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Planck Sorption Cooler System COP and CPV Test Plan

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CHANGE RECORD

Issue	Date	Sheet	Description of Change
0.1	Dec 2008	All	First Draft of the Document
0.2	Feb 2009	All	Second Draft of the Document
1.0	Mar 2008	All	First issue of the document

Acronyms

AD	Applicable Document
AIV	Assembly, Integration and Verification
ASW	Application SoftWare
AVM	Avionics Verification Model
BEM	Back End Module (LFI)
BEU	Back End Unit (LFI)
BIN, bin	Binary
BOL	Begin of Life
CCE	Central Check-out Equipment
CCS	Central Check-out System
CDMS	Command and Data Management Subsystem
CDMU	Central Data Management Unit
CQM	Cryogenic Qualification Model
CSL	Centre Spatial de Liege
CTE	Coefficient of thermal expansion
DAE	Data Acquisition Electronics (LFI)
DC	Direct Current
DMS	Documentation Management System
DPC	Data Processing Centre
DPU	(Data (or Digital) processing Unit
DTCP	Daily Telecommunication Period
ECR	Engineering Change Request
EE	End to End test
EGSE	Electrical Ground Support Equipment
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference
EOL	End of Life
EPS	Electrical Power Subsystem
ESA	European Space Agency
ESD	Electro Static Discharge
ESOC	European Space Operations Centre
ESTEC	European Space Technology and Research Centre
FDIR	Failure Detection, Isolation and Recovery
FEM	Front End Module (LFI)
FEU	Front End Unit (LFI)
FM	Flight Model
FMECA	Failure-Modes, Effects and Criticality Analysis
FOP	Flight Operations Plan
FPU	Focal Plane Unit
FS	Flight Spare
FTS	File Transfer System
GS	Ground Segment
H/W	Hardware
HC	Healthcheck
HFI	High Frequency Instrument (Planck)
HK	House Keeping (data)
ICD	Interface Control Document
ICWG	Instrument Coordination Working Group

ID	Identifier
IID	Instrument Interface Document
IID-B	Instrument Interface Document - part B
ILT	Instrument Level Test
IOM	Instrument Operations Manager
IOT	Instrument Operations Team
IST	Integrated System Test
JPL	Jet Propulsion Laboratory
JT	Joule Thompson
kbps	kilobits per second
LCL	Latch Current Limiter
LFI	Low Frequency Instrument (Planck)
LGA	Low Gain Antenna
LL	Low Limit
LPSC	Laboratoire Physic Subatomic et Cosmologie
Mbps	Megabits per second
MGSE	Mechanical Ground Support Equipment
MLI	Multilayer Insulation
MOC	Mission Operations Centre
N/A, n.a.	Not Applicable
NaN	Not a Number
NCR	Non Conformance Report
NRT	Near-Real-Time
OBCP	On-Board Control Procedure
OBSM	On-Board Software Maintenance
OD	Operational Day
OIRD	Operations Interface Requirements Document
OM	(DPC software) Operations Model
OOL	Out-of-Limits
PGSSG	Planck Ground Segment System Group
PID	Proportional, Integral, Derivative active control
PLFEU	Planck LFI Front End Unit (FEU)
PLM	Payload Module
PM	Project Manager
PPLM	Planck Payload Module
PSO	Planck Science Office
QA	Quality Assurance
QLA	Quick Look Analysis (software)
RD	Reference Document
RFW	Request for Waiver
RT	Real Time
RTA	Real-Time Analysis
S/C	Spacecraft
S/W	Software
SC	SpaceCraft
SCC	Sorption Cooler Compressor
SCCE	Sorption Cooler Cold End
SCE	Sorption Cooler Electronics
SCOE	Special Check-out Equipment
SCOS	Spacecraft Control and Operations System
SCP	Sorption Cooler Pipes
SCS	Sorption Cooler Subsystem (Planck)

SFT	Short Functional Test
SID	Structure Identifier
SPACON	SPAcecraft CONtroller
SR	Secondary Reflector
SS	Stainless Steel
ST	Science Team
STM	Structural/Thermal Model
SVM	SerVice Module
SVT	System Validation Test
TBC	To Be Confirmed
TBD	To Be Defined
TBS	To Be Specified
TBW	To Be Written
TC	TeleCommand
TCS	Thermal Control System
TID	Task Identifier
TM	Telemetry
TMM	Thermal Mathematical Model
TMU	Thermo Mechanical Unit (Sorption cooler)
TOD	Time-Ordered Data
TOI	Time-Ordered Information
TQL	Telemetry Quick-Look
TSA	Temperature Stabilization Assembly
UM	User's Manual
VG	V-Groove radiator
WU	Warm Units

TABLE OF CONTENTS

1. APPLICABLE AND REFERENCE DOCUMENTS

1.1. APPLICABLE DOCUMENTS

[AD1] Planck in-orbit calibration and test requirements, Planck/PSO/2003-024 2.0, July 2007

[AD2] Commissioning Phase Timeline, 090227 PCOP Timeline 1_0_00

[AD3] CPV Phase Timeline, Planck-PSO-2007-018_pre_2_6_CPV_Detailed_Timeline_2009-03-31

[AD4] SCS CSL PFM2 Test Procedures Iss2.3, PL-LFI-PST-PR-025, May 2008

[AD5] SCS CSL PFM2 Test Report Iss1.1, PL-LFI-PST-RP-039, October 2008

1.2. REFERENCE DOCUMENTS

[RD1] Planck SCS User Manual, PL-LFI-PST-MA-002, Issue 3.0

[RD2] Commissioning Phase Timeline, 090227 PCOP Timeline 1_0_00

[RD3] CPV Phase Timeline, Planck-PSO-2007-018_pre_2_6_CPV_Detailed_Timeline_2009-03-31

2. INTRODUCTION

This document describes the test sequence and procedures of the Planck Sorption Cooler System during Commissioning (COP) and Calibration (CPV) Phases in flight.
COP and CPV timelines depend on the specific subsystem considered: SCS, for example, will complete its commissioning and verification phases well before the instruments. For this reason, it will enter Routine Operations when HFI and LFI will still be in their CPV.
For each in-flight SCS test or activity all needed info is reported in a table containing test name, description, constraints, duration, pass/fail criteria, operational requirements, procedures etc.

3. GENERAL REQUIREMENTS

3.1. Responsibilities

MOC H/P team is responsible for all COP and CPV flight operations execution. The SCS Operation Team (SCS OT) will witness and support MOC during tests execution in order to evaluate the results, assess pass/fail criteria, provide system parameters update (TPFs) and respond to any contingency that may arise. SCS Operation team will analyse offline the data for each test and produce a SCS Performance Verification Report.

3.2. Operational Constraints for COP/CPV

Main operational constraints for SCS testing are:

- SCS database loaded in CCS
- I-EGSE Connected to CCS and fully tested.
- TQL machine is connected to I-EGSE and fully tested.
- IOT on site

3.3. COP and CPV SCS Test sequence

SCS activation and verification will be performed according to the COP and CPV timelines.
The main objectives of the two phases are:

- COP, activate SCS and take it into Normal Operations
- CPV, verify full functionality and performance of system in Nominal Ops, comparing results to previous ground test campaigns

SCS steps general sequence during COP/CPV Phases is summarized in Figure 3-1 and Figure 3-2.

