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Herschel

DPU EMC

Test Procedure

Document Ref: CNR.IFSI.2003TR01

Issue 1

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Acronyms

ASI	Agenzia Spaziale Italiana (Italian Space Agency)
AVM	AVionic Model
CDMS	Central Data Management System
CDMU	Central Data Management Unit
CE	Conducted Emission
CEDM	Conducted Emission Differential Mode
CECM	Conducted Emission Common Mode
CGS	Carlo Gavazzi Space
CM	Common Mode
CTR	Cathode Ray Tube (Oscilloscope)
DM	Differential Mode
EEPROM	Electrically Erasable Programmable Read Only Memory
EGSE	Electrical Ground Support Equipment
EIDP	End Item Data Package
EMC	ElectroMagnetic Compatibility
ESD	Electro Static Discharge
EQM	Electrical Qualification Model
DPU	Digital Processing Unit
FIRST	Far Infra-Red and Sub-millimetre Telescope
FCU	Focal plane Control Unit
FM	Flight Model
FP S/S	Focal Plane sub-system
FPU	Focal Plane Unit
FS	Flight Spare
HIFI	Heterodyne Instrument for First
HK	House-Keeping
HRS	High Resolution Spectrometer
HRSU	High Resolution Spectrometer Unit
HW	HardWare
IC	Instrument Control
ICD	Interface Control Document
ICE	In Circuit Emulator
ICU	Instrument Control Unit
I/F	Interface

ILT	Instrument Level Test
LCU	Local oscillator Control Unit
LISN	Line Impedance Stabilization Network
LOA	Local Oscillator Assembly
LO S/S	Local Oscillator sub-system
LOU	Local Oscillator Unit
NA	Not Applicable
NB	Narrow Band
NCR	Non Conformance Report
OBS	On Board Software
PA	Product Assurance
PACS	Photoconductor Array Camera and Spectrometer
PFM	Proto Flight Model
PROM	Programmable Read Only memory
QA	Quality Assurance
QM	Qualification Model
RE	Radiated Emission
S/C	Spacecraft
S/S	Subsystem
SLE	Standard Laboratory Equipment
SPIRE	Spectral and Photometric Imaging Receiver
SW	SoftWare
TBC	To Be Confirmed
TBD	To Be Defined
TBW	To Be Written
TLP	Transfer Layer Protocol
TRB	Test Review Board
TRRB	Test Readiness Review Board
UR	User Requirement
URD	UR Document
VCD	Verification Control Document
WBS S/S	Wide Band Spectrometer sub-system
WBSU	Wide Band Spectrometer Unit

1 INTRODUCTION

1.1 General

The content of this procedure is based on the DPU model philosophy and the DPU subsystem specifications (AD03, AD04)), the DPU product tree; it is consistent with the interface documents AD01, AD02 and AD03. This document specifies how the EMC tests will be carried-out on the DPU, to be sure that the DPU fulfils its Electro-Magnetic performances.

This procedures applies only to PACS and SPIRE as HIFI has its dedicated document as the ICU provides power to the HIFI FCU subsystem.

The subsystem that is delivered for integration and tests at instrument level consists of an electronic box called DPU (dimensions: 274x258x194 mm^3) and of the On Board Software both appropriate for each of the delivered models.

It is underlined that in the same DPU box two full computers are placed and both have to be tested.

1.2 Scope

This document describes the detailed procedure for the various EMC measurements. This procedure applies to the AVM, as far as the DC/DC converter is concerned, and EQM, FM DPU subsystems (AD08).

For the DPU AVM subsystem the EMC tests carried out on the DC/DC converter are reported in RD04 and RD05. It is to be recalled that the AVM has no redundancy.

1.3 Objectives

Verification by means of testing of the DPU subsystem with respect to the subsystem specification, especially with reference to AD01-AD10.

