elements:- Umbilical functions Solar Array Simulator (SAS) Battery Simulator Off-line Battery support Power Subsystem test support functions</td>
<td></td>
</tr>
<tr>
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<td>Object</td>
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<td>The SCOE shall consist of the following elements:</td>
<td></td>
</tr>
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<td>Text</td>
<td></td>
<td>Power / launch Umbilical support Umbilical Monitoring Interface Solar Array Simulator (SAS) Battery Simulator Off-line Battery Support Measurement Error Amplifier Test Interface Thermal Override Unit (TOU) Pyro Function Load Simulator Interface cables (15m from SCOE to Test interface bracket)</td>
<td></td>
</tr>
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<td>3.7</td>
<td>The parameters to be monitored by the remote interface (Core EGSE) shall be automatically and cyclically sent to the remote interface (Core EGSE) every at a time interval of between 1 and 10 seconds, configurable in 1 second increments (the default setting shall be 10 seconds).</td>
<td></td>
</tr>
<tr>
<td>PS-157</td>
<td>section</td>
<td>1.3</td>
<td></td>
<td>Figure 1.3-2: Power /Pyro SCOE general Interfaces</td>
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<td>PS-218</td>
<td>section</td>
<td>4.1.7</td>
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<td>PS-300</td>
<td>section</td>
<td>4.3.1</td>
<td></td>
<td>Table 4.3-1: UBV Receiver Interface Data Sheet—TBD</td>
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<td>PS-300</td>
<td>section</td>
<td>4.3.1</td>
<td></td>
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<tr>
<td>PS-301</td>
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<td>4.3.1</td>
<td></td>
<td>The transmitter (source) circuit for the EBV is included in Table 4.3-2 for reference.</td>
</tr>
<tr>
<td>PS-322</td>
<td>section</td>
<td>4.3.2</td>
<td></td>
<td>Table 4.3-3: EBV Receiver Interface Data Sheet—TBD</td>
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<td>section</td>
<td>4.3.2</td>
<td></td>
<td></td>
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<td>PS-323</td>
<td>section</td>
<td>4.3.2</td>
<td></td>
<td>The transmitter (source) circuit for the EBV is included in Table 4.3-42 for reference.</td>
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<td>PS-350</td>
<td>section 4.3.3</td>
<td>Object Text</td>
<td>Rq</td>
<td>The SCOE umbilical battery temperature monitor shall conform to the receiver circuit specification detailed in the Temperature Acquisition Type PT10YSI-44907/44908 data sheet (ANPANY), Table 4.3-53.</td>
</tr>
<tr>
<td>PS-352</td>
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<td>Inf</td>
<td>The transmitter circuit for the (ANPANY) is included in Table 4.3-64 for reference.</td>
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<td>Object Text</td>
<td>Rq</td>
<td>Table 4.3-53: PTType 1000 (ANPANY) Receiver Circuit Specification</td>
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<td>PS-415</td>
<td>section 6.2</td>
<td>Object Text</td>
<td>Rq</td>
<td>The load current shall be adjustable between 0.1A and 420A as a minimum.</td>
</tr>
<tr>
<td>PS-445</td>
<td>section 6.5</td>
<td>OLE</td>
<td>Inf</td>
<td></td>
</tr>
<tr>
<td>PS-458</td>
<td>section 9</td>
<td>Object Text</td>
<td>Inf</td>
<td>The three types of actuators will be:</td>
</tr>
<tr>
<td>PS-529</td>
<td>section 10.1</td>
<td>Object Text</td>
<td>Rq</td>
<td>Each SAS section shall have the capability to provide an open circuit voltage (Voc) of at least 0 to 681V (TBC).</td>
</tr>
<tr>
<td>PS-531</td>
<td>section 10.1</td>
<td>Object Text</td>
<td>Rq</td>
<td></td>
</tr>
<tr>
<td>PS-573</td>
<td>section 10.6</td>
<td>Object Text</td>
<td>Rq</td>
<td>Cable screens shall be terminated inside the SCOE rack ground to via the SCOE ground rack.</td>
</tr>
<tr>
<td>PS-579</td>
<td>section 10.6</td>
<td>OLE</td>
<td>Rq</td>
<td></td>
</tr>
<tr>
<td>PS-585</td>
<td>section 11.1</td>
<td>Object Text</td>
<td>Rq</td>
<td>The electronic load shall have a load capability of at least 3400W.</td>
