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Title: **EMC Test Plan**

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Issue	Date	Sheet	Description of Change	Release
1	16.02.04		First Issue	
2	27.05.05		Genral complete update concerning especially test stequences and instrument modes. Concerned chapters are: § 2: Documents list § 3.1: CE/CS tests explained § 3.3, § 3.4: CE on PLM PFM representative § 4: reference documents added § 4.2: Test procedures to be written adapted to the need. Remark added to Fig. 4.2-1. § 4.2.1: Complete update § 4.2.2: TBD § 4.3.2: replaced by content of 4.4.2, § 4.4.2 deleted. § 4.3.2.1: Corrected § 4.3.4.3, § 4.4.2.3, § 4.4.3.3, §4.4.4.3, § 4.4.5.2: Electrially isolated pumps § 4.3.3: Remark added § 5.1.1: Complete update	

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1 INTRODUCTION

This plan provides the baseline for EMC testing on HERSCHEL payload modules and satellite.

The plan is based on the HERSCHEL AIT planning as reflected in the Satellite AIT Plan (ref. [AD1]) and the general verification philosophy provided in the PLM EMC Control and Verification Plan, [AD4].

It describes the hardware levels applicable for EMC testing under ASED responsibility, the test flow as well as the tests which are required.

Based on this test plan, the EMC detailed test procedures shall be written.

2 DOCUMENTS

For the EMC test plan the following documents are applicable:

[AD1]	Satellite AIT Plan (part 2)	HP-2-ASED-PL-0026
[AD2]	HERSCHEL GDIR	H-P-1-ASPI-SP-0027
[AD3]	HERSCHEL EMC Specification	H-P-1-ASPI-SP-0037
[AD4]	EMC Control and Verification Plan	HP-2-ASED-PL-0013
[AD5]	HERSCHEL PLM AIV Grounding Diagram	HP-2-ASED-DW-0002
[AD6]	HERSCHEL/PLANCK Frequency Plans	H-P-1-ASPI-PL-0201
[AD7]	HERSCHEL EMC/ESD Control Plan	H-P-1-ASPI-PL-0038

The following documents have been referred to:

[RD1]	EMC/Power Working Group Meeting 17	H-P-ASP-MN-4392
[RD2]	Changes to H/P EMC Specification	HP-ASP-CR-0417
[RD3]	Spire EQM Test Plan	SPIRE-RAL-DOC-001905
[RD4]	PACS EMC/ESD Control Plan and Procedure	PACS-ME-PL-015
[RD5]	HIFI EMC Test Procedure	SRON-U/HIFI/PR/2004-001

3 HERSCHEL EMC TEST PHILOSOPHY

3.1 Objective

EMC qualification will be achieved by EMC tests on EQM as well as on PFM hardware.

We have to distinguish between the PLM EQM equipped with the modified CVV of ISO, the PLM PFM and the complete spacecraft PFM.

An overview about the different tests foreseen with respect to the above mentioned test models is given in table 3.1-1 below.

All EMC test except the bonding and grounding measurements during the integration phase shall be done under COLD conditions in order to be flight representative.

§ EMC Spec	EMC Spec	Subject	PLM EQM	PLM PFM	S/C PFM
3.2.3.2.1	EMCPLM-000	CE Narrow Band Current on primary power lines towards PCDU measured with Spectrum Analyser Common Mode. See also [RD1]	--	--	T (1)
3.2.3.2.1	EMCPLM-010	CE Common and Differential mode on pre-amps and detector power lines (secondary power). See [RD2]	--	--	--
3.2.4.8.4	EMCEQ-500	CS DM Continuous. See [RD1].	--	--	--
3.2.4.8.4	EMCEQ-520	CS CM Continuous. See [RD1].	--	--	--
3.2.4.8.4	EMCEQ-550	CS DM Transient. See [RD1].	--	--	--
3.2.4.8.4	EMCEQ-560	CS DM Transient. See [RD1].	--	--	--
3.2.4.8.4	EMCEQ-570	CS CM Transient. See [RD1].	--	--	--
3.2.3.2.3	EMCPLM-030	RS test - CS on signal cable bundles [AD7] is covered by this test - CS simulating RS as per [AD7] is covered by this test	T	--	--
3.2.2.3	EMCSYS-92	CE Common and Differential Mode and noise tests on power lines between PCDU and instruments	--	--	T
3.2.2.3	EMCSYS-096	CE on TBD links between the SVM and PLM	--	--	T
3.2.2.3	EMCSYS-098	Voltage ripple between SVM and PLM structure	--	--	T
3.2.2.1.1	EMCSYS050	RE E-field Narrowband in VEB plane in Launch Mode	--	--	T
3.2.2.1.1	EMCSYS-052	RE E-field Narrowband at UHF and C-band in Launch Mode	--	--	T
3.2.2.1.2	EMCSYS-60	RE E-field Narrowband in Operational Mode at 3 points around the cryostat from 14 kHz - 18 GHz	--	--	T
3.2.4.6.2.1	EMCEQ-200	RS E-field	--	--	T
3.2.4.6.2.2	EMCEQ-250	RS H-field AC	--	--	T

Table 3.1-1: EMC Tests Overview

(1): Could be seen as test on S/C PFM level (see para 3.3)

3.2 Tests on HERSCHEL PLM EQM Configuration

Tests in this configuration will be performed in a standard integration facility (no anechoic chamber).

In order to be allowed to perform the RS test outside the anechoic chamber the radio regulation community have formally to be requested for permission at least 6 months prior to test.

CE and CS tests on primary power side are not foreseen because of limited representativity of the AVM primary power interfaces and the unavailability of the PCDU. Instead, for the CE/CS performance of the instruments it shall be referred to the instruments test programmes of PACS, SPIRE and HIFI.

The CE/CS tests on signal cable bundles as required in [AD7] are fully covered by the conductance of the RS tests.

3.3 Tests on HERSCHEL PLM PFM Configuration

For EMC tests in this configuration a standard integration facility is sufficient. For the tests, the SVM with the PCDU is necessary for satellite representativity. The test shall therefore be conducted in frame of the SVM integration with the PLM PFM (is therefore be considered as satellite level CE test).

3.4 Tests in Fully Integrated Satellite PFM Configuration

In this configuration the Launcher RS/RE test as well as the autocompatibility test will be performed. All tests will be performed in the integration facility except RE/RS tests which will be tested in the anechoic chamber.

4 HERSCHEL OVERALL EMC TEST PROGRAMME

4.1 General

The objective of the EMC test programme is to demonstrate that the design is in accordance with the EMC requirements. The particular EMC requirements will be summarised in a separate chapter in this document.

