HIRDLS

HIGH RESOLUTION DYNAMICS LIMB SOUNDER

Originators: Stan Jaroslawski Date: 2000-11-22

Subject / Title: Power Subsystem Specifications Document

Contents / Description / Summary:

This document defines the requirements and the specifications for the Power Converter Unit (PCU).
The PCU is a subsystem within the HIRDLS Instrument. Its main function is to provide DC Power for the Instrument. Driving elements in the design of the PCU are Power Requirements of the component Subsystems of the HIRDLS instrument, specifications of Power interfaces with the spacecraft and the design rules defined in the GIRD and the SP-HIR-169, and the Reliability specifications.
In its operations the PCU is totally controlled by Instrument Processor Unit (IPU). The IPU also monitors PCU's performance and status.

Key Words: Power Converter Unit , PCU

Purpose (20 characters maximum): To define the requirements and Specifications of the PCU

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HIRDLS Power Subsystem Requirements and Specifications

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Log of Changes

Rev	Date	Section	Change Description /Reason to Change
	99-05-20	All	Initial Release
A	00-01-25	Sig. Page	Removed Mike Dials
		2.1	Added Instrument Contamination Plan PM-HIR-006 HPD(17)
		2.2.	New Applicable Document NHD(5)
		3.2.1.1	Added information about Primary Power lines switched in the PCU
		3.2.2.1.1.	New specifications for the PCU internal Star Points
			Fig.3.2.1.2. deleted – information available in HPD (2) and NHD (1).
		3.2.1.2.1	Input Voltage range (Primary Power) changed to 27 –31 Volts
		3.2.1.2.8.	Deleted – Overcurrent protection does not apply to PCU
		3.2.2.2.1	Table 3.2.2.2.1. – Line Voltage limits changed to 29.5V and 30.5V.
		3.2.2.3	Table 3.2.2.3. Max. PCU Output resistance deleted
		3.2.2.4.	Table 3.2.2.4.1. Max PCU Output resistance deleted
			Table 3.2.2.4.2. Max PCU output resistance deleted
		3.2.3.2	Table 3.2.3.2 delete items 5 and 6 – change of specification
		3.2.4.3	Change in specification of Secondary Power Star Point
		3.2.6.1.3	Deleted Acceleration requirement. Already covered: 3.2.6.2.2
		3.2.6.1.4	Non-operational thermal: Updated survival temperatures to latest analysis.
		3.2.6.1.6	Pressure Decay. Removed TBD and non-applicable text.
		3.2.6.2.1	In Orbit Pressure Environment, removed TBR
		3.2.6.2.2	In Orbit Acceleration: directed requirement to GIRD.
		3.2.6.2.3	In Orbit Vibrational Envior. Deleted Requirement
		3.2.6.2.4	In Orbit Thermal Environment updated temps to latest anal.
		3.2.6.2.5	Specification for SEL and latchup added
		3.2.7	Cleanliness: Removed TBR
		3.2.7.1	Corrected paragraph number. Changed reference to Instrument Contamination Plan HPD (17)
		3.2.9.1	PCU Mass changes to 10kg
		3.3.3	Outgassing. Removed TBV
		4.2.1.6	Method of test of Mechanical Interfaces changed to “I”; Double entry of “Venting” rectified
		4.3	Fig. 4.3 PCU Test Sequence changed Protoflight tests: change from Limited Performance Test to Comprehensive Performance Test in the Pre-delivery Tests box
		4.3.1.2.	Comprehensive Performance Test changed to include tests at 27Volts , 29Volts and 31Volts input voltage (Primary Power) and for the “A” and “B” Converters
		4.3.1.3.	Limited Performance Tests changed to include tests for the “A” and the “B” Converters. Measurement of Power Dissipation deleted.
		4.3.1.4.	Final Performance Tests –Pre-delivery tests changed to include test of on the fasteners.
		4.3.1.5.	New Section – Mechanical Properties Test
		4.2.2.1	Deleted Section
		4.3.2.3	Fig. 4.3.2.3. Test Profile updated
		4.2.2.2.3	Corrected Reference to STH-PSS ICD, HPD (7)
		4.2.1.6	VCRM: Changed verification of 3.2.6.1.2 Sine Vibration from N/A to T
		6.1	Functionality of the Switching Network updated

		6.2.	Table of Analogue Telemetry changed to show one column of Scaling Factors.
		6.3.	Digital Telemetry updated
B	00-06-02	2.0	Deleted reference to CU as document source.
		2.1	Changed HPD(1) (ITS) to GSFC number Corrected document title and number on HPD(8) Corrected name on HPD(10) Added "HPD(17) HIRDLS Subsystems Environmental Requirements SP-HIR-188 "
		2.2	Corrected Title of NHD(2), D6477
		3.1	Changed "CCS" to "CSS" Deleted duplicate "and Safety"
		3.2.1.2	Updated operational voltage range to reflect Spacecraft ICD.
		3.2.1.2.6	Removed requirement to survive polarity reversal
		3.2.1.2.8.	Deleted – Overcurrent protection does not apply to PCU
		3.2.2.1.1	Removed mention of CSS_COM_GND. Spec now conforms to ICD.
		3.2.2.1.3	Table 3.2.2.1.3. Corrected IPU 28VQB power (watts). Corrected TEU +5V power (watts). Collected all PCU power under 28V. Corrected Notes and references in table.
		3.2.2.1.4	Table 3.2.2.1.4. Deleted PCU row. Not a measured output of the PCU.
		3.2.2.2.1	Table 3.2.2.2.1 changed and noise frequency range to match ICD
		3.2.2.2.2	Table 3.2.2.2.2 Corrected ripple voltage for each rail. Changed to "Vpp" to match IPS-PSS ICD.
		3.2.2.3	Table 3.2.2.3: Updated voltage limits to revision B of the ICD
		3.2.2.4	Table 3.2.2.4.1: Updated voltage limits to revision B of the ICD
		3.2.2.4	Table 3.2.2.4.2: Updated voltage limits to revision B of the ICD
		3.2.2.4.1	Corrected nomenclature
		3.2.2.4.2	Corrected nomenclature
		3.2.3.2.2	Number of Direct Commands changed to eight, four from each (A and B) IPU Command and Control interface
		3.2.6.1.4	Specification for "Shock" deleted per GSFC Waiver
		3.2.6.1.5	Survival temperatures changed to "-39°C and +60°C". "The PSS shall survive temperatures specified in HPD(10)" removed – it is a repetition of the preceding sentence.
		3.2.6.1.7	"TBD" replaced by "The PSS shall be designed to withstand a maximum atmospheric pressure decay specified in NHD(1) Section 10.5 and without malfunction or degradation of performance."
		3.2.6.2.1	…"a period of "six (6) (TBR) years" changed " a period of 5 years".
		3.2.6.2.4	Changed to "The PSS shall perform as specified herein during exposure to operational temperatures between -5°C and +50°C. This range includes the required +/-10degC test margins. Added cold start at -39°C
		3.2.6.3	Deleted section. Duplicates other sections
		3.2.8.3	Deleted explanatory text.
		3.2.9.1	Changed mass allocation to ITS Rev. U (GSFC initial issue) value.
		3.2.7	Entire section on "Cleanliness" changed for a section on "Contamination Controls"
		3.2.9.1	Changed to reflect ITS allocation
		3.2.9.4	Added phrase "external to the PCU chassis". Deleted second sentence.
		3.3.3	Deleted duplicate Outgassing requirement
		4.2.1.6	VCRM; Peak and Average Power, changed to "N/A", no requirement to verif.

			Sine Vibe changed to "T" Shock requirement deleted Relative Humidity changed to "A" Venting changed to "A"
		4.2.2.2.3	Corrected reference for geometry specs.
		4.2.2.2.4	Corrected reference for mechanical interface
		4.2.2.2.4	Corrected reference to STH-PSS ICD, HPD (7)
		4.3	Test and Integration Task Flow: Limited Performance Tests replaced by Electrical Interfaces Verification Tests in Pre-Vibration and Post Vibration Tests. Limited Performance Tests added to the EMC . Limited Performance Tests and Electrical Interfaces Verification Tests added to Thermal Tests. Mass Properties Tests moved to Pre-Vibration Tests and Inspection Box. PCU C.G. test added to the Post Vibration Tests Thermal Balance Test remove Vibration Tests: Specification SP-HIR-188
		4.3.1.1	Corrected reference to HPD(8)
		4.3.1.2	Added text: "Output Voltages shall be measured for each loaded PCU output. This shall include a record of analogue telemetry."
		4.3.1.3.	.New Section – Electrical Interface Verification Tests
		4.3.1.4.	Limited Performance Tests changed. Now also includes tests for the "A" and the "B" Converters. Measurement of Power Dissipation and Data and Control Interface deleted. Measurement of Current Transients added. The last paragraph changed to "These tests will be done with Primary Power supplied at any input voltage in the range of 27Volts and 31Volts. The tests shall be done for the "A" and for the "B" Sides (The TSS, Quiet Bus, and Noisy Bus), and for the Prime and Redundant converters of the PCU. The tests shall verify the performance of Primary Power and Secondary Power switching performed in the PCU.
		4.3.1.6	New Section – Mechanical Properties Test
		4.3.1.8	PCU Thermal-Vacuum Test Profile updated to show four and a half cycles and operating temperature limits between –5°C and +50°C. Tests on rising and falling edges of one of the thermal cycles added. Electrical Interfaces Test added. Identified LPTs. Moved cold start to -39°C. Deleted last sentence (TBC). Corrected confusing note 3).
		4.3.1.9	Corrected reference to HPD(8)
		4.3.1.9.1	Deleted section. No requirement specified.
		4.3.1.9.2	Deleted section. No requirement specified.
		4.3.1.9.3	Deleted section. No requirement specified.
		4.3.1.11	Corrected reference to HPD(8)
		4.3.1.12.5	"TBR" Removed
		4.3.1.12.7	Removed exception and associated TBD.
		4.3.2.2.	Section on Thermal Balance removed
		6.2	Table of Analogue Telemetry: Scaling Factors added. Line 27 changed to: Temperature; +15Volts DC-DC Converter SPU B Line 28 changed to: Temperature; -15Volts DC-DC Converter SPU A Line 29 changed to: Temperature; -15Volts DC-DC Converter SPU B
		6.2.7	Lower limit changed to 25.5Volts

1. SCOPE

This document defines the requirements specifications of the Power Converter Unit (PCU). The specifications comply with characteristics of Primary Power Interfaces with the spacecraft designated Quiet Bus A , Quiet Bus B; and Noisy Bus A and Noisy Bus B. The Buses are defined in the documents referenced NHD (1) and NHD (2).
The specifications define operational functionality of the PCU and reflect Power switching requirements of HIRDLS subsystems. The document also covers the PCU performance and status monitoring.

2. Applicable Documents

Design of Power Converter Unit is based on the documents listed below. There are two basic kinds of reference documents; the HIRDLS Program Documents and the Non-HIRDLS Documents. In the event of conflict the information held in the HIRDLS program documents shall take precedence over the information provided in the Non-HIRDLS documents.

2.1 HIRDLS Program Documents

Current Version of the documents shall apply

REF. No.	Title	Document Reference
HPD (1)	Instrument Technical Specifications (ITS)	GSFC28-21-13
HPD (2)	HIRDLS Power Distribution, Switching and Grounding	SP-HIR-169
HPD (3)	IPS to PSS Interface Control Document (ICD)	SP-HIR-279
HPD (4)	CSS to PSS Interface Control Document (ICD)	SP-HIR-289
HPD (5)	GSS to PSS Interface Control Document (ICD)	SP-HIR-239
HPD (6)	TSS to PSS Interface Control Document (ICD)	SP-HIR-249
HPD (7)	STH to PSS Interface Control Document (ICD)	SP-HIR-219
HPD (8)	HIRDLS Verification Specification	SP-HIR-064
HPD (9)	HIRDLS Performance Verification Plan	TP-HIR-008
HPD (10)	HIRDLS Thermal Interface Requirements	SP-HIR-111
HPD (11)	Power Converter Unit Random Vibration Specification	TC-LOC-286
HPD (12)	RAL Performance Assurance Plan	PA-RAL-12
HPD (13)	Electromagnetic Compatibility Control Plan	SP-LOC-084
HPD (14)	Command and Telemetry Handbook	SP-HIR-103

HPD (15)	Electronic Parts Radiation Requirements	TC-UCB-017
HPD (16)	Performance Assurance Implementation Plan for High Resolution Dynamics Limb Sounder (HIRDLS) Instrument Programme	PA-HIR-0003A
HPD (17)	HIRDLS Subsystem Environmental Requirements	SP-HIR-188

2.2 Non-HIRDLS Documents

Current Versions of the documents shall apply

Ref. No.	Document Title	Document Reference
NHD(1)	General Interface Requirements Document (GIRD) for EOS Common Spacecraft/Instruments	GSFC 422-11-12-01
NHD (2)	Interface Control Document for the High Resolution Dynamics Limb Sounder (HIRDLS), EOS Common Spacecraft Project	D26477
NHD (3)	Mission Assurance Requirements for the High Resolution Dynamics Limb Sounder (HIRDLS) EOS Chemistry Mission	GSFC 424-11-13-01
NHD(4)	Unique Instrument Interface Document for HIRDLS (UIID)	GSFC 424-28-21-06
NHD(5)	Torque Settings for Screw Fasteners (RAL Document)	ISO:SPAS/ MECH/001

2.3 Acronyms

Acronym	Definition
ATM	Analogue Telemetry
DTM	Digital Telemetry
HPD	HIRDLS Program Document
ICD	Interface Control Document
NHD	Non-HIRDLS Document
PR	Prime Relay
RR	Redundant Relay (Standby Relay)
TBR	To Be Revised
TBV	To be Verified

3. Power Converter Unit (PCU) Design Requirements.

Power Converter Unit shall be a single point Primary Power interface for the HIRDLS Instrument. The PCU shall implement redundancy in the Primary Power supply by providing separate interfaces with the spacecraft Quiet Bus A and B, and with the spacecraft Noisy Bus A and B.
The PCU power outputs shall match the requirements of HIRDLS sub-systems.
Power Converter Unit shall be housed in its own enclosure within the HIRDLS envelope.
The mechanical interface with the spacecraft shall be through one side (the base) of the PCU enclosure.
Links with the rest of the Instrument and with the spacecraft shall be made through a harness connecting onto a set of 11 connectors.
The thermal design of the PCU shall be based on a Radiator radiating heat directly into Space.