</tr>
<tr>
<td>PS-603</td>
<td>section 11</td>
<td>Object Text</td>
<td>Inf</td>
<td>The definition of a LCL is:- a commandable solid state switch, which after switch on and in case of any overload on the output shall provide current limiting capability for a definite time. If the overcurrent condition exceeds this definite time, the outlet shall autonomously switch off. The characteristic of a typical LCL are shown in Figure 101.1.5-1 where Ilim is dependant on the LCL class and ttrip-off is between 8 and 15ms (TBC).</td>
</tr>
<tr>
<td>PS-620</td>
<td>section 11.3</td>
<td>Object Text</td>
<td>Rq</td>
<td>The interface between the Load Test Rack and the satellite shall be as shown in Figure 101.3-1, Figure 11.3-2, Figure 11.3-3 and Figure 11.3-4.</td>
</tr>
<tr>
<td>PS-621</td>
<td>section 11.3</td>
<td>Object Text</td>
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<tr>
<td>PS-622</td>
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<td>Inf</td>
<td>Figure 101.3-2: Load Test LCL/FCL AIT 3 Interface and -AIT TBD 3A Interface</td>
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<tr>
<td>PS-622</td>
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<td>Figure 101.3-3: Load Test LCL/FCL AIT 4 Interface and -AIT TBD 4A Interface</td>
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<td>Figure 101.3-4: Load Test LCL/FCL AIT 5 Interface → TBD</td>
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<td>The preliminary details of the LISA-Pathfinder heater circuits and thermostats are shown in Figure 78.0-3-1. for information (TBC).</td>
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<td>Figure 78.0-3-1: LISA-Pathfinder Heater and Thermostat circuits (TBC)</td>
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<tr>
<td>PS-645</td>
<td>Object Text</td>
<td>Rq</td>
<td>All SCOE interface cables shall be manufactured using screened twisted pair wirethe of most suitable gauge. The wire twisted for pairthe wresignal shalltype beapplied, furbere g, 'laytwisted twisted'screened topair form(TSP), aRS422 manageablecompatible cable, etc.</td>
<td></td>
</tr>
<tr>
<td>PS-682</td>
<td>Object Text</td>
<td>Rq</td>
<td>The Product Assurance requirements for the SCOE shall be in accordance with the requirements of [AD-43].</td>
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<td>PS-692</td>
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<td>Core-EGSE Interface Control Document</td>
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<td>PS-698</td>
<td>Object Text</td>
<td></td>
<td>[AD-43]</td>
<td></td>
</tr>
<tr>
<td>PS-743</td>
<td>Object Text</td>
<td>Rq</td>
<td>The SCOE back up battery shall be sized such to allow all four battery safety relay OPEN commands to be sent at least 3 times without the need for recharging the battery.</td>
<td></td>
</tr>
<tr>
<td>PS-756</td>
<td>Object Text</td>
<td>Rq</td>
<td>The resistance between each pin on the TM/TC bypass connector and its corresponding pin at the satellite end of the 15 metre SCOE interface cables shall be &lt;0.52W.</td>
<td></td>
</tr>
<tr>
<td>PS-822</td>
<td>Object Text</td>
<td>Rq</td>
<td>The Bus support power supply ripple outputand voltage spikes shallpresent havon &lt;280mvthe (1%output of nominalthe busBus voltage)support peak-to-peak power ripple supply measuredshall inconform theo timelines the domain requirements between of 3[AD-0Hz] and section 50MHz into a resistive load 12.1.</td>
<td></td>
</tr>
</tbody>
</table>
### Identifier | Attribute | OT | New Text | Old Text
--- | --- | --- | --- | ---
PS-823 section 4.1.4 | Object Text | Rq | The Bus support power supply output voltage shall have <560mV (2% of nominal bus voltage) peak-to-peak spikes, measured in the time domain, between 30Hz and 50MHz into a resistive load. | deleted |
PS-827 section 4.1.5 | Object Text | Rq | The Bus support power supply output current, while in-operating in constant current mode, shall vary by <1% FS for an output voltage transition of ±10 volts. | deleted |
PS-828 section 4.1.4 | Object Text | Rq | The Bus support power supply output current shall have <50mA peak-to-peak ripple, measured in the time domain, between 30Hz and 50MHz into a resistive load. | deleted |