During the test programme it shall be verified that the PLM and the HERSCHEL satellite is:

- compliant with the Launcher requirements
- compliant with the satellite requirements and in particular
- self compatible

4.2 Test Sequence

Under consideration of the different configurations the EMC test programme comprises the main test blocks in a sequential order as shown in figure 4.2-1 and figure 4.2-2 below.

Based on the test descriptions provided in this plan, 6 kinds of test procedures will be written:

- Mechanical and electrical integration procedures
- PLM EQM EMC test procedures
- PLM PFM EMC test procedures
- HERSCHEL PFM Radiated Test Procedure
- HERSCHEL Autocompatibility Test Procedure

The content of these procedures will be in line with the test planning and testing amount as defined in this test plan.

The mentioned test blocks will be embedded into the overall test sequence considering the applicable PLM modes and instruments operationability. For the PLM the EMC test sequence will be proposed in the present test plan. The test sequence for the PLM PFM and the satellite level shall be defined later, based on the experiences gained from the EQM programme.

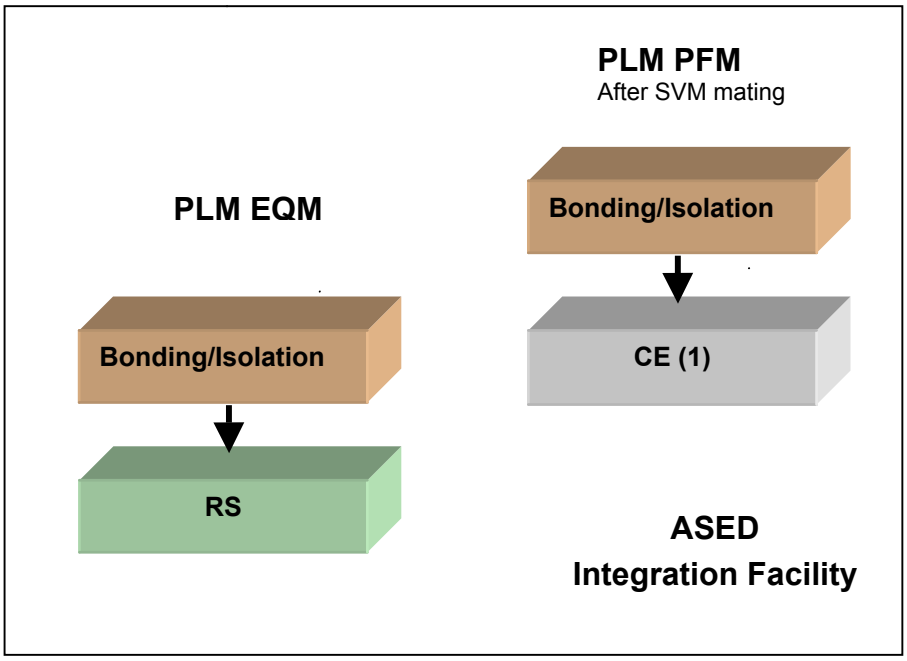

Fig. 4.2-1: PLM EMC Test Blocks

(1): Is to be considered as test on S/C PFM level (refer to para 3.3)

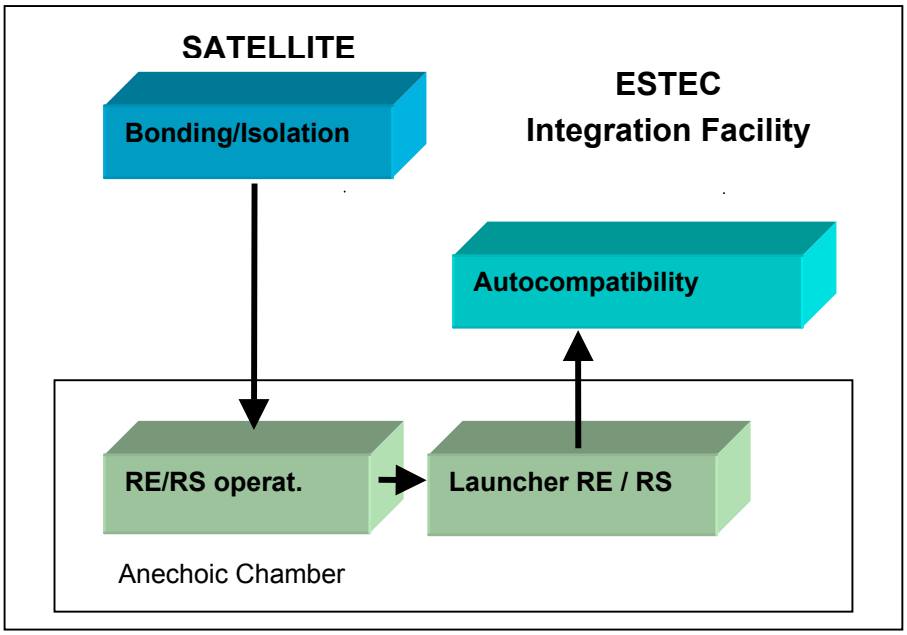

Fig. 4.2-2: Satellite EMC Test Blocks

4.2.1 PLM EQM EMC Test Sequence

In the following the test sequence for the PLM EQM test is given. After the nominal sequence the results shall be revisited in order to identify where re-test and/or susceptibility tjhreshold prediction is required.

4.2.1.1 HIFI ON, PACS, SPIRE SAFE

Mode: PRIMARY,

LO frequency 850 GHz (tbc)

HRS mode: High resolution

HRS band centre frequency

For the 4 – 6 GHz range: 4.25 GHz, 4.75 GHz, 5.25 GHz, 5.75 GHz

For the 6 – 8 GHz Range. 6.25 GHz, 6.75 GHz, 7.25 GHz, 7.75 GHz

WBS: On

Observing mode: Total power

Integration time: 1 s

Chopper: cold source

The susceptibility tests shall be performed first for the 4 – 6 GHz range and repeated for the 6 – 8 GHz range. For the E-field RS test 3 antenna locations each with vertical and horizontal polarisation shall be applied. For the RS H-field 3 antenna locations (one polarisation only) is sufficient. During the tests the external source shall be switched on.

Due to the fact that the integration time is relatively short in comparison with PACS and SPIRE, it was decided to apply some kind of ''synchronised by call'' automatic-EMC-stepwise sweep.

At the beginning of the test day a reference test shall be performed in order to prove for proper functioning and performance of HIFI. This test may last several minutes (30 min maximum) and could be repeated during the normal test, e.g. during EMC set-up changes.