2 DOCUMENTS

2.1 Applicable Documents

AD	Title
01	Herschel/Planck Instrument Interface Document, part A
02	Herschel/Planck Instrument Interface Document, part B-Instrument PACS
03	Herschel/Planck Instrument Interface Document, part B-Instrument SPIRE
04	Herschel PACS DPU Subsystem Specification Document
05	Herschel SPIRE DPU Subsystem Specification Document
06	PACS DPU ICD
07	SPIRE DPU ICD
08	DPU/ICU P.A.Plan
09	PACS DPU AIT Plan
10	SPIRE DPU AIT Plan

2.2 Reference Documents

RD	Title
01	PACS DPU HW User manual
02	SPIRE DPU HW User Manual
03	DC/DC BOARD Test Procedure
04	DC/DC Converter Test Report (PACS)
05	DC/DC Converter Test Report (SPIRE)

3 DPU Set Up and Instrumentation (AD01)

For the various tests the set up will be indicated. The DPU will be put on the testing table (Ground Plane) with, in the case of PACS:

- one cable to the power supply;
- one cable to the S/C simulator (EGSE);
- one cable to the DEC/MEC simulator;
- two cables to the SPU simulator,

the DEC/MEC and SPU simulators are made with a PC board implementing the MIL STD 1355.

The DPU will be put on the testing table (Ground Plane) with, in the case of SPIRE:

- one cable to the power supply;
- one cable to the S/C simulator (EGSE);
- one cable to the DCU simulator;
- one cable to the MCU simulator
- one cable to the SCU simulator,

the DCU, MCU and SCU simulators are implemented with a dedicated PC board.

.

The cables will be connected to the Nominal (Prime) DPU and after a first RUN of the tests they will be connected to the Redundant DPU and a new RUN of the tests will be carried out. The S/Ss simulator, the power supply and the EGSE shall be placed in another attached shielded enclosure located outside the shielded test enclosure area.

3.1 Test Site Conditions

Testing shall be performed under the following atmospheric conditions where possible:
- Temperature 19 °C ÷ 26 °C
- Pressure 813 ÷ 1040 hPa
- Relative humidity 20% ÷ 80%

Restriction as required by the ESA (e.g. Cleanliness class) might be added to those requirements. It is understood that the tests will be carried out in a suitable anechoic chamber.

3.2 Ground Plane

The anechoic chamber will be provided with a solid plate ground plane. It shall have a minimum thickness of 0.25 mm for copper or 0.63 mm for brass and be 2.25 m^2 or larger in area with the smaller side no less than 76 cm in length. The ground plane shall be bonded to the shielded room such that the DC bonding resistance shall not exceed 2.5 mΩ. In addition, the bonds shall be placed at distances no greater than 90 cm apart. The DPU box bonding lug will be connected to the ground plane with a braided short cable.

3.3 Ambient Electromagnetic Levels

Ambient conducted and radiated emission levels shall be measured prior to test and shall be at least 6dB below the applicable limits. These measurements shall be performed with the DPU turned off and with all the auxiliary equipment turned on. Ambient levels on power leads shall be measured with the leads disconnected from the DPU and connected to a resistive load which draws the same current as the test article The LISN (see § 3.8) shall be included in the test set-up. In this case, accurate calibration of the double ridge horn shall be proven and included in the EMC Test procedure.

3.4 Test Antenna Counterpoise (Monopole)

The following requirements shall be used when rod antennas that require a counterpoise are used. The test antenna counterpoise shall be referenced to the same ground reference used for the Electromagnetic Interference (EMI) meters. In shielded enclosures, the counterpoise shall be bonded to the reference ground plane. The bonding strap shall be a solid metal sheet having the same width as the counterpoise, welded along the entire edge at the points of contact. Alternatively, the counterpoise shall be clamped and/or soldered to the ground plane in two places. If desired, the counterpoise may be configured so that one dimension is of adequate length to reach the test article ground plane.

3.5 Impulse generators

Impulse generators shall conform to the following requirements:
a) Calibrated in terms of output to a 50 ? load.
b) Spectrum shall be flat over its frequency range with an amplitude accuracy of ± 1 dB within the frequency band being displayed by the spectrum analyzer.

