



**HERSCHEL / PLANCK**

**PPLM CQM EMC**  
**Test Requirement Specification**  
**H-P-3-ASP-TS-0650**  
**Product Code : 200 000**

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## ENREGISTREMENT DES EVOLUTIONS / *CHANGE RECORD*

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### 1. SCOPE

The purpose of this Test Requirement Specification (TRS) is to define the tests to be performed at Alcatel during AIT phase and at CSL on the Planck PLM CQM in order to assess the susceptibility of HFI in cold conditions.

Susceptibility tests have been performed successfully at unit and detection chain levels, however all tests have not been performed in particular the test with the 4K cooler which has never been available before. Some preliminary conducted emission tests will be performed during AIT phase on the 4 K cooler lines. The aim of the EMC test is to perform at CSL a "system level test" where the perturbing signals (derived from the preliminary conducted emission measurements and Planck units EMC specification) are injected onto power supply lines of HFI units.

For the purpose of this TRS, it has been assumed that all bonding/isolation testing has been successfully carried out at equipment, Instrument and PPLM levels.

This test verifies the following requirement

IIDB-HFI 3.2 – Ch.7 to 10 [HP-HFI-REQ-1370] (Cold EMC conductive test)

### 2. DOCUMENTS

#### 2.1 Applicable documents

[AD01] Herschel/Planck EMC Specification, H-P-1-ASPI-SP-0037, issue 4

[AD02] Planck CQM Technical Description, H-P-3-ASP-TN-0671, issue 1

#### 2.2 Reference documents

[RD01] HFI EMC Susceptibility Criteria, TN-PH215-400488-IAS

[RD02] 4K Sub-system Functional Test Procedure, PR-PHD740-500130-IAS

### 3. SUSCEPTIBILITY CRITERIA

HFI shall be operated throughout conducted susceptibility test in its most susceptible mode.

Throughout the test there shall be no degradation in the output of the HFI instrument and there shall be no malfunctioning of it.

This will be determined by Real Time monitoring of the HFI instrument performance by the HFI Support Engineer throughout this testing.

The susceptibility criteria (see [RD 01]) are defined hereafter :

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When EMC-testing Planck/HFI scientific chain, the readout signal is analysed in Fourier space.

Defining :

**Fech**, the sampling frequency (Ex: 200 Hz)

**N**, Sample number analysed in a single FFT. (Ex: 2048)

FFT Power Spectrum samples  $N/2+1$  frequency bins. Each bin is the average of the power spectrum over a bin width of

$$\Delta f = \text{Fech}/N \text{ (Hz)}.$$

Then HFI apparatus is loaded with a carrier, sine wave modulated at a frequency in the scientific signal range. The perturbative signal is thus a Dirac in frequency (neglecting the windowing effects in the FFT), diluted in a frequency band  $\Delta f$ : for a perturbation output amplitude  $V$  at the output of EGSE, we will detect a bin spectrum amplitude:

$$V/\sqrt{\Delta f}.$$

Thus if we decide that the susceptibility threshold **Seuil** ( $V/\sqrt{\text{Hz}}$ ), this converts to an amplitude at the output of EGSE **Vseuil** of

$$\text{Vseuil} = \text{Seuil} * \sqrt{\text{Fech}/N}$$

To give order of magnitude, assuming a readout noise of  $6 \text{ nV}/\sqrt{\text{Hz}}$ , we chose a susceptibility threshold of  $40 \text{ nV}/\sqrt{\text{Hz}}$ . This corresponds to an amplitude at the output of instrument of  $12,6 \text{ nV}$ , buried in the baseline noise of  $60 \text{ nVrms}$ .

## 4. PPLM CONFIGURATION DURING TESTS

The PPLM will contain the HFI instrument only and any thermal dummy loads considered necessary

## 5. PPLM CQM EMC TESTS

### 5.1 Description of PPLM CQM EMC tests

- ~~Test n°1~~ : CE in Differential Mode on HFI 4K CRU and 4K CDE 28V power lines at ambient temperature during AIT phase ([AD01]§3.2.4.8.4.1.1). (The test have been cancelled due to the non availability of the pre-regulator to power the 4K compressor).
- ~~Test n°2~~ : CE in Common Mode on HFI 4K CRU and CDE 28V power lines at ambient temperature during AIT phase ([AD01]§3.2.4.8.4.1.1). (The test have been cancelled due to the non availability of the pre-regulator to power the 4K compressor).
- ~~Test n°3~~ : CE in Common Mode (20 Hz up to 1 kHz) on 4K pipes at Ancillary Panel output before the ceramic electrical insulator at ambient temperature

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during AIT phase (It is not possible to perform the measurement because it is not possible to put the current probe on the pipe)