Then, the stepwise increase of the RS frequencies (set by the law using a fixed frequency multiplying factor, e.g. f1 = n x fo, f2 = n x f1, f3 = n x f2, and so on), shall be started simultaneously with the continuous performance data acquisition of HIFI. Every frequency step shall be active for exact 10 seconds enabling the synchronisation of the performance data with the RS frequency by time reference, time tags must be available in the performance data stream. One test session should not exceed 10 min (tbd), in order to avoid loss of the synchronisation for the case that the time of 10 second cannot exactly be adjusted or for the case of ''dead times'' between the setting from one frequency to the other.

The performance data will be evaluated offline and may give a rough order of magnitude estimation about the quantitative amount of exceeding (if any).

The number of step frequencies shall be about 160 (tbc) for the RS E-field test and about 70 for the RS H-field test

With above assumptions and definitions the expected testing time is calculated in table 4.2.1.1.-1

Reference					
SPOT Frequencies for RS E-Field		160			
E-Field Antenna Positions		6			
SPOT Frequencies for RS H-Field		70			
H-Field Antenna Positions		3			
Integration Time per SPOT [min]		10	sec		
SPOT Set-up Time [min]		0	sec		
Instrument set-up and reference test [min]		20	min		
Test Revisit and Post Test Data Analysis [h]/day		80	min		
==> Effective test time /day [h] (8 hours per day)		8	h		
Total test time [h] for one Mode		3,25	h		
Total test time [h] for two Mode		**6,5**	**h**		
=> The total test time is expected to be determined by the time needed for set-up changes					

Table 4.2.1.1-1: Expected HIFI RS Test Duration

Refer also to para 5.1.1.1.

4.2.1.2 PACS ON, HIFI, SPIRE SAFE

The RS tests shall be started with a Reference test as described in [RD4].

[RD4] describes the most sensitive mode for the Photometer as well as for the Spectrometer. In the Photometer mode cooler recycle is required every day and will take about 2 h.

For the E-field RS test 3 antenna locations each with vertical and horizontal polarisation shall be applied. For the RS H-field 3 antenna locations (one polarisation only) is sufficient. The complete campaign shall be started with a reference test, in spectrometer mode and photometer mode respectively. The integration time is about 30 seconds for each frequency and the data can be checked by the quick-Look-Analysis of PACS from which the results can be stored after every frequency step. The QLA will take about 2 minutes and shall therefore be performed offline.

The following general Test sequence is proposed:

1. Reference test and QLA – H-field STEPS in Spectrometer mode for the 3 antenna positions – H-field test in Photometer mode for all 3 antenna positions and cooler recycle every morning.

2. Reference test and QLA – E-field STEPS in Spectrometer mode for the 3 antenna positions – E-field test in Photometer mode for all 3 antenna positions and cooler recycle every morning. Refer also to para 5.1.1.2.

The expected test duration is assessed in table 4.2.1.2-1.

		PACS				
Reference						
Sweep Duration 14 kHz - 18 GHz, E-field [h]		0				
Sweep Duration 30 Hz - 50 MHz, H-field [h]		0				
Number of sweeps E-field (= Number of Ant Pos)		2				
Number of sweeps H-field (= Number of Ant Pos)		3				
Total SWEEP time		**0**				
SPOT Frequencies for RS E-Field		90				
E-Field Antenna Positions		6				
SPOT Frequencies for RS H-Field		50				
H-Field Antenna Positions		3				
Integration Time per SPOT [min]		1	min			
SPOT Set-up Time [min]		0,6	min			
Dark Noise Measurement [min]		4	min			
Dark Noise Measurements (1 after 30 SPOTs) TBC		23				
Switch-on [min]		10		to be covered outside the test da		
Cooler Recycling Time [h]		2	h	to be covered outside the test da		
Recycling per Day		1		to be covered outside the test da		
Upset Instrument per 24 h [min]/day		10	min	to be covered outside the test da		
Decay Time Thermal Transients [min]/day		30	min	to be covered outside the test da		
Test Revisit and Post Test Data Analysis [h]/day		80	min	to be covered outside the test da		
==> Effective test time /day [h] (8 hours per day)		8	h			
Total test time [d] for one Mode		2,491667	days			
Total test time [d] for two Modes (Phot + Spec)		**4,983333**	**days**			
EMC Set-up changes, each 10 minutes (not included)		90				

Table 4.2.1.2-1: PACS RS Test Duration

4.2.1.3 SPIRE ON, PACS, HIFI SAFE

Cooler recycle (2h) every 24 h with a subsequent reference test in order to check for stabilisation (about 4 h maximum). This recycle and upset of the instrument will be done outside of the normal test time, quite early in the morning or after a test day..

Reference test , MODE:''Photometer Mode'' The detector sampling frequency shall be set to the maximum (about 80 Hz).

For the RS E-field RS test 2 antenna locations each with vertical and horizontal polarisation (to be selected in advance to the test) shall be applied (not exceeding the total number of 60 SPOTs per antenna location. For the RS H-field 3 antenna locations (one polarisation only) will be applied.

A sweep at the beginning will verify for the potential susceptible frequencies. This sweep over the range from 14 kHz to 18 GHz shall not last longer than about 3 hours. The performance data as got during this sweep shall be stored together with a time tag in order to get the reference to the RS frequency. After evaluation o the retrieved data, the critical frequencies will be tested with a RS SPOT frequency test.

Maximum 60 SPOT frequencies shall be tested for E-field and maximum 30 for H-field RS test.

Exposure time for each frequency shall be 3 minutes. After about 6 SPOTs a reference dark noise test shall be performed (in Photometer Mode).

After each SPOT quicklook analysis will be performed in parallel to the continuation to the next frequency SPOT. The result of the quicklook analysis will be available quite soon and stored on the disk for further analysis purposes, etc. with designation of the respective SPOT frequency

Refer also to para 5.1.1.3.

The test sequence is shown in figure 4.2.1.3-1 and fig. 4.2.1.3-2. Table 4.2.1.3-1 shows an assessment of the time duration needed for the test. It is considered to use 3 antenna positions for the H-field test and 2 positions (each with application of two polarisations) for the E-field.