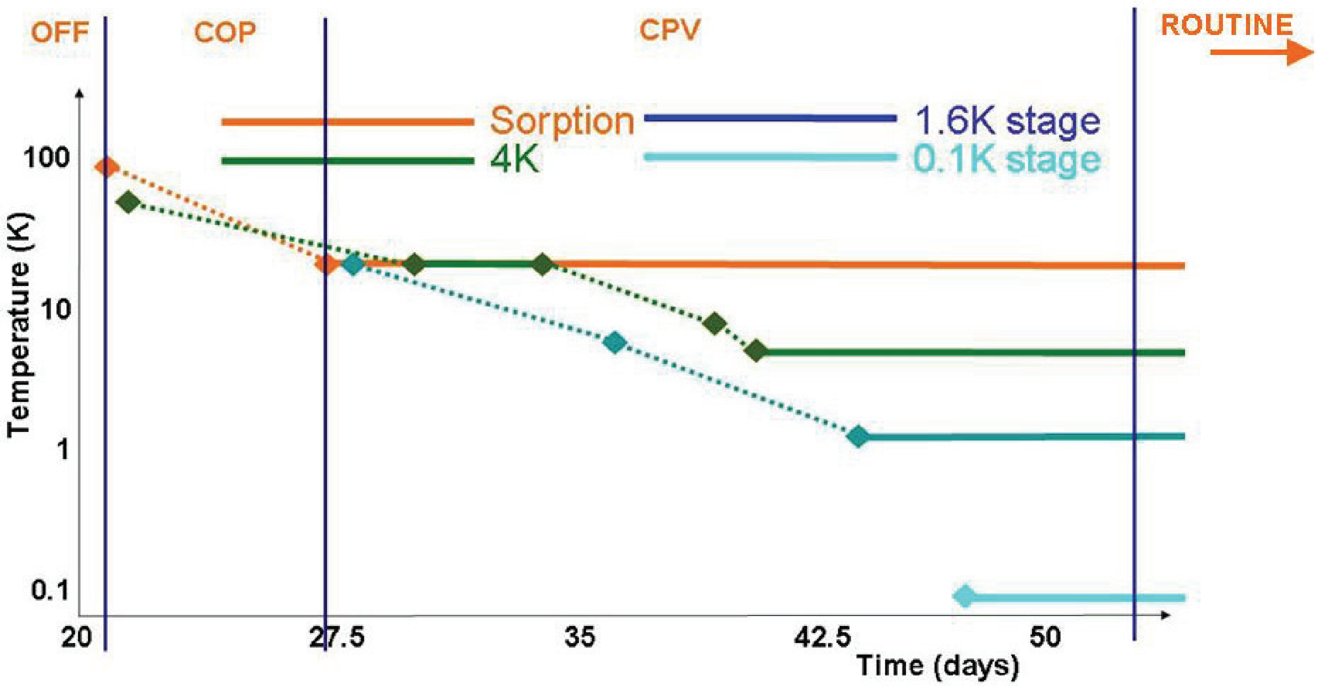

Figure 3-1. SCS COP/CPV phases over general sequence

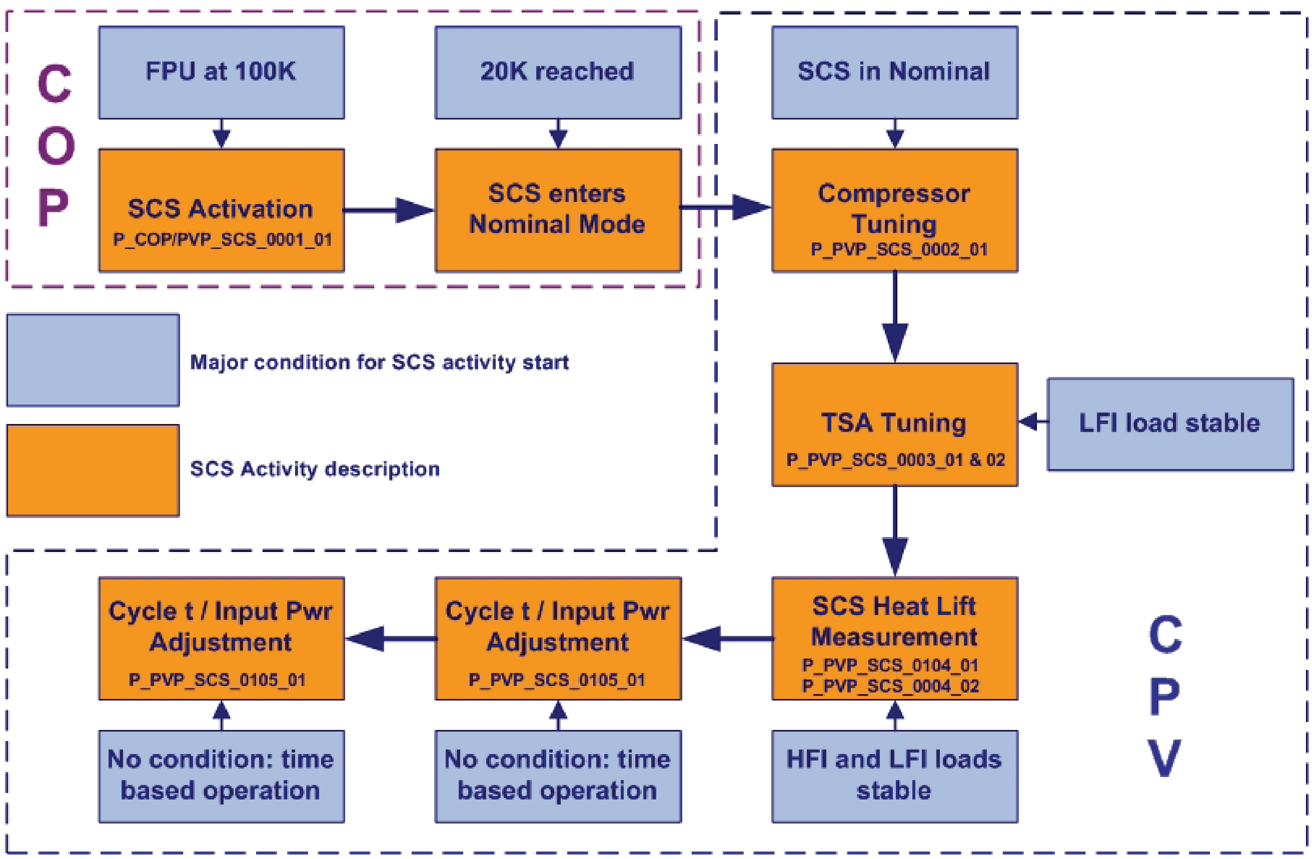

Figure 3-2. SCS COP/CPV phases sequence

3.4. SCS Performance Requirements

TMU Spec	Requirement Value	TM Mnemonic
Cold End T	17.5 K < LVHX1 < 19.02 K 17.5 K < TSA < 22.50 K	SD028540 (LVHX1) SD030540 (TSA)
Cold End T Fluctuations	ΔT @ LVHX1 < 450 mK ΔT @ TSA < 100 mK	SD028540 (LVHX1) SD030540 (TSA)
Cooling Power	Cooling power @ LVHX1 > 190 mW Cooling power @ LVHX2 > 646 mW TSA dissipation = 150 mW Total Cooling Power > 986 mW	N/A
Input Power	TMU Input power < 426 W @ BOL	N/A

3.5. Data analysis

SCS telemetry will be checked by SCS OT on-line during satellite pass (DTCP). Full data processing will be performed off-line and reported in a final report.
During system tuning steps in COP/CPV, it is required that SCS data will be made available before the next DTCP for analysis purposes.

4. SCS Commissioning Phase

4.1. P_COP/PVP_SCS_0001_01 – SCS Activation

4.1.1. Objective

Objective of this activity is to start the SCS-N and take it into Run Mode and, finally, into Nominal Operations. Completion of this step closes Commissioning phase for the SCS.

4.1.2. Initial configuration

LFI	HFI	SCS	SVM
OFF	OFF	ON	ON

4.1.3. Thermal environment

Warm Radiator	VGroove3	FPU	4K Cooler
Steady State	Steady State	<100K	<100K

4.1.4. Test sequence

SCS Flight LUT parameters have been already loaded before launch but they will be confirmed or adjusted on the basis of actual thermal boundary conditions (see LUT Appendix).

Sequence Step	Procedure	Comments	Time Duration
Activate SCE (BOOT Mode)	SCS BOOT	Switch ON SCE if not already ON from previous phase	0:10
Enter INIT	SCS INIT	“	0:05
Enter READY	SCS READY	“	0:05
Adjust LUT values	LUT UPLOAD	If needed	0:30
Dump LUT	LUT READ BACK	Check loaded LUT	0:20
Enter RUN	SCS RUN	Start Cooldown	0:05
SCS enters Nominal	NA	Autonomous transition	About 200:00

Table 4-1

Note: Procedures description and details are reported in Appendix 1 and [RD1].

4.1.5. P_COP/PVP_SCS_0001_01 Description

Item	Description
Sequence number	P_COP/PVP_SCS_0001_01
Test name	SCS Activation
Instrument	SCS
Point of Contact	G. Morgante / D. Pearson
Test objective	Switch on the SCS and enter RUN Nominal Mode
Test duration (including overhead)	About 8 days
Test frequency	Once
Constraints	During DTCP
LFI mode	OFF
SCS mode	From OFF, to ON, to RUN Start up, to RUN Nominal
HFI mode	Configuration mode
HFI state	N/A
4K cooler state	T < 100K
Spacecraft state	Nominal Mode of the Satellite
Pointing requirements	N/A
Contact with SPACON	Yes
Near Real Time	Yes
TMTC procedure	See Table 4-1
IOTCRD section	NA
Data analysis timing	- Real time TM data analysis - Out-of-visibility packets will be analised off line
Pass/fail assessment timing	In real time, during DTCP
Data analysis tools	NA
Pass/Fail criteria	- No unexpected event Packets - SCS shall enter RUN Mode - SCS shall enter Nominal Operations
Action in case of failure/anomalies	Stop the sequence. NCR raised. NRB meeting called. IOM contacts specialists to analyze and prepare plan to solve the contingency.
Data analysis duration before set parameters	N/A
Set parameters	TPFs (LUT parameters)
Priority	Essential
Include in mini CPV	No
Comments/Questions	
Sequential to	Nothing, this is system first activation
Criticality for COP/CPV cont.	Yes

Table 4-2

All requirements on S/C and instruments configuration are reported in the test table (see above) and in COP/CPV timelines [RD2, RD3].

It is important to remind here that:

- **any activity during the COP Phase that can increase load on the cooler or change warm radiator or VGrooves conditions might require new SCS adjustment (tuning) steps.**

- **at the transition into Nominal Operation it may be needed to adjust part of SCS parameters in order to keep it in Nominal and to maintain basic performance**

5. SCS Calibration and Performance Verification Phase

5.1. P_PVP_SCS_0002_01 – SCS Compressor Tuning

5.1.1. Objective

Objective of this test is to adjust the SCS compressor operational parameters for nominal cooler performance in order to ensure optimal conditions for instruments calibration and flight operations. In such a way, the cooler will perform in nominal conditions, meeting all requirements, while maximising lifetime. This is a fundamental step for the whole COP/CPV phase, an out of balance SCS has a strong impact on the thermal status of other sub-systems and of the whole thermal balance of the S/C.

It is important to note here that any activity during COP/CPV that can thermally unbalance the SVM, PLM or SCS itself might require new or more frequent SCS adjustment (tuning) iterations.

This test is performed by optimizing cooler operational parameters in terms of input power and cycle time in order to produce required heat lift and achieve stable cold end conditions for instruments CPV.

5.1.2. Initial configuration set-up

LFI	HFI	SCS	SVM
ON (full load)	ON	ON (Nominal Ops)	ON

5.1.3. Thermal environment

Warm Radiator	VGroove3	FPU	4K Cooler IF
Steady State	Steady State	20K	Nom. Stroke

5.1.4. Test sequence

Sequence Step	Procedure	Comments	Time Duration
Upload "tuned" LUT	LUT UPLOAD		0:20
Powers and times section	SC502559	Cycle and Power are updated	
		"	
Dump LUT Sections	SC602559	Check LUT sections	0:10
"	SC606559	"	
Wait for stability	NA	Checked on next DTCP	> 6:00

Table 5-1

Note: Procedures description and details are reported in Appendix 1 and [RD1]

5.1.5. P_PVP_SCS_0002_01 Description

Item	Description
Sequence number	P_PVP_SCS_0002_01
Test name	Compressor Tuning
Instrument	SCS
Point of Contact	G. Morgante / D. Pearson
Test objective	Tune SCS compressor operational parameters for nominal cooler performance and stable operations
Test duration (including overhead)	About 0.5 hours
Test frequency	Once, before routine tuning, if boundary conditions remain stable
Constraints	During DTCP
LFI mode	ON (full load, within 50 mW)
SCS mode	RUN Nominal
HFI mode	Configuration mode
HFI state	N/A
4K cooler state	Nominal stroke
Spacecraft state	Nominal Mode of the Satellite
Pointing requirements	N/A
Contact with SPACON	Yes
Near Real Time	Yes
TMTC procedure	See Table 5-1
IOTCRD section	NA
Data analysis timing	- Real time TM data analysis - Out-of-visibility packets will be analyzed off line
Pass/fail assessment timing	In real time, during DTCP
Data analysis tools	NA
Pass/Fail criteria	- No unexpected event Packets - SCS shall remain in Nominal Operations - SCS shall meet performance requirements
Action in case of failure/anomalies	Stop the sequence. NCR raised. NRB meeting called. IOM contacts specialists to analyze and prepare plan to solve the contingency.
Data analysis duration before set parameters	N/A
Set parameters	TPFs (LUT parameters)
Priority	Essential
Include in mini CPV	No
Comments/Questions	
Sequential to	System activation (P_COP/PVP_SCS_0001_01)
Criticality for COP/CPV cont.	Yes

Table 5-2

The nominal load (within 50 mW) from LFI and HFI should be applied to SCS when performing this activity.

5.2. P_PVP_SCS_0003_01 & 02 – SCS TSA Tuning

5.2.1. Objective

Objective of this test is to adjust TSA active control parameters relatively to all other parameters for optimized cold end absolute temperature and fluctuations. In such a way temperature oscillations at the LFI and HFI interfaces will be maintained below the required limits, reaching expected operational stable conditions for both instruments.
During TSA tuning, the OpenLoop algorithm will also be activated to achieve better stabilization. At present, it is planned to enable and use both control systems (PID and OpenLoop) for flight operations.
This activity is split in two subsequent DTCPs:
in the first OD parameters will be uploaded and required stability will be achieved
the second OD will be used to check if stability is maintained and, if needed, to perform extra tuning

5.2.2. Initial configuration set-up

LFI	HFI	SCS	SVM
ON (full load)	ON	ON (Nominal Ops)	ON

5.2.3. Thermal environment

Warm Radiator	VGroove3	FPU	4K Cooler
Steady State	Steady State	20K	Nom. Stroke

5.2.4. Test sequence

The final stabilization has to be reached before starting Instruments calibration. It should be performed with both instruments in nominal operating conditions and after 4K setting to Nominal stroke.