3.1 PCU Functional Specifications

Functionality of the PCU shall reflect Power Requirements and Power Switching Requirements of the HIRDLS sub-systems HPD (1), HPD (2). The PCU shall generate all control lines for switching operations of the Primary and of the Secondary Power and for monitoring the performance. In all these operations the PCU shall act as a slave to the IPS.
The requirements of the sub-systems range between being supplied the Primary Power directly (not switched) to the IPU, switched Primary Power to the TSS, GSS, and CSS, and switched Secondary Power for the Instrument.
The PCU shall provide Analogue and Digital Telemetry defining its operational Health and Safety. The Analogue Telemetry shall comprise a representative set of Voltages and Temperatures.
In addition the PCU shall measure Input Current to the HIRDLS instrument on the Quiet Bus A and Quiet Bus B. The result of this measurement shall be included in the Analogue Telemetry set.
The digital Telemetry shall provide information about the status of the switching network.
The PCU shall implement the overall In Rush control for the Quiet Bus A and Quiet Bus B Power lines supplying Primary Power on those Buses to all sub-systems excluding the IPU.

3.1.1 Primary Power

The Primary Power shall be supplied to the sub-systems listed below. Each Primary Power link shall comprise *Power* and *Power Return*.

3.1.1.1 The IPS

Two direct and not switched links with the spacecraft Primary Power shall be provided for the IPS; one with the Quiet Bus A and the other with the Quiet Bus B.

3.1.1.2 The TSS

Two switched Primary Power links shall be provided for the TSS.

3.1.1.3 The GSS

One switched Primary Power link shall be provided for the GSS.

3.1.1.4 The CSS

The Primary Power for the CSS shall be obtained from the Noisy Bus A and the Noisy Bus B. The PSS shall implement a switched Wire-OR of the two inputs and shall supply the CSS with a single set of lines comprising *Power* and *Power Return*. Both *Power* and *Power Return* lines shall be included in the Wire-OR.

3.1.1.5 The PSS

The PCU Internal Power shall be supplied directly from the Quiet Bus A and the Quiet Bus B on separate and switched Power lines.
Primary Power shall be supplied to the on board DC-DC Converter through switched lines

3.1.2 Secondary Power

The Secondary Power shall be generated by the PSS and supplied to the sub-systems listed below. Secondary Power links with each sub-system shall comprise a required set power rails and a common sub-system Return. All Secondary *Power* lines shall be switched in the PCU. The PSS shall implement a detachable link in each common *Return*.

3.1.2.1 The IPS

The PSS shall supply the two switched and redundant Power rails at +30Volts for the IPU.
The PSS shall also provide redundant Secondary Power to the SPU at +/-15 Volts (nominal) and at +5Volts (nominal). The SPU power supply shall not be shared with any other sub-system.

3.1.2.2 The TSS

The PSS shall supply redundant Secondary Power to the TEU at +/-15Volts (nominal) and at +5Volt (nominal). The PSS shall also supply a single set of the Secondary Power rails to the EEA at +/-15Volts (nominal) and +5Volts (nominal).

3.1.2.3 The GSS

The PSS shall supply a single set of Secondary Power rails to the GSS at +/-15Volts (nominal) and at +5Volts (nominal).

3.2 PSS Interfaces Specifications.

PSS shall implement Electrical Interfaces with the spacecraft Primary Power, Electrical Interfaces with the sub-systems, Mechanical interface with HIRDLS Structure, and Thermal Interface with Space.

3.2.1 Primary Power Interface with the Spacecraft.

Primary Power Interface between PSS and the spacecraft shall be compliant with document references: HPD (1) Section 3.7.1, NHD (1) Section 5, NHD (2) Section 5 as defined below.

3.2.1.1 General Information.

HIRDLS shall be provided with three types of redundant Power interfaces with the spacecraft. The three types of interfaces are designated: The Quiet Bus, the Noisy Bus., and the Survival Heater Power Bus The Prime and the Redundant buses are known as Bus "A" and Bus "B" respectively.
The PSS shall interface to the Spacecraft through the Quiet Bus and the Noisy Bus as shown in Fig, 3.2.1.1.
Both Power_Power and Power_Returns lines shall be switched inside the PCU as shown in HPD (2).

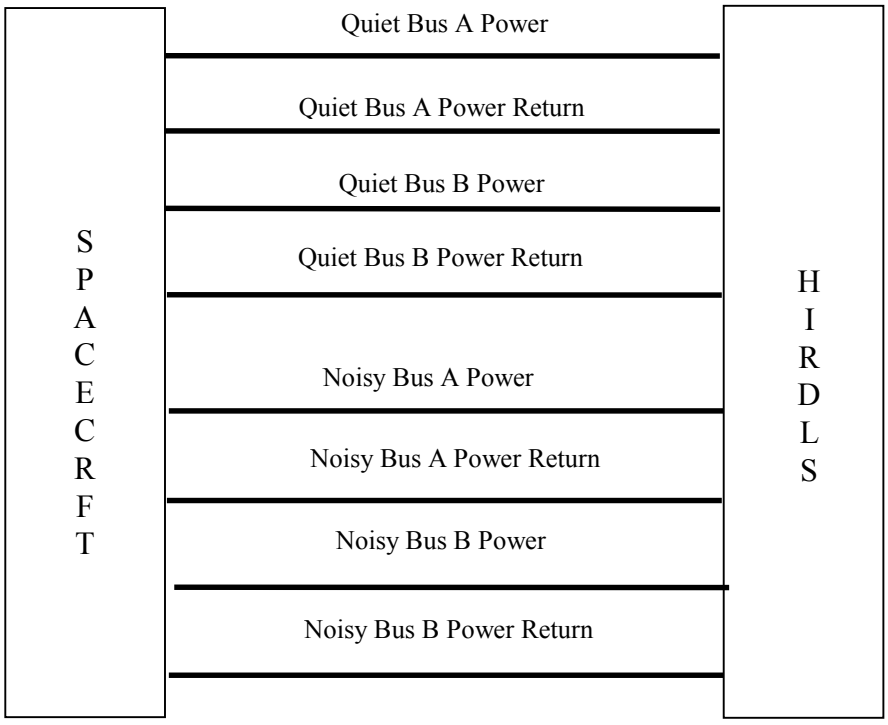

Fig. 3.2.1.1. Spacecraft /HIRDLS Power Interface

3.2.1.2 Primary Power Interface: Salient Characteristics.

The design of HIRDLS PCU shall comply with the following specifications:

3.2.1.2.1 Primary Power.

PCU design shall be based on the Primary Power at 29Volts d.c. (designated in this document as "nominal") and shall operate inside the range of the Primary Power voltage of 29 Volts +/- 2.9 Volts.

3.2.1.2.2 Turn ON Transient

The Turn ON transient current shall not exceed 100% of the maximum steady state current of HIRDLS. The duration of that state should not exceed 50msec.

3.2.1.2.3 Operational Current transients

Operational transients, other than the initial turn ON, shall not exceed 125% of the peak operational current. The duration of such transients shall not exceed 50msec.
HIRDLS induced current transients shall not exceed rates of 50mA/ μsec averaged over any 100μsec. period.

3.2.1.2.4 Turn OFF Transients

The PSS shall not generate voltage Turn Off transients outside the limits of –2Vdc and +40Vdc specified in NHD(1) Section 5.2.5.2.2. and in doing so shall meet he requirements described in that Section.

3.2.1.2.5 Reflected Ripple Current

The reflected Ripple current shall be less than 5% of the average load current. Note that the ripple on the input Primary Voltage lines is specified to be less than 5% peak to peak of the line voltage (< 1.4Volt at 29 Volt nominal).

3.2.1.2.6 Spacecraft failure

Under Spacecraft failure conditions the PCU shall survive, without permanent degradation, Primary Voltage excursions between 36Volts and 42 Volts of duration of longer that 10msec.
The PCU shall survive Primary Voltage excursion of 42Volts of the duration of 10msec.
The PCU shall survive indefinitely Primary Voltage excursions between 0Volts and 24Volts.
PCU shall withstand an unannounced Primary Power removal without any permanent degradation in performance. Loss of one side of the Primary Power shall not damage the PCU.

3.2.1.2.7 Power lines isolation

Isolation shall be provided between all Primary Power Buses: the Quiet Bus A, the Quiet Bus B; the Noisy Bus A and the Noisy Bus B. Power on the QA shall be returned via the QA ***Return*** only. Power on the QB shall be returned on the QB ***Return*** only. Similarly for the Noisy Bus, the ***Return*** on the Noisy Bus A shall not be mixed with the ***Return*** of the Noisy Bus B .
The isolation between the ***Power*** line, the ***Return*** line and ***Signal Return*** to the chassis shall be greater than 1MΩ (dc)
Primary Power ***Returns*** shall not be connected to the Chassis at the PCU end.
(Fig.3.2.1.2)
Capacitance between the Primary Power ***Returns*** and chassis shall be not more that 1nF.

3.2.1.2.8 Primary Power Isolation

Isolation between any Primary Power line and any Secondary Power line shall greater than 1MΩ and less that 1μF.

3.2.2 Power Interfaces with the Sub-systems

Power interfaces shall be compliant with the requirements defined in the sub-systems' ICDs and in the case of conflicts the information provided in the ICDs shall take precedence over this SSD.

3.2.2.1 Secondary Power Characteristics.

3.2.2.1.1 Secondary Power Star Points

PCU shall provide a connection for the TSS, EEA and GSS Secondary Power Returns to a single star point designated "SYS" Return Star-Point. SYS Return Star-Point shall be mounted on a dedicated feed-though terminal inside the PCU and isolated from the PCU chassis.

PCU shall provide a connection of the IPU_28REG_RTN to a single start point designated 28REG Return Star-Point. 28REG Return Star-Point shall be mounted on a dedicated feed-through terminal inside the PCU and isolated from the PCU chassis.

There shall be no electrical connection inside the PCU between SYS Return Star Point and 28REG Return Star-Point. In operations at the Unit level these two start points may be connected together and to the PCU chassis by detachable links mounted on the outside of the PCU Enclosure.

PCU shall provide separate Secondary Power Returns for the SPU. There shall be separate Returns for the SPU_5A, SPU_5B, SPU_15A, and SPU_15B. These Returns shall not be connected to the SYS Return Star-Point or 28REG Return Star Point inside the PCU.

PCU shall provide a hardwired connection for the SPU_COM_GND and a detachable connection for the IPU_COM_GND to the PCU Chassis Ground Terminal.

3.2.2.1.2 Secondary Power Isolation

Isolation between Secondary Power lines and the structure shall be greater than 1MΩ (Megaohm) and less than 1μF.

3.2.2.1.3 Sub-systems' Peak Power Requirements.

Summary of Peak Power requirements of the sub-systems is shown in the Table 3.2.2.1.3. This table is included for convenience only. Sections 3.2.2.2 through to 3.2.2.5 define the requirements for each sub-system.
The mA values are the worst (the largest) values found in the sub-systems' Interface Control Documents and may not agree with the current version of the SP-HIR-145 (The Power Workbook).

Sub-system	28Q(2), 28N(3), 28QC(4)		28REG		+15Volts		-15Volts		+5Volts	
	mA	Watts	mA	Watts	mA	Watts	mA	Watts	mA	Watts
IPU (2)	1309	40.66	1440	42	-	-	-	-	-	-
SPU	-	-	-	-	1200	18.3	530	8.1	560	3.2
GSS (4)	860	26.7	-	-	562	8.6	522	8	984	5.2
TEU (4)	672	21	-	-	307	4.7	279	4.3	1150	6.1
EEA	-	-	-	-	105	1.7	60	1	400	2.1
PCU(2)	-	10	-	-	-	-	-	-	-	-
CCU (3)	5000	155	-	-	-	-	-	-	-	-

Table. 3.2.2.1.3 Sub-systems' Peak Power Requirements

Note 1. Power values were computed using maximum rail voltages and maximum current values shown in the ICDs; HPD(3) for the IPU and the SPU, HPD(4) for the CCU, HPD(5) for the GSS, HPD(6) for the TEU and the EEA.
Note 2. "28Q" is the un-switched Primary Power supplied at nominal 29Volts derived form the Quiet Bus. 28Q is supplied to the IPU and the PCU
Note 3. "28N" is the switched Primary Power supplied at nominal 29 Volts derived form the Noisy Bus. 28N is supplied to the CCU
Note 4. "28QC" is the switched Primary Power supplied at nominal 29Volts derived from the Quiet Bus. 28QC is supplied to the GEU and the TEU

3.2.2.1.4 PCU Regulated Average Power Outputs

Summary of Average Power requirements of the sub-systems is shown in the Table 3.2.2.1.4. This table is included for convenience only. Sections 3.2.2.2 through to 3.2.2.5 define the requirements for each sub-system.

Sub-system	28REG		+15Volts Rails		-15Volts		+5Volts		Sub-system Totals
	mA	Watts	mA	Watts	mA	Watts	mA	Watts	Watts
IPU	240	6.9	-	-	-	-	-	-	
SPU	-	-	840	12.9	370	5.7	400	2.3	20.9
GSS	-	-	442	6.8	402	6.2	984	5.1	18.1
TEU	-	-	307	4.7	279	4.3	1150	5.9	14.9
EEA	-	-	105	1.7	60	1	400	2.1	4.8

Table 3.2.2.1.4. PCU Regulated Average Power Outputs

Note 1. Power values were computed using maximum rail voltages and average current values shown in the ICDs ; HPD(3) for the IPU and the SPU, HPD(4) for the CCU, HPD(5) for the GEU, HPD(6) for the TEU and the EEA.