- **Test n°4** : CE in Common Mode (20 Hz up to 1 kHz) on 4K pipes at Ancillary Panel output after the ceramic electrical insulator at ambient temperature during AIT phase
- **Test n°5** : CE in Common Mode (10 kHz up to 500 MHz) on pipes just before the last bonding connection of the pipes on the PPLM at ambient temperature during AIT phase
- **Test n°6** : CE in Common Mode (10 kHz up to 500 MHz) on pipes just before the connection of the FPU 4K clamp at ambient temperature during AIT phase
- **Test n°7** : CS in Differential Mode on HFI 28V power lines in cold conditions ([AD01]§3.2.4.8.4.1.1)
- **Test n°8** : CS in Common Mode on HFI 28V power lines in cold conditions ([AD01]§3.2.4.8.4.1.2)

### 5.2 Aim of the measurements

The aim of the test n°1 and n°2 is to get information on the conducted emissions of the 4K subsystem. These information will be used to define the levels to be used during susceptibility tests (tests n°7 and n°8).

The aim of the test n°3 and n°4 is to measure the effectiveness of the ceramic insulator w.r.t. low frequency perturbations (current generated by the compressor).

The aim of the test n°5 and n°6 is to control the effectiveness of the bonding of the pipes, and in particular to measure the currents which are injected at FP level.



## **6. TEST REQUIREMENT SHEETS**

The configuration of the 4K subsystem to be used during the various tests are to be found in HFI document RD02.

### **6.1 CE on HFI 28V power lines during AIT phase**

#### ***6.1.1 Test objectives***

The objective of this test is to measure the HFI 4K CRU and 4K CDE conducted emissions. If the conducted emission measurements show out of specification then the measurement results will be used to define discrete frequencies to be injected during CS in differential mode at low frequency.

#### ***6.1.2 Type of test***

Power line Conducted Emission test in accordance with §3.2.4.8.2 of [AD01] (see annex 2). Measurements will be performed in differential mode and in common mode.

##### **6.1.2.1** Spacecraft Configuration

The Spacecraft overall configuration is defined in [AD02]

##### **6.1.2.2** Environment

The actual EMC measurements will be made during AIT phase in Alcatel Cannes under ambient conditions.

##### **6.1.2.3** Measurements Definition

Conducted emission test shall be performed in accordance with § 3.2.4.8.2 of [AD01] (see annex 2)

### **6.2 CE on HFI pipes during AIT phase**

#### ***6.2.1 Test objectives***

Measure the conducted emissions on HFI pipes at defined positions.

### **6.2.2 Type of test**

#### 6.2.2.1 Spacecraft Configuration

The Spacecraft overall configuration is defined in [AD02]

#### 6.2.2.2 Environment

The actual EMC measurements will be made during AIT phase in Alcatel Cannes under ambient conditions.

#### 6.2.2.3 Measurements Definition

- Conducted Emission in Common Mode (20 Hz up to 1 kHz) on 4K pipes at Ancillary Panel output after the ceramic electrical insulator.
- Conducted Emission in Common Mode (10 kHz up to 500 MHz) on pipes just before the last bonding connection of the pipes on the PPLM.
- Conducted Emission in Common Mode (10 kHz up to 500 MHz) on pipes just before the connection of the FPU 4K clamp.

## **6.3 CS on HFI 28V power lines in cold conditions**

### **6.3.1 Test objectives**

The objective of these tests is to verify that the HFI subsystem equipment does not exhibit any malfunction, degradation of performance or deviation beyond the tolerance indicated in its individual specification when the interference voltage susceptibility profile, as defined in §3.2.4.8.4 of [AD01] (see annex 3), is induced onto its subsystem power leads.

### **6.3.2 Type of test**

Power line Conducted Susceptibility test in accordance with §3.2.4.8.4 of [AD01] (see annex 3).

Testing will be performed with injections in both common mode and differential mode configurations.

#### 6.3.2.1 Spacecraft Configuration

The Spacecraft overall configuration is defined in [AD02]

It should be possible to switch-off the power supply of HFI instrument units in order to install the test set-up (injection transformer, ....).

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## 6.3.2.2 Environment

The measurement will be made whilst the PPLM containing the HFI instrument is under Low temperature/Vacuum conditions.

The actual EMC injections/measurements will be made under Ambient conditions external to the Thermal Vacuum Chamber.

