Herschel

SPIRE DPU Test Plan

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1 Introduction

1.1 Purpose of the document

The Istituto di Fisica dello Spazio Interplanetario (IFSI) of the Italian Consiglio Nazionale delle Ricerche (CNR) is responsible for the design and manufacturing of the three Digital Processing Units/Instrument Control Unit for the three instruments to be flown on board of the ESA satellite Herschel Space Observatory: HIFI, PACS and SPIRE.

A contract between ASI and the firm Carlo Gavazzi Space (CGS) is active and CGS will provide to IFSI the CPU, I/F, DC/DC boards and the Mother-Board, electrically and functionally working, while IFSI is responsible for the mechanical box, the cabling between the front wall connectors and the motherboard, the OBS and the environmental tests.

This document specifies the tests to be carried-out on the DPU, both at CGS premises during acceptance tests of the boards and the following tests, to be sure that the DPU fulfils its mechanical, electrical and functional interfaces with the SPIRE subsystems and with the S/C subsystems.

Acronyms and Abbreviations

1.1.1 Acronyms

AD	Architectural Design
ATP	Acceptance Test Plan
AVM	Avionic Model
CNR	Consiglio Nazionale delle Ricerche
CPP	Coordinated Parts Procurement
CPU	Control Processing Unit
CDMS	Central Data Management System
CDMU	Central Data Management Unit
CGS	Carlo Gavazzi Space
CM	Common Mode
CQM	Cryogenic Qualification Model
COG	Centre Of Gravity
DDD	Detailed Design Document
DPU	Digital Processing Unit
DRAM	Data RAM
EEPROM	Electrically Erasable Programmable Read Only Memory
EGSE	Electrical Ground Support Equipment
EMC	ElectroMagnetic Compatibility
EMI	ElectroMagnetic Interference
EQM	Engineering Qualification Model
ESA	European Space Agency

FCU	Focal plane Control Unit
FM	Flight Model
FPU	Focal Plane Unit
FIRST	Far InfraRed and Submillimeter Telescope
FS	Flight Spare
FSDL	Fast Serial Data Link
GSE	Ground Support Equipment
HIFI	Heterodyne Instrument for FIRST
HK	HouseKeeping
HRS	High Resolution Spectrometer
HW	HardWare
IBDR	Instrument Baseline Design Review
ICD	Interface Control Document
ICDR	Instrument Critical Design Review
ICU	Instrument Control Unit
I/F	InterFace
IHDR	Instrument Hardware Design Review
IFSI	Istituto di Fisica dello Spazio Interplanetario
ISVR	Instrument Science Verification Review
LCU	Local oscillator Control Unit
LSL	Low Speed Link
LSU	Local oscillator Source Unit
MOI	Moment Of Inertia
NA	Not Applicable
OBS	On-Board Software
PA	Product Assurance
PACS	Photoconductor Array Camera and Spectrometer
PDU	Power Distribution Unit
PRAM	Program RAM
PROM	Programmable Read Only Memory
RAM	Random Access Memory
S/C	SpaceCraft
SCC	SpaceCraft Components
SEU	Single Event Upset
SPIRE	Spectral and Photometric Imaging Receiver
S/S	SubSystem
SVM	Service Module
SW	Software
TBC	To Be Confirmed
TBD	To Be Defined
TBW	To Be Written
TV	Thermal Vacuum
WBS	Work Breakdown Structure

1.2 References

1.2.1 Applicable Documents

Document Reference	Name
AD1	SPIRE Instrument Specification
AD2	FIRST/Planck Instrument Interface Document Part A
AD3	FIRST/Planck Instrument Interface Document Part B Instrument “SPIRE”
AD4	FIRST SPIRE DPU Subsystem Specification
AD5	FIRST-DPU/ICU Subsystem Development Plan
AD6	DPU-ICU P.A. Plan
AD7	SPIRE DPU AIV Plan
AD8	SPIRE Interface Control Document
AD9	PS-ICD
AD10	DPU/ICU On Board Software Product Assurance Plan

1.2.2 Reference Documents

Document Reference	Name
RD1	CPU Board Test Procedure
RD2	Interface Board Test Procedure
RD3	DPU/ICU Spacecraft Interface Acceptance Test Plan

2 Introduction

The tests planned and described in this document aim at verifying that the DPU meets the requirements for which it was designed and manufactured.

All units, AVM, EQM, FM and FS will undergo the planned tests, but as far as the environmental tests are concerned, the Qualification Units will undergo the vibration and thermal vacuum tests at qualification levels while the flight units (FM and FS) will be submitted to vibration and thermal vacuum tests only at acceptance levels.