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3.2.2.2 PSS/IPS Interface.

PSS shall provide Power Interfaces between PCU and the IPU and the PCU and the SPU. PSS/IPS interface shall be compliant with HPD (3).

3.2.2.2.1 PCU/IPU Power Interface

PCU shall provide IPU with Primary Power at 29Volts (nominal). The Primary Power shall be supplied over two sets of not switched lines directly connected to Quiet Bus A and Quiet Bus B. Each set shall comprise *Power* and Power *Return* lines designated A_IPU_+28QA_PWR, A_IPU_QA_RTN, and B_IPU_+28QB_PWR, B_IPU_QB_RTN.

PCU shall provide IPU with Secondary Power at 30Volts. The Secondary Power shall be supplied over two redundant sets of lines designated: A_IPU_+28REG_PWR, A_IPU_28REG_RTN; and B_IPU_+28REG_PWR, B_IPU_28REG_RTN. A_IPU_+28REG_PWR and B_IPU_+28REG_PWR lines shall be switched ON/OFF by the PCU. Switching shall be commanded by the IPU (through the dedicated Data and Control Interface).
The Secondary Power Return, provided by the IPU shall be connected to 28REG Return Star Point terminal in the PCU. This terminal shall provide a feedthrough connection to the outside of the PCU enclosure and shall be isolated form the PCU chassis.
Both the Primary and the Secondary Power shall be supplied to the IPU (for the Side A and the Side B) on a single cable. Connector type 311P409-3S-B12.
Pin redundancy shall be implemented in harness wiring. Pin allocation is defined in HPD (3). Section 3.2.5.2

Power Rails	Average Current (mA)	Peak Current (mA)	Comments
A_IPU_+28QA & B_IPU_+28QB	1124	1309	Direct from the active Quiet Bus At +29Volts nominal <5%pp of nominal voltage, 1Hz to 10MHz
A_IPU_+28REG & B_IPU_+28REG	2 40	1440	Regulated in the PCU to give: Line Voltage limits between +29.5V and +30.5V, Ripple and Noise <0.25Vpp, at frequency range of 1Hz to 10MHz

Table 3.2.2.2.1. IPU Power requirements

3.2.2.2.2 PCU/SPU Interface.

The PCU shall supply Secondary Power to the SPU on two sets of switched Voltage Rails of +/-15 Volts and +5Volts. The two sets shall be designated SPU A and SPU B. Switching of the SPU supply shall be commanded by the IPU.
The Secondary Power shall be generated independently of the other sub-systems and the Secondary Power Returns shall be isolated from each other and other Power Returns in the PCU. A single SPU Common Return shall be implemented as shown in HPD (2).
The interface between the PCU and the SPU shall be compliant with the specifications defined in HPD(3).

Table 3.2.2.2.2. SPU Secondary Power Requirements

Power Rail	Average Current (mA)	Peak Current (mA)	Comments
SPU_+5A & SPU_+5B	400	560	Regulated in the PCU to give: Line Voltage limits between +5.38V and 5.62V, Ripple of <40mVpp, 10Hz-10MHz, 200mV max. spikes at switching frequency, Regulation, line and load: <50mV
SPU_+15 A & SPU_+15 B	840	1200	Regulated in the PC to give: Line Voltage limits between +14.75V and +15.25V, Ripple of <25mVpp, 10Hz-10MHz 100mV max spikes at switching frequency, Regulation, line and load: <20mV
SPU_-15A & SPU_-15B	370	530	Regulated in the PCU to give: Line Voltage limits between -14.75V and -15.25V, Ripple of <25mVpp, 10Hz- 10MHz, 100mV max. spikes at switching frequency, Regulation, line and load: <20mV

The PCU/SPU Interface shall capable of withstanding an accidental short between the Power lines and between any power line and Ground
Harness connections for the PCU/SPU Power link shall conform to HPD (3). Section 3.2.5.2.
The Connector Type: 311P409-2S-B12.

3.2.2.3 PSS/GSS Interface

The PSS shall supply Switched Primary Power to the GSS at 29Volts and switched Secondary Power at +15Volts, -15Volts and + 5Volts. In all cases only the *Power* lines shall be switched. The Secondary Power Return shall be connected to the Secondary Star Point in the PCU. Ref. HPD (2). Turning the GSS Power ON/OFF shall be commanded by the IPU.
The Interface between the PCU and the GEU shall be compliant with the specifications defined in HPD (5).

	GSS_+5	**GSS+15**	**GSS-15**	**+28QC**	**Comments**
Voltage limits (Volts)	+5.17 +5.27	+15.00 +15.30	-15.15 -15.45	+24.00 +35.00	at PCU end of harness Note 1
Peak Current (mA)	984	562	522	860	
Average Current (mA)	984	442	402	33	
PCU-induced spikes at PCU end of cable	<150 mV peak	<150 mV peak	<150 mV peak		Note 3
PCU induced ripple	20mV pk.	20mV pk.	20mV pk.		Note 2

Table 3.2.2.3. GSS Power Supply Requirements and Characteristics.

Note 1. At specified nominal DC load. In the case of the +28QC Voltage limits a correction needs to be made for voltage drops across relay contacts
Note 2. Over a bandwidth of 0-5MHz.
Note3. At the switching frequency

The PCU to GEU interface shall be capable of withstanding accidental short between the power line and between any power line and Ground.

Harness connections shall conform to HPD (5). Section 3.4.

3.2.2.4 PSS/TSS Interface

This interface is made up from the PCU/TEU Interface and the PCU/EEA Interface.

3.2.2.4.1 PCU/TEU Interface

The PCU shall supply the Primary Power to the TEU on two redundant and switched lines designated A and B. In both cases only the Power lines shall be switched.
The PCU shall also supply the Secondary Power on two sets of switched Voltage Rails of +15Volt, -15Volt and +5 Volt. One set of the of the Voltage rails shall be designated TEU A and the other TEU B. Turning the Primary and the Secondary Power ON/OFF shall be commanded by the IPU. In all cases only the Power lines shall be switched. The TEU common Power Return shall be connected to the instrument secondary star point (SYS_RETURN).
The interface between the PCU and the TEU shall be compliant with the specifications defined in HPD(6). Table 3.2.2.4.1. is shown for reference.

	A_TEU_+5 & B_TEU_+5	**A_TEU_+15 & B_TEU_+15**	**A_TEU_-15 & B_TEU_-15**	**A_TEU_+28QC & B_TEU_+28QC**	
Voltage limits (Volts)	+5.21 +5.31	+15.05 +15.35	-15.10 -15.40	+24.00 +35.00	Note 1
Peak Current (mA)	1150	307	279	672	
Average Current (mA)	1150	307	279	347	
PCU-induced spikes at PCU end of cable	<150 mV peak	<150 mV peak	<150 mV peak		Note 3
PCU induced ripple	20mV pk.	20mV pk.	20mV pk.		Note 2

Table 3.2.2.4.1. TEU Power Supply Requirements and Load Characteristics.

Note 1. at specified nominal DC load and at the PCU end of harness. In the case of the +28QC Voltage limits a correction needs to be made for voltage drops across relay contacts
Note 2. Over a band-width of 0-5MHz.
Note3. At the switching frequency

Harness connection shall conform to the specification defined in HPD(6). Section 3.2.2.5

3.2.2.4.2 PCU/EEA Interface

PCU shall supply the EEA with Secondary Power on a single set of switched power lines at +5Volts, +15Volts and -15Volts. Turning Power ON/OFF shall be commanded by the IPU.
All ***Power*** lines shall be switched. The sub-system common ***Power Return*** shall not be switched, it shall be connected to the Secondary Power Star Point through a detachable link.
The interface shall be compliant with the specifications defined in HPD (6).

Table 3.2.2.4.2. Secondary Power Supply and Load Characteristics.

	EEA_+5	**EEA_+15**	**EEA_-15**	**Comments**
Voltage limits (Volts)	+5.21 +5.31	+15.05 +15.35	-15.10 -15.40	at the PCU end of harness Note 1
Peak Current (mA)	400	105	60	
Average Current (mA)	400	105	60	
PCU induced spikes	<150mVpk. at 25MHz	<150mVpk. at 25MHz	<150mVpk. at 25MHz	at the PCU end of harness
PCU induced ripple	20mV pk.	20mV pk.	20mV pk.	Note 2

Note 1. at specified nominal DC load.
Note 2. Over a band-width of 0-5MHz.

Harness connection shall conform to HPD (6). Section 3.2.2.5.

3.2.2.5 PSS/CSS Interface

The Interface between the PCU and the CCU shall be compliant with the specifications defined in HPD (2) and HPD (4).
The PCU shall supply Primary Power to the CCU on a single line switched between the Noisy Bus A and the Noisy Bus B. Harness connections shall be compliant with the specifications defined in HPD (4). Section 3.2.5.2.
Switching shall be commanded by the IPU.
CCU Power Requirements are listed in Table 3.2.2.1.3.

3.2.3 Data and Control Interfaces with the Sub-systems.

PSS shall implement Data and Control Interface with the IPS compliant with the specifications defined in HPD(3). Section 3.2.3. In case of a conflict between comments in this document any other document the information held in HPD (3) shall take precedence.
Switching of the Primary and the Secondary Power, controlling redundancy of the DC-DC Converters, and monitoring the operational status of the PCU shall be totally commanded by the IPU. In all such operations the PCU shall act as a slave to the IPU.
The PCU shall receive a set of Interpreted Commands and a set of Direct Commands. These commands shall implement Switching strategy defined in HPD (2). A subset of the Interpreted Commands shall also provide addresses for the analogue Telemetry.

3.2.3.1 Data Architecture.

The data exchanged between the IPU and the PCU shall comprise commands sent by the IPU and the data sent by the PCU. The command data and the data generated in the PCU shall be formatted as 16bit words.
There shall be two types of commands: the commands configuring relays in the Switching Network within the PCU, and Telemetry Requests.

3.2.3.1.1 The Command Word Architecture

Each command word shall be subdivided into three fields as shown below

Bit 15	Bit 14	Bit 13	Bit 12	Bit 11										Bit 0
F1	F2	F2	F2	F3										F3

Field 1 shall comprise the Most Significant Bit only; Bit15.
Bit15 = 1 shall signify the command configuring the Switching Network
Bit15 = 0 shall signify a Telemetry Request

Field 2 shall comprise three bits; Bits14-12
This field shall specify a Group Address.

Field 3 shall comprise 12 bits: Bits11-0.
This field shall specify an address of the destination in any particular Group.

Each relay coil in the Switching network within the PCU shall be allocated an address and shall be stored either on the Ground or in the IPU. The reference record all commands shall be held in the Command and Telemetry Handbook
Functionality of the Switching Network is shown in Appendix 1.
The Analogue Telemetry is listed in Appendix 2.
The Digital Telemetry Is listed in Appendix 3.

3.2.3.2 Command and Telemetry Hardware Interfaces.

There shall be two redundant hardware Interfaces.
Each Data and Control Interface shall comprise a set of five digital signal lines, one analogue channel and a set of six Direct Commands.

3.2.3.2.1 Digital Interfaces (Interpreted Commands)

The interfaces shall be bi-directional and shall be implemented by two sets of digital signal lines defined in the Table 3.2.3.1.1., and two analogue signal lines.
The digital lines shall be balanced differential (RS422); the digital signals driven and received by a set of 26C32/26C31 drivers/ receivers.
The PCU shall decode all commands and generate the necessary control signals to implement them.

Item Number	Functional name	Additional information
1	Clock	20kHz, Active Low Gated
2	Commands(Interpreted)	Serial format ; based on 16 bit words
3	Select	Hi = Control data/commands LO = PCU Status/Telemetry
4	Execute	A single pulse, T = 50μsec. Active LO
5	Data from the PCU	Serial format; based on 16 bit words

Table 3.2.3.2. Digital Interface lines

Timing of all data transfers between the PCU and the IPU shall be compliant with the HPD (3)

3.2.3.2.2 Digital Interfaces (Direct Commands)

PCU shall receive a set of 8 direct commands from the IPU. There shall be 4 such direct commands for each side (A and B) of the Data and Control Interface. Each command shall be sent on a dedicated twisted pair line and shall be a digital pulse of T = 25msec. and amplitude of 20mA and shall operate an opto-coupler in the PCU.

Item Number	Command Definition	Comments
1	Connect PCU Internal Supply A to QBA Connect PCU Internal Supply B to QBB	
2	Connect PCU Internal Supply A to QBB Connect PCU Internal Supply B to QBA	
3		Spare (No function Implemented)
4		Spare (No function Implemented)

Table.3.2.3.2. Direct Commands for the PCU

3.2.3.2.3 Analogue Signal Channels.

The Analogue Signal Channel shall provide direct unidirectional link with the IPU. The drivers should be capable of signal excursions between the limits of +/- 10Volts.
The Analogue data shall be selected by an address specified in a given Command sent over the Digital lines described above.

3.2.3.2.4 Harness Connection

The Control and Telemetry Interface shall be serviced by one cable link specified in HPD (3). Section 3.2.5.2. (Harness connections shall conform to Fig.3.2.3-1.)

3.2.4 PSS Interfaces with HIRDLS Structure/Thermal Sub-systems

The PSS shall conform to the STH/PSS Interface Control Document, HPD (7).

3.2.4.1 Mechanical Interfaces.

The PCU Enclosure shall be secured to the HIRDLS structure according to the specifications given in HPD (7) Section 3.1.2. The Alignment and Reference Co-ordinate Frames are defined in Section 3.1.3 of HPD (7)
All mechanical parts shall conform to standard ISO metric specifications.

3.2.4.1.1 Strength of Materials

Requirements defined in HPD1 Section 3.6.3.2.3 shall be met

3.2.4.1.2 Interface Limit Loads

Requirements defined in NHD1 Section 3.6.3.3. shall be met

3.2.4.1.3 Design Limit Loads

Requirements defined in NHD1 Section 3.6.3.3.1. shall be met.