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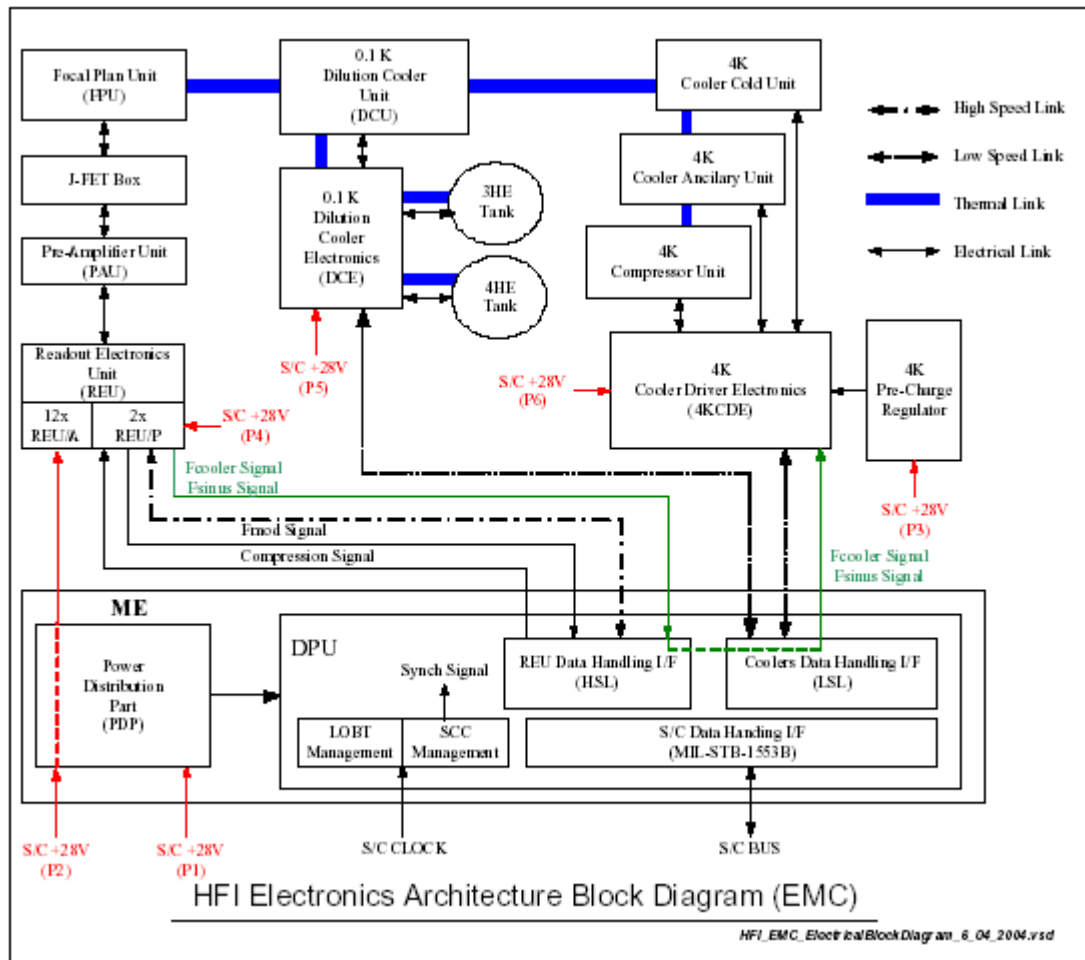
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## 6.3.2.3 Measurements Definition

The following diagram indicates the positions where the EMC measurements are to be made within the HFI Instrument;



## 6.3.2.4 Measurements

The CS test will be performed on the following HFI input lines, in both Common Mode and Differential Mode;

1. ~~Power lines of 4K CRU, (point P3 on the diagram). (The test have been cancelled due to the non availability of the pre-regulator to power the 4K compressor).~~
2. ~~Power line of 4K CDE, (point P6 on the diagram). (The test have been cancelled due to the non availability of the pre-regulator to power the 4K compressor).~~
3. Power lines of DPU and/or 0.1K, (points P1 and P5 on the diagram)

4. Power lines REU/P and/or REU/A (1 belt), (points P2 (partially) and P4 on the diagram)

Number of measurements : see chapter 7.

To allow for a simple connection of the probes in both a common mode and differential mode a test wire adapter will be inserted into the CQM power test harness that performs the required wire grouping. The definition of this adapter will be included in the corresponding test procedure.

#### 6.3.2.5 Processing and output format specification

This will be determined by HFI support Engineer prior to the start of test.

If a susceptibility is detected, some individual unit measurements could be performed.

### **6.3.3 Calibration of HFI power cables**

To simplify the Conducted Susceptibility tests performed on the HFI power input lines it is proposed to place all injection and monitoring probes outside of the Thermal Vacuum Chamber. This could result in some uncertainty in the measurement of the actual current at each of the equipment under test as the measurement probes will be some distance away, outside of the TV chamber whilst the equipment under test will be inside (due to standing wave or resonance effects).