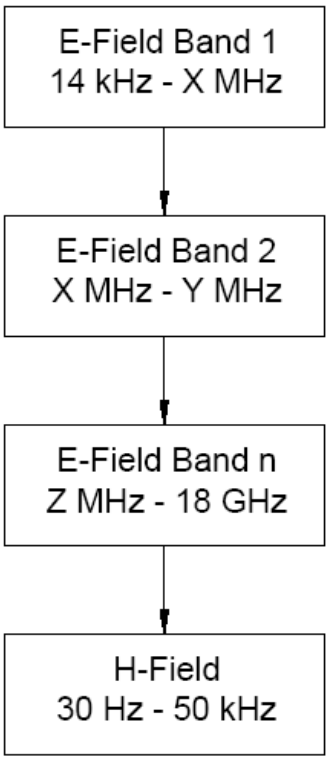

Fig. 4.2.1.3-1: SPIRE Level 1 RS Test Sequence

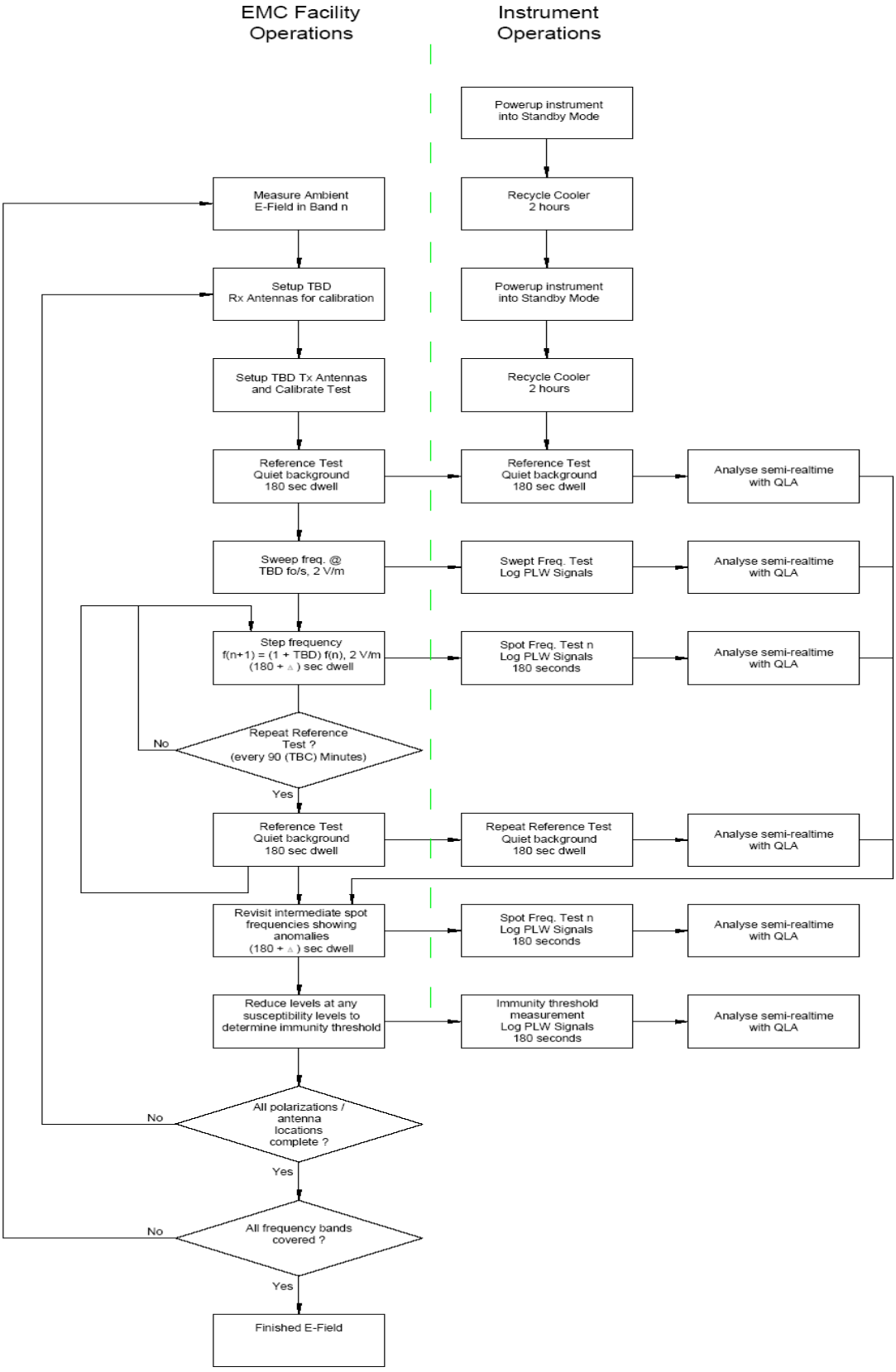

Fig. 4.2.1.3-2: SPIRE Level 2 RS Test Sequence

		SPIRE				
Reference		**Power/EMC WG #17**				
Sweep Duration 14 kHz - 18 GHz, E-field [h]		4				
Sweep Duration 30 Hz - 50 MHz, H-field [h]		3				
Number of sweeps E-field (= Number of Ant Pos)		2				
Number of sweeps H-field (= Number of Ant Pos)		3				
Total SWEEP time		**2,125**				
SPOT Frequencies for RS E-Field		60				
E-Field Antenna Positions		4				
SPOT Frequencies for RS H-Field		30				
H-Field Antenna Positions		3				
Integration Time per SPOT [min]		3	min			
SPOT Set-up Time [min]		0,6	min			
Dark Noise Measurement [min]		4	min			
Dark Noise Measurements (1 after 6 SPOTs)		55				
Switch-on [min]		10		covered outside the test day		
Cooler Recycling Time [h]		2	h	covered outside the test day		
Recycling per Day		1		covered outside the test day		
Upset Instrument per 24 h [min]/day		10	min	covered outside the test day		
Decay Time Thermal Transients [min]/day		30	min	covered outside the test day		
Test Revisit and Post Test Data Analysis [h]/day		80	min	covered outside the test day		
==> Effective test time /day [h] (8 hours per day)		8	h			
Total test time [d]		**5,058333**	**days**			

Table 4.2.1.3-1: SPIRE RS Test Duration

4.2.2 PLM PFM EMC Test Sequence

TBD.

4.2.3 Satellite EMC Test Sequence

TBD. The satellite test sequence shall consider the lessons learnt from PLM test sequence.

4.3 Applicable EMC Requirements for PLM

The EMC requirements as applicable for HERSCHEL are shown in the EMC requirements specification, [AD2]. Bonding, grounding isolation requirements shall be retrieved from the GDIR, [AD2]. The relevant requirements for the PLM (EQM and PFM), are summarised below.