Sequence Step	Procedure	Comments	Time Duration
Upload “tuned” LUT	LUT UPLOAD		0:20
Enable TSA	SC501530	Enable PID in LUT SW Section	-
PID/OL section	SC506559	PID/OL parameters are updated	-
Dump LUT Sections	SC601530	Check LUT sections	0:10
“	SC606559	“	
“	“	Repeated several times	
Achieve stability	NA	Several iterations may be needed	6:00 (Total)

Table 5-3

Note: Procedures description and details are reported in Appendix 1 and [RD1]

5.2.5. P_PVP_SCS_0003_01 & 02 Description

Item	Description
Sequence number	P_PVP_SCS_0003_01 & 02
Test name	TSA Tuning
Instrument	SCS
Point of Contact	G. Morgante / D. Pearson
Test objective	Tune SCS TSA to achieve required cold end T stability
Test duration (including overhead)	About 6 hours total
Test frequency	Once if boundary conditions remain stable, except for Routine tuning
Constraints	During two subsequent DTCPs, split in 5 hours on first DTCP and 1 hour in the following pass
LFI mode	ON (full load, within 50 mW)
SCS mode	RUN Nominal
HFI mode	Configuration mode (full load, within 50 mW)
HFI state	N/A
4K cooler state	Nominal stroke
Spacecraft state	Nominal Mode of the Satellite
Pointing requirements	N/A
Contact with SPACON	Yes
Near Real Time	Yes
TMTC procedure	See Table 5-3
IOTCRD section	NA
Data analysis timing	Real time TM data analysis
Pass/fail assessment timing	In real time, during DTCP
Data analysis tools	NA
Pass/Fail criteria	- No unexpected event Packets - SCS shall remain in Nominal Operations - SCS shall meet performance requirements - Peak-to-peak T fluctuations at the TSA stage shall be below 100 mK, while LVHX1 ΔT shall remain below 450 mK - TSA PID control power below 150 mW
Action in case of failure/anomalies	Stop the sequence. NCR raised. NRB meeting called. IOM contacts specialists to analyze and prepare plan to solve the contingency.
Data analysis duration before set parameters	N/A
Set parameters	TPFs (LUT parameters)
Priority	Essential
Include in mini CPV	No
Comments/Questions	
Sequential to	Compressor Tuning (P_ PVP_SCS_0002_01)
Criticality for COP/CPV cont.	Yes

Table 5-4

The nominal load (within 50 mW) from LFI and HFI should be applied to SCS when performing this activity.

5.3. Phase 6-09 SCS Heat lift Measurement

5.3.1. Objective

The objective of this test is to measure the cooling power produced by the SCS in the actual thermal flight conditions. This is a fundamental verification of cooler functional performance and LFI thermal behaviour: it will allow not only to measure SCS performance in terms of heat lift but also to provide an indirect estimation of the LFI passive dissipation (parasitics).

5.3.2. Initial configuration set-up

LFI	HFI	SCS	SVM
ON	ON	ON (Run Mode)	ON

5.3.3. Thermal environment

Warm Radiator	VGroove3	FPU	4K Cooler IF
Steady State	Steady State	20K	4K Nominal

5.3.4. Test sequence

High Level Test Sequence:

1. TSA is deactivated to measure LFI load on LVHX2
2. Switch TSA on again and change TSA set-point, T_{TSA}, to increase the heat load to the sorption cooler. Approximately 200 mK is 100 mW.
3. Use the measurement of the TSA heater circuit current, I_{TSA}, and the TSA heater resistance, ~480 ohm, to check the transfer function between T_{TSA} and the heat load applied to the sorption cooler.
4. If dry-out of LVHX2 is observed before LVHX2 T stabilizes (usually takes about 30 min), then cooling power produced is confirmed. End of test.
5. If no dry-out is noticed then increase TSA set-point by 100mK (that is about 50mW) and wait for the liquid to evaporate.
6. Follow this procedure until LVHX2 dry-out is observed (usually from 3 to 4 steps are required). End of test.

Sequence Step	Procedure	Comments	Time Duration
Upload new LUT	LUT UPLOAD	TSA PID set-point changes are used to perform such measurement	0:20
Enable TSA	SC501530	Enable TSA in LUT SW Section	-
PID section	SC506559	Set PID set-point	-
Dump LUT sections	SC601530	Check LUT	0:10
"	SC606559	"	-
Wait for stabilization	NA	Cold End and Instrument IFs	-
Check Cold End T	NA	Check stability/dry-out	-
If needed repeat step 1	-	Several steps might be required	Up to 6:00
TSA tuning LUT upload	LUT UPLOAD	Go back to stable operations	0:10
PID section	SC506559	Set PID parameters for TSA stability	
Dump LUT section	SC606559	Check LUT	0:05

Table 5-5

Note: Procedures description and details are reported in Appendix 1 and [RD1]

At the end of the heat lift measurement, nominal stable conditions should be achieved back before proceeding with instruments calibration activities.

5.3.5. P_PVP_SCS_0004_02 Description

Item	Description
Sequence number	P_PVP_SCS_0004_02
Test name	SCS Heat Lift measurement
Instrument	SCS
Point of Contact	G. Morgante / D. Pearson
Test objective	Measure produced heat lift
Test duration (including overhead)	About 6 hours total
Test frequency	Once, unless significant change in cooler setting is needed for other reasons
Constraints	During one DTCP: this activity cannot be split is two DTCPs. Extended pass is requested, if not possible the measurement will be reduced to the available time in one single DTCP. This will increase uncertainty of measurement. Nominal stable conditions should be achieved back before proceeding with next instruments calibration activities.
LFI mode	ON Nominal (full load, within 50 mW)
SCS mode	RUN Nominal
HFI mode	ON Nominal (full load, within 50 mW)
HFI state	N/A
4K cooler state	Nominal stroke at 4K
Spacecraft state	Nominal Mode of the Satellite
Pointing requirements	N/A
Contact with SPACON	Yes
Near Real Time	Yes
TMTC procedure	See Table 5-5

IOTCRD section	NA
Data analysis timing	Real time TM data analysis
Pass/fail assessment timing	In real time, during DTCP
Data analysis tools	NA
Pass/Fail criteria	- No unexpected event Packets - SCS cooling power shall be compliant to requirement with a max error of 100mW
Action in case of failure/anomalies	Stop the sequence. NCR raised. NRB meeting called. IOM contacts specialists to analyze and prepare plan to solve the contingency.
Data analysis duration before set parameters	N/A
Set parameters	TPFs (LUT parameters)
Priority	Essential
Include in mini CPV	No
Comments/Questions	
Sequential to	TSA Tuning (P_ PVP_SCS_0003_01&02)
Criticality for COP/CPV cont.	Yes

Table 5-6

The nominal full load (within 50 mW) from LFI and HFI must be applied. Both instruments shall be in their nominal science acquisition state. Thermal conditions of instruments and pre-cooling stages will be perturbed for the whole duration of this measurement.

5.4. P_PVP_SCS_0105_01 - SCS Cycle time and Power small adjustment

5.4.1. Objective

SCS operations will be optimized to maximize cooler lifetime. The baseline Routine operational scenario is requiring frequent (weekly) small adjustment steps of the cooler parameters. This test is intended to check possible effects on cooler balance and instruments performance during CPV phase of such small tuning iterations.
Objective of this test is to change SCS tuning parameters (usually cycle time and input power) by the typical amount of a weekly tuning step (i.e. by about 10-20 s and few watts) to check cooler response and performance to this variation together with instrumental effects on scientific data. This test will allow to check and, possibly, quantify the effect of small cooler performance variations on instruments scientific output.

This activity will be repeated every week, with a period of about 7 days during CPV.

Before starting this test SCS should be in stable Nominal operations, meeting all performance requirements.

5.4.2. Initial configuration set-up

LFI	HFI	SCS	SVM
ON (Nominal)	ON (Nominal)	ON (Nominal Ops)	ON

5.4.3. Thermal environment

Warm Radiator	VGroove3	FPU	4K Cooler
Steady State	Steady State	20K	4K Nominal

5.4.4. Test sequence

Sequence Step	Procedure	Comments	Time Duration
Upload “tuned” LUT	LUT UPLOAD		0:20
Powers and times section	SC502559	Cycle time and Power are updated	
Dump LUT Section	SC602559	Check LUT	0:10

Table 5-7

Note: Procedures description and details are reported in Appendix 1 and [RD1]

5.4.5. P_PVP_SCS_0105_01 Description

Item	Description
Sequence number	P_PVP_SCS_0105_01
Test name	Cycle time and input power adjustment
Instrument	SCS
Point of Contact	G. Morgante / D. Pearson
Test objective	Apply SCS parameters weekly tuning
Test duration (including overhead)	About 0.5 hours
Test frequency	Every week, period about 7 days
Constraints	During one DTCP: this activity cannot be split is two DTCPs. Extended pass is requested, if not possible the measurement will be reduced to the available time in one single DTCP. This will increase uncertainty of measurement. Nominal stable conditions should be achieved back before proceeding with next instruments calibration activities.
LFI mode	ON Nominal (full load, within 50 mW)
SCS mode	RUN Nominal
HFI mode	ON Nominal (full load, within 50 mW)
HFI state	N/A
4K cooler state	Nominal stroke at 4K
Spacecraft state	Nominal Mode of the Satellite
Pointing requirements	N/A
Contact with SPACON	Yes
Near Real Time	Yes
TMTC procedure	See Table 5-7
IOTCRD section	NA
Data analysis timing	- Real time TM data analysis - Out-of-visibility packets will be analyzed off line
Pass/fail assessment timing	In real time, during DTCP
Data analysis tools	NA
Pass/Fail criteria	- No unexpected event Packets - SCS shall remain in Nominal Operations - SCS shall meet performance requirements
Action in case of failure/anomalies	Stop the sequence. NCR raised. NRB meeting called. IOM contacts specialists to analyze and prepare plan to solve the contingency.
Data analysis duration before set parameters	N/A
Set parameters	TPFs (LUT parameters)
Priority	Essential
Include in mini CPV	No
Comments/Questions	
Sequential to	Heat Lift measurement (P_ PVP_SCS_0004_01)
Criticality for COP/CPV cont.	No

Table 5-8

Off-line scientific analysis of instrument data shall verify possible perturbations introduced by SCS adjustments and quantify their impact on data quality.

The nominal full load (within 50 mW) from LFI and HFI must be applied. Both instruments shall be in their nominal science acquisition state.

A1 Appendix 1. SCS Operational Procedures for COP/CPV

A1.1 Procedures Blocks (Level 2)

These procedures are the building blocks for the Level 1 procedures that shall be performed during COP/CPV Phases. Each one can be considered as a stand-alone micro-procedure but they are usually executed only as steps of transitions to Op Modes. They can be considered completed when the TM(5.1) event report for that Mode is received.

SCS COP/CPV procedure blocks are listed in the Table below:

Procedure	Name	Description	SCS UM ref	Comments
BOOT	SCE Boot	SCE Switch ON and Boot	N&R	Activation of SCS, system BOOT, ASW transfer
INIT	SCS Enter INIT	Transition to INIT Mode	N&R	Initialization of system
LUT_UP	LUT Upload	Load LUT in memory	N&R	Optional step. Needed if is required a change in SCS parametrers
LUT_DU	LUT Dump	Dump LUT values	N&R	Dump of LUT values for checking
READY_HM	HealthMonitoring	Enter READY Mode in Health Monitoring State	N&R	READY state for system monitoring. No cooler cycle is performed
RUN	SCS Enter RUN	SCS start-up	N&R	Cooler start-up, compressor cycling enabled

Table A1- 1

A1.2 Procedures (Level 1)

Procedure	Description	Comments
SCE_INIT	Transition OFF to INIT	Used to initialise SCE
READY_HM	SCS Health monitoring	From OFF to Health monitoring
READY_HC	SCS Health Check	From OFF to Health Check process
START_UP	SCS Startup	From OFF to RUN

Table A1- 2

A1.2.1 System Initialization (SCE_INIT)

This higher level procedure is used only to initialise the SCS, to perform diagnostic checks and/or to upload a new LUT.