To reduce this uncertainty the test cable harness will be calibrated before the TV chamber is sealed and the Vacuum created.

With this calibration it will be ensured that the test level at the equipment connectors never exceeds the individual equipment qualification test level.

#### 6.3.3.1 Calibration procedure

Differential mode , low frequency (<100 kHz):

An injection transformer will be used, the voltage will be measured at point B level (see figure 6.2.3.1) and will be used for the calibration.

The current will be measured at LISN output. It is not anticipated that any resonance effects will be seen below 100 kHz

Differential mode , high frequency (> 100 kHz) :

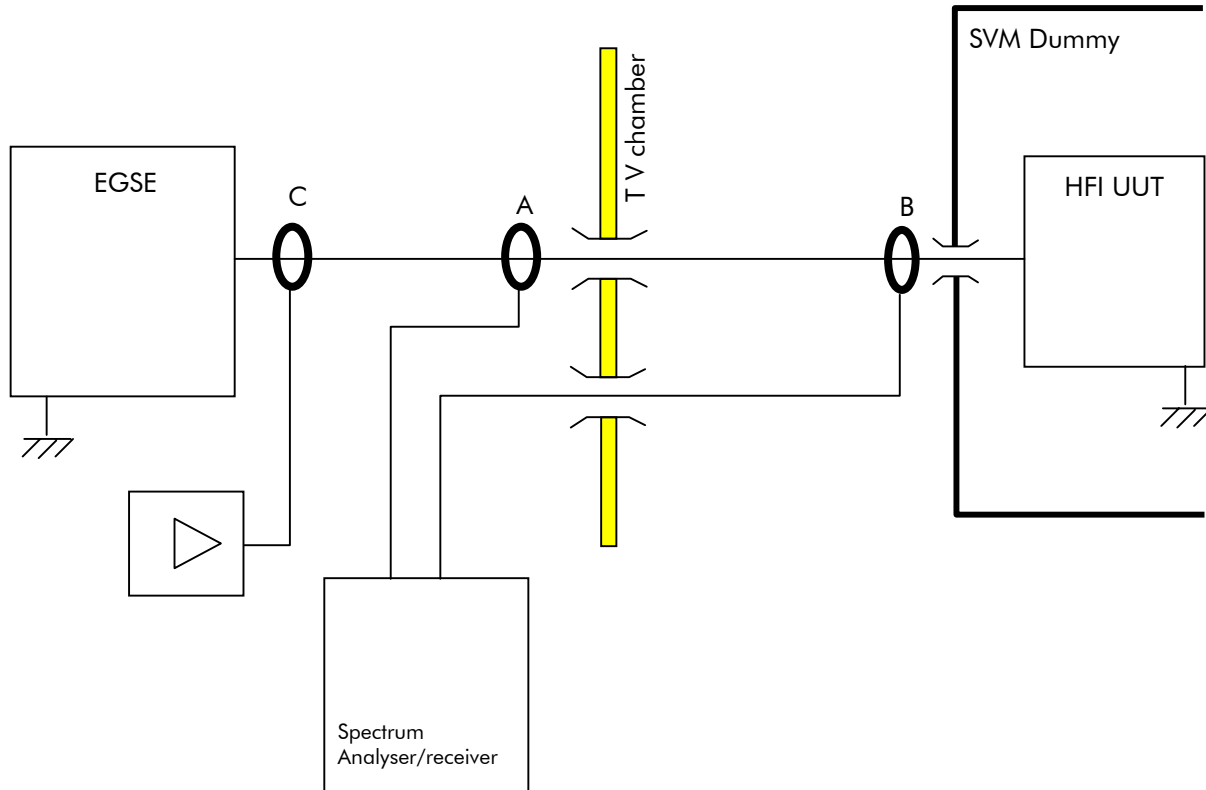
A current probe will be used to perform the injection. The current and the voltage will be measured at point B level (see figure 6.2.3.1).

Common mode (>10 kHz) :

A current probe will be used to perform the injection (point C(see figure 6.2.3.1)). The current and the voltage will be measured at point B level (see figure 6.2.3.1).

Depending of the calibration values in DM with high frequencies and in CM , the power lines will be grouped if the injected levels are the same.

The basic test set-up to be used during calibration is shown in figure 6.2.3.1.



**Figure 6.2.3.1 – Calibration of the HFI power input cables**

### **6.3.4 Test Requirement**

The test is to be conducted in a similar manner to the standard laboratory EMC qualification CS test the only slight difference being that the measured current at position 'A' must be corrected using the pre-calibrated cable factors to determine the actual currents that are seen at the equipment connectors 'B'

In the case of the voltage measurement it is to be made at position 'A' without correction.