3.2.4.1.4 Limit Loads Application

Requirements defined in NHD1 Section 3.6.3.1. shall be met

3.2.4.1.5 Limit Loads Application Axis

Requirements defined in NHD1 Section 3.6.3.2. shall be met

3.2.4.1.6 Qualification Loads

Requirements defined in NHD1 Section 3.6.3.3.2. shall be met

3.2.4.1.7 Screw Fasteners

All screw fasteners shall be tightened to Torque settings specified in NHD(5).

3.2.4.2 Thermal Interfaces

The PSS shall implement a mechanical and thermal interface with a Radiator Panel as described in HPD (7).
The PSS design shall be based on the Thermal requirements specified in HPD (7) and HPD (10)
Temperature sensors specified in HPD(1), Section 3.7.7c, shall be used.

3.2.4.3 Electrical Ground Interface

The Electrical interfaces shall be based on the electrical contact between the PCU feet and HIRDLS base-plate. MIL-B-5087, Class R and MIL-STD-889 shall be used for design implementation.
Electrical connector bonding shall meet the requirements defined in HPD (1) Section 3.7.3.6.2

PSS shall not use chassis ground to conduct power and signal currents in normal operation.
Requirements in NHD(1) Section 5.3.4.2.3 regarding Component Bonding Straps do not apply.

3.2.5 Sub-systems Capability Relationship

3.2.5.1 PSS Modes of Operation

PSS modes shall implement modes of operation defined in Section 3.2 of HPD(1)

3.2.5.2 Operational Capability of the PSS

The PSS shall implement the capability defined in the HPD(1) and HPD (2). Functionality of the PCU shall conform to the schematics included in HPD(2). The schematics in question are Fig1, Fig.2, Fig. 2a, Fig.2b, and.3. in HPD(2).
All operations within the PSS shall be commanded by the IPS and shall implement the following modes of the Instrument.

3.2.5.2.1 Instrument Off Mode

The requirements defined in NHD (1), Section 6.1.1 shall be met.

3.2.5.2.2 Instrument Survival Mode

The requirements defined in NHD (1), Section 6.1.2 shall be met.

3.2.5.2.3 Instrument Operational Modes

The requirements defined in NHD (1), Section 6.1.3 shall be met.

3.2.6 Environmental Conditions

The PSS shall perform as specified herein after exposure to all natural and induced environmental conditions that may occur during manufacture, test, handling, storage, the pre-launch phase, ascent and in-orbit operations.

3.2.6.1 Non-operating/Survival Conditions

The PSS shall perform as specified herein after exposure to the non-operational/survival environments defined below.

3.2.6.1.1 Random Vibration

The PSS shall withstand Vibration Tests specified in HPD(17). Minimum fixed base frequency requirement defined in NHD1 Section 3.6.2.1 shall be met

3.2.6.1.2 Sine Vibration

This test shall be performed to characterise the PCU before and after each axis random shake. The amplitude shall be 0.5g swept between 10Hz and 2kHz at 2octaves/minute. Minimum fixed base frequency requirement defined in NHD1 Section 3.6.2.1 shall be met

3.2.6.1.3 Deleted in Revision A

3.2.6.1.4 Deleted in Revision B

3.2.6.1.5 Thermal

The PSS shall perform as specified after exposure to the non-operation/survival temperatures between –39°C and +60°C.

3.2.6.1.6 Relative Humidity

The PSS shall perform as specified herein after exposure to relative humidity ranging from 0% to 65%.

3.2.6.1.7 Pressure decay

The PSS shall be designed to withstand a maximum atmospheric pressure decay specified in NHD(1) Section 10.5 and without malfunction or degradation of performance. Venting of boxes, cases, housing, enclosures, honeycomb panels shall be employed as necessary to meet the above pressure environment restrictions.

3.2.6.1.8 Venting

The PCU shall be directly vented to the outside as described in HPD(1) Section 3.12.3.1.

3.2.6.2 Mission Operating Environments

The PSS shall be capable of performing as specified herein while being subjected to the in-orbit operational environmental conditions defined below.

3.2.6.2.1 The In orbit Pressure Environment

The PSS shall be capable of performance as specified herein during exposure to a vacuum of
10^{-14} torr for a period of five years. The PSS shall also be capable of withstanding and operating, where applicable, through all pressure environments that occur during flights, ranging from 760 torr at the launch site and to 10^{-10} torr in orbit.

3.2.6.2.2 In Orbit Acceleration (In Orbit)

The PSS shall be capable of performance as specified in 3.2 and sub-sections during exposure to the manoeuvring accelerations of 0.1115 g as specified in GIRD Section 10.3.

3.2.6.2.3 Deleted in Revision A

3.2.6.2.4 In Orbit Thermal Environment

3.2.6.2.5 The PSS shall perform as specified herein during exposure to operational temperatures between –39°C and +50°C. This range includes the required test margins. Radiation

The PSS shall be capable of operation after 5 years of exposure to $1x10^4$ RAD (Si) while shielded by the equivalent of 0.1inch aluminium within the design safety factor of 2.
The PSS shall meet performance requirements in the Cosmic Ray and the High-Energy Proton radiation environment specified in NPD(1) Section 10.9.1.1 and 10.9.2.1.2.
The PSS design shall use information contained in Electronics Parts Radiation Requirements TC-UCB-017 as a guideline.
PSS shall meet all performance requirements as specified in this document after exposure to Cosmic Ray and High Energy Proton Radiation not less than 50MeV for single event upset or latchup.

3.2.6.2.6 Atomic Oxygen

The PSS shall meet all performance requirements during exposure to the atomic oxygen environmental conditions specified in GIRD Section 10.10.

3.2.6.2.7 Spacecraft Charging

All unused pins or wires in cable bundles shall be connected to chassis ground. All circuit boards shall be free of loose metalization and ungrounded pins and connectors.
Requirements defined in HPD (1), Section 3.11.10.3a and Section 3.11.10.3b shall be met.

3.2.6.3 Deleted in Revision B

3.2.6.4 EMI/EMC

3.2.6.4.1 Electromagnetic Compatibility

The PSS, in its operation, shall not affect adversely other sub-systems and other on board instruments by generating Electromagnetic Interference and shall not be susceptible to such emissions from the external sources.
The PSS shall be compliant with the Tests on Conducted Emissions described in NPD (1), Sections 10.11.1 and 10.11.2.
The PSS shall be compliant with the Tests on Conducted Susceptibility described in NPD (1), Sections 10.11.3 and 10.11.4.

3.2.6.4.2 Grounding and Shielding

Grounding and shielding will be implemented to conform to the instrument sub-system grounding and shielding requirements defined in HPD (2).
Connector shells shall be electrically bonded to the Enclosure.

3.2.7 Contamination Control

3.2.7.1 General

Contamination control of the PCU shall assure that required external and internal surface cleanliness levels and outgassing requirements are met at delivery for integration into the HIRDLS instrument. The PCU shall be cleaned, assembled, inspected and tested in a

controlled environment which shall establish and maintain the required cleanliness level of the completed hardware with respect to molecular and particulate surface deposits.

3.2.7.2 Contamination-Control Covers

PCU shall be separately covered during storage and transportation to prevent transfer of contaminants on to clean surfaces. Connector covers shall be compatible with clean surfaces.

3.2.7.3 Materials Selection Criteria

In addition to the requirements of section 3.3.1.5 materials and processes used in the design and production of PCU flight hardware shall not generate particle contamination during handling, storage, test, or launch.

3.2.7.4 Deleted

3.2.7.5 Outgassing of Materials and Subsystems

In addition to meeting the screening criteria for TML and CVCM, the PCU shall have an outgassing rate $\leq 3.0\times10^{-11}$ g cm^{-2} s^{-1} , as measured at the vent, at time of delivery for integration into the HIRDLS instrument, under the following test conditions and definitions: temperature of PCU no less than 10 degrees C above its maximum on orbit operating temperature, as specified in 3.2.6.2.4, pressure $\leq 1x10^{-5}$ torr, condensing onto a Temperature-controlled Quartz Crystal Microbalance (TQCM) maintained at –20 degrees C having a full, unobscured view of the hardware at a distance of no more than 250 mm from the vent, and with the sensor view completely filled by the hardware.

3.2.7.6 Contamination Levels

Surface contamination levels shall be as defined in MIL-STD-1246 unless explicitly stated otherwise.

3.2.7.6.1 Particle Cleanliness Levels on Exterior Surfaces

Particle levels on external surfaces shall not exceed Level 500 at the time of delivery for integration into the HIRDLS instrument.

3.2.7.6.2 Particle Cleanliness Levels on the Internal Surfaces

At final assembly of the box, particle cleanliness levels on boards and other internal surfaces shall meet visible cleanliness levels as determined by inspection as determined by visual inspection using normal, or corrected to normal vision, and with illumination better than 50 candle power (such as at a desktop in a shop work area). To pass visible cleanliness there shall be no stains, discoloration, particles, debris or other visible contamination on any of the board or other internal surfaces.

3.2.7.6.3 Cleanliness Levels for Molecular Contamination or Nonvolatile Residue (NVR)

3.2.7.6.3.1 Molecular Contamination Levels of External Surfaces

Molecular Contamination levels for all external surfaces shall be Level A per Mil-Std 1246.

3.2.7.6.3.2 Molecular Contamination Levels of Internal Surfaces

The molecular contamination levels of all boards and other internal box surfaces shall be visibly clean as inspected per 3.7.1.5.2. The internal surfaces shall be free of all oil, grease, fingerprints, smears, or sheen, to comply with this visibly clean requirement.

3.2.8 Operational and Storage Life

PSS shall have the operational and storage life as follows

3.2.8.1 Operational Life in Ambient Atmosphere

The PSS shall be built to operate in ambient Atmosphere for 3 years (integration, test, spacecraft integration, and pre-launch preparation)

3.2.8.2 Storage in Ambient Atmosphere

PSS shall withstand storage in Ambient Atmosphere for the duration of 1-year (potential storage after calibration and before launch)

3.2.8.3 In-Orbit Operation

The PSS shall be capable of full operation in-orbit for the duration of 5 years (in-orbit instrument life).

3.2.9 Physical Characteristics

3.2.9.1 Mass

Mass of the PCU shall not exceed 9.5kg.

3.2.9.2 Volume

The PSS design shall be based on as single enclosure whose dimension shall be compliant with the Requirements defined in HPD (7).
The Footprint: length = 315mm. , Width = 283.08mm. (Including mounting feet)
The dimensional constraints on the PCU enclosure are the shape of the HIRDLS overall envelope.
Height of the PCU Enclosure = 200mm.

3.2.9.3 Power Dissipation

The conversion efficiency of 70% shall be assumed.
The PCU own housekeeping Power dissipation shall not exceed 10Watts.

3.2.9.4 Physical Access and Reserve Volume

The design of the PCU shall implement an accessible panel mounting the sub-systems' Power *Returns* external to the PCU chassis.

3.3 Parts Materials and Processes

3.3.1 Parts and Materials Selection

NASA Grade 2 (MIL-STD-975, Appendix A) shall be used as EEE Standard Parts. ESA/SCC level C parts shall be considered equivalent. There shall be no distinction between the interface and the non-interface EEE parts. The requirements defined in NHD (3), Section 5.2.2. and in Section 5.2.2.1 shall be met .

3.3.1.1 Parts Identification List

Parts Identification List (PIL) shall be prepared itemising all EEE parts planned to be used in the flight hardware. PIL shall be submitted to the PCB for a review done by GSFC.

3.3.1.2 Non standard EEE parts.

The criteria for selecting and qualifying non-standard EEE parts defined in HPD (12) Section 5.4 shall be met.

3.3.1.3 Derating Guidelines

EEE Parts Derating Guidelines outlined in PPL shall be used and the requirements described in NHD (3), Section 5.3.3 shall apply.

3.3.1.4 Destructive Physical Analysis

Destructive Physical Analysis (DPA) will not be normally required for microcircuits and semiconductors procured to Standard Military Drawings (SMD). PCB may decide on case for case basis whether exceptions need to be subjected to that analysis. In these cases the DPA shall conform to the requirements defined in NHD(3), Section 5.2.6.

3.3.1.5 Materials Selection

Requirements for materials and Processes Plan, and Material Selection defined in NHD(3), Section 6.1 and Section 6.2 shall be met.
Requirements for the use Compliant Materials and the Non-Compliant Materials defined in NHD(3), Section 6.2.1 and Section 6.2.2.shall be met. The requirements for the use of the off the shelf hardware described in NHD(3), Section 6.2.2.1 shall apply.

3.3.1.6 Material Nonconventional Applications.

The requirements specified in NHD(3), Section 6.2.4 shall be met.

3.3.2 Acceptance Screening on Non-metallics

All nonmetallic materials used in the PSS shall be shown to meet, as minimum, the requirements of Total Mass Loss (TML)<1.0% and Collected Volatile Condensable Material (CVCM) < 0.1% when tested in accordance with ASTM E595.

3.3.2.1 Polymeric Materials

All polymeric materials used in the PSS shall be documented in accordance with NHD(3) Section 6.2.5. Flammability requirements of such materials defined in NHD(3), Section 6.2.5.1 and requirements for Vacuum outgassing of such materials defined in NHD(3), Section 6.2.5.2 shall be met.
Polymeric materials with a limited shelf life and that are used in the PSS shall be identified and monitored in accordance with the requirements defined in NHD(3), Section 6.2.5.3.

3.3.2.2 Inorganic Materials.

All inorganic materials used in the PSS shall be documented and reported on in accordance with NHD(3), Section 6.2.6. Non-compliance will be monitored by GSFC Materials Assurance Engineer.
The requirements regarding fasteners described in NHD(3), Section 6.2.6.1 shall be met.