4.3.1 Bonding/Isolation

For the various Bonding/Isolation requirements it shall be referred to the GDIR, [AD2]. The conductance of those tests shall be covered by integration procedures, i.e. mechanical integration procedures.

4.3.2 PLM Conducted Emission

4.3.2.1 Requirements

- On each primary power lines from the PCDU to the instruments warm unit spectral analysis of common and differential mode current shall be performed in the frequency range from 30 Hz to 50 MHz. Details TBD
- On each primary power lines from the PCDU to the instruments warm unit RMS noise measurement shall be performed on a 10 MHz frequency bandwidth (measured with RMS voltmeter or digital oscilloscope capable to compute it). Details TBD
- CE measurements on TBD links between service module and payload module shall be performed.
- The voltage ripple between SVM and PLM structures shall be measured.

Remark: The TBDs shall be clarified by ASPI for the Test Procedure

4.3.2.2 Operation

All equipment shall be operated in their nominal modes inclusive the most power consuming modes.

4.3.2.3 Configuration

PLM and SVM configuration without outer MLI, TBD

The PCDU will be powered with the solar array simulator unit in order to provide for best representativity.

The CVV will be connected to the Helium pumping units via large tubes. Ceramic shims and specific screws are used to isolate the pumping devices electrically from the CVV so that no interaction will occur.

The use of break-out boxes shall be limited because they allow the facility generated noise to enter the equipment. Spacecraft antennas shall be covered with test caps which can handle the amount of radiated power.

4.3.3 PLM Conducted Susceptibility

N/A

Remark:

The request of additional CE/CS tests for HIFI on PLM EQM level is covered by the HP_HIFI_CR_0128 and the corresponding procedures. The reports shall also be written by the Instrument staff and not by ASED who however will support and take care about all activities performed on PLM.

4.3.4 PLM Radiated Susceptibility

4.3.4.1 Requirements

- ***The RS E-field*** levels as required shall not lead to malfunction:
  2 V/m in the frequency range from 14 kHz to 18 GHz
  10 V/m and 18 V/m in particular notches
  The sine wave signal shall be 30% amplitude modulated by 1 kHz squarewave. Above 30 MHz the requirement shall be met both for horizontal and vertical polarization. The test shall be performed as per MIL 462 RS03.

- ***The RS H-field*** level of 140 dBpT in the frequency range from 30 Hz to 50 kHz shall not lead to malfunction.

Above tests are required for the EQM PLM only and not for the PFM PLM. At least 3 frequencies per decade shall be tested. The instruments have to define a table of relevant frequencies prior to test. 3 antenna positions shall be used for the RS E-field as well for the RS H-field test.

4.3.4.2 Operation

For the RS tests the PLM shall be in operational mode. In any case the equipment shall be operated to be sensitive.

Performance checks shall be performed as usual. In case of susceptibility, the susceptibility threshold shall be predicted. The details for the prediction of the susceptibility threshold shall be clarified with the manufacturer of the equipment which has failed.

4.3.4.3 Configuration

The RS test will be performed in the standard integration facility. In order to minimize interferences from neighbored facility, the clearance between the PLM and the facility shall be at least 2 m (see also figure 4.3.4.3-1 below). As far as possible absorber walls shall be installed, at least however at the opposite side of the radiating antenna as well as behind the antenna in order to minimize effects of standing waves.

The PLM EQM will be equipped with the SVM Simulator fully loaded with the avionics modules, whereas the PLM PFM will be used with the SVM FM.

The CVV will be connected to the Helium pumping units via large tubes. Ceramic shims and specific screws are used to isolate the pumping devices electrically from the CVV so that no interaction will occur.

The use of break-out boxes is not permitted because they would allow the RS noise to enter the equipment.

The wiring between the PLM and the EGSE shall be specifically shielded with Al foil (to be integrated before start of test).

The test antennas shall be placed at TBD positions directed to the PLM openings and the harness.