3.6 Standard Laboratory Equipment

All SLE shall be operated as prescribed by the applicable instruction manual unless otherwise specified therein. This requirements document shall take precedence in the event of conflict with instruction manuals or other documents issued by industry or other Agencies unless identified in an approved test plan. For test repeatability, **all test parameters used to configure the test shall be recorded in the EMC test report. These parameters shall include measurement bandwidths, video bandwidths, sweep speeds etc.**

3.7 Power Supply Characteristics

The power supply for the DPU box will be at least a 0-30 V 3A device, provided by the TBD firm where the tests will be carried out (TBC), shall have good characteristics of stability and noise. The voltage will be measured at the DPU box input.

3.8 Line Impedance Stabilization Network (AD01)

In order to reproduce the S/C power bus impedance and to standardize the measurement conditions used in different test sites, emissions and susceptibility measurements on primary power lines shall be performed on inserting a Line Stabilization Network (LISN) between the power supply and the DPU. The LISN schematic and the relevant impedance versus frequency are chosen in accordance with the S/C bus impedance mask.
NOTE: The design of the LISN is usually provided by the spacecraft contractor. In case it is not available in time the LISN schematic and the relevant impedance versus frequency given in Fig. 3.8-1 and Fig. 3.8-2 shall be used.

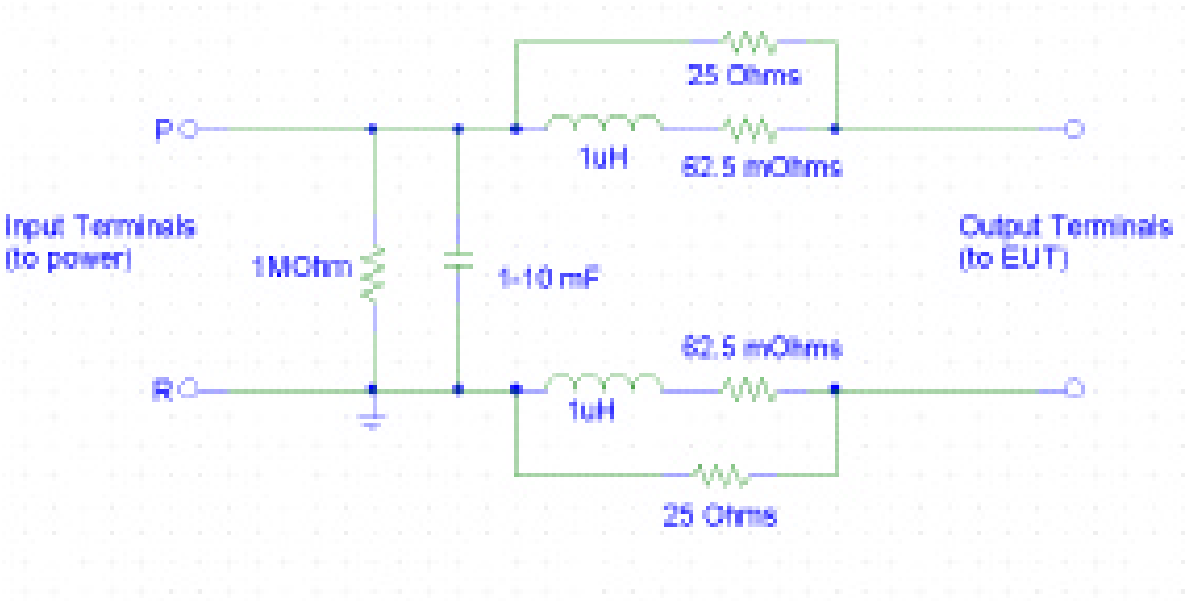

Figure 3.8-1 LISN Schematic

Figure 3.10-1 LISN Schematic

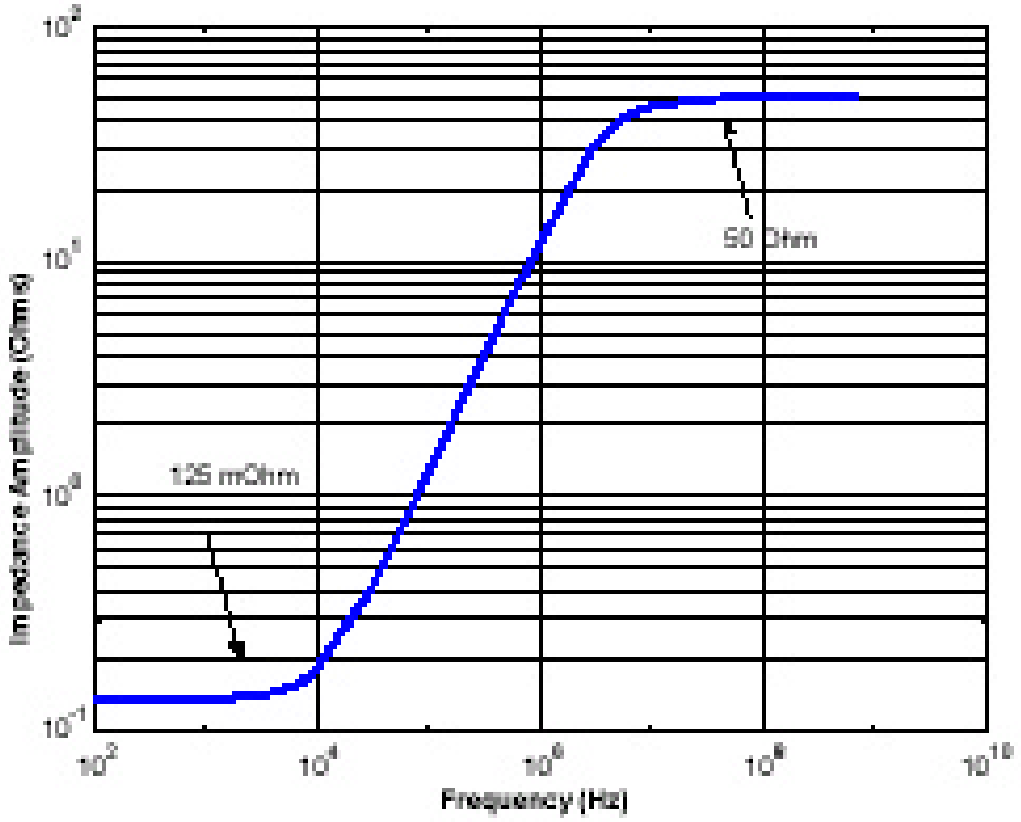

Figure 3.8-2 LISN Output Impedance with shorted input terminals

3.9 Signal Sources (AD01)

Any commercially available signal source, power amplifier and general purpose amplifier capable of supplying the power required to develop the susceptibility level specified herein, may be used provided the following requirements are met:

a) Frequency accuracy shall be within ± 2%.

b) Amplitude accuracy shall be within ± 2 dB.

c) Harmonic content and spurious outputs shall be no more that -30 dB as related to the fundamental power level.

4 Measurement Requirements (AD01)

4.1 Measuring Equipment Calibration

Measuring instruments and accessories used in determining compliance with this document shall be calibrated under an approved program in accordance with MIL-STD-45662A.

4.2 Measurement Accuracy

All test equipment shall be capable of measuring to within the following accuracy:
a) 2% for frequency
b) 3 dB for amplitude

4.3 Measurement Bandwidths

Narrow-band ranges for each tuned frequency range are listed in Table 4.3-1 below:

Tuned Frequency (Hz)	Bandwidth Range (Hz)
30 - 300	1 – 30
300 - 3 k	5 – 50
3 k -30 k	10 – 500
30 k -1 M	300 – 5 k
1 M -30 M	1 k – 50 k
30 M -1 G	1 k – 100 k
1 G - 40 G	100 k – 50 M

Table 4.3-1: Narrow-band range for each tuned frequency range

N.B. For conducted emission 30 Hz to 15 kHz range the limit shall be measured with an effective bandwidth not exceeding 100 Hz.