3.3.3 Deleted in Revision B

3.3.4 Safety

Preventive measures shall be taken against electrostatic discharge (ESD). Handling of the PCU shall be in accordance with the requirements given in HPD (1), Section 3.14.14.1
A hazard analysis shall be performed identifying any possible dangers created by the PCU to the personnel handling it. The analysis shall meet the requirements described in NHD (3), Section 11.4.1.
Test procedures shall be approved by RAL Safety Group in accordance with NHD (3), Section 11 6.
The requirements on minimising flammability hazards defined in NHD (3), Section 11.10 shall be met.

3.3.5 Manufacture and Assembly

Manufacture of the PSS shall be in accordance with the established practices recommended by NASA and ESA.
Manufacture of the PCU shall be compliant with the requirements defined in HPD (12) Section 4

3.3.5.1 Process Selection Requirements

A material process utilisation list shall be prepared in accordance with the requirements described in NHD(3), Section 6.3.

3.3.5.2 Lubrication.

Not applicable to the PSS.

3.3.5.3 Raw Material Procurement Requirements

Not Applicable to the PSS.

3.4 Reliability

The PSS shall meet the overall Reliability of 0.990 specified in HPD (1) Section 5.1, Table 5.1-3.
The Reliability calculation shall be based on a 5-year longevity in Space of the HIRDLS Instrument.
The PSS design shall allow one internal failure in the PCU. Any single internal failure in the PCU shall not prevent the sub-systems switching over to the other Primary or Secondary Power source.

3.5 Transportation and Storage

Transportation cases and packing shall be provided to transport the PCU from the fabrication facility to the Instrument Integration facility.
Storage containers shall meet requirements of GSFC 424-11-13-01, Mission Assurance Requirements for the HIRDLS Instrument.

3.6 Identification and Markings

The individual components of the PCU shall be permanently marked in conspicuous area. The minimum marking shall comprise a part number, a serial number, and a configuration identifier.
These markings shall be in accordance with EOS MAR Section 8.4.
Markings for the purpose of configuration identification and control shall be provided for any component which may be removed or replaced prior to the launch of the satellite.

4. Quality Assurance Requirements.

Quality Assurance criteria described in HPD (12) shall apply and shall be met for the PCU EM and the PCU PFM.

4.1 General

Quality Assurance provisions shall be as specified herein and in accordance with MAR (GFSC 424-11-13-01). Certain quality assurances are required to support the reliability of the PCU operating for an extended time in Space environment. Qualification and acceptance testing of the PCU shall be combined into a single test programme , the PCU Protoflight Tests (4.3). The PCU shall be considered ready for flight upon successful completion of inspection, analysis, and tests as specified in Section 4, which verifies the conformance to the requirements specified in Section 3.

4.1.1 Responsibility for Tests

Unless otherwise specified testing shall be conducted as the PCU RO's facility in accordance with an approved Test and /or Verification Plan and Acceptance Procedures as defined in Section 6.4.1. of the Performance Verification Plan (TP-HIR-008). The RO shall be responsible for designing and performing all qualification tests of the PCU.

4.1.2 Special Tests and Examinations

4.1.2.1 Components and Sub-systems

All active components, sub-assemblies, and assemblies shall be inspected prior to assembly. They shall be tested and accepted in accordance with their respective specifications or drawings. Selection of any new parts or components shall also undergo acceptance in accordance with their specifications and drawings.

4.1.2.2 Environmental Stress Screening

Environmental stress screening shall be performed in accordance with HIRDLS Parts Control Plan (PA-LOC-203) at the component, module and sub-assembly level deemed appropriate and with the approval of LMMS. The purpose of the Environmental Stress Screening is to stress the hardware in order to identify failed and weak parts or workmanship defects.

4.1.2.3 Engineering Development Tests and Evaluations

Measurement, tests and evaluations shall be used for obtaining design parameters and for verifying that the PCU meets the performance and safety requirements specified herein before ProtoFlight testing.

4.1.2.4 Problem/Failure Reporting

Problem/Failures Reports (PFR) shall be prepared in accordance with NHD (3), Section 8.1.1.

4.1.3 Structural and Mechanical Test Requirements

PSS shall meet all pertinent Structural and Mechanical test requirements described in NHD(3), Section 3.4. Tests by Demonstration or Analysis shall verify its fight worthiness with regards to safety , workmanship and quality of materials.

4.1.3.1 Structural Loads: Design verification

Requirements defined in NHD (3) Section 3.4.1 do not apply to the PSS

4.1.3.2 Structural Loads: Flight Acceptance

Requirements defined in NHD(3) Section 3.4.2. do not apply to the PSS

4.1.3.3 Vibro-acoustics

Requirements designed in NHD(3) Section 3.4.2.1 and in Section 3.4.2.2 do not apply to the PSS

4.1.3.4 Mechanical Function: Design Verification

Requirements defined in NHD(3) Section 3.4.5.1, Section 3.4.5.2, Section 3.4.5.3. and Section 3.4.5.4. do not apply to the PSS.

4.2 Quality Conformance

4.2.1 Methods of Verification

The requirements of Section 3 of this Specification shall be verified by the methods defined below and as itemised in Table 4.2.1. “Verification Cross Reference Matrix”. Formal verification testing (protoflight tests) shall be performed in accordance with Section 4.2.

4.2.1.1 Inspection (I)

This method involves examining an item against the applicable documentation to confirm compliance with the requirements. This method also involves physically examining athe artice to ensure conformance with envelope, mass, and electrical grounding requirements.

4.2.1.2 Analysis (A)

This method consists of interpreting or interpolating/extrapolating analytical or empirical data with reference to defined conditions or analytical procedures to ascertain theoretical compliance with stated requirements.

4.2.1.3 Test (T)

This method entails performance of a functional operation under specific conditions. Instrumentation and special test equipment shall be used to generate, acquire, and record data. This method shall also include analysis of the test data.

4.2.1.4 Demonstration (D)

This method of verification involves performance of a functional operation under specific conditions in Pass/Fail circumstances. Instrumentation and special test equipment may be used to generate, acquire, and record data which will be used to determine if the instrument performance lies within the required range.

4.2.1.5 Not Applicable (N)

Use of the term "Not Applicable" shall be limited to those paragraphs/ paragraph headings for which there is no method of verification or where verification is specified in sub-paragraphs.

4.2.1.6 Verification Cross Reference Matrix (VCRM)

The Matrix shall follow Section 3 of this document and specify methods of verification in each case as applicable to the PCU. Notation used in the Matrix is defined in the Table 4.2.1.6. below.

Notation	Meaning	Defined in Section
I	Inspection	4.2.1.1
A	Analysis	4.2.1.2.
T	Test	4.2.1.3
D	Demonstration	4.2.1.4
N/A	Not Applicable	4.2.1.5

Table 4.2.1.6. Notation used in the VCRM

Section	Title	Method
3.1	PCU Functional Specification	I
3.1.1	Primary Power	I
3.1.1.1	The IPS	I
3.1.1.2	The TSS	I
3.1.1.3	The GSS	I
3.1.1.4	The CSS	I
3.1.1.5	The PSS	I
3.1.2	Secondary Power	
3.1.2.1	The IPS	I/T
3.1.2.2	The TSS	I/T
3.1.2.3	The GSS	I/T
3.2	PSS Interfaces Specifications	
3.2.1	Primary Power Interface with the Spacecraft	I
3.2.1.1	General Information	I
3.2.1.2	Primary Power Interface: Salient Characteristics	
3.2.1.2.1	Primary Power	D
3.2.1.2.2	Turn ON Transient	D/T
3.2.1.2.3	Operational Current Transients	D/T
3.2.1.2.4	Turn OFF Transients	D
3.2.1.2.5	Reflected Ripple Current	D
3.2.1.2.6	Spacecraft Failure	D/T
3.2.1.2.7	Power Lines Isolation	T
3.2.1.2.8	Primary Power Isolation	D
3.2.2	Power Interfaces with the Sub-systems	
3.2.2.1	Secondary Power Characteristics	
3.2.2.1.1	Secondary Power Star Points	D
3.2.2.1.2	Secondary Power Isolation	T
3.2.2.1.3	Sub-systems Peak Power Requirements	N/A
3.2.2.1.4	PCU Regulated Average Power Outputs	N/A
3.2.2.2	PSS/IPS Interface	
3.2.2.2.1	PCU/IPU Power Interface	T/D
3.2.2.2.2	PCU/SPU Interface	T/D
3.2.2.3	PSS/GSS Interface	T/D
3.2.2.4	PSS/TSS Interface	
3.2.2.4.1	PSS/TSS Interface	T/D
3.2.2.4.2	PCU/EEA Interface	T/D
3.2.2.5	PSS/CSS Interface	T/D
3.2.3	Data and Control Interface with Sub-systems	
3.2.3.1	Data Architecture	D
3.2.3.1.1	The Command Word Architecture	D

Section	Title	Method
3.2.3.2	Command and Telemetry Hardware Interfaces	N/A
3.2.3.2.1	Digital Interfaces (Interpreted Commands)	T/D
3.2.3.2.2	Digital Interfaces (Direct Commands)	T/D
3.2.3.2.3	Analogue Signal Channels	T/D
3.2.3.2.4	Harness connection	T
3.2.4	PSS Interfaces with HIRDLS Structure/Thermal Sub-systems	N/A
3.2.4.1	Mechanical Interfaces	I
3.2.4.2	Thermal Interfaces	D
3.2.4.3	Electrical Ground Interface	D/T
3.2.5	Sub-system Capability Relationships	
3.2.5.1	PSS Modes of Operation	D
3.2.5.2	Operational Capability of the PSS	D
3.2.6	Environmental Conditions	
3.2.6.1	Non-Operating/Survival Conditions	D
3.2.6.1.1	Random Vibration	T
3.2.6.1.2	Sine Vibration	T
3.2.6.1.3	Acceleration	N/A
3.2.6.1.4	Deleted	N/A
3.2.6.1.5	Thermal	T/D
3.2.6.1.6	Relative Humidity	A
3.2.6.1.7	Pressure Decay	A
3.2.6.1.8	Venting	A
3.2.6.2	Mission Operating Environments	A
3.2.6.2.1	In-Orbit Pressure Environment	A
3.2.6.2.2	In-Orbit Acceleration	A
3.2.6.2.3	In-Orbit Vibration Environment	N/A
3.2.6.2.4	In-Orbit Thermal Environment	A
3.2.6.2.5	Radiation	A
3.2.6.2.6	Atomic Oxygen	A
3.2.6.2.7	Spacecraft Charging	I
3.2.6.3	Deleted	N/A
3.2.6.3.1	Deleted	N/A
3.2.6.3.2	Deleted	N/A
3.2.6.3.3	Deleted	N/A
3.2.6.4	EMI/EMC	N/A
3.2.6.4.1	Electromagnetic Compatibility	T/D
3.2.6.4.2	Grounding and Shielding	D

Section	Title	Method
3.2.7	Cleanliness	
3.2.7.1	Particulate levels	
3.2.8	Operational and Storage Life	A
3.2.9	Physical Characteristics	
3.2.9.1	Mass	D
3.2.9.2	Volume	D
3.2.9.3	Power Dissipation	D
3.2.9.4	Physical Access and Reserve	D
3.3	Parts, Materials and Processes	
3.3.1	Parts and Materials Selection	D
3.3.2	Acceptance of Screening of Non-metallics	A/D
3.3.3	Outgassing	A
3.3.4	Safety	D
3.3.5.	Manufacture and Assembly	D/A
3.4	Reliability	A
3.5	Transportation and Storage	D
3.6	Identification and Markings	D/I

Verification Cross Reference Matrix.

4.2.2 Verification Tests

This section describes which tests and verifications are required for the delivered PCU in different phases of the programme. Unless otherwise specified the tests shall be conducted in the order given Details of verification methods are given in Section 4.3.

4.2.2.1 Deleted in Revision A

4.2.2.2 Instrument Level Pre-test Inspection

Before testing the PCU shall be inspected for compliance with the requirements listed in the Table 4.2.1. under Method of Verification: Inspection. The following physical properties shall be verified in accordance with Section 4.2.4.1.1. of the Performance Verification Specification (SP-HIR-064).

4.2.2.2.1 Mass Properties

Mass of each of the PCU units shall be measured. The allowable tolerance on the sum total masses in excess of those specified in Section 3.2.4.1 is +/-0.02kg. or +/-1.0%, whichever is greater.

4.2.2.2.2 Centre of Mass

The centre of mass locations of the PCU shall be determined either by test or by analysis. The allowed tolerance shall be +/-0.30cm. in each of three orthogonal axes.

4.2.2.2.3 Geometry

The geometry of the PCU, including size, shape , and volume shall be verified by inspection to comply with the drawings specified in the STH-PSS ICD, HPD(7), Figure 1.

4.2.2.2.4 Mechanical Interface

The mechanical interface of the PCU shall be verified for compliance with the envelope drawings specified in the STH-PSS ICD, HPD(7), Figure 3.