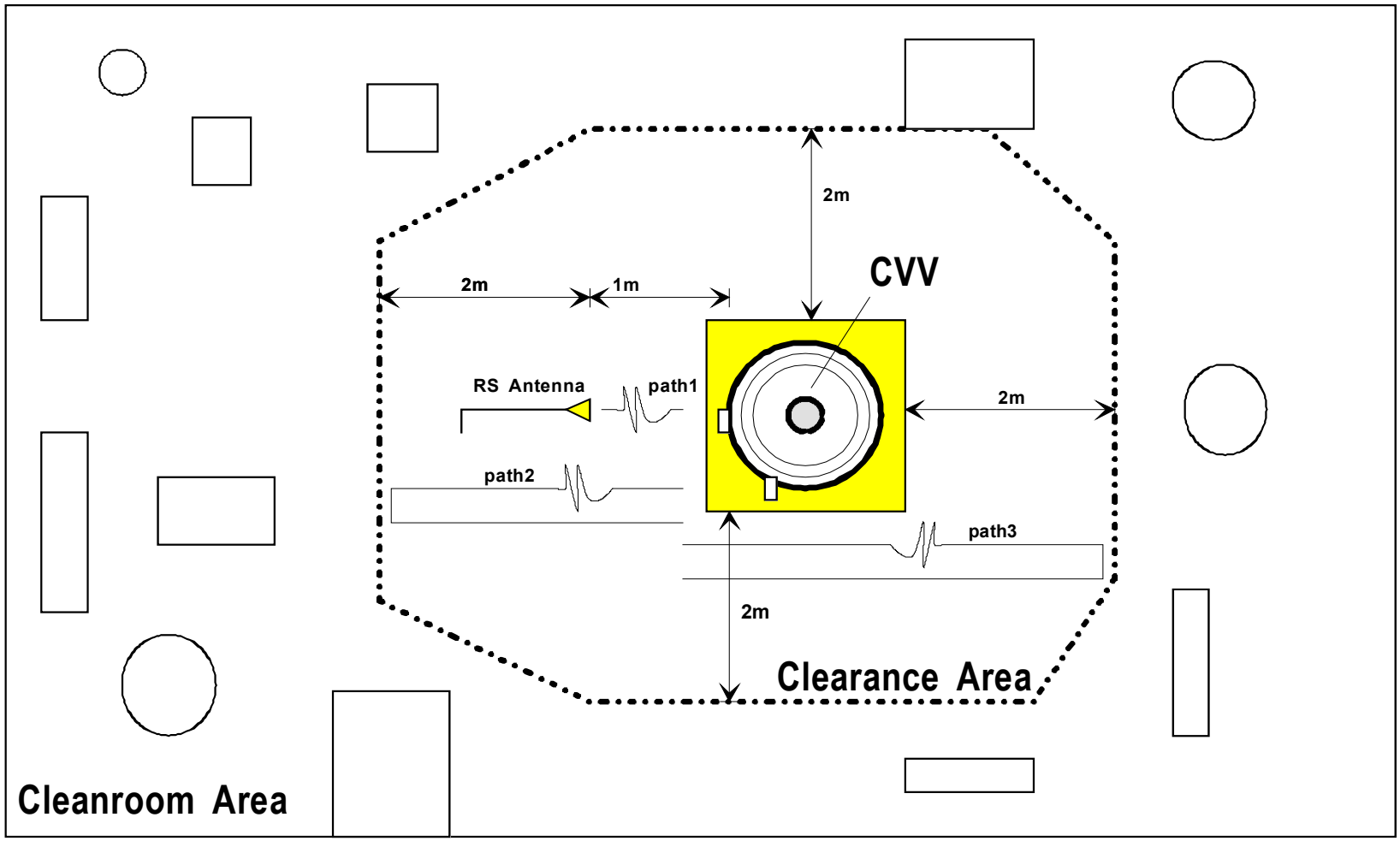

Fig. 4.3.4.3-1: Configuration of the PLM Within the Integration Facility during the RS Test

4.4 Applicable EMC Requirements for HERSCHEL Satellite (S/C PFM)

The EMC requirements as applicable for HERSCHEL are shown in the EMC requirements specification, [AD2]. Bonding, grounding isolation requirements shall be retrieved from the GDIR, [AD2]. In the following, the requirements relevant for the HERSCHEL satellite, are summarised below.

4.4.1 Bonding/Isolation

For the various Bonding/Isolation requirements it shall be referred to the GDIR, [AD2]. The conductance of those tests shall be covered by integration procedures, i.e. mechanical integration procedures.

4.4.2 Spacecraft Radiated Emission

4.4.2.1 Requirement

- In Launch mode the RE-E-field shall not exceed the figure below as measured at VEB plane.
- In operational mode the E-field shall be measured from 3 different locations around the cryostat in the frequency range from 14 kHz to 18 GHz.

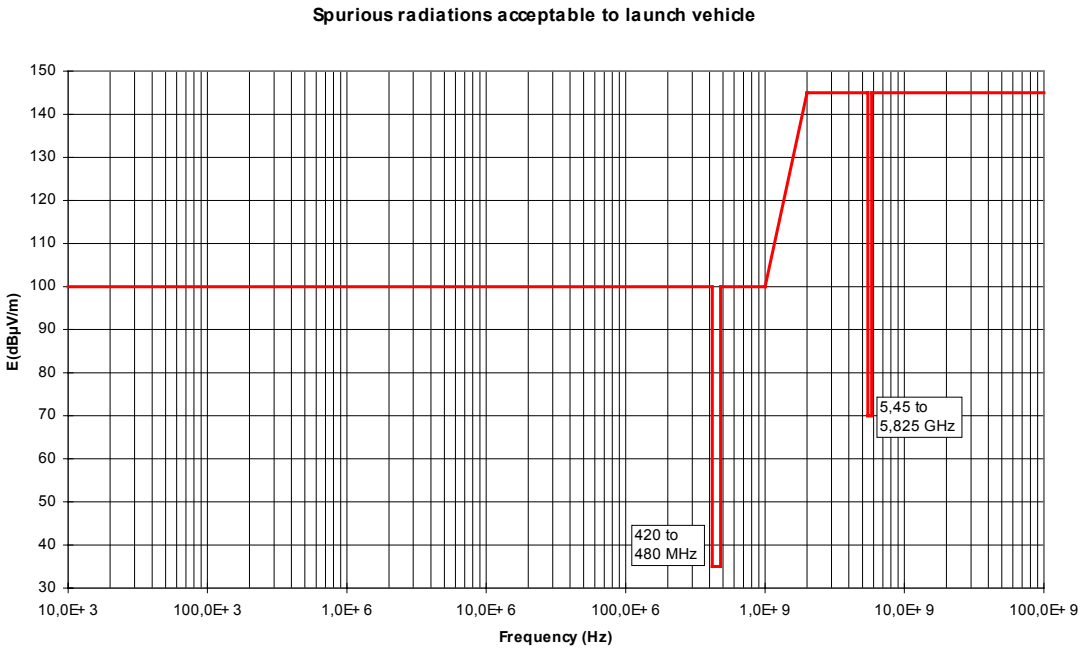

Fig.4.4.3.1-1: Maximum tolerable E-field in Launch Mode

4.4.2.2 Operation

All equipment shall be operated in their nominal modes inclusive the most power consuming modes. In Launch mode the measurement shall be made once the satellite is powered by the solar array simulator power supply (prelaunch) and when powered by internal battery (launch mode). When powered by the battery the test duration must not exceed 2 hours (TBC).

Remark: Battery Management TBD by ASPI

4.4.2.3 Configuration

The test shall be performed in the anechoic chamber: The test antennas shall be placed at 1 m distance and shall aim at 3 positions directed to harness and optical apertures of the cryostat for the operational mode. For the Launch mode 1 position is sufficient to be directed to the spacecraft separation interface. The positions shall be proposed in the corresponding test procedures.

The on-board antennas shall be covered with test caps in order to limit the radiation at TX frequency. The test caps shall be capable to handle the TX power without constraints. The wiring between the satellite and the EGSE shall be specifically shielded with Al foil (to be integrated before start of test).

The CVV will be connected to the Helium pumping units via large tubes. Ceramic shims and specific screws are used to isolate the pumping devices electrically from the CVV so that no interaction will occur.

4.4.3 Spacecraft Radiated Susceptibility

4.4.3.1 Requirements

- The RS E-field levels as required shall not lead to malfunction:
  2 V/m in the frequency range from 14 kHz to 18 GHz
  10 V/m and 18 V/m in particular notches
  The sine wave signal shall be 30% amplitude modulated by 1 kHz squarewave. Above 30 MHz the requirement shall be met both for horizontal and vertical polarization. The test shall be performed as per MIL 462 RS03.
- The RS H-field level of 140 dBpT in the frequency range from 30 Hz to 50 kHz shall not lead to malfunction.

4.4.3.2 Operation

For the RS E-field test the satellite shall be tested both in operational as well as in launch mode. For RS H-field only operational mode shall be tested. In any case the equipment shall be operated to be sensitive.

Performance checks shall be performed as usual. In case of susceptibility, the susceptibility threshold have to be predicted. The details for the prediction of the susceptibility threshold shall be clarified with the manufacturer of the equipment which has failed.