Step #	Description	Comments
1	**Execute BOOT procedure**	
	Transfer ASW if not automatically executed	
2	**Execute INIT Procedure**	
3	***Execute LUT_UP, if needed***	Optional Step for Uploading new LUT

Table A1- 3

A1.2.2 SCS in HealthMonitoring (READY_HM)

This Procedure can be used to enter the SCS Monitoring state: the sorption cooler cannot be run but all its sensor lines status can be monitored.

Step #	Description	Comments
1	**Execute BOOT Procedure**	
	Transfer ASW if not automatically executed	
2	**Execute INIT Procedure**	
3	***Execute LUT_UP, if needed***	Optional Step for Uploading new LUT
4	**Execute READY_HM Procedure**	

Table A1- 4

A1.2.3 LUT Upload (LUT_UP)

LUT upload is not mandatory. A LUT upload should be executed only if parameters need to be changed; if no change is applied the ASW uses the parameters stored in EEPROM.

Step #	Description	Type	Action	Result
1	**LUT Memory Load**	TC(6.2)	See LUT Upload TC Table A1- 6	
1.1	Wait for TC acknowledgment TM(1.3)	TM(1.3)	10 - TM(1.3), TC started	TM(1.3) - CVS_ID=2
1.2	Wait for TC acknowledgment TM(1.7)	TM(1.7)	10 - TM(1.7), TC completed	TM(1.7) - CVS_ID=3

Table A1- 5

Dedicated LUT Upload TC depends on the model of SCE used.

CCF Name	Description
SC501530	TC 6_2 Load LUT Software – FM1, FM2, PFM1 and PFM2
SC502559	TC 6_2 Load LUT Powers and Times – FM1, FM2, PFM1 and PFM2
SC503559	TC 6_2 Load LUT Health Check and Regeneration – FM2
SC504559	TC 6_2 Load LUT Run Mode transitions – FM2
SC505559	TC 6_2 Load LUT Fault Conditions and Bad Bed Detection – FM2
SC506559	TC 6_2 Load LUT PID and Open Loop Algorithms – FM2
SC507559	TC 6_2 Load LUT Heaters Resistances – FM1, FM2, PFM1 and PFM2
SC508530	TC 6_2 Load LUT Calibrations 1 – FM1, FM2, PFM1 and PFM2
SC509530	TC 6_2 Load LUT Calibrations 2 – FM1, FM2, PFM1 and PFM2
SC510559	TC 6_2 Load LUT health Check and Regeneration – FM1
SC511559	TC 6_2 Load LUT Run Mode transitions – FM1
SC512559	TC 6_2 Load LUT Fault Conditions and Bad Bed Detection – FM1
SC513559	TC 6_2 Load LUT PID and Open Loop Algorithms – FM1
SC514559	TC 6_2 Load LUT health Check and Regeneration – PFM2
SC515559	TC 6_2 Load LUT Run Mode transitions – PFM2x
SC516559	TC 6_2 Load LUT Fault Conditions and Bad Bed Detection – PFM2
SC517559	TC 6_2 Load LUT PID and Open Loop Algorithms – PFM2
SC518559	TC 6_2 Load LUT health Check and Regeneration – PFM1
SC519559	TC 6_2 Load LUT Run Mode transitions – PFM1
SC520559	TC 6_2 Load LUT Fault Conditions and Bad Bed Detection – PFM1
SC521559	TC 6_2 Load LUT PID and Open Loop Algorithms – PFM1

Table A1- 6

The parameter for each LUT upload TC will be transmitted to MOC in TPF files, according to the agreed process.

A1.2.4 *LUT Dump (LUT_DU)*

Step #	Description	Type	Action	Result
1	**LUT Memory Dump**	TC(6.5)	See LUT Dump TC Table A1-8	
1.1	Wait for TC acknowledgment TM(1.3)	TM(1.3)	10 - TM(1.3), TC started	TM(1.3) - CVS_ID=2
1.2	Wait for TC acknowledgment TM(1.7)	TM(1.7)	10 - TM(1.7), TC completed	TM(1.7) - CVS_ID=3
1.3	LUT Read Back TM		See LUT Read Back TM Table	

Table A1- 7

CCF Name	Description
SC601530	TC 6_5 Dump LUT Software
SC602559	TC 6_5 Dump LUT Powers and Times
SC603559	TC 6_5 Dump LUT health Check and Regeneration
SC604559	TC 6_5 Dump LUT Run Mode transitions
SC605559	TC 6_5 Dump LUT Fault Conditions and
SC606559	TC 6_5 Dump LUT PID and Open Loop
SC607559	TC 6_5 Dump LUT Heaters Resistances
SC608530	TC 6_5 Dump LUT Calibrations 1
SC609530	TC 6_5 Dump LUT Calibrations 2

Table A1- 8

Name	Description	LUT position	Monitoring Parameter	Command Parameter
SA100530	LUT SOFTWARE	0x00 to 0x2f	SM325530 to SM384530	SP101530 to SP168530
SA102559	LUT Powers Times	0x30 to 0x55	SM201540 to SM238540	SP001540 to SP038540
SA103559	LUT HC Regen	0x56 to 0x65	SM239540 to SM254540	SP039540 to SP055540
SA104559	LUT Run Mode	0x66 to 0x7e	SM255540 to SM279540	SP056540 to SP080540
SA105559	LUT Faults	0x7f to 0x9b	SM280540 to SM308540	SP081540 to SP109540
SA106559	LUT PID	0x9c to 0xa7	SM309540 to SM320540	SP110540 to SP121540
SA107559	LUT Heaters	0xa8 to 0x2	SM321540 to SM347540	SP121540 to SP148540
SA108530	LUT Calibrations 1	0xc3 to 0xe0	SM385530 to SM414530	SP169530 to SP199530
SA109530	LUT Calibrations 2	0xe1 to 0x104	SM415530 to SM450530	SP200530 to SP235530

Table A1- 9

A1.2.5 *Cooler Start-up (START_UP)*

START_UP is the procedure the starts running the compressor cycle, taking to cooler first in CONDITIONING State and then, after the limits defined in the LUT are reached, automatically into Normal Operations.

IMPORTANT

If this is the first start-up after a long time (more than 12 hours), no special check on cooler status is required before starting the system except for the usual health monitoring.
If this is a re-start after (within 12 hours) SCS cycle has been stopped or after a REGENERATION process, it is important to check that SCS parameters are well within the Faults conditions defined in LUT (Faults Section) before restarting the system. In particular, it should be verified that:

- **Beds Pressure (SM044540 – SM049540) < 8 bar**
- **High Pressure (SM050540) < 8 bar**
- **Beds Temperature (SM034540 – SM039540) < 310 K**
- **LPSB Temperature (SM031540 & SM032540) < 310 K**

If these conditions are not met it is required to RUN from 2 to 4 Cooldown cycles (see [RD1]) before restarting the cooler with the nominal LUT.

Step #	Description	Comments
1	**Execute BOOT Procedure**	
	Transfer ASW if not automatically executed	
2	**Execute INIT Procedure**	
3	***Execute LUT_UP, if needed***	Optional Step for Uploading new LUT
4	**Execute READY_HM Procedure**	
5	**Execute RUN Procedure**	

Table A1- 10

A2 ASW TM Parameters and Limits

Parameter	Short description	Long description	Unit	H/S	Minimum			Maximum		
					Regen	Ambient	Cold	Regen	Ambient	Cold
SM004540	H11 value	Bed 1 Variable Heater Voltage	V		N/A					
SM005540	H12 value	Bed 2 Variable Heater Voltage	V							
SM006540	H13 value	Bed 3 Variable Heater Voltage	V							
SM007540	H14 value	Bed 4 Variable Heater Voltage	V							
SM008540	H15 value	Bed 5 Variable Heater Voltage	V							
SM009540	H16 value	Bed 6 Variable Heater Voltage	V							
SM010540	H7 value	LPSB Heater Voltage	V							
SM011540	H31 value	Nominal LR3 Heater Voltage	V							
SM012540	H32 value	Redundant LR3 Heater Voltage	V							
SD028540	T1 OR T2 VALUE	LR1 Temperature	K	S	16	N/A	16****	25	N/A	25****
SD029540	T3 OR T4 VALUE	LR2 Temperature	K	S						
SD030540	T5 OR T6 VALUE	LR3 Temperature	K	S						
SD031540	T7 OR T30 VALUE	JT Temperature	K	S						
SM022540	T8 value	HX4 Out Temperature (PC3C)	K	S	40			325		
SM023540	T9 value	PC3 Out Temperature	K	S						
SM024540	T10 value	PC3 In Temperature	K	S						
SM025540	T11 value	PC2 Temperature	K	S	80					
SM026540	T12 value	PC1 Temperature	K	S	120					
SM027540	T13 value	HPSB right Temperature	K		N/A					
SM028540	T14 value	HPSB Left Temperature	K							
SM029540	T15 value	Bed 1 External Temperature	K	S	255	N/A	255	285	N/A	285
SM029540	T15 value	Bed 1 External Temperature	K	H	250		250	300		300
SM030540	T16 value	Bed 2 External Temperature	K	S	255		255	285		285
SM030540	T16 value	Bed 2 External Temperature	K	H	250		250	300		300
SM031540	T17 value	LPSB Left Temperature	K	S	240***			350	306	350
SM031540	T17 value	LPSB Left Temperature	K	H				370	307	370
SM032540	T18 value	LPSB Middle Temperature	K	S				350	306	350
SM032540	T18 value	LPSB Middle Temperature	K	H				370	307	370
SM034540	T20 value	Bed 1 Delta T (Internal/External)	K	S	-3			410	18	230
SM034540	T20 value	Bed 1 Delta T (Internal/External)	K	H	-6			430	20	255
SM035540	T21 value	Bed 2 Delta T (Internal/External)	K	S	-3			410	18	230
SM035540	T21 value	Bed 2 Delta T (Internal/External)	K	H	-6			430	20	255
SM036540	T22 value	Bed 3 Delta T (Internal/External)	K	S	-3			410	18	230
SM036540	T22 value	Bed 3 Delta T (Internal/External)	K	H	-6			430	20	255
SM037540	T23 value	Bed 4 Delta T (Internal/External)	K	S	-3			410	18	230
SM037540	T23 value	Bed 4 Delta T (Internal/External)	K	H	-6			430	20	255
SM038540	T24 value	Bed 5 Delta T (Internal/External)	K	S	-3			410	18	230
SM038540	T24 value	Bed 5 Delta T (Internal/External)	K	H	-6			430	20	255
SM039540	T25 value	Bed 6 Delta T (Internal/External)	K	S	-3			410	18	230
SM039540	T25 value	Bed 6 Delta T (Internal/External)	K	H	-6			430	20	255
SM040540	T26 value	Bed 3 External Temperature	K	S	255	N/A	255	320	N/A	320
SM040540	T26 value	Bed 3 External Temperature	K	H	250		250	330		330
SM041540	T27 value	Bed 4 External Temperature	K	S	255		255	320		320
SM041540	T27 value	Bed 4 External Temperature	K	H	250		250	330		330
SM042540	T28 value	Bed 5 External Temperature	K	S	255		255	320		320
SM042540	T28 value	Bed 5 External Temperature	K	H	250		250	330		330
SM043540	T29 value	Bed 6 External Temperature	K	S	255		255	320		320
SM043540	T29 value	Bed 6 External Temperature	K	H	250		250	330		330
SM044540	P1 value	Bed 1 Pressure	bar	S	0***			53.8	1.93	53.8
SM044540	P1 value	Bed 1 Pressure	bar	H				55.2*	2.07	55.2*
SM045540	P2 value	Bed 2 Pressure	bar	S				53.8	1.93	53.8
SM045540	P2 value	Bed 2 Pressure	bar	H				55.2*	2.07	55.2*
SM046540	P3 value	Bed 3 Pressure	bar	S				53.8	1.93	53.8
SM046540	P3 value	Bed 3 Pressure	bar	H				55.2*	2.07	55.2*
SM047540	P4 value	Bed 4 Pressure	bar	S				53.8	1.93	53.8
SM047540	P4 value	Bed 4 Pressure	bar	H				55.2*	2.07	55.2*
SM048540	P5 value	Bed 5 Pressure	bar	S				53.8	1.93	53.8
SM048540	P5 value	Bed 5 Pressure	bar	H				55.2*	2.07	55.2*
SM049540	P6 value	Bed 6 Pressure	bar	S				53.8	1.93	53.8
SM049540	P6 value	Bed 6 Pressure	bar	H				55.2*	2.07	55.2*
SM050540	P7 value	HPSB pressure	bar	S				53.8	1.93	53.8
SM050540	P7 value	HPSB pressure	bar	H				55.2*	2.07	55.2*
SM051540	P8 value	LPSB Pressure	bar	S				1.6**		