PS-829 section 4.1.4 | Object Text | Rq | The Bus support power supply output current shall have <80mA peak-to-peak spikes, measured in the time domain, between 30Hz and 50MHz into a resistive load. | deleted |
PS-830 section 10.1 | Object Text | Rq | The SAS shall be capable of simulating 6 individual array sections (SAS section) (TBC). | deleted |
PS-855 section 10.3 | Object Text | Rq | For transition times greater than 60 seconds the actual value of the transition time shall be within ±0.165% FS, or better, of the time set (FS shall be taken as 5 minutes). | deleted |
PS-862 section 10.4 | Object Text | Rq | The SAS shall be capable of simulating 6 individual array sections (SAS section) (TBC). | deleted |
PS-863 section 10.4 | Object Text | Rq | The SAS output voltage shall have <560mV (2% of nominal bus voltage) peak-to-peak spikes, measured in the time domain, between 30Hz and 50MHz into a resistive load. | deleted |
PS-864 section 10.4 | Object Text | Rq | The SAS output current shall have <50mA peak-to-peak ripple, measured in the time domain, between 30Hz and 50MHz into a resistive load. | deleted |
PS-865 section 10.4 | Object Text | Rq | The SAS output current shall have <80mA peak-to-peak spikes, measured in the time domain, between 30Hz and 50MHz into a resistive load. | deleted |

**Inserted Objects**

| Identifier | Object Type | Text |
--- | --- | ---
PS-867 section 7.1 | Information | The MEA testing scheme is dependant on the PCDU supplier, so details will only be available when a supplier has been chosen. |
PS-868 section 3.12 | Requirement | Each cable shall be indelibly part marked as detailed in [AD-1] Paragraph 5.15. |
PS-870 section 3.12 | Requirement | Multiple wires within a cable shall be 'lay twisted' between 150mm and 500mm, depending on wire type, in order to form a manageable cable. |
PS-871 section 3.12 | Requirement | The wire type used for the cable construction shall be suitably flexible, at ambient temperature, in order to allow easy 'run out' of the cables between the SCOE and their destinations. |
PS-872 section 3.12 | Requirement | The cable construction shall be suitably robust in order to survive the rigours of a full AIV test campaign, involving several SCOE relocations. |
PS-873 section 4.4.2.1 | Requirement | The TM/TC Bypass to Power SCOE cable, shown in Figure PS-406, shall be provided with the SCOE. |
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<th>Identifier</th>
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</thead>
<tbody>
<tr>
<td>PS-874 section 4.4.2.1</td>
<td>Requirement</td>
<td>The TM/TC Bypass to Power SCOE cable shall be manufactured in accordance with the pertinent details contained in [AD-2].</td>
</tr>
<tr>
<td>PS-875 section 1.3</td>
<td>Information</td>
<td>The Battery Isolation Box (BIB) is shown in Figure PS-157 for completeness, it does not form part of the SCOE delivery. The BIB will be fitted to the satellite Offline Battery Support skin connector and utilised to isolate this interface from the live battery. This will ensure hazard free connection and disconnection of the EGSE cables from the battery.</td>
</tr>
<tr>
<td>PS-876 section 3.6</td>
<td>Requirement</td>
<td>The test configuration file auto-generated file names shall contain at least a time / date reference.</td>
</tr>
<tr>
<td>PS-877 section 3.6</td>
<td>Requirement</td>
<td>The test configuration file unique names shall be auto-generated, with the ability to be edited by the user before saving.</td>
</tr>
<tr>
<td>PS-878 section 10.6</td>
<td>Requirement</td>
<td>Each SAS section output shall incorporate an easily adjustable matching network in order to allow the section effective capacitance and inductance to be set as close as possible to the actual solar array parameters.</td>
</tr>
<tr>
<td>PS-880 section 2.3</td>
<td>TBD</td>
<td>[RD-6]</td>
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<td>PS-881 section 2.3</td>
<td>TBD</td>
<td>S2.ASU.RS.2012</td>
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<tr>
<td>PS-882 section 2.3</td>