#### **6.3.4.1 CS continuous Differential mode**

The HFI unit or subsystem under test shall keep nominal performance, following susceptibility criteria defined in chapter 3, when subjected to the perturbations defined in annex 3.

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Below 100 kHz, the injection could be performed at discrete frequencies which will be defined with regard to HFI units tests results. In particular 4K CRU and 4K CDE conducted emissions results will be used to define the discrete frequencies to be injected on the respective lines when necessary.

### 6.3.4.2 CS continuous Common mode

The HFI unit or subsystem under test shall keep nominal performance, following susceptibility criteria defined in chapter 3 when subjected to the perturbations defined in annex 3 on its input power lines.

The injected current shall be monitored and limited to one Ampere peak.

### 6.3.4.3 Injection frequencies

For Differential and Common mode tests, if the CS is performed by sweeping the injection frequency, the sweep speed of the sine wave tests shall be less than 1 octave/minute.

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### ***6.3.5 Test set-up and test support***

Facility :

CSL thermal Vacuum chamber

EGSE's :

CCS

PACE

HFI ISS

PLM SCOE

CDMU DFE

EMC test material :

Current Injection probes

Current Monitoring Probes

Spectrum Analyser with pre-selector

Signal Generator

Power Amplifier

### ***6.3.6 Test acceptance criteria***

The exact test acceptance criteria have been provided by HFI (see chapter 3).

The requirement is that up to the limit of the test, there shall be no susceptibility or degradation in performance of the HFI instrument, this will be determined in real time by the HFI support engineer throughout the test.



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### 6.3.7 Responsibilities

Test specimen	ASP/HFI
Test Facility	CSL
Test Specification	ASP
Test Procedure	ASP
Test execution	ASP/HFI
Test Report	ASP
Test Evaluation	HFI

## 7. SYNTHESIS OF TESTS TO BE PERFORMED

The following tables present a synthesis of all EMC tests to be performed at CQM level :

HFI lines	Conducted emission test
4K CRU	Differential Mode (30 Hz – 50 MHz)
4K CRU	Common Mode (10 kHz – 50 MHz)
4K CDE	Differential Mode (30 Hz – 50 MHz)
4K CDE	Common Mode (10 kHz – 50 MHz)
4K pipes at Ancillary Panel output before the ceramic electrical insulator	Common Mode (20 Hz – 1 kHz)
4K pipes at Ancillary Panel output after the ceramic electrical insulator	Common Mode (20 Hz - 1 kHz)
4K pipes just before the last bonding connection of the pipes on the PPLM	Common Mode (10 kHz – 500 MHz)
4K pipes just before the connection of the FPU 4K clamp	Common Mode (10 kHz – 500 MHz)

HFI Power lines	CS DM (*) (30Hz – 100kHz)	CS DM (100kHz – 50 MHz)	CS CM (10kHz – 50 MHz)
<del>4K cooler</del>	<del>X</del>	<del>X</del>	<del>X</del>
<del>4K CDE</del>	<del>X</del>	<del>X</del>	<del>X</del>
<b>DPU</b>	<b>X</b>		
<b>0.1 K</b>	<b>X</b>		

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<b>DPU + 0.1K</b>		<b>X</b>	<b>X</b>
<b>REU/P</b>	<b>X</b>		
<b>REU/A (1belt)</b>	<b>X</b>		
<b>REU/P + REU/A(1belt)</b>		<b>X</b>	<b>X</b>

(\* this test will be performed either by sweeping or by injecting discrete frequencies (these frequencies and the injected levels will be defined after analysis of conducted emission test results and agreement of HFI).

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### A1-1 ANNEX 1 : HFI power budget

Power bus voltage is 28V.