SM052540	voltage 28v	primary 28V/20A Voltage	V	H	23	31
SM052540	voltage 28v	primary 28V/20A Voltage	V	S	25	29
SM053540	voltage 12v	Secondary 12V Voltage	V	H	10	14
SM053540	voltage 12v	Secondary 12V Voltage	V	S	11	13
SM054540	voltage 5v	Secondary 5V Voltage	V	H	4	6
SM054540	voltage 5v	Secondary 5V Voltage	V	S	4.5	5.5
SM055540	voltage 15v	Secondary 15V Voltage	V	H	13	17
SM055540	voltage 15v	Secondary 15V Voltage	V	S	14	16
SM056540	Voltage - 15v	Secondary -15V Voltage	V	H	-17	-13
SM056540	Voltage - 15v	Secondary -15V Voltage	V	S	-16	-14
SM101540	voltage 31v	Secondary 31V Voltage	V	H	27	35
SM101540	voltage 31v	Secondary 31V Voltage	V	S	29	33
SM058540	intensity H7	LPSB Heater Current	mA		N/A	
SM059540	intensity H21	Bed 1 gas gap Current	A	H	0***	0.9
SM059540	intensity H21	Bed 1 gas gap Current	A	S		0.8
SM060540	intensity H22	Bed 2 gas gap Current	A	H		0.9
SM060540	intensity H22	Bed 2 gas gap Current	A	S		0.8
SM061540	intensity H23	Bed 3 gas gap Current	A	H		0.9
SM061540	intensity H23	Bed 3 gas gap Current	A	S		0.8
SM062540	intensity H24	Bed 4 gas gap Current	A	H		0.9
SM062540	intensity H24	Bed 4 gas gap Current	A	S		0.8
SM063540	intensity H25	Bed 5 gas gap Current	A	H		0.9
SM063540	intensity H25	Bed 5 gas gap Current	A	S		0.8
SM064540	intensity H26	Bed 6 gas gap Current	A	H		0.9
SM064540	intensity H26	Bed 6 gas gap Current	A	S		0.8
SM065540	intensity H31	Nominal LR3 heater Current	mA	H		100
SM065540	intensity H31	Nominal LR3 heater Current	mA	S		70
SM066540	intensity H32	Redondant LR3 heater Current	mA	H		100
SM066540	intensity H32	Redondant LR3 heater Current	mA	S		70
SM071540	T cold face	SCE temperature	K	H	253	323
SM071540	T cold face	SCE temperature	K	S	263	313
SM072540	T warmest face	SCE temperature	K	H	253	333
SM072540	T warmest face	SCE temperature	K	S	263	323
SM073540	T warm face	SCE temperature	K	H	253	353
SM073540	T warm face	SCE temperature	K	S	263	343

Table A2- 1

Notes:

** 55.2 bar = 800 psi. Switch-off of 20A line is requested at this limit (53.8 bar = 780 psi)*

*** = 1200 torr*

**** These low limits are set for those parameters that don't have physical low limit. This is not acceptable as if no low limit is set in OCP/OCF entries, then SCOS EGSE set it to 0, that might not be in the corresponding calibration curve. So values are defined as:*

- *0 for pressure sensors, even if it is out of limit*
- *for parameter whose numerical calibration curves depend on used model a specific range is defined (Planck SCE MIB User Guide)*
- *the minimum value of the calibration curve, when it is a numerical one*
- *0 if the calibration curve is a polynomial one*

***** Except in RUN Conditioning Mode, in which no monitoring limit is applied*

For GGA Intensities other limits have been implemented using synthetic parameters:

Soft Limits [0;0.1] and [0.5;0.8]

Hard Limits [0;0.2] and [0.4;0.9]

See section 3.3.1.3 of MIB User Guide Document

A3 Flight LookUpTable

In the following pages are reported the LUT values uploaded in SCS-N (and R) before launch. Most of Look Up Table (LUT) parameters must be set in accordance to SCS thermal boundary conditions. Main operational parameters can (and will) be adjusted only once actual values of the boundary interfaces will be known. For this reason, the following tables have been built on the basis of cryo test results and present predictions of flight conditions. They should be considered only as a basic starting set of values that have to be confirmed during flight operations.

The LookUp Table parameter values are defined depending on the following issues :

Thermal boundary conditions at interfaces

If the environment changes the SCS has to be “retuned” to insure same (or better) performance

TMU unit

LUT values depend on the physical components (and their performance) of each TMU like heaters, sensors, harness etc.

SCE unit

LUT electronic values depend on the specific components of the TMU like heaters, sensors calibration, harness etc.

All LUT parameters are subject to change in accordance with thermal environmental conditions found in flight

IMPORTANT
For SCS-R unit has been reported an error in EEPROM#1. This EEPROM section should not be used for any SCS memory operations. However, since no OBSW or data is stored in such memory area this has no impact on functionality of SCS-R.

The maximum size of memory load commands allowed is 50 SAUs. Bigger size uploads lead to failure of SCS to accept command and eventual switch-off of SCS by OBCP from 1553 FDIR on TFh TC = SCS RT \"SICK TC\".

TC memory upload rate of 1 Hz (one TC per second) is ok.

IMPORTANT:
HEALTHCHECK Step1, LPSB H7 Sustain Heater Test, is performed by using power value 0x48 POWER_LPSB and NOT H7 max power.
0x48 POWER_LPSB should always be set higher than 1 W to have a successful HealthCheck step#1.

SOFTWARE

Pos	Parameter Name	Description	Engineering Value				Notes
			bit	SCS-Nom Flight	SCS-Red Flight	Units	
0x00	SW_AUTO_FUNCTIONS Autonomous functions that can be enabled or disabled	Boot Mode ASW Transfer EEPROM→RAM	0	**0**	**0**	N/A	
		Boot Auto Hardware Tests	1	**1**	**1**	N/A	
		ASW Auto Hardware Tests	2	**1**	**1**	N/A	
		Run Diagnostic Sorption Cooler	3	**1**	**1**	N/A	
		Run Diagnostic Electronics	4	**1**	**1**	N/A	
		Run Diagnostic Bad Heaters	5	**1**	**1**	N/A	
		Run Diagnostic Bad ADC	6	**1**	**1**	N/A	
		Run Diagnostic Bad Sensors	7	**1**	**1**	N/A	
		Auto GoTo Startup	8	**1**	**1**	N/A	
		Auto GoTo Defrost	9	**0**	**0**	N/A	
		Auto GoTo Off-Normal	10	**1**	**1**	N/A	
		TSA PID Regulation Enable	11	**0**	**0**	N/A	
		OPEN LOOP Enable	12	**0**	**0**	N/A	
0x01	SW_ASW_ADR	Base address of the applicative software to use		**8005000**	**8005000**	Hex	
0x02	SW_CHECKSUM_1_ADR	Base address of the eeprom 1 checksums		**8003000**	**8003000**	Hex	
0x03	SW_CHECKSUM_N_ADR	Base address of the eeprom n checksums		**8007000**	**8007000**	Hex	
0x04	SW_TEST_EXT_TIMER_LENGTH	Test external timers duration		**1**	**1**	s	
0x05	SW_TEST_FPGA_TIMER_LENGTH	Test fpga timer duration		**62.5**	**62.5**	ns	
0x06	SENSORS_MEAN_T	Number of read to average sensor T1		**30**	**30**	decimal	
0x07	SENSORS_MEAN_T+1	Number of read to average sensor T2		**30**	**30**	decimal	
0x08	SENSORS_MEAN_T+2	Number of read to average sensor T3		**30**	**30**	decimal	
0x09	SENSORS_MEAN_T+3	Number of read to average sensor T4		**30**	**30**	decimal	
0x0A	SENSORS_MEAN_T+4	Number of read to average sensor T5		**30**	**30**	decimal	
0x0B	SENSORS_MEAN_T+5	Number of read to average sensor T6		**30**	**30**	decimal	
0x0C	SENSORS_MEAN_T+6	Number of read to average sensor T7		**30**	**30**	decimal	
0x0D	SENSORS_MEAN_T+7	Number of read to average sensor T8		**30**	**30**	decimal	

0x0E	SENSORS_MEAN_T+8	Number of read to average sensor T9		**30**	**30**	decimal	
0x0F	SENSORS_MEAN_T+9	Number of read to average sensor T10		**30**	**30**	decimal	
0x10	SENSORS_MEAN_T+10	Number of read to average sensor T11		**30**	**30**	decimal	
0x11	SENSORS_MEAN_T+11	Number of read to average sensor T12		**30**	**30**	decimal	
0x12	SENSORS_MEAN_T+12	Number of read to average sensor T13		**30**	**30**	decimal	
0x13	SENSORS_MEAN_T+13	Number of read to average sensor T14		**30**	**30**	decimal	
0x14	SENSORS_MEAN_T+14	Number of read to average sensor T15		**30**	**30**	decimal	
0x15	SENSORS_MEAN_T+15	Number of read to average sensor T16		**30**	**30**	decimal	
0x16	SENSORS_MEAN_T+16	Number of read to average sensor T17		**30**	**30**	decimal	
0x17	SENSORS_MEAN_T+17	Number of read to average sensor T18		**30**	**30**	decimal	
0x18	SENSORS_MEAN_T+18	Number of read to average sensor T20		**30**	**30**	decimal	
0x19	SENSORS_MEAN_T+19	Number of read to average sensor T21		**30**	**30**	decimal	
0x1A	SENSORS_MEAN_T+20	Number of read to average sensor T22		**30**	**30**	decimal	
0x1B	SENSORS_MEAN_T+21	Number of read to average sensor T23		**30**	**30**	decimal	
0x1C	SENSORS_MEAN_T+22	Number of read to average sensor T24		**30**	**30**	decimal	
0x1D	SENSORS_MEAN_T+23	Number of read to average sensor T25		**30**	**30**	decimal	
0x1E	SENSORS_MEAN_T+24	Number of read to average sensor T26		**30**	**30**	decimal	
0x1F	SENSORS_MEAN_T+25	Number of read to average sensor T27		**30**	**30**	decimal	
0x20	SENSORS_MEAN_T+26	Number of read to average sensor T28		**30**	**30**	decimal	
0x21	SENSORS_MEAN_T+27	Number of read to average sensor T29		**30**	**30**	decimal	
0x22	SENSORS_MEAN_T+28	Number of read to average sensor T30		**30**	**30**	decimal	
0x23	SENSORS_MEAN_P	Number of read to average sensor P1		**30**	**30**	decimal	
0x24	SENSORS_MEAN_P+1	Number of read to average sensor P2		**30**	**30**	decimal	
0x25	SENSORS_MEAN_P+2	Number of read to average sensor P3		**30**	**30**	decimal	
0x26	SENSORS_MEAN_P+3	Number of read to average sensor P4		**30**	**30**	decimal	
0x27	SENSORS_MEAN_P+4	Number of read to average sensor P5		**30**	**30**	decimal	
0x28	SENSORS_MEAN_P+5	Number of read to average sensor P6		**30**	**30**	decimal	
0x29	SENSORS_MEAN_P+6	Number of read to average sensor P7		**30**	**30**	decimal	
0x2A	SENSORS_MEAN_P+7	Number of read to average sensor P8		**30**	**30**	decimal	