4.4.3.3 Configuration

The test shall be performed in the anechoic chamber: The test antennas shall be placed at 1 m distance and shall aim at 3 positions directed to harness and optical apertures of the cryostat for the operational mode. For the Launch mode 1 position is sufficient to be directed to the separation interface. The positions shall be proposed in the corresponding test procedures.

The on-board antennas shall be covered with test caps in order to limit the radiation via on-board antennas at TX frequency. The test caps shall be capable to handle the TX power without constraints. It shall be checked if the venting holes of the test caps are suitable not to let the RS fields penetrating to the inside. In any case of question they shall be closed e.g. by aluminised adhesive foil The wiring between the satellite and the EGSE shall be specifically shielded with Al foil (to be integrated before start of test).

The CVV will be connected to the Helium pumping units via large tubes. Ceramic shims and specific screws are used to isolate the pumping devices electrically from the CVV so that no interaction will occur.

4.4.4 Satellite Autocompatibility

Autocompatibility of the satellite shall be demonstrated by this test

4.4.4.1 Operation

In general the operational mode of the satellite with its RF instruments shall allow a fully flight representative operation of the equipment.

During the test the performance checks shall be performed as usual for susceptibility tests. In case of susceptibility, possible disturbance sources shall be switched-off, one after another, to identify the source of the disturbance. Moreover the susceptibility threshold have to be predicted.

The details for the prediction of the susceptibility threshold shall be clarified with the manufacturer of the equipment which has failed.

4.4.4.2 Configuration

The test of the fully assembled satellite (inclusive MLI) shall be performed in the anechoic chamber just after the EMC test campaign. The antenna shall be covered by a test cap in order to be able for commanding and telemetry reception of the TT&C subsystem.

The CVV will be connected to the Helium pumping units via large tubes. Ceramic shims and specific screws are used to isolate the pumping devices electrically from the CVV so that no interaction will occur.

5 GENERAL SET-UP

5.1 Satellite Set-up

5.1.1 Satellite Mode

For emissive tests (CE, and RE), the satellite must be set up to generate the maximum amount of noise, whereas for the susceptibility tests (RS), it have to be in the most sensitive mode possible.

5.1.1.1 HIFI Modes

Emission tests
Emission tests shall be performed with:

- The reference signal switched off.
- HRS settings first for the range 6 - 8 GHz and repeated (optional) for the range 4 - 6 GHz.
- Instrument settings

HIFI mode: Primary (normal operations mode)
LO band: 3a
LO Frequency: 807 GHz
HRS mode: Wide Band
HRS band centre frequencies
for 6 - 8 GHz range: 6.25, 6.75, 7.25 and 7.75 GHz
for 4 - 6 GHz range (optional): 4.25, 4.75, 5.25 and 5.75 GHz
WBS: on
Observing mode: Total Power
Integration time: 1sec.
Chopper: Cold source

Susceptibility tests
Susceptibility tests shall be performed with:

- The reference signal switched on.
- Continuous observation during EMI stimuli. Synchronisation by operators call.
- Instrument settings

HIFI mode: Primary
LO band: 3a
LO Frequency: 807 GHz
HRS mode: High Resolution
HRS band centre frequency: 6.6 GHz
WBS: on
Observing mode: Total Power
Integration time: 1sec.
Chopper: Cold source

5.1.1.2 SPIRE Modes

Most sensitive Mode: Photometer Mode with sampling frequency = 80 Hz

Most emissive Mode: As above

For more details it shall be referred to Refer to [RD3]

5.1.1.3 PACS Modes

Refer to [RD4]:

Photometer Most Sensitive Mode:

DPU, SPU: ON, nominal operation
BOLC: ON, Bolometers ON
DMC: ON
Cal. Source: ON, T = TBD K, closed loop control settling necessary, T should be minimum nominal
Temp. Sensors: ON
CRE: OFF
Chopper: ON, const. position at max. angular throw, f= 0,5 Hz, closed loop control necessary for assessment
Grating: OFF
Filter wheels: OFF, const position TBD
M/O/EGSE - Status:
BB1 = TBD K
BB2 = TBD K
FM1 = TBD Position
FM2 = TBD Position
Chopper Wheel = TBD Status
XY-Stage: Source Status

Spectrometer Most Sensitive Mode:

DPU, SPU: ON, nominal operation
BOLC: ON, Bolometers OFF, no cooler recycling required
DMC: ON
Cal. Source: ON, T = TBD K, closed loop control settling necessary, T should be minimum nominal
Temp. Sensors: ON
CRE: ON, nominal BIAS TBD as reported from CQM ILT
Chopper: ON, const. position at max. angular throw, f= 0 Hz, closed loop control necessary for assessment
Grating: f = 2 Hz = 2 Steps / second, angular change = 1 arc minute
Filterwheels: OFF, as Grating is in use, const. position 'TBD
M/O/EGSE - Status:
BB1 = TBD K
BB2 = TBD K
FM1 = TBD Position
FM2 = TBD Position
ChopperWheel = TBD Status
XY-Stage: Source Status
Cryostat Parameters: TBD

5.1.2 Performance Verification

Prior to the start of the EMC test programme the satellite will have been subjected to the full functional tests. As a result, a high degree of confidence will exist with respect to its proper performance.

A functional check (reference test) shall be performed prior the conducted and the radiated EMC test sequences for the purpose of a health check. A reference test is not required after the EMC test campaign since proper operation is verified throughout the EMC tests, in much more detail than the information provided by the reference test. Therefore functional checks should be clearly distinguished from performance evaluation of equipment during RS tests, during which the performance is investigated in detail. Therefore the RS test forms the end of the EMC test campaign.

5.1.3 Built Status

The built status w.r.t. EMC representativity, as well as the built status of the instruments used in the HERSCHEL test campaign, is addressed in the test readiness review (TRR).

5.1.4 Susceptibility Criteria

A susceptible condition may be defined as a malfunction, unintentional mode change or degradation of performance occurring during application of the susceptibility test signal.

5.1.4.1 HIFI Criteria

Fail/Pass criteria are **TBD by HIFI.** To be clarified by HIFI.

5.1.4.2 SPIRE Criteria

Refer to [RD2]

5.1.4.3 PACS Criteria

Fail/Pass criteria are **TBD by PACS**. To be clarified by PACS.