4.4 Measurement frequency range

A continuous scan and recording of the specified frequency range for each applicable test shall be performed.

5 Measuring Equipment/Instrumentation (AD01)

This section describes the test equipment and instrumentation used in the test methods contained in this document. Any other instruments that are capable of measuring the parameters of this procedure may be used, after approval by ESA.

5.1 Measurement Receivers / Spectrum Analyzers.

Any frequency selective receiver can be used to perform the testing described in this document. The receiver characteristics (i.e. sensitivity, selection of the bandwidths, detector functions, dynamic range and frequency of operations) shall meet the requirements specified in this procedure and shall be sufficient to demonstrate compliance with the applicable limits. Concerning the use of spectrum analyzers, they can be used when overloading protection is provided by means of pre-selection input filters.

Commentary: In EMI testing, one of the most important considerations is preventing saturation of the spectrum analyzer because spurious responses can be created.

5.2 Computer Controlled Receivers

A description of the operations that are directed by software for computer controlled receivers, shall be included in the test report.

5.3 Detector Function

A peak detector shall be used for all emission and susceptibility measurements. This device shall detect the peak value of the modulation envelope in the receiver band-pass. The output of the measurement receiver shall be calibrated in terms of equivalent root mean square (RMS) value of a

sine wave with the same peak value. When other measurement devices such as oscilloscopes, non-selective voltmeters etc. are used for testing, correction factors shall be applied for modulated test signals to correct the reading to equivalent RMS values under the peak of the modulation envelope.

5.4 Current Probes Transfer Impedance

The current probe transfer impedance which is defined as the ratio between secondary voltage across a 50 ? load to the primary current shall be determined using the following procedure:
Terminate the signal generator with a short length of wire (20 cm) and a 50 ? non-inductive resistor. The primary current Ip can be calculated.
Clamp the current probe around the wire between the signal generator and the 50 ? load.
Connect the current probe to a receiver (50 ? input impedance) and measure the secondary voltage Vs.
The transfer impedance is Zt = Vs/ Ip
The transfer impedance of the current probe shall be included in the Test Report.
Any current probe capable of measuring to the limits specified in this document may be used. The current probe shall be located not more than 5 cm apart from the test article.

5.5 Test Antennas

Antennas used in performing the radiated emission and susceptibility tests shall be listed in the EMC test report. The following antenna characteristics are recommended:
- 30 Hz - 50 kHz: Sensors that measure only magnetic fields
    a) Electrically small loops, whose impedance shall not resonate over the frequency range of use.
    b) Active magnetic sensors, which sense amplitude as opposed to the time derivative of the amplitude.
- 14 kHz - 30 MHz: Electrically short high impedance electric field probe, vertically polarized. Traditionally the 41'' rod with active or passive matching network to 50 ? has been used.
- 14 kHz - 30 MHz: The parallel plate (and its numerous modifications), long wire, and E-Field generator are available and listed in order of preference. The E-Field generator should be reserved for the case in which the test article is too large for other methods.
- 30 MHz - 200 MHz: Dipole-like antennas. Typical antenna used in this band has been the bi-conical. Care should be exercised in the antenna selection to ascertain that the balun does an adequate job of matching the low frequency high antenna impedance to 50?

- 200 MHz - 1 GHz: The traditional Log-Periodic and Log-Conical are available. The double ridge horn can also be used, although the gain increases dramatically with the frequency**. In this case, accurate calibration of the double ridge horn shall be proven and included in the EMC Test report**.
- 1 GHz - 10 GHz: Broadband (ridged) or standard gain horn. Log-Conicals are also available.
- 10 GHz and above: 20 dB standard gain horns.

6 Test set-up arrangement (AD01)

6.1 Isolation

Test instruments shall use an isolation transformer on the AC power lines and a separate ground cable to the central ground point. The ground cable shall consist of a braided cable.