<td>TBD</td>
<td>LISA-Pathfinder OBC Specification</td>
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<tr>
<td>PS-884 section 5</td>
<td>Heading</td>
<td>Battery Simulator</td>
</tr>
<tr>
<td>PS-885 section 5</td>
<td>Information</td>
<td>The Battery Simulator will be required to simulate, as close as practicable, the LISA-Pathfinder flight battery, which will be a Lithium-ion 30 to 36Ahr, 29V unit.</td>
</tr>
<tr>
<td>PS-886 section 5.3</td>
<td>Heading</td>
<td>Battery Charge</td>
</tr>
<tr>
<td>PS-887 section 5.3</td>
<td>Requirement</td>
<td>The Battery Simulator shall be capable of simulating the Lithium-ion taper charge functionality. Note - it is not necessary to simulate the change in battery terminal voltage as a function of battery state-of-charge. It is sufficient for the Battery Simulator to present a constant voltage load to the satellite bus.</td>
</tr>
<tr>
<td>PS-888 section 5.3</td>
<td>Requirement</td>
<td>The Battery Simulator shall be capable of sinking at least 20A from the satellite bus.</td>
</tr>
<tr>
<td>PS-890 section 5.1</td>
<td>Heading</td>
<td>General</td>
</tr>
<tr>
<td>PS-891 section 5.1</td>
<td>Requirement</td>
<td>The Battery Simulator shall be capable of simulating the following functions: The charge and discharge functionality of a 29V 30-36 Ahr lithium-ion batteryBattery thermistorsBattery heaters</td>
</tr>
<tr>
<td>PS-892 section 5.1</td>
<td>Requirement</td>
<td>It shall be possible to set the Battery Simulator terminal voltage, as a minimum, between 18V and 30V.</td>
</tr>
<tr>
<td>PS-893 section 5.1</td>
<td>Requirement</td>
<td>The actual value of the Battery Simulator terminal voltage, at the satellite end of the Battery Simulator interface cables, shall be within ±0.2% FS or better of the value set, under all steady state load or charge conditions.</td>
</tr>
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<tr>
<td>PS-894 section 5.3</td>
<td>Requirement</td>
<td>The value of the Battery Simulator charge current shall be displayed on the SCOE local controller with a resolution of 100mA, or better.</td>
</tr>
<tr>
<td>PS-895 section 5.3</td>
<td>Requirement</td>
<td>The Battery Simulator charge current shall be monitored by the SCOE with an accuracy of ±0.1% FS or better.</td>
</tr>
<tr>
<td>PS-896 section 5.1</td>
<td>Requirement</td>
<td>The value of the Battery Simulator terminal voltage shall be displayed on the SCOE local controller with a resolution of 10mV, or better.</td>
</tr>
<tr>
<td>PS-897 section 5.1</td>
<td>Requirement</td>
<td>It shall be possible to set the Battery Simulator terminal voltage with a resolution of 10mV or better.</td>
</tr>
<tr>
<td>PS-898 section 5.1</td>
<td>Requirement</td>
<td>The value of the Battery Simulator terminal voltage shall be monitored by the SCOE with an accuracy of ±0.1% FS, or better.</td>
</tr>
<tr>
<td>PS-899 section 5.4</td>
<td>Heading</td>
<td>Battery Discharge</td>
</tr>
<tr>
<td>PS-900 section 5.4</td>
<td>Requirement</td>
<td>The Battery Simulator shall be capable of sourcing at least 20A to the satellite bus.</td>
</tr>
<tr>
<td>PS-901 section 5.1</td>
<td>Requirement</td>
<td>The Battery Simulator shall be able to seamlessly transfer from charge to discharge mode and vice versa without the need for user intervention.</td>
</tr>
<tr>
<td>PS-902 section 5.4</td>
<td>Requirement</td>
<td>The value of the Battery Simulator discharge current shall be displayed on the SCOE local controller with a resolution of 100mA, or better.</td>
</tr>
<tr>
<td>PS-903 section 5.4</td>
<td>Requirement</td>
<td>The Battery Simulator discharge current shall be monitored by the SCOE with an accuracy of ±0.1% FS or better.</td>
</tr>
<tr>
<td>PS-906 section 5.1</td>
<td>Requirement</td>
<td>It shall be possible to change the Battery Simulator terminal voltage during charging and discharging activities without interruption to the charging or discharging functions</td>
</tr>
<tr>
<td>PS-907 section 5.5</td>
<td>Heading</td>
<td>Thermistor Simulation</td>
</tr>
<tr>
<td>PS-908 section 5.5</td>
<td>Requirement</td>