4.2.2.3 Verification Reports

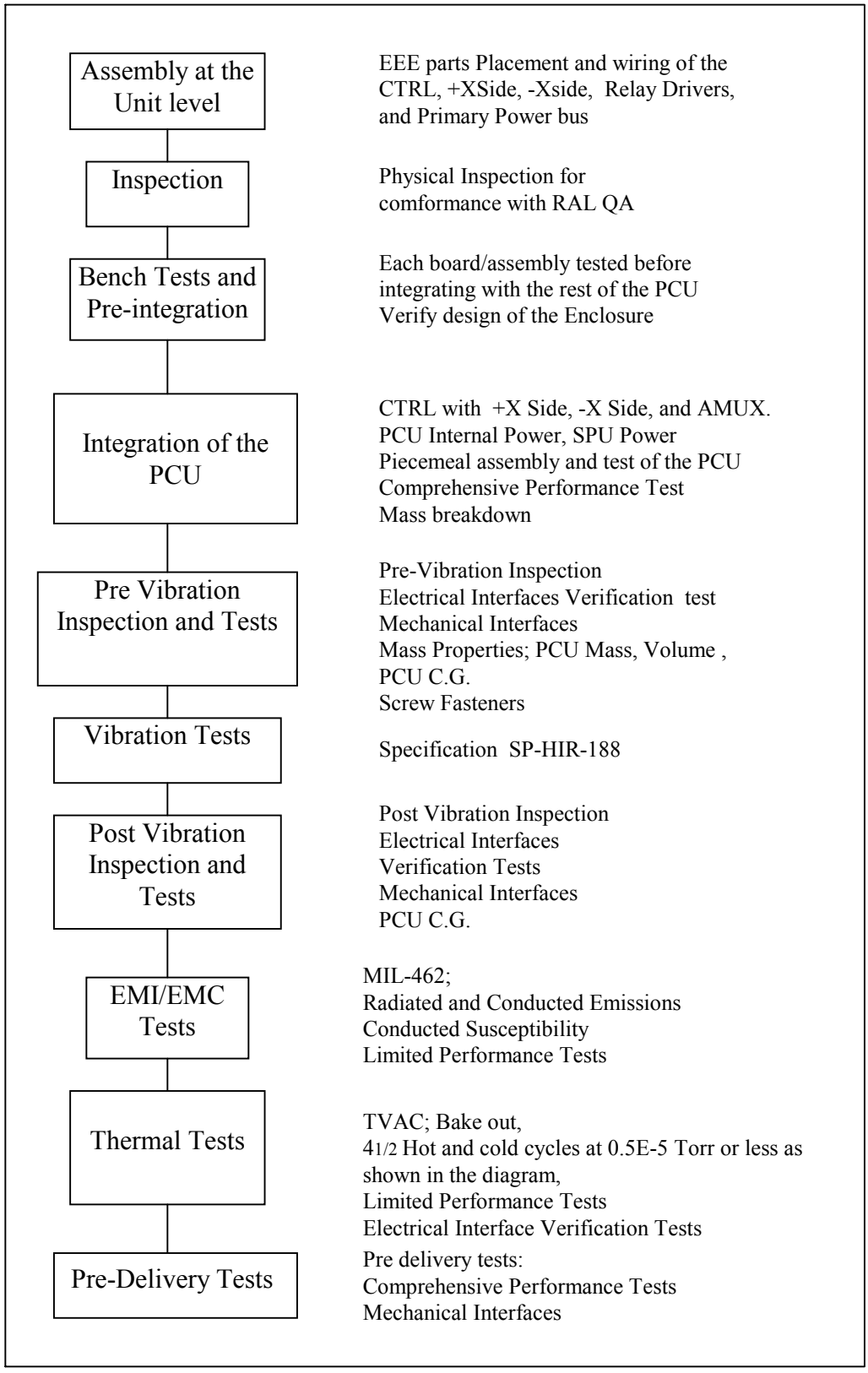
Dedicated reports shall be produced after each Verification Tests. The environmental test report shall convey as a minimum the information described in NHD(3), Section 3.2.6. The requirements listed in Table 4.2.1 that are verified by analysis shall be documented by Analysis Reports. The requirements for the Analysis reports shall meet the requirements described in NHD(3), Section 3.2.6

4.2.2.4 Limited Life EEE Parts

Limited Life Items shall be identified and reported to HIRDLS Project Engineer. Limited Life EEE parts shall undergo a life test program. Such tests will require dedicated Verification Test Plan.

4.3 Protoflight Tests

The PCU shall be subjected to the Test and Integration Task Flow shown below.



4.3.1 Demonstration and Functional Tests.

The following demonstrations and functional tests shall be carried out on the PCU to verify functional performance of Section 3.0

4.3.1.1 Electrical Interface Tests

The PCU shall be subjected to a series of electrical interface tests as defined in Section 4.2.4.1.2 of the Performance Verification Specification , HPD(8). These tests shall be conducted to verify that all interface signals meet the requirements defined in Section 3.2 and are within acceptable limits of the applicable performance specification.

4.3.1.2 Comprehensive Performance Test

This test shall verify the requirements listed in Table 4.3.1.2

Section	Title
3.1	PCU Functional Specifications
3.2	PSS Interface Specifications
3.2.1.2	Primary Power Interface
3.2.2	Power Interfaces with the Sub-systems
3.2.3	Data and Control Interfaces with the Sub-systems
3.2.5.2	PSS Operational capability vs. Modes of Operation
3.2.9.4	Power Dissipation

Table 4.3.1.2. Comprehensive Performance Tests

These tests shall be carried out for the “A” and for the “B” converters of the PCU and at 27Volts, 29Volts and 31Volts inputs (Primary Power). Output Voltages shall be measured for each loaded PCU output. This shall include a record of analogue telemetry.

4.3.1.3 Electrical Interfaces Verification Tests

Tests shall be done with Primary Power inputs at nominal 29Volts for the "A" and the "B" Sides and for the Prime and Redundant Converters and all characteristics of electrical interfaces verified. Connector pin allocation at the external interfaces shall be verified.

Section	Title
3.1.1	Primary Power
3.1.2	Secondary Power
3.2.1.2.7	Primary Power Isolation
3.2.2.1.2	Secondary Power Isolation
3.2.2.2.	PSS/IPS Interface
3.2.2.3	PSS/GSS Interface
3.2.2.4	PSS/TSS Interface
3.2.2.5	PSS/CSS Interface
3.2.3	Data and Control Interfaces with Subsystems

Table 4.3.1.3. Electrical Interfaces Verification Tests

4.3.1.4 Limited Performance Test

The Limited Performance Test of the PCU shall verify the requirements listed below:

Section	Title
3.1.1	Primary Power
3.1.2	Secondary Power
3.2.1.2.2	Turn ON current transients
3.2.1.2.3	Operational current transients
3.2.1.2.4	Turn OFF current transients
3.2.2.1.3	Sub-systems' Power Requirements (defined by the EGSE Load Box)
3.2.2.2	PSS/IPS Interface (load provided by the EGSE Load Box)
3.2.2.3	PSS/GSS Interface (load provided by the EGSE Load Box)
3.2.2.4	PSS/TSS Interface (load provided by the EGSE Load Box)
3.2.2.5	PSS/CSS Interface (load provided by the EGSE Load Box)

Table 4.3.1.4. Limited Performance Tests

These tests will be done with Primary Power supplied at any input voltage in the range of 27Volts and 31Volts. The tests shall be done for the "A" and for the "B" Sides (The TSS, Quiet Bus, and Noisy Bus), and for the Prime and Redundant converters of the PCU. The tests shall verify the performance of Primary Power and Secondary Power switching performed in the PCU.

4.3.1.5 Final Performance Test – Pre-delivery Tests

The Final Performance Test of the PCU shall comprise the Comprehensive Performance Tests and Mechanical Properties Tests , and verification of specification of Screw Fasteners defined in Section 3.2.4.1.7

4.3.1.6 Mechanical Properties Tests.

Section	Title
3.2.4.1	Mechanical Interfaces
3.2.9.1	Mass
3.2.9.2	Volume
4.2.2.2.1	Mass Properties
4.2.2.2.2	Centre of Mass
4.2.2.2.3	Geometry
4.2.2.2.4	Mechanical Interface

Table 4.3.1.6. Mechanical Properties Tests

<u>*Environmental Testing*</u>

The PCU shall be subjected to the sequence of environmental tests specified in Figure 4.3 (PCU Test Sequence).

4.3.1.7 Random Vibration Test

The PCU shall undergo Random Vibration testing defined in Section 4.2.4.3.1 of the Performance Verification Specification (SP-HIR-064).
The random vibration input levels shall be as specified in the HIRDLS Sub-system Environmental Requirements document (SP-HIR-188). This testing can be performed at the sub-system level or at the individual unit level. Testing shall be conducted with the sub-system, or unit, secured at its mounting locations to the shaker armature using a test fixture or fixture combination. Random vibration shall be applied to the sub-system, or unit, for a duration of 1 minute in each of three orthogonal axes. Vibration shall be measured and controlled with an accelerometer mounted on the vibration test fixture near one of the instrument mounting points. At the completion of the test, the instrument shall be visually examined for evidence of damage or permanent deformation.

4.3.1.8 Thermal Vacuum Test

The PCU shall undergo Thermal Vacuum testing as defined in Section 4.2.4.3.2. of the Performance and Verification Specification (SP-HIR-064).
During the Test the PCU shall be subjected to 4 ½ cycle (four and a half) thermal-vacuum test. The test shall commence with a hot cycle and shall conclude with a hot cycle. The

temperature levels required for verification of the PCU shall be as specified in the HIRDLS Sub-system Environmental Requirements document (SP-HIR-188). The PCU test profile is depicted in Figure 4.3.2. The pressure shall be $5x10^{-6}$ Torr ($6.64x10^{-4}$ Pascal) or less. During the test the PCU shall be configured and operating in its Operational Mode except during periods of Limited Performance Testing and during Hot and Cold survival temperatures. The cycling test environment shall be initiated by a high temperature soak. Each cycle shall include a 4-hour soak at the high and low temperature levels. Limited Performance tests shall be conducted for the PCU at the extremes of the operating temperature range as shown in Fig.4.3.2.3. The transition of between extreme temperature levels shall be made at a maximum rate of 20.0deg.C per hour. The last three cycles shall be failure free.

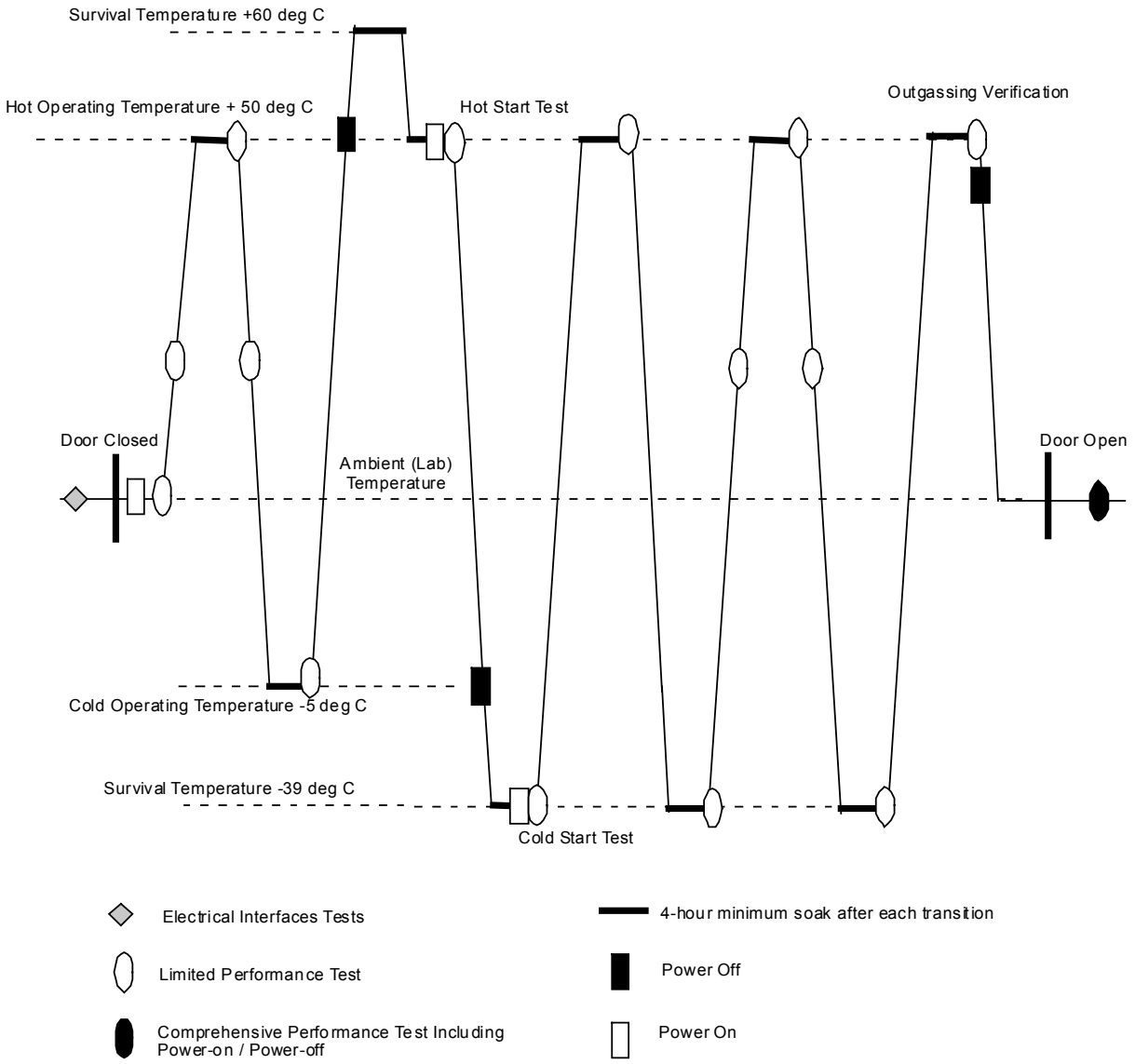


Fig. 4.3.1.8. PCU Thermal-Vacuum Test Profile

Notes for Profile: 1) Maintain plateaus for 4 hours minimum; 2) Maximum rate of change between plateaus shall be less than 20 deg C per hour; 3) PCU shall be configured in its operational state during thermal vacuum testing and outputs shall be monitored throughout the thermal cycling except when the PCU os powered-off; 4) vacuum pressure shall be $5X10^{-6}$ Torr ($6.64x10^{-4}$ Pascal)

4.3.1.9 Outgassing Verification

Verification of the PCU outgassing rate defined in paragraph 3.3.3 shall occur by test at vacuum with the PCU at its highest operational temperature of +1-deg.C as defined in Section 4.2.4.1.3.3 of the Performance Verification Specification ,HPD(8). Outgassing levels for each subsystem shall be in accordance with the requirements defined in the HIRDLS Contamination Control Plan (PA-HIR-006). This verification can be included as part of the sub-system Thermal Vacuum testing as shown in Figure 4.3.2.3. Verifications shall be made to the levels defined in each SSD and may be performed either at the sub-system level or at the unit levels. The PCU Outgassing test as defined in paragraph 9.4 of the MAR (GSFC 424-11-13-01) or an equivalent method. During Outgassing testing the TQCM shall be at 10deg.C below the minimum in orbit operating temperature of the Unit under test.