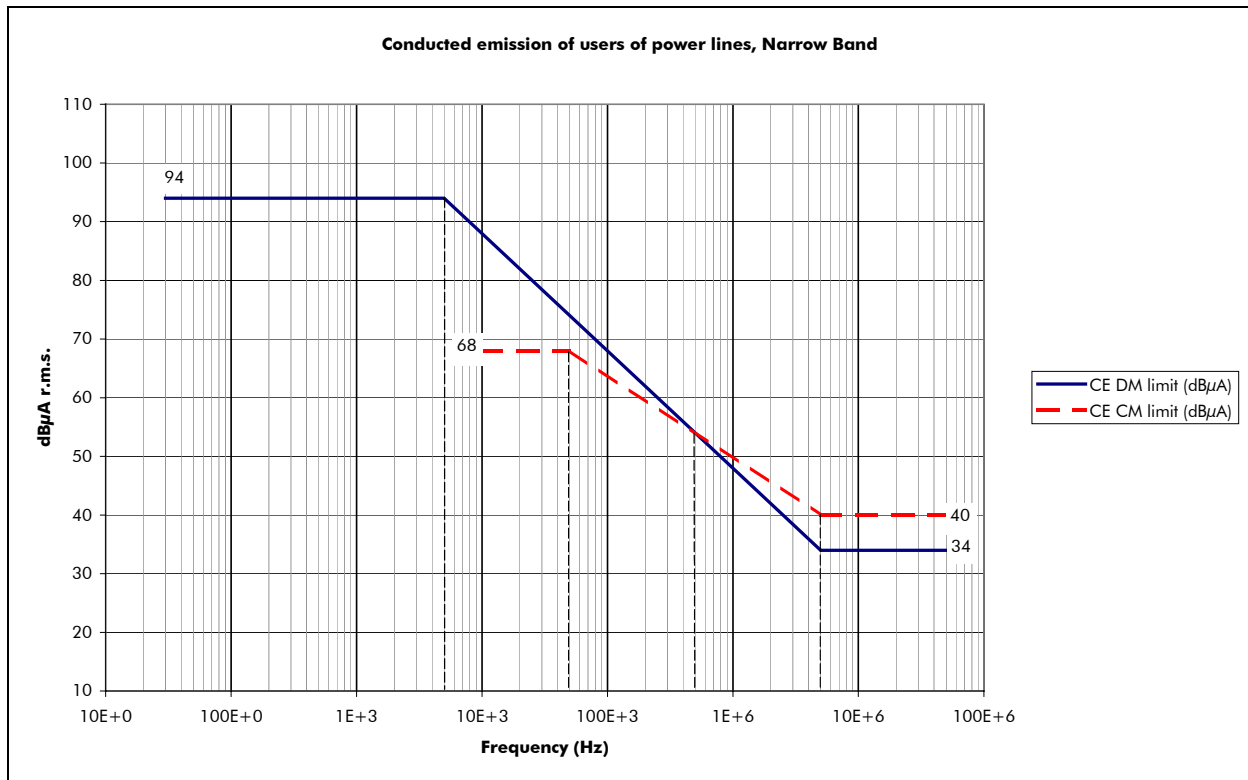
Reference in diagram of § 6.2.2.3	LINES	Average power	Long peak
P1	DPU	32 W	
P4	REU pro	24 W	
P6	4K CDE	12 W	
P3	4KC drive bus including regulator	124 W	
P5	DCE	10 W	19 W
P2	REU belts group 1	41.4 W	
	REU belts group 2	41.4 W	

**A1-2 ANNEX 2 : Conducted emission requirements**

The following information are extracted from the EMC specification [AD01], §3.2.4.8.2.2

Narrow band emissions:

The conducted emission shall not exceed the values shown in figure 3.2.4.8.2.2-1.



**Figure 3.2.4.8.2.2-1 : CE of users of power lines**

For nominal DC input current less than 1 A, the DM curve of figure 3.2.4.8.2.2-1 is directly applicable.

For nominal DC input current greater than 1 A, the DM curve of figure 3.2.4.8.2.2-1 shall be relaxed by  $10 \cdot \log I(A)$ ,  $I(A)$  being the nominal DC input current in Ampere.

# \*

# Reference **EMCEQ-430**

In order to reproduce the system power bus impedance and to standardise the measurement conditions used in different test sites, conducted emissions and susceptibility measurements on primary power lines shall be performed by inserting a Line Impedance Stabilisation Network (LISN) between the EGSE power supply and the unit under test.