<td>The Battery Simulator shall simulate three battery thermistors of type &quot;ANY&quot;, details of which are shown in Table PS-371:One prime temperature monitor to the OBCOne redundant temperature monitor to the OBCOne umbilical temperature monitor to the EGSE</td>
</tr>
<tr>
<td>PS-910 section 5.6</td>
<td>Heading</td>
<td>Heater Simulation</td>
</tr>
<tr>
<td>PS-911 section 5.6</td>
<td>Requirement</td>
<td>The Battery Simulator shall provide two simulated heaters (prime and redundant).</td>
</tr>
<tr>
<td>PS-912 section 5.7</td>
<td>Heading</td>
<td>Terminal Voltage Monitors</td>
</tr>
<tr>
<td>PS-913 section 5.7</td>
<td>Requirement</td>
<td>The Battery Simulator shall provide three Battery terminal voltage monitors:One prime voltage monitor to the OBCOne redundant voltage monitor to the OBCOne umbilical voltage monitor to the EGSE</td>
</tr>
<tr>
<td>PS-914 section 5.7</td>
<td>Requirement</td>
<td>Each voltage monitor shall be individually protected by a 10kW ±1% resistor to simulate the flight battery monitoring interface.</td>
</tr>
<tr>
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</tr>
<tr>
<td>PS-915</td>
<td>Requirement</td>
<td>The heaters may be simulated by suitable static, low inductance, resistors of 175W ±1%, 5W.</td>
</tr>
<tr>
<td>PS-916</td>
<td>Requirement</td>
<td>It shall be possible to individually adjust the value of the Battery Simulator thermistors in order to simulate temperature values between 5°C and 25°C, as a minimum. Note - it is acceptable to have a manual adjustment of the thermistors at the Battery Simulator front panel, if necessary.</td>
</tr>
<tr>
<td>PS-917</td>
<td>Requirement</td>
<td>It shall be possible to adjust the value of the Battery Simulator thermistors with a resolution of 0.5°C, or better.</td>
</tr>
<tr>
<td>PS-918</td>
<td>Heading</td>
<td>Battery Simulator Interface</td>
</tr>
<tr>
<td>PS-919</td>
<td>Information</td>
<td>The Battery Simulator will connect directly to the on-board flight battery harness and will be situated in close proximity to the satellite.</td>
</tr>
<tr>
<td>PS-920</td>
<td>Requirement</td>
<td>The input DC resistance of the Battery simulator, including the 3m interface cables, shall be 20mW &lt; R &lt; 60mW</td>
</tr>
<tr>
<td>PS-921</td>
<td>Requirement</td>
<td>The interface between the Battery Simulator and the satellite shall be as shown in Figure PS-930. The exact details of this interface are not presently known and will only be defined after the battery supplier selection.</td>
</tr>
<tr>
<td>PS-922</td>
<td>Requirement</td>
<td>Cable screens shall be terminated to SCOE ground via the Battery Simulator rack.</td>
</tr>
<tr>
<td>PS-924</td>
<td>Requirement</td>
<td>The AC input resistance of the Battery Simulator shall be: - lower than 190 mW for a frequency of up to 2 kHz - lower than 750 mW for 2kHz &lt; f &lt; 10 kHz This shall include the effects of any power supply and load control loops in the Battery Simulator.</td>
</tr>
<tr>
<td>PS-925</td>
<td>Requirement</td>
<td>The set temperature value of each thermistor shall be individually displayed on the SCOE local controller with a resolution of 0.1°C, or better.</td>
</tr>
<tr>
<td>PS-926</td>
<td>Requirement</td>
<td>The set temperature of each thermistor shall be monitored by the SCOE with an accuracy of 0.5% FS, or better</td>
</tr>
<tr>
<td>PS-927</td>
<td>Requirement</td>
<td>The Battery Simulator shall be controlled from the SCOE local controller.</td>
</tr>
<tr>
<td>PS-928</td>
<td>Requirement</td>
<td>The Battery Simulator will require to be located close to the satellite, therefore all interfaces between the Battery Simulator and the SCOE controller and other SCOE racks shall be 15m, or more.</td>
</tr>
<tr>
<td>PS-929</td>
<td>Requirement</td>
<td>The Battery Simulator Interface cables shall exit the Battery Simulator rack as close as possible to the top of the rack (on the rear). This is to allow for the interface cables to be as short as possible and still allow connection to the satellite battery harness in all satellite orientations.</td>
</tr>
<tr>
<td>PS-930</td>
<td>Information</td>
<td>[wdFCaption: Battery Simulator Interface]</td>
</tr>
<tr>