0x2B	SENSORS_MEAN_TEST	Number of read to average sensor VGAIN		**30**	**30**	decimal	
0x2C	SENSORS_MEAN_TEST+1	Number of read to average sensor VOFF		**30**	**30**	decimal	
0x2D	SENSORS_MEAN_TEST+2	Number of read to average sensor CAL1		**30**	**30**	decimal	
0x2E	SENSORS_MEAN_TEST+3	Number of read to average sensor CAL2		**30**	**30**	decimal	
0x2F	SENSORS_TRESEHOLD	Used for software averaged sensors : the first 'tresehold' values will not be taken into account		**5**	**5**	decimal	

POWER AND TIMES						
Pos	**Parameter Name**	**Description**	**Engineering Values**			**Notes**
			SCS-Nom Flight	**SCS-Red Flight**	**Units**	
0x30	POWER_HEATUP_BEDS	Bed 0 Heatup power for normal operation	**100**	**134**	W	
0x31	POWER_HEATUP_BEDS+1	Bed 1 Heatup power for normal operation	**100**	**134**	W	
0x32	POWER_HEATUP_BEDS+2	Bed 2 Heatup power for normal operation	**100**	**134**	W	
0x33	POWER_HEATUP_BEDS+3	Bed 3 Heatup power for normal operation	**100**	**134**	W	
0x34	POWER_HEATUP_BEDS+4	Bed 4 Heatup power for normal operation	**100**	**134**	W	
0x35	POWER_HEATUP_BEDS+5	Bed 5 Heatup power for normal operation	**100**	**134**	W	
0x36	POWER_DESORB_BED	Bed 0 Desorb power for normal operation	**160**	**130**	W	
0x37	POWER_DESORB_BED+1	Bed 1 Desorb power for normal operation	**160**	**130**	W	
0x38	POWER_DESORB_BED+2	Bed 2 Desorb power for normal operation	**160**	**130**	W	
0x39	POWER_DESORB_BED+3	Bed 3 Desorb power for normal operation	**160**	**130**	W	
0x3A	POWER_DESORB_BED+4	Bed 4 Desorb power for normal operation	**160**	**130**	W	
0x3B	POWER_DESORB_BED+5	Bed 5 Desorb power for normal operation	**160**	**130**	W	
0x3C	POWER_HEATUP_BEDS_STARTUP	Bed 0 Heatup power for startup operation	**100**	**134**	W	
0x3D	POWER_HEATUP_BEDS_STARTUP+1	Bed 1 Heatup power for startup operation	**100**	**134**	W	
0x3E	POWER_HEATUP_BEDS_STARTUP+2	Bed 2 Heatup power for startup operation	**100**	**134**	W	
0x3F	POWER_HEATUP_BEDS_STARTUP+3	Bed 3 Heatup power for startup operation	**100**	**134**	W	
0x40	POWER_HEATUP_BEDS_STARTUP+4	Bed 4 Heatup power for startup operation	**100**	**134**	W	
0x41	POWER_HEATUP_BEDS_STARTUP+5	Bed 5 Heatup power for startup operation	**100**	**134**	W	
0x42	POWER_DESORB_BEDS_STARTUP	Bed 0 Desorb power for startup operation	**160**	**130**	W	
0x43	POWER_DESORB_BEDS_STARTUP+1	Bed 1 Desorb power for startup operation	**160**	**130**	W	

0x44	POWER_DESORB_BEDS_STARTUP+2	Bed 2 Desorb power for startup operation	**160**	**130**	W	
0x45	POWER_DESORB_BEDS_STARTUP+3	Bed 3 Desorb power for startup operation	**160**	**130**	W	
0x46	POWER_DESORB_BEDS_STARTUP+4	Bed 4 Desorb power for startup operation	**160**	**130**	W	
0x47	POWER_DESORB_BEDS_STARTUP+5	Bed 5 Desorb power for startup operation	**160**	**130**	W	
0x48	POWER_LPSB	Low Pressure Stabilization Bed Power	**1.35**	**1.35**	W	
0x49	TIME_CYCLE_NORMAL	Cycle Time in Normal Mode	**1050**	**940**	s	
0x4A	TIME_GASGAP_ON_BEDS	Time delay for GGA switch ON	**0**	**0**	s	
0x4B	TIME_GASGAP_ON_BEDS+1	Time delay for GGA switch ON	**0**	**0**	s	
0x4C	TIME_GASGAP_ON_BEDS+2	Time delay for GGA switch ON	**0**	**0**	s	
0x4D	TIME_GASGAP_ON_BEDS+3	Time delay for GGA switch ON	**0**	**0**	s	
0x4E	TIME_GASGAP_ON_BEDS+4	Time delay for GGA switch ON	**0**	**0**	s	
0x4F	TIME_GASGAP_ON_BEDS+5	Time delay for GGA switch ON	**0**	**0**	s	
0x50	TIME_GASGAP_OFF_BEDS	Anticipated GGA switch OFF Time	**60**	**60**	s	
0x51	TIME_GASGAP_OFF_BEDS+1	Anticipated GGA switch OFF Time	**60**	**60**	s	
0x52	TIME_GASGAP_OFF_BEDS+2	Anticipated GGA switch OFF Time	**60**	**60**	s	
0x53	TIME_GASGAP_OFF_BEDS+3	Anticipated GGA switch OFF Time	**60**	**60**	s	
0x54	TIME_GASGAP_OFF_BEDS+4	Anticipated GGA switch OFF Time	**60**	**60**	s	
0x55	TIME_GASGAP_OFF_BEDS+5	Anticipated GGA switch OFF Time	**60**	**60**	s	

IMPORTANT:
HEALTHCHECK Step1, LPSB H7 Sustain Heater Test, is performed by using power value 0x48 POWER_LPSB and NOT H7 max power.
0x48 POWER_LPSB should always be set higher than 1 W to have a successful HealthCheck step#1.

HEALTHCHECK REGENERATION

Pos	Parameter Name	Description	Engineering Values Flight Cold HC SCS-N	Engineering Values Flight Cold HC SCS-R	Units	Notes
0x56	HEALTHCHECK_DELTA_P_LP	Delta pressure low pressure	**0.001**	**0.001**	bar	
0x57	HEALTHCHECK_TIME_LIMIT	Health check time out	**120**	**120**	s	
0x58	HEALTHCHECK_TLPSB	LPSB temperature limit	***	***	K	
0x59	HEALTHCHECK_MAX_POWER	Maximum Power	**130**	**130**	W	
0x5A	HEALTHCHECK_MIN_POWER	Minimum Power	**5**	**5**	W	
0x5B	HEALTHCHECK_TBED_LIMIT	Bed temperature limit	**305**	**305**	K	
0x5C	HEALTHCHECK_PBED_LIMIT	Bed pressure limit	**1.38**	**1.38**	bar	
0x5D	HEALTHCHECK_DELTAT_COLD	Delta temperature cold	**0.5**	**0.5**	K	
0x5E	HEALTHCHECK_TIME_LIMIT_COLD	Cold End Heaters Time-out	**2**	**2**	s	
0x5F	REGENERATION_POWER	CE heater power to run the regeneration procedure	**150**	**150**	W	
0x60	REGENERATION_TEMPERATURE	T to be maintained for the regeneration process	**350**	**350**	K	
0x61	REGENERATION_MAX_PRESSURE	Max P in HPST not to be exceeded	**5**	**5**	bar	
0x62	REGENERATION_TIME	Time needed to maintain the CE at REGEN_TEMPERATURE to complete the regeneration process	**180**	**180**	s	
0x63	REGENERATION_MAX_TIME	Maximum time allowed during a regeneration process	**72000**	**72000**	s	
0x64	REGENERATION_GGON_TEMPERATURE	Max CE T that allows the GGA to be turned ON	**320**	**320**	K	
0x65	REGENERATION_DELTAT	set bang-bang level	**2**	**2**	K	

*** LPSB T limit parameter (HEALTHCHECK_TLPSB) must be set to T17 + 0.5K **just before** executing the test

IMPORTANT:
HEALTHCHECK Step1, LPSB H7 Sustain Heater Test, is performed by using power value 0x48 POWER_LPSB and NOT H7 max power. 0x48 POWER_LPSB should always be set higher than 1 W to have a successful HealthCheck step#1.

RUN MODE TRANSITION

Pos	Parameter Name	Description	Engineering Values			Notes
			SCS-Nom Flight	SCS-Red Flight	Units	
0x66	STARTUP_TIME_ADJUST_MDP	Conditioning Maximum Desorption Pressure	**34.5**	**34.5**	bar	
0x67	STARTUP_TIME_ADJUST_MDT	Maximum Desorbing temperature	**460**	**460**	K	
0x68	STARTUP_TIME_ADJUST_MHT	Maximum Heatup Temperature	**420**	**420**	K	
0x69	STARTUP_TIME_ADJUST_MCTFIRST	Maximum cycle time (first cycle)	**390**	**390**	s	
0x6A	STARTUP_TIME_ADJUST_MCTNEXT	Maximum cycle time (next cycles)	**1200**	**1200**	s	
0x6B	STARTUP_ENTER_DEFROST_MTP	Maximum Tank Pressure	**54**	**54**	bar	
0x6C	STARTUP_ENTER_DEFROST_MJT_T7	Maximum JT Temperature (using T7)	**100**	**100**	K	
0x6D	STARTUP_ENTER_DEFROST_MJT_T30	Maximum JT Temperature (using T30)	**100**	**100**	K	
0x6E	STARTUP_ENTER_DEFROST_FLOW	Condition to enter in defrost : Flow Expected	**65535**	**65535**	decimal	
0x6F	STARTUP_EXIT_DEFROST_TIME	Defrost Time out (maximum defrost duration)	**1000**	**1000**	s	
0x70	STARTUP_EXIT_DEFROST_MJT_T7	Exit Defrost Condition (using T7)	**80**	**80**	K	
0x71	STARTUP_EXIT_DEFROST_MJT_T30	Exit Defrost Condition (using T30)	**80**	**80**	K	
0x72	STARTUP_ENTER_NORMAL_MCONJT_T7	Maximum startup JT Temperature (using T7)	**22**	**22**	K	
0x73	STARTUP_ENTER_NORMAL_MCONJT_T30	Maximum startup JT Temperature (using T30)	**22**	**22**	K	
0x74	STARTUP_ENTER_NORMAL_MINCONJT	Minimum Tank Pressure In Startup operation	**27.3**	**28.3**	bar	
0x75	STARTUP_ENTER_NORMAL_MAXCONJT	Maximum Tank Pressure In Startup operation	**35.5**	**36.5**	bar	
0x76	NORMAL_ENTER_STARTUP_MINNTP	Minimum Tank Pressure in Normal operation	**25.5**	**26.5**	bar	
0x77	NORMAL_ENTER_STARTUP_MAXNTP	Maximum Tank Pressure in Normal operation	**36.2**	**37.2**	bar	
0x78	NORMAL_ENTER_STARTUP_MNCET	Maximum Normal compressor element temperature	**480**	**480**	K	
0x79	NORMAL_ENTER_STARTUP_MNJT_T7	Maximum normal JT Temperature (using T7)	**23**	**23**	K	
0x7A	NORMAL_ENTER_STARTUP_MNJT_T30	Maximum normal JT Temperature (using T30)	**23**	**23**	K	
0x7B	STARTUP_LPSB_HIGH_TEMPERATURE_LIMIT	LPSB ‘bang bang’ procedure higher limit	**296**	**296**	K	
0x7C	STARTUP_LPSB_LOW_TEMPERATURE_LIMIT	LPSB ‘bang bang’ procedure lower limit	**295**	**295**	K	
0x7D	STARTUP_HPST_PRESSURE_LIMIT	Startup HPST Pressure Limit	**28**	**28**	bar	
0x7E	NORMAL_H8_RATE_IF_H7_BAD	H8 on % when H7 is bad (see FMECA 6.2.4, AD08)	**5**	**5**	dec %	