# \*

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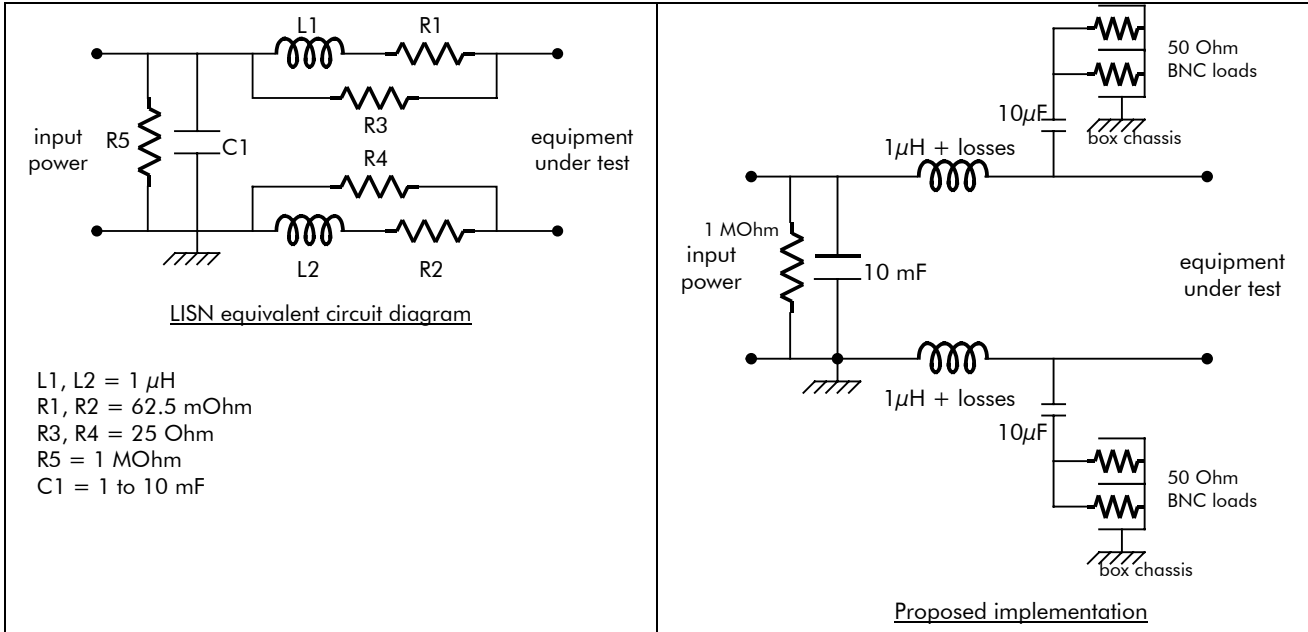
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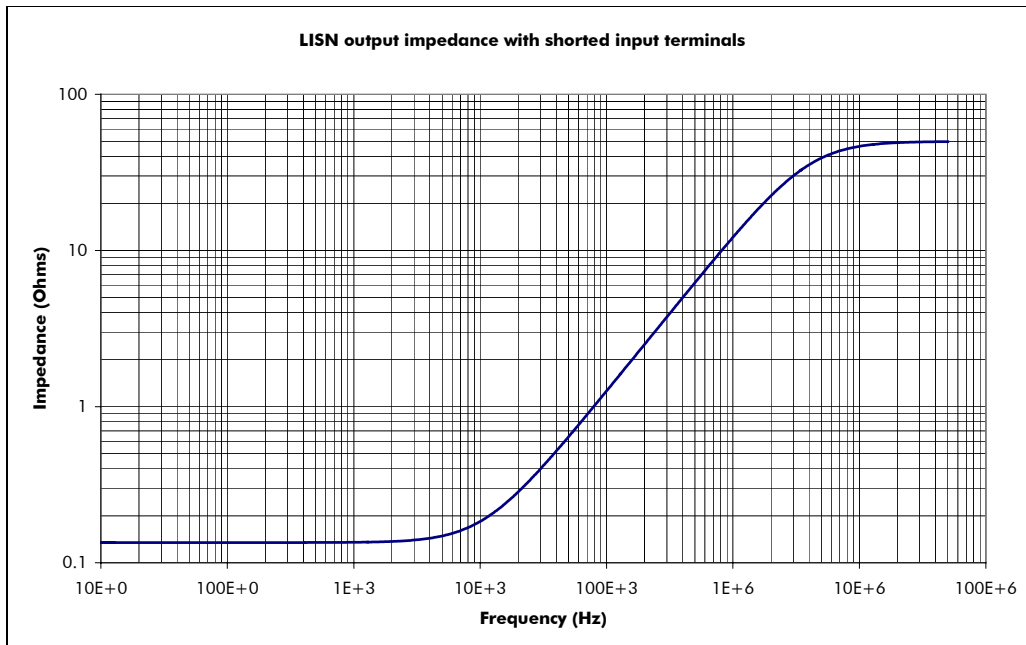
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# Reference **EMCEQ-440**

The LISN schematic and the relevant impedance versus frequency are given in figures 3.2.4.8.2.2-2 and 3.2.4.8.2.2-3.