3 Test Types

The following tests are foreseen:

- Metrological tests
- Electrical tests
- Performance tests
- Vibration tests
- Thermal Vacuum tests
- EMC/EMI tests
- Functional tests

3.1 Metrological Tests

The DPU box shall comply with the physical characteristics shown in the Interface Control Drawing in AD3.

The parameters to be measured are:

- Mass
- Dimensions
- Centre of Gravity (COG)
- Moment Of Inertia (MOI)
- Baseplate and Feet Flatness
- Bonding Strap Position
- Connectors Positions
- Connectors Identification Position

NOTE: The Moment Of Inertia will not be measured but derived by analysis.

3.2 Electrical Tests

The different models AVM, EQM, FM and FS are specified to be electrically identical, as far as the hardware interfaces with S/C and subsystems are concerned, and functionally identical.

The AVM will contain only one computer unit while the remaining models will be fully hardware redundant containing two computer units.

As far as the On Board Software is concerned, the AVM OBS can be upgradable and so will be the EQM. Of course the AVM OBS will be checked up to the level of the subsystems implementation or to the level of the subsystems simulators implementation.

In order for the OBS to be tested the interface between the DPU, as Remote Terminal, and the S/C simulator, as Bus Controller, will be carried out in agreement with AD9 and RD3.

The electrical tests that will be carried out at CGS premises are the following:

3.2.1 Tests on the CPU Board (RD1)

1. DSP and Program Memory
2. Data Memory
3. 32-Bit Internal Bus
4. Interval Timer & Interrupt Manager
5. Watch-dog
6. EEPROM
7. Check power consumption

3.2.2 Tests on the I/F Board (RD2)

1. Check absence of short circuit to power supply
2. Check digital ground to analogue ground insulation
3. Check power consumption
4. Check Power-On reset generation
5. Check external Hardware Reset generation
6. Check control Logic
7. Check Fast Science Data Link Interfaces
8. Check Low Speed Link Interfaces
9. Check Analogue Inputs
10. Check MIL-STD-1553 Clock Generation
11. Check MIL-STD-1553 Interface
12. Check Control Logic Status Register

3.2.3 Test SW Package Menus

3.2.3.1 MAIN MENU

1 HW Reset Board
2 Reset Board
3 FSDL Interfaces
4 LSL Interfaces
5 Analogue Inputs
6 MIL-STD-1553 Interface
7 Status Register

3.2.3.2 RESET BOARD

1 FSDL0 Reset
2 FSDL1 Reset
3 FSDL2 Reset
4 MIL-STD-1553 Reset
5 LSL Reset
6 Software Reset
7 Return to the Main Menu

3.2.3.3 FSDL Interfaces

1 Reset all FSDL Interfaces
2 Send Single Datum
3 Send Single Data Packet
4 Send half FIFO Data Packet
5 Read Single Datum
6 Read All Data

3.2.3.4 LSL Interfaces

1 Reset LSL Interface
2 Send Single Datum without Echo
3 Send Single Datum with Echo
4 Read Data
5 Read Status Register
6 Timeout Check
7 Abort Check

3.2.3.5 Analogue Inputs

No Sub-menus are present

3.2.3.6 MIL-STD-1553 Interface

See RD3

3.2.3.7 Status Register

No Sub-menus are present

3.2.4 Tests on the DC/DC Converter for DPU

TBW

3.2.5 Electrical Test Objectives at IFSI

The main parameters to be checked are:

- Voltage levels for the DPU
- Noise on voltage levels for DPU
- Converter efficiency of the DC/DC for DPU
- Inrush current
- Conducted emission on power lines
- Conducted susceptibility on power lines and signal lines
- Total power drain
- Interface signal timing to/from S/C (repeated as there is a different CDMS I/F simulator)
- Pin functions
- Isolation and Grounding

Some of the above tests are part of the EMC/EMI environmental tests and their results will be contained in the EMC/EMI test report.

3.2.6 Test Set-Up

To meet the objectives described in section 3.2.5 the test set-up will ensure:

- Isolation and grounding
- Input and output impedances

- Signal level and duration
- Rise and fall times

The measurements will be carried-out under nominal power supply generation/drain and environmental conditions, but they will be repeated at the extremes of the operational conditions to verify the electrical performance.