FAULTS

Pos	Parameter Name	Description	Engineering Values			Notes
			SCS-Nom Flight	SCS-Red Flight	Units	
0x7F	FAULT_COND_BED_TEMPERATURE_LIMIT	Fault condition bed temperature limit	**525**	**525**	K	
0x80	FAULT_COND_BED_PRESSURE_LIMIT	Fault condition bed pressure limit	**54.1**	**54.1**	bar	
0x81	FAULT_COND_LPSB_TEMPERATURE_LIMIT	Fault condition lpsb temperature limit	**350**	**350**	K	
0x82	FAULT_COND_PRT_TEMPERATURE_DEFAULT	Default T for PRT sensors in case of failure	**270**	**270**	K	
0x83	FAULT_COND_JT_TEMPERATURE_DEFAULT	Default T for JT sensors in case of failure	**23**	**23**	K	
0x84	BAD_BED_DETECT_COOL_TEMP_LIMIT	Bad Bed Detection : cooldown bed must be removed if its temperature is higher than this limit	**330**	**330**	K	
0x85	BAD_BED_DETECT_COOL_PRESSURE_LIMIT	Bad Bed Detection : cooldown bed must be removed if its pressure is higher than this limit	**7.58**	**7.58**	bar	
0x86	BAD_BED_DETECT_HEATUP_TEMP_LIMIT	Bad Bed Detection : heatup bed must be removed if its temperature is higher than this limit	**330**	**330**	K	
0x87	BAD_BED_DETECT_HEATUP_PRESSURE_LIMIT	Bad Bed Detection : heatup bed must be removed if its pressure is higher than this limit	**7.58**	**7.58**	bar	
0x88	BAD_BED_DETECT_CYCLE_PERIOD	Bad Bed Detection : Bad Bed Detection is enabled if cycle time is below this limit	**390**	**390**	s	
0x89	FAULT_ELECTRONIC_28V_DEFAULT	If 28 volts is wrong use this value to calculate the power	**27.5**	**27.5**	V	
0x8a	FAULT_ELECTRONIC_28V_UP_LIMIT	If 28 volts is greater than this value, 28 volts is wrong	**32**	**32**	V	
0x8b	FAULT_ELECTRONIC_28V_LOW_LIMIT	If 28 volts is lower than this value, 28 volts is wrong	**25**	**25**	V	
0x8c	FAULT_ELECTRONIC_12V_UP_LIMIT	If 12 volts is greater than this value, 12 volts is wrong	**13**	**13**	V	
0x8d	FAULT_ELECTRONIC_12V_LOW_LIMIT	If 12 volts is lower than this value, 12 volts is wrong	**11**	**11**	V	
0x8e	FAULT_ELECTRONIC_12V_TIME	See FMECA 6.3.2 [AD08]	**120**	**120**	s	
0x8f	FAULT_ELECTRONIC_TEMP_FIRST	See FMECA 6.3.1 [AD08]	**333**	**333**	K	
0x90	FAULT_ELECTRONIC_TEMP_SECOND	See FMECA 6.3.1 [AD08]	**353**	**353**	K	

0x91	FAULT_ELECTRONIC_ADC_REF	Digital output from reference sensor shall be compared to this value + - delta	**60800**	**60800**	decimal	
0x92	FAULT_ELECTRONIC_ADC_DELTA	Digital output from reference sensor shall be compared to reference value +- this parameter	**250**	**250**	decimal	
0x93	FAULT_HEATERS_H2I_ON	Gas Gaps current must be up this limit when active	**0.5**	**0.5**	A	
0x94	FAULT_HEATERS_H2I_OFF	Gas Gap current must be lower than this limit when inactive	**0.1**	**0.1**	A	
0x95	FAULT_HEATERS_H7	I measured on H7 must be equal to I applied (from DAC value) ± this parameter	**0.1**	**0.1**	A	
0x96	FAULT_HEATERS_H31	I measured on H31/H32 must be equal to I applied (from DAC value) ± this parameter	**0.1**	**0.1**	A	
0x97	FAULT_HEATERS_H8	If T17 and T18 temperature are above this limit, H8 is always on (Failure from FDIR)	**320**	**320**	K	
0x98	FAULT_HEATERS_H34_H35_T_UP_T7	H33/H34 bad if JT temperature up this limit (using T7)	**110**	**110**	K	
0x99	FAULT_HEATERS_H34_H35_T_UP_T30	H33/H34 bad if JT temperature up this limit (using T30)	**110**	**110**	K	
0x9a	FAULT_HEATERS_H34_H35_DELTA_T	H33/H34 bad if this value is not reached within ‘rise time’	**25**	**25**	K	
0x9b	FAULT_HEATERS_H34_H35_RISE_TIME	H33/H34 bad if ‘delta T’ is not reached within this time value	**180**	**180**	s	

PID						
Pos	**Parameter Name**	**Description**	**Engineering Values**			**Notes**
			SCS-Nom Flight	**SCS-Red Flight**	**Units**	
0x9c	PID_SETPOINT_T5	Set Point of the L3 PID regulator (using T5)	**18.05**	**18.05**	K	
0x9d	PID_SETPOINT_T6	Set Point of the L3 PID regulator (using T6)	**18.05**	**18.05**	K	
0x9e	PID_P	P parameter of the L3 PID regulator	**500**	**500**	decimal	
0x9f	PID_I	I parameter of the L3 PID regulator	**15**	**15**	decimal	
0xa0	PID_D	D parameter of the L3 PID regulator	**0**	**0**	decimal	
0xa1	PID_RATE	Sampling rate of the L3 PID regulator	**1**	**1**	s	
0xa2	PID_UPPER_LIMIT	Upper Limit of the L3 PID regulator	**22**	**22**	V	
0xa3	PID_LOWER_LIMIT	Lower Limit of the L3 PID regulator	**0**	**0**	V	
0xa4	PID_TEMPERATURE_LIMIT_T5	Temperature Limit of the L3 PID regulator (using T5)	**22**	**22**	K	
0xa5	PID_TEMPERATURE_LIMIT_T6	Temperature Limit of the L3 PID regulator (using T6)	**22**	**22**	K	
0xa6	OPEN_LOOP_R1	R1 value from the open loop algorithm	**1.63**	**1.63**	K/W	Thermal R
0xa7	OPEN_LOOP_N	Number of previous Q_LFI value to average from open loop	**60**	**60**	decimal	

RESISTORS						
Pos	Parameter Name	Description	Engineering Values SCS-Nom Flight	Engineering Values SCS-Red Flight	Units	Notes
0xa8	HW_HEATERS_RB	Loss resistor ‘rb’ for bed 0 power calculation	**5.01**	**5.00**	Ω	
0xa9	HW_HEATERS_RB+1	Loss resistor ‘rb’ for bed 1 power calculation	**4.99**	**5.00**	Ω	
0xaa	HW_HEATERS_RB+2	Loss resistor ‘rb’ for bed 2 power calculation	**4.98**	**5.10**	Ω	
0xab	HW_HEATERS_RB+3	Loss resistor ‘rb’ for bed 3 power calculation	**5.10**	**5.00**	Ω	
0xac	HW_HEATERS_RB+4	Loss resistor ‘rb’ for bed 4 power calculation	**4.94**	**5.00**	Ω	
0xad	HW_HEATERS_RB+5	Loss resistor ‘rb’ for bed 5 power calculation	**5.04**	**4.90**	Ω	
0xae	HW_HEATERS_RBL	Loss resistor ‘rbl’ for bed 0 power calculation	**5.11**	**5.10**	Ω	
0xaf	HW_HEATERS_ RBL+1	Loss resistor ‘rbl’ for bed 1 power calculation	**5.09**	**5.10**	Ω	
0xb0	HW_HEATERS_RBL+2	Loss resistor ‘rbl’ for bed 2 power calculation	**5.08**	**5.20**	Ω	
0xb1	HW_HEATERS_RBL+3	Loss resistor ‘rbl’ for bed 3 power calculation	**5.20**	**5.10**	Ω	
0xb2	HW_HEATERS_RBL+4	Loss resistor ‘rbl’ for bed 4 power calculation	**5.04**	**5.10**	Ω	
0xb3	HW_HEATERS_RBL+5	Loss resistor ‘rbl’ for bed 5 power calculation	**5.14**	**5.00**	Ω	
0xb4	HW_HEATERS_RV	Loss resistor ‘rv’ for bed 0 power calculation	**5.38**	**5.40**	Ω	
0xb5	HW_HEATERS_RV+1	Loss resistor ‘rv’ for bed 1 power calculation	**5.30**	**5.40**	Ω	
0xb6	HW_HEATERS_RV+2	Loss resistor ‘rv’ for bed 2 power calculation	**5.37**	**5.40**	Ω	
0xb7	HW_HEATERS_RV+3	Loss resistor ‘rv’ for bed 3 power calculation	**5.43**	**5.20**	Ω	
0xb8	HW_HEATERS_RV+4	Loss resistor ‘rv’ for bed 4 power calculation	**5.30**	**5.40**	Ω	
0xb9	HW_HEATERS_RV+5	Loss resistor ‘rv’ for bed 5 power calculation	**5.43**	**5.30**	Ω	
0xba	HW_HEATERS_RVL	Loss resistor ‘rvl’ for bed 0 power calculation	**5.48**	**5.50**	Ω	
0xbb	HW_HEATERS_RVL+1	Loss resistor ‘rvl’ for bed 1 power calculation	**5.40**	**5.50**	Ω	
0xbc	HW_HEATERS_RVL+2	Loss resistor ‘rvl’ for bed 2 power calculation	**5.47**	**5.50**	Ω	
0xbd	HW_HEATERS_RVL+3	Loss resistor ‘rvl’ for bed 3 power calculation	**5.53**	**5.30**	Ω	
0xbe	HW_HEATERS_RVL+4	Loss resistor ‘rvl’ for bed 4 power calculation	**5.40**	**5.50**	Ω	
0xbf	HW_HEATERS_RVL+5	Loss resistor ‘rvl’ for bed 5 power calculation	**5.53**	**5.40**	Ω	