**Figure 3.2.4.8.2.2-2: LISN equivalent circuit diagram and proposed implementation**



**Figure 3.2.4.8.2.2-3 : LISN output impedance (input in short circuit)**

# \*

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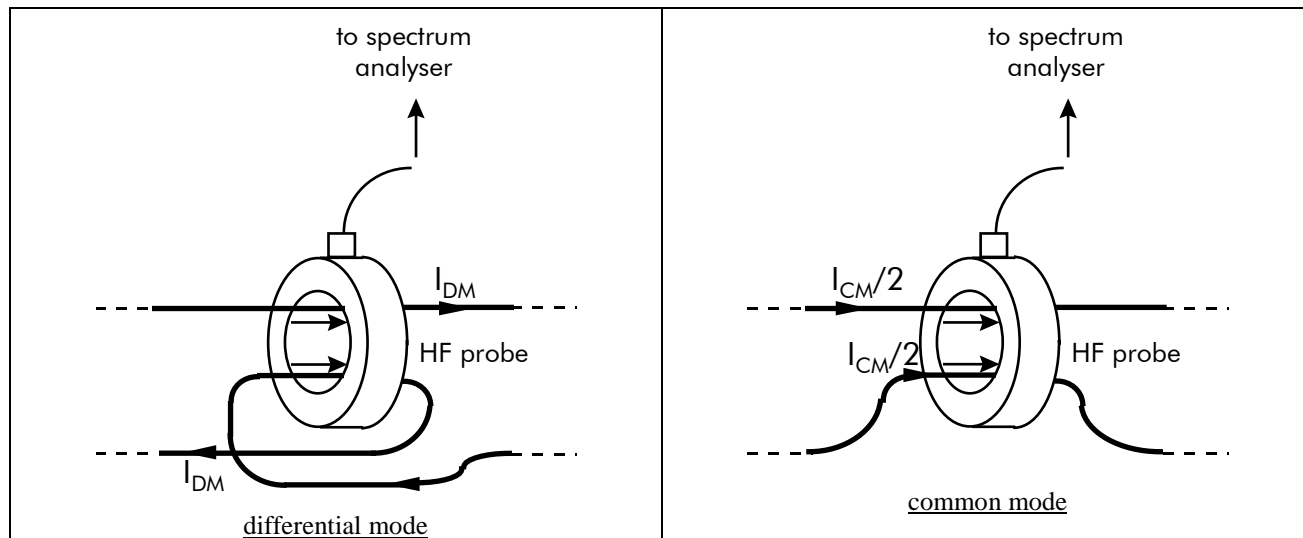
# Reference **EMCEQ-450**

The harness length between the equipment and the LISN shall be 1 meter.

# \*

# Reference **EMCEQ-460**

The current measurements shall be performed separately in both differential and common modes, as defined below.



**Figure 3.2.4.8.2.2-4 : differential and common mode measurements**

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### A1-3 ANNEX 3 : Conducted Susceptibility requirements

The following information are extracted from the EMC specification [AD01], §3.2.4.8.4

Conducted susceptibility of users of PCDU power lines :

#### 3.2.4.8.4.1 CS continuous

##### 3.2.4.8.4.1.1 CS continuous Differential mode

# Reference EMCEQ-500

The unit or subsystem under test shall keep nominal performance as specified in the relevant equipment/subsystem specification when subjected to the following perturbations on their input power lines :

Continuous sine wave : 1 Vrms from 30 Hz to 150 kHz, decreasing 6dB/octave up to 300 kHz and 0.5 Vrms from 300 kHz to 50 MHz (30% AM modulated by 1 kHz square wave between 50 kHz and 50 MHz)

# \*

# Reference EMCEQ-510

For continuous sine wave signals, the injected current shall be monitored and the requirement shall be considered to have been met when :

□ Frequency range 30 Hz – 50 kHz : the specified test voltage level cannot be generated but the injected current has reached 1 A r.m.s. and the equipment/subsystem is still operating without malfunction and without degraded performance within its specified tolerances

□ Frequency range 50 kHz – 50 MHz : a power source of 1 W, 50 Ω impedance cannot develop the required voltage at the equipment power input terminals and the subsystem equipment is still operating without malfunction and without degraded performance within its specified tolerances

# \*

##### 3.2.4.8.4.1.2 CS continuous Common mode

# Reference EMCEQ-520

The unit or subsystem under test shall keep nominal performance as specified in the relevant equipment/subsystem specification when subjected to the following perturbations on their input power lines :

Continuous sine wave : 2 Vpp from 10 kHz to 50 MHz (30% AM modulated by 1 kHz square wave between 50 kHz and 50 MHz)

# \*

# Reference EMCEQ-530

This voltage is to be obtained between power return and chassis (cf. test set-up figure 6.1.3.1-4).

# \*

# Reference EMCEQ-535

The injected current shall be monitored and limited to one Ampere peak.

# \*

##### 3.2.4.8.4.1.3 Injection frequencies

# Reference EMCEQ-540

# **PPLM CQM EMC TEST REQUIREMENT SPECIFICATION**

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For Differential and Common mode tests, if the CS is performed by sweeping the injection frequency, the sweep speed of the sine wave tests shall be less than 1 octave/minute.

# \*

# Reference EMCEQ-545

It will also be possible to inject discrete frequencies instead. A frequency table shall then be agreed prior to EMC TRR with the Prime.

# \*

**END OF DOCUMENT**