4.3.1.9.1 Deleted

4.3.1.9.2 Deleted

4.3.1.9.3 Deleted

4.3.1.10 EMI/EMC Test

The PCU shall undergo EMI/EMC testing for radiated emissions, conducted emissions and conducted susceptibility as defined in HPD (9), Section 4.3.7.

4.3.1.10.1 Radiated Emissions, Magnetic Field.

Radiated AC Magnetic Field Emissions (RE04) defined in NHD (1) Section 10.11.5.1 and Radiated DC Magnetic Field Emissions defined in NHD (1) Section 10.11.5.2 shall be met.

4.3.1.10.2 Radiated Emissions, Electric Field.

Narrowband Radiated Emissions (RE02) requirements defined in NHD (1), Section 10.11.6.1 and Broadband Emissions (RE02) requirements defined in NHD(1), Section 10.11.6.2. shall be met.

4.3.1.10.3 Conducted Emissions, Power Leads

Narrowband and Broadband Conducted Emissions (CE01/CE03) requirements defined in NHD (1) Section 10.11.1 shall be met. Test method of MIL-STD-462 shall be used.

4.3.1.10.4 Conducted Emissions, Antenna Terminal (CE06).

Conducted Emissions at the receiving antenna terminal requirements defined in NHD(1), Section 10.11.2 shall be met. Test methods of MIL-STD-462 shall be used.

4.3.1.10.5 Conducted Susceptibility, Power Leads (CS01/CS02)

Conducted Susceptibility requirements defined in NHD(1), Section 10.11.3 shall be met. MIL-STD-462 test methods shall be used.

4.3.1.10.6 Conducted Susceptibility, Spike, Power Leads (CS06)

Conducted Susceptibility requirements defined in NHD(1), Section 10.11.4 shall be met. MIL-STD-461 test methods shall be used.

4.3.1.11 Failure Free Operation

At the conclusion of testing programme the PCU shall have demonstrated failure free operation for at least the last 100 hours of testing as required by Section 4.2.4.1.3.4 of the Performance Verification Specification ,HPD(8). Failure free operation during the sub-system thermal vacuum exposure is included as part of demonstration. Major hardware changes during or after the verification programme shall invalidate previous demonstration.

4.3.1.12 Environmental Test Equipment Tolerance

Unless otherwise specified test apparatus shall be capable of controlling test conditions within the following tolerances of specified or equivalent units

4.3.1.12.1 Temperature

The test apparatus shall be capable of controlling test conditions within temperature tolerances of +/- 2^{O}C or +/- 5% of difference from 21^{O}C, whichever is greater.

4.3.1.12.2 Pressure

The test apparatus shall be capable of controlling test conditions within pressure tolerances of +/-200Pa or +/-5%, whichever is greater, greater than 1atm, +Pa for less than 1atm.

4.3.1.12.3 Relative Humidity

The test apparatus shall be capable of controlling test conditions within 5%.

4.3.1.12.4 Vibration Frequency (Hz).

The test apparatus shall be capable of controlling test conditions within tolerance in frequency of +/-2% or +/-1 Hz, whichever is greater.

4.3.1.12.5 Time Period

The test apparatus shall be capable of controlling test conditions within tolerance in Time Period of +/-5% seconds, whichever is greater.

4.3.1.12.6 Random Vibration Acceleration (g, RMS).

The test apparatus shall be capable of controlling test conditions within tolerance of +/-10%

4.3.1.12.7 Acceleration Spectral Density (g^2/Hz)

The test apparatus shall be capable of controlling test conditions within+/-3dB.

4.3.1.12.8 Heat Flux (W/m-s)

The test apparatus shall be capable of controlling test conditions within +/-10% or +/-0.5 W/m-s, whichever is greater.

4.3.1.12.9 Controlled Rate of Repressurization

The test apparatus shall be capable of controlling test conditions within 1Torr/minute.

4.3.1.13 Variation of Data during Environmental Tests.

Data shall be taken in all states before and after the exposure to the environmental tests. The data taken before the environmental tests shall be used as a baseline to which the data taken after the environmental tests shall be compared. The subsequent data sets shall not vary from the baseline values by more than a statistically significant amount. This variation is to account for variability in test results due to Ground support Equipment.

4.4 General Test Requirements

4.4.1 Test Equipment Accuracy

The test equipment shall be calibrated in accordance with MIL-STD-45662. The inaccuracies due the test equipment shall not be greater than 10% (unless otherwise instructed) of the tolerance of the parameter being measured

4.4.2 Special Testability Provisions

The PCU shall provide means for isolating the Secondary Power Point from the chassis. The PCU shall implement detachable links isolating Secondary Power Returns for each sub-system as shown in HPD (2).

5. Packaging, Delivery and Storage Requirements.

Packaging, Delivery and Storage of the PCU EM and of the PCU PFM shall be done in accordance with the Quality Assurance criteria described in HPD (12).

6. Appendices

The information provided in the Appendices is for a temporary reference only and shall be, in due course, superseded by the information held in Command and Telemetry Handbook SP-HIR-103.

6.1 Appendix 1. Functionality of the Switching Network

Item Number	Definition	Command Code (Hex)	Comments
1	28QA_PWR (PR) Relay ON	F00A	Also 28QA_RTN ON
2	28QA_PWR (RR) Relay ON	D00A	Also 28QA_RTN ON
3	28QB_PWR (PR) Relay ON	F00B	Also 28QB_RTN ON
4	28QB_PWR (RR) Relay ON	D00B	Also 28QB_RTN ON
5	28NA_PWR (PR) Relay ON	F01C	Also 28NA_RTN ON
6	28NA_PWR (PR) Relay OFF	E01C	Also 28NA_RTN OFF
7	28NB_PWR (PR) Relay ON	F01D	Also 28NB_RTN ON
8	28NB_PWR (PR) Relay OFF	E01D	Also 28NB_RTN OFF
9	28NA_PWR (RR) Relay ON	D01C	Also 28NA_RTN ON
10	28NA_PWR (RR) Relay OFF	C01C	Also 28NA_RTN OFF
11	28NB_PWR (RR) Relay ON	D01D	Also 28NB_RTN ON
12	28NB_PWR (RR) Relay OFF	C01D	Also 28NB_RTN OFF
13	SPU +5Volts, +/-15 Volts (Con. A) ON	B005	28QC switched ON
14	SPU +5Volts, +/-15Volts (Con. A) OFF	A005	28QC switched OFF
15	SPU +5Volts, +/-15Volts (Con. B) ON	9005	28QC switched ON
16	SPU +5Volts, +/-15Volts (Con. B) OFF	8005	28QC switched OFF
17	SYS1; 28Volts, +5Volts (Con. A) ON	B001	28QC switched ON
18	SYS1; 28Volts, +5Volts (Con. A) OFF	A001	28QC switched OFF
19	SYS1; 28 Volts, +5Volts (Con. B) ON	9001	28QC switched ON
20	SYS1; 28 Volts, +5Volts (Con. B) OFF	8001	28QC switched OFF
21	SYS2; +15Volts, -15Volts (Con. A) ON	B002	28QC switched ON
22	SYS2; +15Volts, -15Volts (Con. A) OFF	A002	28QC switched OFF
23	SYS2; +15Volts, -15Volts (Con. B) ON	9002	28QC switched ON
24	SYS2; +15Volts, -15Volts (Con. B) OFF	8002	28QC switched OFF
25	A_TEU_+28QC_PWR (PR) Relay ON	F014	Power to subsystem ON
26	A_TEU_+28QC_PWR (PR) Relay OFF	E014	Power to subsystem OFF
27	A_TEU_+28QC_PWR (RR) Relay ON	D014	Power to subsystem ON
28	A_TEU_+28QC_PWR (RR) Relay OFF	C014	Power to subsystem OFF
29	B_TEU_+28QC_PWR (PR) Relay ON	F015	Power to subsystem ON
30	B_TEU_+28QC_PWR (PR) Relay OFF	E015	Power to subsystem OFF
31	B_TEU_+28QC_PWR (RR) Relay ON	D015	Power to subsystem ON
32	B_TEU_+28QC_PWR (RR) Relay OFF	C015	Power to subsystem OFF
33	A_IPU_+28REG_PWR (PR) Relay ON	F002	Power to subsystem ON
34	A_IPU_+28REG_PWR (PR) Relay OFF	E002	Power to subsystem OFF
35	A_IPU_+28REG_PWR (RR) Relay ON	D002	Power to subsystem ON
36	A_IPU_+28REG_PWR (RR) Relay OFF	C002	Power to subsystem OFF
37	B_IPU_+28REG_PWR (PR) Relay ON	F003	Power to subsystem ON
38	B_IPU_+28REG_PWR (PR) Relay OFF	E003	Power to subsystem OFF
39	B_IPU_+28REG_PWR (RR) Relay ON	D003	Power to subsystem ON
40	B_IPU_+28REG_PWR (RR) Relay OFF	C003	Power to subsystem OFF

Item Number	Definition	Command Code (Hex)	Comments
41	GSS_+28QC_PWR (PR) Relay ON	F016	Power to subsystem ON
42	GSS_+28QC_PWR (PR) Relay OFF	E016	Power to subsystem OFF
43	GSS_+28QC_PWR (RR) Relay ON	D016	Power to subsystem ON
44	GSS_+28QC_PWR (RR) Relay OFF	C016	Power to subsystem OFF
45	GSS_+5_PWR (PR) Relay ON	F004	Power to subsystem ON
46	GSS_+5_PWR (PR) Relay OFF	E004	Power to subsystem OFF
47	GSS_+5_PWR (RR) Relay ON	D004	Power to subsystem ON
48	GSS_+5_PWR (RR) Relay OFF	C004	Power to subsystem OFF
49	GSS_+/-15_PWR (PR) Relay ON	F005	Power to subsystem ON
50	GSS_+/-15_PWR (PR) Relay OFF	E005	Power to subsystem OFF
51	GSS_+/-15_PWR (RR) Relay ON	D005	Power to subsystem ON
52	GSS_+/-15_ PWR (RR) Relay OFF	C005	Power to subsystem OFF
53	A_TEU_+5_PWR (PR) Relay ON	F00C	Power to subsystem ON
54	A_TEU_+5_PWR (PR) Relay OFF	E00C	Power to subsystem OFF
55	A_TEU_+5_PWR (RR) Relay ON	D00C	Power to subsystem ON
56	A_TEU_+5_PWR (RR) Relay OFF	C00C	Power to subsystem OFF
57	A_TEU_+/-15_PWR (PR) Relay ON	F00D	Power to subsystem ON
58	A_TEU_+/-15_PWR (PR) Relay OFF	E00D	Power to subsystem OFF
59	A_TEU_+/-15_PWR (RR) Relay ON	D00D	Power to subsystem ON
60	A_TEU_+/-15_PWR (RR) Relay OFF	C00D	Power to subsystem OFF
61	B_TEU_+5_PWR (PR) Relay ON	F010	Power to subsystem ON
62	B_TEU_+5_PWR (PR) Relay OFF	E010	Power to subsystem OFF
63	B_TEU_+5_PWR (RR) Relay ON	D010	Power to subsystem ON
64	B_TEU_+5_PWR (RR) Relay OFF	C010	Power to subsystem OFF
65	B_TEU_+/-15_PWR (PR) Relay ON	F011	Power to subsystem ON
66	B_TEU_+/-15_PWR (PR) Relay OFF	E011	Power to subsystem OFF
67	B_TEU_+/-15_PWR (RR) Relay ON	D011	Power to subsystem ON
68	B_TEU_+/-15_PWR (RR) Relay OFF	C011	Power to subsystem OFF
69	EEA_+5_PWR (PR) Relay ON	F008	Power to subsystem ON
70	EEA_+5_PWR (PR) Relay OFF	E008	Power to subsystem OFF
71	EEA_+5_PWR (RR) Relay ON	D008	Power to subsystem ON
72	EEA_+5_PWR (RR) Relay OFF	C008	Power to subsystem OFF
73	EEA_+/-15_PWR (PR) Relay ON	F009	Power to subsystem ON
74	EEA_+/-15_PWR (PR) Relay OFF	E009	Power to subsystem OFF
75	EEA_+/-15_PWR (RR) Relay ON	D009	Power to subsystem ON
76	EEA_+/-15_PWR (RR) Relay OFF	C009	Power to subsystem OFF
77	SPU_+5A_PWR Relay ON	F018	Power to subsystem ON
78	SPU_+5A_PWR Relay OFF	E018	Power to subsystem OFF
79	SPU_+/-15A_PWR Relay ON	F019	Power to subsystem ON
80	SPU_+/-15A_PWR Relay OFF	E019	Power to subsystem OFF
81	SPU_+5B_PWR Relay ON	D018	Power to subsystem ON
82	SPU_+5B_PWR Relay OFF	C018	Power to subsystem OFF
83	SPU_+/-15B_PWR Relay ON	D019	Power to subsystem ON
84	SPU_+/-15B_PWR Relay OFF	C019	Power to subsystem OFF
85	PCU A Converter to QA PCU B Converter to QB	Direct Command	Primary Power switched to the PCU Internal Power supply
86	PCU A Converter to QB PCU B Converter to QA	Direct Command	Primary Power switched to the PCU Internal Power supply