3.3 Performance tests

Performance tests shall be carried-out to exercise all hardware and software functions in:
- normal environmental conditions
- marginal power supply conditions
- thermal vacuum conditions

3.3.1 Test objectives

The tests shall be carried-out to exercise all hardware and software functions, including non destructive negative conditions, to verify the correct response of the equipment.

The tests shall be carried-out in normal conditions, during thermal vacuum test steps and after vibrations.

3.3.2 Test set-up

At subsystem level the DPU performance will be tested by means of the CDMS simulator, the EGSE and with IFSI subsystems simulator. The subsystems simulators are very simple and at basic levels (see AD7) to mainly test the hardware to/from the SPIRE subsystems.

At integrated SPIRE instrument the DPU performance will be tested by means of the SPIRE EGSE and the subsystems simulators or the subsystems units.

3.4 Vibration tests

The vibration tests will include:
- a low level sinusoidal vibration for resonance frequencies research
- sinusoidal vibration at qualification level for the EQM or at acceptance levels for the FM and FS
- random vibration at qualification level for the EQM or at acceptance levels for the FM and FS

The pertinent vibration levels are shown in AD2 sections 9.5.3.3.2 and 9.5.3.4.

3.4.1 Test Objectives

The tests shall demonstrate the capability of the DPU to withstand the stress induced by vibrations during the launch phase without degradation of performances.

The resonance research will indicate the frequencies at which the maximum stresses will be induced by the vibrations to the structure and to all devices internal to the box.

3.4.2 Test set-up

A rigid interface flange between the DPU and the shaker is required having the appropriate interface holes.

The EGSE and subsystems simulators are required to verify that after vibrations, at subsystem level, no damage was sustained.

3.5 Thermal Vacuum tests

3.5.1 Test objectives

Thermal vacuum (TV) tests are carried-out to check that:

- The thermal design is correct
- no assembly defects exist as they are emphasised by the combined effects of thermal cycling and heat dissipation.

The pertinent TV requirements are shown in AD2 section 9.5.4.

3.5.2 Test set-up

Meaningful TV tests at subsystem level, in order to check also the OBS performance, require the interconnection with the SPIRE subsystems (or the S/S simulators) and with the FPU (or FPU simulator), together with the SPIRE EGSE in order to allow thorough performance testing checks to be carried-out as required during thermal cycling and/or soaking phases.

TV tests only at unit level will be carried-out, with the EGSE and subsystems simulators but only low level software functions will be tested.

3.6 EMC/EMI tests

3.6.1 Test objectives

The EMC/EMI tests have to be carried out to verify the compatibility of the instrument subsystems with the electromagnetic environment of Herschel.

At unit level the meaningful tests that will be carried out are:

- conducted emission on power lines
- conducted susceptibility on power lines
- conducted susceptibility on signal lines (CM)
- CM tests on power lines
- CM tests on signal lines
- radiated emission
- radiated susceptibility (susceptibility thresholds, if any, assessed only on dedicated software routines)
- radiated ESD susceptibility tests
- conducted ESD susceptibility tests

3.6.2 Test set-up

For the various EMC/EMI tests the suggested set-up is shown in the relevant subsections of section 9.5.6 of AD2, i.e.:

- section 9.5.6.12 for conducted emission tests
- section 9.5.6.13 for conducted susceptibility tests
- section 9.5.6.14 for radiated emission tests
- section 9.5.6.15.1 for radiated ESD susceptibility tests
- section 9.5.6.15.2 for conducted ESD susceptibility tests

3.7 Functional tests

The following functional tests will be foreseen in order to check the performance of the DPU at various levels:

- GO/NO-GO test
- Short functional test
- Functional test

3.7.1 GO/NO-GO test

The GO/NO-GO test will be performed every time a quick assessment of the vitality of the DPU unit is required. It will consist in a check of the current drain at the nominal power supply voltage and of the DPU HK content. It can be carried-out with the DPU and the EGSE. The performance assessment is just limited to the good health of the DPU itself and the HK content should reflect the situation of all subsystems being missing.

3.7.2 Short functional test

The short functional test will be performed together with the subsystems (or their simulators) and the SPIRE EGSE and will consist in the full procedure of the default settings of all the subsystems following the switch on procedure up to a pre-defined stand-by mode. The check of the whole HK content will provide information of the good health of the DPU and its interfaces (HW and SW) with the instrument subsystems.

3.7.3 Functional test

The functional test will be performed with the full integrated instrument in such conditions as to allow scientific measurements in order to check all OBS functions in the various operating modes, the various settings and including the autonomous functions. The SPIRE EGSE will be used to assess the performance of the DPU OBS.