<td>PS-931</td>
<td>TBD</td>
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<td>PS-933</td>
<td>Requirement</td>
<td>An overvoltage occurrence on the Battery terminal voltage shall be able to trigger the SCOE local protection facility.</td>
</tr>
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<tr>
<td>PS-934</td>
<td>Requirement</td>
<td>An overvoltage occurrence on the Battery terminal voltage shall be able to trigger the SCOE system protection facility.</td>
</tr>
<tr>
<td>PS-935</td>
<td>Requirement</td>
<td>The SCOE protection facility shall be triggered if the Battery terminal voltage exceeds a preset value by a maximum of 250mV, but should never be able to exceed 30V.</td>
</tr>
<tr>
<td>PS-936</td>
<td>Requirement</td>
<td>It shall be possible to set the Battery Terminal overvoltage protection between 18V and 30V.</td>
</tr>
<tr>
<td>PS-937</td>
<td>Requirement</td>
<td>It shall be possible to set the Battery Terminal overvoltage level with a resolution of 100mV or better.</td>
</tr>
<tr>
<td>PS-938</td>
<td>Requirement</td>
<td>The actual value of the Battery Terminal overvoltage level shall be within ±1% FS or better of the value set.</td>
</tr>
<tr>
<td>PS-939</td>
<td>Requirement</td>
<td>The local controller shall display the value of the overvoltage protection.</td>
</tr>
<tr>
<td>PS-941</td>
<td>Requirement</td>
<td>Precautions shall be taken to maintain the integrity of any flight standard connectors fitted to the Battery Simulator Interface cables. This shall be achieved by ensuring that the Battery Simulator Interface cables are only mated to flight standard connectors during Battery Simulator development and test activities.</td>
</tr>
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**Deleted Objects**

PS-302 section 4.3.1 : Information
PS-324 section 4.3.2 : Information
PS-694 section 2.1 : TBD
PS-695 section 2.1 : TBD
PS-696 section 2.1 : TBD

129 differences found
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<tr>
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<tr>
<td>PS-514 ..........4.5</td>
<td>PS-635 ..........8</td>
</tr>
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<td>PS-533 ..........10.1</td>
<td>PS-650 ..........12</td>
</tr>
<tr>
<td>PS-534 ..........10.1</td>
<td>PS-651 ..........12</td>
</tr>
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<td>PS-541 ..........10.1</td>
<td>PS-656 ..........12</td>
</tr>
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<td>PS-657 ..........12</td>
</tr>
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</tr>
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</tr>
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<td>PS-682 ..........14</td>
</tr>
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<td>PS-571 ..........10.6</td>
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<td>PS-742 ..........4.3.2.2</td>
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<td>PS-743 ..........4.2.1.2</td>
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</table>

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## DOCUMENT CHANGE DETAILS

<table>
<thead>
<tr>
<th>ISSUE</th>
<th>CHANGE AUTHORITY</th>
<th>CLASS</th>
<th>RELEVANT INFORMATION/INSTRUCTIONS</th>
</tr>
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<tbody>
<tr>
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<td>-</td>
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<td>Replaced TBD’s where possible, enhanced requirements in line with latest flight equipment requirements.</td>
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<td>-</td>
<td>-</td>
<td>Ripple and spike requirements modified – ESA RID SY-038. Added Battery Simulator requirements – ESA RID SY-039. Added ‘Derived from’ in place of ‘Created’ for the origin of requirements, where necessary – ESA RID SY-040. SAS Voc value increased to from 65V to 81V in line with the PCDU requirement spec – ESA RID SY-041.</td>
</tr>
</tbody>
</table>

## DISTRIBUTION LIST

### INTERNAL
- S. Amos
- D. Head
- R. Gray
- H. Sondermann (ASD)
- Configuration Management

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