6.2 Appendix 2. Analogue Telemetry

Item	ATM Definition	ATM Command (Hex)	Scaling Factors
01	PSSV01; 28Volts DC-DC Converter SYS A	000B	TBA
02	PSSV02; 28Volts DC-DC Converter SYS B	000F	TBA
03	PSSV03; +5Volts DC-DC Converter SPU A	1001	TBA
04	PSSV04; +5Volts DC-DC Converter SPU B	1005	TBA
05	PSSV05; +15Volts DC-DC Converter SPU A	1002	TBA
06	PSSV06; +15Volts DC-DC Converter SPU B	1006	TBA
07	PSSV07; -15Volts DC-DC Converter SPU A	1003	TBA
08	PSSV08; -15Volts DC-DC Converter SPU B	1007	TBA
09	PSSV09; +5Volts DC-DC Converter SYS A	0008	TBA
10	PSSV10; +5Volts DC-DC Converter SYS B	000C	TBA
11	PSSV11; +15Volts DC-DC Converter SYS A	0009	TBA
12	PSSV12; +15Volts DC-DC Converter SYS B	000D	TBA
13	PSSV13; -15Volts DC-DC Converter SYS A	000A	TBA
14	PSSV14; -15Volts DC-DC Converter SYS B	000E	TBA
15	PSSV15; +5Volts PCU Internal Power Rail, +5C	0001	TBA
16	PSSV16; +15Volts PCU Internal Power Rail, +15C	0002	TBA
17	PSSV17; -15Volts PCU Internal Power Rail, -15C	0003	TBA
18	PSSV18; +5Volts PCU Internal Power Rail, +5A	0004	TBA
19	PSSV 19; +5Volts PCU Internal Power Rail, +5B	0005	TBA
20	QA Primary Current	0006	TBA
21	QB Primary Current	0007	TBA
22	Temperature; 28Volts DC-DC Converter A	2003	10mV/K
23	Temperature; 28Volts DC-DC Converter B	2007	10mV/K
24	Temperature; +5Volts DC-DC Converter SPU A	1009	10mV/K
25	Temperature; +5Volts DC-DC Converter SPU B	100D	10mV/K
26	Temperature; +15Volts DC-DC Converter SPU A	100A	10mV/K
27	Temperature; +15Volts DC-DC Converter SPU B	100E	10mV/K
28	Temperature; -15Volts DC-DC Converter SPU A	100B	10mV/K
29	Temperature; -15Volts DC-DC Converter SPU B	100F	10mV/K
30	Temperature; +5Volts DC-DC Converter SYS A	2000	10mV/K
31	Temperature; +5Volts DC-DC Converter SYS B	2004	10mV/K
32	Temperature; +15Volts DC-DC Converter SYS A	2001	10mV/K
33	Temperature; +15Volts DC-DC Converter SYS B	2005	10mV/K
34	Temperature; -15Volts DC-DC Converter SYS A	2002	10mV/K
35	Temperature; -15Volts DC-DC Converter SYS B	2006	10mV/K
36	Temperature; +/-15Volts DC-DC Converter PCU A	1008	10mV/K
37	Temperature; +/-15Volts DC-DC Converter PCU B	100C	10mV/K
38	Temperature; In Rush A and Current QA sensor	200A	10mV/K
39	Temperature; In Rush B and Current QB sensor	200B	10mV/K
40	Temperature; QA Relay (PR)	200C	10mV/K
41	Temperature; QA Relay (RR)	200D	10mV/K
42	Temperature; QB Relay (PR)	200E	10mV/K
43	Temperature; QB Relay (RR)	200F	10mV/K

Appendix 3. Digital Telemetry

DTM Number	Command / Address	Description
0	4000	Status of the +28QC input to SYS1 Converters Status of SPU_5A_PWR, SPU_+/-15_PWR Status of A_IPU_+28REG_PWR, Status of B_IPU_+28REG_PWR
1	4001	Status of the +28QC input to SYS2 Converters Status of the Secondary Power Relays for the TEU A
2	4002	Status of the +28QC inputs to the SPU Converters Status of the inputs to PCU Internal Power Converters Status of the Secondary Power Relays for the SPU B Status of the Secondary Power Relays for the GSS
3	4003	Status of the CSS_+28NC_PWR Status of the +28NA Relays Status of the +28NB Relays
4	4004	Status of the Secondary Power Relays for the TEU B
5	4005	Status of the Secondary Power Relays for the EEA
6	4006	Status of A_TEU_+28QC_PWR Status of B_TEU_+28QC_PWR Status of GSS_+28QC_PWR Status of the +28QC_PWR Relays
7	4007	Status of the +28QA Status of the +28QB Status of the +28QC Status of the +28QA Relays Status of the +28QB Relays

6.1.1 DTM 00. Primary Power for the SYS1. Sec. Power for the IPU and SPU A. Command/Address 4000.

Bit	Bit Definition	Description/Comments
15	Power input to the +28B Converter	Logic 1 = Primary Power supplied
14	Power input to the +28A Converter	Logic 1 = Primary Power supplied
13	Power input to the _+5B Converter	Logic 1 = Primary Power supplied
12	Power input to the _+5A Converter	Logic 1 = Primary Power supplied
11	SPU_-15A_PWR Status	Logic 1 = Relay ON; SPU_-15A_PWR ON
10	SPU_+15A_PWR Status	Logic 1 = Relay ON; SPU_+15A_PWR ON
09	SPU_+5A_PWR Status	Logic 1 = Relay ON; SPU_+5A_PWR ON
08	GND	Permanent Logic 0
07	Logic 0	Input to the 4000 Buffer grounded
06	Logic 0	Input to the 4000 Buffer grounded
05	B_IPU_ +28REG_PWR Status	Logic 1 indicates that IPU B is supplied with +28Volts
04	B_IPU_+28REG (PR) Relay	Logic 1 = Relay ON
03	B_IPU_+28REG (RR) Relay	Logic 1 = Relay ON
02	A_IPU_+28REG_PWR Status	Logic 1 indicates that IPU A is supplied with +28Volts
01	A_IPU_+28REG (PR) Relay	Logic 1 = Relay ON
00	A_IPU_+28REG (RR) Relay	Logic 1 = Relay ON

6.1.2 DTM 01. Primary Power for the SYS2. Secondary Power for the TEU A. Command/Address (4001).

Bit	Bit Definition	Description/Comments
15	Power input to the -15B Converter	Logic 1 = Primary Power supplied
14	Power input to the -15A Converter	Logic 1 = Primary Power supplied
13	Power input to the +15B Converter	Logic 1 = Primary Power supplied
12	Power input to the +15A Converter	Logic 1 = Primary Power supplied
11	Logic 0	Input to the 4001 Buffer grounded
10	Logic 0	Input to the 4001 Buffer grounded
09	Logic 0	Input to the 4001 Buffer grounded
08	GND	Permanent Logic 0
07	Logic 0	Input to the 4001 Buffer grounded
06	A_TEU_-15_PWR Status	Logic 1 indicates that TEU A is supplied with -15Volts
05	A_TEU_+15_PWR Status	Logic 1 indicates that TEU A is supplied with +15Volts
04	A_TEU_+/-15_PWR (PR) Relay	Logic 1 = Relay ON
03	A_TEU_+/-15_PWR (RR) Relay	Logic 1 = Relay ON
02	A_TEU_+5_PWR Status	Logic 1 indicates that TEU A is supplied with +5Volts
01	A_TEU_+5_PWR (PR) Relay	Logic 1 = Relay ON
00	A_TEU_+5_PWR (RR) Relay	Logic 1 = Relay ON

6.1.3 DTM 02. Primary Power for the SPU B Supply. Primary Power for the PCU Internal Supply. Secondary Power for the GSS. Command/Address (4002)

Bit	Bit Definition	Description/Comments
15	Power input to the SPU B Converters	Logic 1 = Primary Power supplied
14	Power input to the SPU A Converters	Logic 1 = Primary Power supplied
13	Power input Relay for the PCU Internal Power Converter B	Logic 1 = Primary Power supplied
12	Power input to the PCU Internal Power Converter A	Logic 1 = Primary Power supplied
11	SPU_-15B_PWR Status	Logic 1 = Relay ON; SPU_-15B_PWR ON
10	SPU_+15B_PWR Status	Logic 1 = Relay ON; SPU_+15B_PWR ON
09	SPU_+5B_PWR Status	Logic 1 = Relay ON; SPU_+5B_PWR ON
08	GND	Permanent Logic 0
07	Logic 0	Input to the 4002 Buffer grounded
06	GSS_–15_PWR Status	Logic 1 indicates that GSS is supplied with -15Volts
05	GSS_+15_PWR Status	Logic 1 indicates that GSS is supplied with +15Volts
04	GSS_+/-15_PWR (PR) Relay	Logic 1 = Relay ON
03	GSS_+/-15_PWR (RR) Relay	Logic 1 = Relay ON
02	GSS_+5_PWR Status	Logic 1 indicates that GSS is supplied with +5Volts
01	GSS_+5_PWR (PR) Relay	Logic 1 = Relay ON
00	GSS_+5_PWR (RR) Relay	Logic 1 = Relay ON

6.1.4 DTM03. Primary Power for the CSS. Command/Address 4003.

Bit	Bit Definition	Description/Comments
15	don't care	
14	don't care	
13	don't care	
12	don't care	
11	don't care	
10	don't care	
09	don't care	
08	GND	Permanent Logic 0
07	Logic 0	Input to Buffer 4003 grounded
06	+28NB_PWR (PR) Relay	Logic 1 = Relay ON; 28NB_RTN is switched
05	+28NB_PWR (RR) Relay	Logic 1 = Relay ON; 28NB_RTN is switched
04	Logic 0	Input to Buffer 4003 grounded
03	Logic 0	Input to Buffer 4003 grounded
02	CSS_+28NC Status	Logic 1 indicates that CCS is supplied with Power
01	+28NA_PWR (PR) Relay	Logic 1 = Relay ON; 28NA_RTN is switched
00	+28NA_PWR (RR) Relay	Logic 1 = Relay ON; 28NA_RTN is switched

6.1.5 DTM 04. Secondary Power for the TEU B. Command/Address (4004).

Bit	Bit Definition	Description/Comments
15	don't care	
14	don't care	
13	don't care	
12	don't care	
11	don't care	
10	don't care	
09	don't care	
08	GND	Permanent Logic 0
07	Logic 0	Input to Buffer 4004 grounded
06	B_TEU_-15_PWR Status	Logic 1 indicates that TEU B is supplied with -15Volts
05	B_TEU_ +15_PWR Status	Logic 1 indicates that TEU B is supplied with +15Volts
04	B_TEU_+/-15_PWR (PR) Relay	Logic 1 = Relay ON
03	B_TEU_+/-15_PWR (RR) Relay	Logic 1 = Relay ON
02	B_TEU_+5_PWR Status	Logic 1 indicates that TEU B is supplied with +5Volts
01	B_TEU_+5_PWR (PR) Relay	Logic 1 = Relay ON
00	B_TEU_+5_PWR (RR) Relay	Logic 1 = Relay ON

6.1.6 DTM 05. Secondary Power for the EEA. Command/Address 4005.

Bit	Bit Definition	Description/Comments
15	don't care	
14	don't care	
13	don't care	
12	don't care	
11	don't care	
10	don't care	
09	don't care	
08	GND	Permanent Logic 0
07	Logic 0	Input to Buffer 4005 grounded
06	EEA_-15_PWR Status	Logic 1 indicates that EEA is supplied with -15Volts
05	EEA_+15_PWR Status	Logic 1 indicates that EEA is supplied with +15Volts
04	EEA_+/-15_PWR (PR) Relay	Logic 1 = Relay ON
03	EEA_+/-15_PWR (RR) Relay	Logic 1 = Relay ON
02	EEA_+5_PWR Status	Logic 1 indicates that EEA is supplied with +5Volts
01	EEA_+5_PWR (PR) Relay	Logic 1 = Relay ON
00	EEA_+5_PWR (RR) Relay	Logic 1 = Relay ON

6.1.7 DTM 06. +28QC Status. Primary Power for GSS and TSS. Command/Address 4006

Bit	Bit Definition	Description/Comments
15	+28QC_PWR Low Volts	Logic 1 = +28QC Volts above the Low limit (25.5Volts)
14	GSS_+28QC_PWR Status	Logic 1 indicates that GSS is supplied with Primary Power
13	GSS_+ 28QC_PWR (PR) Relay	Logic 1 = Relay ON
12	GSS_+28QC_PWR (RR) Relay	Logic 1 = Relay ON
11	don't care	
10	don't care	
09	don't care	
08	GND	Permanent Logic 0
07	Logic 0	Input to 4006 Buffer grounded
06	Logic 0	Input to 4006 Buffer grounded
05	B_TEU_+28QC_PWR Status	Logic 1 indicates that TEU B is supplied with Primary Power
04	B_TEU_+28QC_PWR (PR) Relay	Logic 1 = Relay ON
03	B_TEU_+28QC_PWR (RR) Relay	Logic 1 = Relay ON
02	A_TEU_+28QC_PWR Status	Logic 1 indicates that TEU A is supplied with Primary Power
01	A_TEU_+28QC_PWR (PR) Relay	Logic 1 = Relay ON
00	A_TEU_+28QC_PWR (RR) Relay	Logic 1 = Relay ON

6.1.8 DTM 07. +28QA and +28QB Relay Status. Command/Address 4007.

Bit	Bit Definition	Description/Comments
15	don't care	
14	don't care	
13	don't care	
12	don't care	
11	don't care	
10	don't care	
09	don't care	
08	GND	Permanent Logic 0
07	Logic 0	Input to Buffer 4007 grounded
06	+28QC_PWR Status	Logic 1 indicates that the +28QC Power is ON.
05	+28QB_PWR Status	Logic 1 indicates that the Primary Power is present
04	+28QB_PWR and +28QB_RTN (RR) Relay	Logic 1 = Relay ON
03	+28QB_PWR and +28QB_RTN (PR) Relay	Logic 1 = Relay ON
02	+28QA_PWR Status	Logic 1 indicates that the Primary Power is present
01	+28QA_PWR and +28QA_RTN (RR) Relay	Logic 1 = Relay ON
00	+28QA_PWR and +28QA_RTN (PR) Relay	Logic 1 = Relay ON;