5.1.5 Satellite Operating Constraints

5.1.5.1 HK Sampling Rate (TBC by ASPI)

The Satellite HK data is sampled on-board every 1 second but transmitted only every 4 seconds. Therefore, instead of continuous sweeping step-wise frequency adjustment shall be considered for susceptibility testing. A minimum exposure time of 8 seconds is recommended for each RS frequency step. The HK and transmission sampling rate could be increased to 1 Hz for single parameters, on the expense of the number of parameters which can be monitored. Therefore, an increase of the sampling rate may be considered only for specially selected parameters, based on unit level test results, e. g. where susceptibility was found. (which parameters are in the baseline to be monitored, what is the granularity of the frequency steps)

To clearly identify if HK parameters are affected during susceptibility tests, more stringent monitoring limits than used in flight may be considered for these tests.

The HK data is transmitted from HERSCHEL via the data front end to the core EGSE for data monitoring and evaluation.

The H/K parameters checked during susceptibility testing will be listed in the test procedures.

5.2 Ground supports set-up

5.2.1 Test sites

All tests on PLM EQM will be performed in the cleanroom of Astrium facilities. PLM/SVM FM level and satellite level testing is foreseen at ESTEC facilities. For conducted tests a standard integration facility is sufficient. The autocompatibility test will be performed in the anechoic chamber as well as the radiated emission and susceptibility tests. The anechoic chamber of ESTEC have to be prepared to allow testing under clean room conditions.

5.2.2 GSE

A schematic of all EGSE/MGSE used for satellite level testing is given in the AIV Grounding Diagram, [AD04]. For more details it may be referred to the respective design descriptions and users manuals. A detailed list of all EGSE used for the various configurations shall be given in the respective TRR.

5.2.3 Software

As discussed before, the various test sequences will command HERSCHEL into noise generating or sensitive modes. The S/C will be operated during EMC testing in a flight representative manner, i.e. the flight OBSW and the Test S/W as defined for the functional tests can be used with the following exceptions:

Monitoring limits may have to be modified for radiated susceptibility tests (OBSW and Test SW).

5.2.3.1 Reference Test

For the definition of the reference test objectives it shall be referred to the System Test Plan

5.2.3.2 Emission test mode

A dedicated sequence shall be used during conducted and radiated emission tests. This sequence has to command to noise generating modes. Hence this mode should comprise

- powering of equipment
- commanding of equipment into most noisiest mode
- HK data monitoring

This will be covered by nominally used AP's combined to a sequence as required.

5.2.3.3 Susceptibility test mode

Another dedicated sequence shall be used during susceptibility (radiated) tests. This sequence has to command the satellite to sensitive modes. Hence this mode should comprise

- powering of equipment
- commanding of equipment into most sensitive mode
- application of instrument stimuli if necessary (to be clarified)
- transmission and distribution of the scientific data to the various instrument EGSE for further analysis and evaluation.

- HK data monitoring

This will be covered by nominally used AP's combined to a sequence as required.

6 TEAM ORGANISATION

Test conductance will be performed by the HERSCHEL EMC responsible. HERSCHEL operation personnel will be participating as required.

For tests at ASED, test engineering will be performed by ASED EMC facility personnel.

For tests at ESTEC facilities, test engineering will be performed by ESTEC EMC facility personnel.

The customer is invited to witness the tests as desired.

DISTRIBUTION

	Name	Dep./Comp.		Name	Dep./Comp.
X	Alberti von Mathias Dr.	SM 34		Rühe Wolfgang	ED 6
	Alo Hakan	OTN/IP 35		Runge Axel	OTN/EN 64
X	Barlage Bernhard	ED 11		Sachsse Bernt	ED 21
X	Bayer Thomas	ED 541		Schäffler Johannes	OTN/EN 64
			X	Schink Dietmar	ED 422
	Fehringer Alexander	SM 33	X	Schlosser Christian	OTN/EN 64
	Frey Albrecht	ED 422			OTN/ED 421
	Grasl Andreas	OTN/EN 64		Schweickert Gunn	SM 34
	Grasshoff Brigitte	ED 521		Stauss Oliver	SM 33
	Hartmann Hans Dr.	ED 422		Steininger Eric	ED 422
	Hauser Armin	SM 31	x	Stritter Rene	ED 11
	Hinger Jürgen	SM 31		Suttner Klaus	SM 32
X	Hohn Rüdiger	ED 541		Tenhaeff Dieter	SM 34
	Hölzle Edgar	ED 421		Thörmer Klaus-Horst Dr.	OTN/ED 65
	Huber Johann	ED 543		Wagner Adalbert	OTN/IP 35
	Hund Walter	SE 76		Wagner Klaus	SM 31
X	Idler Siegmund	ED 432	X	Wietbrock, Walter	ED 521
	Iványi von András	ACE 32		Wöhler Hans	SM 34
	Jahn Gerd Dr.	SM 31		Zipf Ludwig	ACE 32
X	Kalde Clemens	ED 532			
	Kameter Rudolf	OTN/EN 64			
	Kersting Stefan	OTN/EN 63	X	Alcatel	ASPI
	Kettner Bernhard	SM 34	X	ESA/ESTEC	ESA
X	Knoblauch August	ED 531			
	Koelle Markus	ED 533		**Instruments:**	
X	Kroeker Jürgen	ED 542	x	MPE (PACS)	MPE
	Kunz Oliver	SM 31	x	RAL (SPIRE)	RAL
	Lamprecht Ernst	OTN/SM 222	x	SRON (HIFI)	SRON
	Lang Jürgen	SE 76			
	Langfermann Michael	ED 541		**Subcontractors:**	
	Mack Paul	OTN/EN 64		Air Liquide	AIR
	Maier Hans-Ulrich	ED 11		Astrium Sub-Subsyst. &	ASSE
	Mauch Alfred	SM 34		Austrian Aerospace	AAE
	Moritz Konrad Dr.	ED 65		APCO Technologies S. A.	APCO
	Müller Lutz	OTN/EN 64		Astrium GmbH Space Infrastr.	ASIP
	Muhl Eckhard	OTN/EN 64		BOC Edwards	BOCE
X	Pastorino Michel	ASPI Resid.		EADS CASA ESPACIO	CASA
	Peitzker Helmut	ED 65		Eurocopter	ECDE
	Peltz Heinz-Willi	SM 33		HTS AG Zürich	HTSZ
	Peters, Gerhard	ED 531		Linde	LIND
	Pietroboni Karin	ED 65		Patria New Technologies Oy	PANT
	Puttlitz Joachim	OTN/EN 64		Phoenix, Volkmarsen	PHOE
	Raupp Helmut	SM 33		Rembe, Brilon	REMB
	Rebholz Reinhold	ED 541		SENER Ingenieria SA	SEN
	Reuß Friedhelm	ED 62			