0xc0	HW_HEATERS_RH7	H7 resistor for LPSB power H7 calculation	**32.60**	**32.60**	Ω	
0xc1	HW_HEATERS_RH31	H31 resistor for LR3 (nom) power calculation	**488.00**	**488.00**	Ω	
0xc2	HW_HEATERS_RH32	H32 resistor for LR3 (red) power calculation	**488.00**	**488.00**	Ω	

CALIBRATION 1

Pos	Parameter Name	Description	Engineering Values		Units	Notes
			SCS-Nom Flight	SCS-Red Flight		
0xc3	HW_CAL_ADC_V31	Calibration ADC to volts for 31 volts	**1310.7**	**1310.7**	decimal	
0xc4	HW_CAL_ADC_V28	Calibration ADC to volts for 28 volts	**2184.5**	**2184.5**	decimal	
0xc5	HW_CAL_ADC_V12	Calibration ADC to volts for 12 volts	**3276.75**	**3276.75**	decimal	
0xc6	HW_CAL_GAIN_H7	GAINh7 part of Ih7 = GAINh7 + OFFSETh7	**0.9736**	**0.9736**	decimal	
0xc7	HW_CAL_OFFSET_H7	OFFSETh7 part of Ih7 = GAINh7 + OFFSETh7	**0**	**0**	decimal	
0xc8	HW_CAL_GAIN_H31	GAINh31 part of Ih31 = GAINh31 + OFFSETh31	**0.0812**	**0.0812**	decimal	
0xc9	HW_CAL_OFFSET_H31	OFFSETh31 part of Ih31 = GAINh31 + OFFSETh31	**0**	**0**	decimal	
0xca	HW_CAL_GAIN_H32	GAINh32 part of Ih32 = GAINh32 + OFFSETh32	**0.0812**	**0.0812**	decimal	
0xcb	HW_CAL_OFFSET_H32	OFFSETh32 part of Ih32 = GAINh32 + OFFSETh32	**0**	**0**	decimal	
0xcc	HW_CAL_T3_R0	T3(ADC) → T3(K). Resistance = T3(ADC) * R0 / 65535 + R1	**4400.51**	**4418.24**	decimal	
0xcd	HW_CAL_T3_R1	T3(ADC) → T3(K). Resistance = T3(ADC) * R0 / 65535 + R1	**121.57**	**122.32**	decimal	
0xce	HW_CAL_T3_ZL	T3(ADC) → T3(K). Chebychev ZL coefficient	**3.067725563**	**2.907696155**	decimal	
0xcf	HW_CAL_T3_ZU	T3(ADC) → T3(K). Chebychev ZU coefficient	**4.358324119**	**4.03298032**	decimal	
0xd0	HW_CAL_T3_A0	T3(ADC) → T3(K). Chebychev A0 coefficient	**11.918839**	**11.962971**	decimal	
0xd1	HW_CAL_T3_A1	T3(ADC) → T3(K). Chebychev A1 coefficient	**-11.124553**	**-11.194584**	decimal	
0xd2	HW_CAL_T3_A2	T3(ADC) → T3(K). Chebychev A2 coefficient	**3.48778**	**3.515801**	decimal	
0xd3	HW_CAL_T3_A3	T3(ADC) → T3(K). Chebychev A3 coefficient	**-0.782669**	**-0.783545**	decimal	
0xd4	HW_CAL_T3_A4	T3(ADC) → T3(K). Chebychev A4 coefficient	**0.119087**	**0.113076**	decimal	
0xd5	HW_CAL_T3_A5	T3(ADC) → T3(K). Chebychev A5 coefficient	**-0.010445**	**-0.006186**	decimal	
0xd6	HW_CAL_T4_R0	T4(ADC) → T4(K). Resistance = T4(ADC) * R0 / 65535 + R1	**4401.31**	**4417.24**	decimal	

0xd7	HW_CAL_T4_R1	T4(ADC) → T4(K). Resistance = T4(ADC) * R0 / 65535 + R1	**121.69**	**122.35**	decimal	
0xd8	HW_CAL_T4_ZL	T4(ADC) → T4(K). Chebychev ZL coefficient	**2.842756794**	**2.76194118**	decimal	
0xd9	HW_CAL_T4_ZU	T4(ADC) → T4(K). Chebychev ZU coefficient	**3.93386007**	**3.938180357**	decimal	
0xda	HW_CAL_T4_A0	T4(ADC) → T4(K). Chebychev A0 coefficient	**11.929172**	**11.837288**	decimal	
0xdb	HW_CAL_T4_A1	T4(ADC) → T4(K). Chebychev A1 coefficient	**-11.28089**	**-11.036423**	decimal	
0xdc	HW_CAL_T4_A2	T4(ADC) → T4(K). Chebychev A2 coefficient	**3.512276**	**3.529423**	decimal	
0xdd	HW_CAL_T4_A3	T4(ADC) → T4(K). Chebychev A3 coefficient	**-0.758478**	**-0.86858**	decimal	
0xde	HW_CAL_T4_A4	T4(ADC) → T4(K). Chebychev A4 coefficient	**0.102641**	**0.169652**	decimal	
0xdf	HW_CAL_T4_A5	T4(ADC) → T4(K). Chebychev A5 coefficient	**-0.004946**	**-0.026502**	decimal	
0xe0	HW_CAL_T4_A6	T4(ADC) → T4(K). Chebychev A6 coefficient	**0**	**0.003555**	decimal	

Calibration 2

Pos	Parameter Name	Description	Engineering Values		Units	Notes
			SCS-Nom Flight	SCS-Red Flight		
0xe1	HW_CAL_T5_R0	T5(ADC)→T5(K).Resistance=T5(ADC)*R0/65535+R1	1758.53	1764.12	decimal	
0xe2	HW_CAL_T5_R1	T5(ADC)→T5(K).Resistance=T5(ADC)*R0/65535+R1	665.49	665.29	decimal	
0xe3	HW_CAL_T5_ZL	T5(ADC) → T5(K). Chebychev ZL coefficient	2.855945561	2.822024226	decimal	
0xe4	HW_CAL_T5_ZU	T5(ADC) → T5(K). Chebychev ZU coefficient	3.963267678	3.759289252	decimal	
0xe5	HW_CAL_T5_A0	T5(ADC) → T5(K). Chebychev A0 coefficient	11.918305	11.86822	decimal	
0xe6	HW_CAL_T5_A1	T5(ADC) → T5(K). Chebychev A1 coefficient	-11.274393	-11.125414	decimal	
0xe7	HW_CAL_T5_A2	T5(ADC) → T5(K). Chebychev A2 coefficient	3.521261	3.568656	decimal	
0xe8	HW_CAL_T5_A3	T5(ADC) → T5(K). Chebychev A3 coefficient	-0.765057	-0.809943	decimal	
0xe9	HW_CAL_T5_A4	T5(ADC) → T5(K). Chebychev A4 coefficient	0.1047	0.107181	decimal	
0xea	HW_CAL_T5_A5	T5(ADC) → T5(K). Chebychev A5 coefficient	-0.004926	0.003469	decimal	
0xeb	HW_CAL_T5_A6	T5(ADC) → T5(K). Chebychev A6 coefficient	0	-0.004578	decimal	
0xec	HW_CAL_T5_A7	T5(ADC) → T5(K). Chebychev A7 coefficient	0	0.000383	decimal	
0xed	HW_CAL_T6_R0	T6(ADC)→T6(K). Resistance=T6(ADC)*R0/65535+R1	1758.6	1765.74	decimal	
0xee	HW_CAL_T6_R1	T6(ADC)→T6(K). Resistance=T6(ADC)*R0/65535+R1	665.34	665.51	decimal	
0xef	HW_CAL_T6_ZL	T6(ADC) → T6(K). Chebychev ZL coefficient	3.093303734	2.995075652	decimal	
0xf0	HW_CAL_T6_ZU	T6(ADC) → T6(K). Chebychev ZU coefficient	4.461153937	4.313704991	decimal	
0xf1	HW_CAL_T6_A0	T6(ADC) → T6(K). Chebychev A0 coefficient	11.793828	11.714016	decimal	
0xf2	HW_CAL_T6_A1	T6(ADC) → T6(K). Chebychev A1 coefficient	-11.093765	-11.039031	decimal	
0xf3	HW_CAL_T6_A2	T6(ADC) → T6(K). Chebychev A2 coefficient	3.667011	3.722686	decimal	
0xf4	HW_CAL_T6_A3	T6(ADC) → T6(K). Chebychev A3 coefficient	-0.916537	-0.938237	decimal	

0xf5	HW_CAL_T6_A4	T6(ADC) → T6(K). Chebychev A4 coefficient	**0.168287**	**0.158954**	decimal	
0xf6	HW_CAL_T6_A5	T6(ADC) → T6(K). Chebychev A5 coefficient	**-0.019377**	**-0.007817**	decimal	
0xf7	HW_CAL_T6_A6	T6(ADC) → T6(K). Chebychev A6 coefficient	**0**	**-0.00354**	decimal	
0xf8	HW_CAL_T7_R0	T7(ADC)→T7(K). Resistance=T7(ADC)*R0/65535+R1	**4402.4**	**4423.38**	decimal	
0xf9	HW_CAL_T7_R1	T7(ADC)→T7(K). Resistance=T7(ADC)*R0/65535+R1	**121.66**	**122.53**	decimal	
0xfa	HW_CAL_T7_A	T7(K) from T7(ADC). R=ADC * R0 / 65535 + R1. X = log R. T (Kelvin) = exp(A – B . x)	**9.7955**	**9.1952**	decimal	
0xfb	HW_CAL_T7_B	T7(K) from T7(ADC). R=ADC * R0 / 65535 + BR1 X = log R. T (Kelvin) = exp(A – B . x)	**0.9856**	**0.824**	decimal	
0xfc	HW_CAL_T30_R0	T30(ADC) → T30(K). Resistance = T30(ADC) * R0 / 65535 + R1	**4398.04**	**4415.3**	decimal	
0xfd	HW_CAL_T30_R1	T30(ADC) → T30(K). Resistance = T30(ADC) * R0 / 65535 + R1	**121.64**	**122.36**	decimal	
0xfe	HW_CAL_T30_A	T30(K) from T3(ADC). R=ADC * R0 / 65535 + R1. X = log R. T (Kelvin) = exp(A – B . x)	**9.0919**	**9.2067**	decimal	
0xff	HW_CAL_T30_B	T30(K) from T3(ADC). R=ADC * R0 / 65535 + R1. X = log R. T (Kelvin) = exp(A – B . x)	**0.755**	**0.824**	decimal	
0x100	HW_CAL_TBED_UVA	UVA term for bed temperature calculation : uV = tThermocouple * UVA / 65535 - UVB	**20**	**20**	decimal	
0x101	HW_CAL_TBED_UVB	UVB term for bed temperature calculation : uV = tThermocouple * UVA / 65535 - UVB	**1.3954**	**1.3954**	decimal	
0x102	HW_CAL_TBED_TRA	TRA term for bed temp. calc. r = tReferenceK * TRA / 65535 - (tReferenceK -65535)* TRB / 65535	**139**	**139**	decimal	
0x103	HW_CAL_TBED_TRB	TRB term for bed temp. calc. r = tReferenceK * TRA / 65535 - (tReferenceK -65535)* TRB / 65535	**78.8**	**78.8**	decimal	
0x104	RATE_BED_POWER_ADJUST	Bed heaters power readjustment frequencey (number of sensors set between two power adjustment)	**3**	**3**	decimal	

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