6.2 DPU Arrangement

The diagrams of all cables, shielded and unshielded, that interconnect the DPU box to:

- the power supply;
- the S/C simulator;
- the S/Ss simulators;

are shown in AD06 and in AD07, showing all conductors and shields**..** The cables and the DPU box shall be so arranged that there is minimum shielding interposed between the DPU cables and the measurement antennas. All leads and cables shall be located within 10 cm from the ground plane edge nearest to the measurement antenna and shall be supported at least 5 cm above the ground plane on non-conductive spacers.

7 Measurement Antenna Position (AD01)

7.1 Location

When performing radiated emission and susceptibility tests, no points of the antennas shall be less than 1 m from the walls, ceiling or floors of the shielded enclosure or obstruction.

7.2 Bi-conical Antenna

A minimum distance of 30 cm from the floor and ceiling and 1 m from the walls of the shielding enclosure or obstruction can be accepted when the bi-conical antenna is used in vertical polarization.

7.3 Linearly polarized antennas

For radiated emission measurements above 30 MHz, linearly polarized antennas shall be positioned to measure the vertical and horizontal components of the emission.
For radiated susceptibility measurements above 30 MHz, linearly polarized test antennas shall be positioned so as to generate vertical and horizontal fields.

8 DPU Operations (AD01)

The DPU shall be operated in "primary mode" in order to obtain optimum design performance. The same mode will be selected both for susceptibility testing and for emission noise.

8.1 Susceptibility Criteria

If the DPU is unable to meet the susceptibility criteria the threshold of susceptibility shall be determined.

8.2 Time Duration

Each susceptibility level shall be maintained for a minimum time in order to ensure that possible susceptibility conditions are achievable and detectable.

8.3 Test Equipment Warm-up time.

Prior to performing tests, the measuring equipment shall have been switched on for a period of time adequate to allow parameter stabilization. If the operation manual does not specify a specific warm up time, the minimum warm up period shall be 1 hour.

9 Conducted Emission on Power Lines (AD01)

Conducted emissions on power lines generated by the DPU shall be tested as follows:

9.1 Conducted Emission on Primary Power Lines, Frequency Domain, Differential Mode, NB

Narrow Band conducted emission Differential Mode in the frequency range 30 Hz ÷ 50 MHz generated by the DPU on each primary power line shall not exceed the following adjustable limit:

A. For nominal DC input current less than 1 A, use the curve of Figure 9.1-1 as shown.

B. For nominal DC input current greater than 1 A, the curve of Figure 9.1-1 shall be relaxed by the factor 10*log [I (A)], where I (A) is the nominal input current in Ampere.

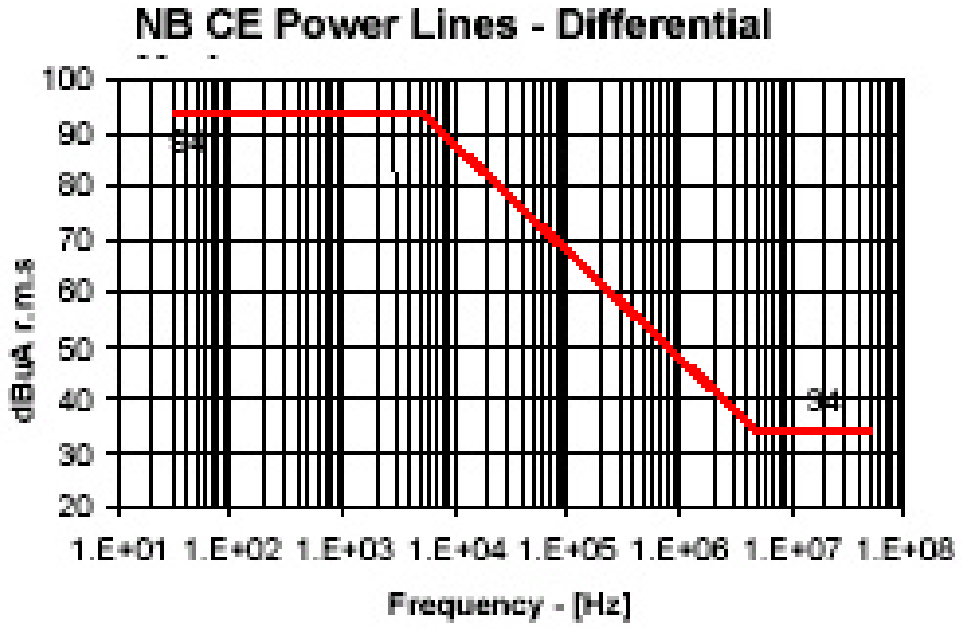

Figure 9.1-1 Narrow Band Conducted Emission Current- Differential Mode

9.1.1 Conducted Emission Tests Set Up (AD01)

The suggested test set-ups for ŒDM and CECM are shown in figure 9.1-2. For test in time domain, any switch for ON/OFF test will be positioned between a 10mF capacitor and the DPU. The transients are then measured on the power lines between the switch and the DPU.

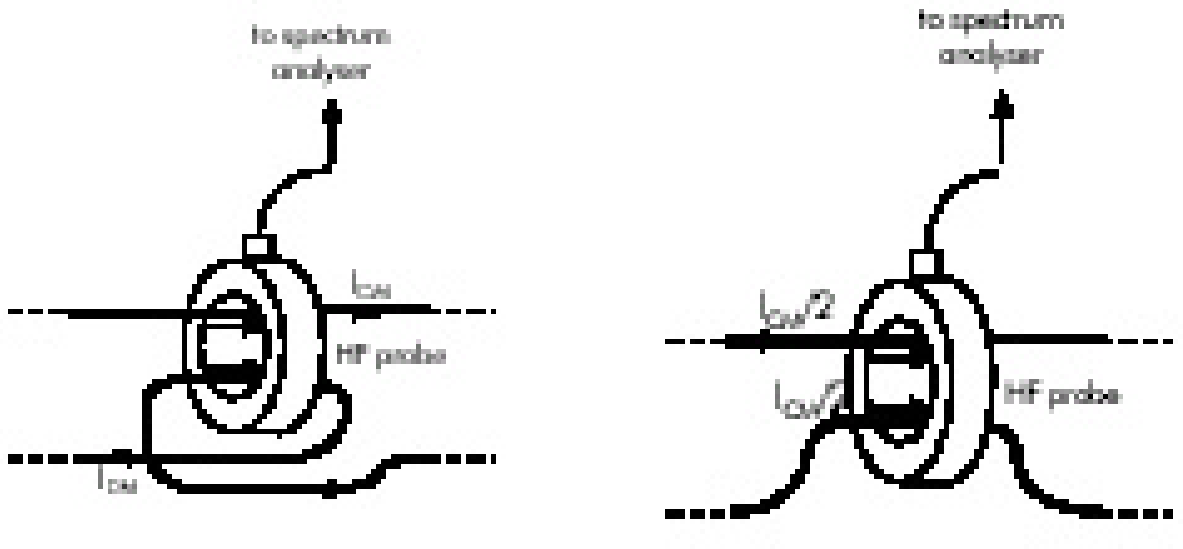

Figure 9.1-2 Conducted Emission Test set-up for DM and CM

9.1.2 Conducted Emission on Primary Power Lines, Frequency Domain, Common Mode, NB

Narrow Band conducted emission Common Mode in the frequency range 10 kHz ÷ 50 MHz generated by the DPU on the primary power lines shall not exceed the following adjustable limit:

A. For nominal DC input current less than 1 A, use the curve of fig. 9.1-3 as shown.

B. For nominal DC input current greater than 1 A, the curve of fig. 9.1-3 shall be relaxed by the factor 10*log [I (A)]. I (A) is the nominal input current in Ampere.

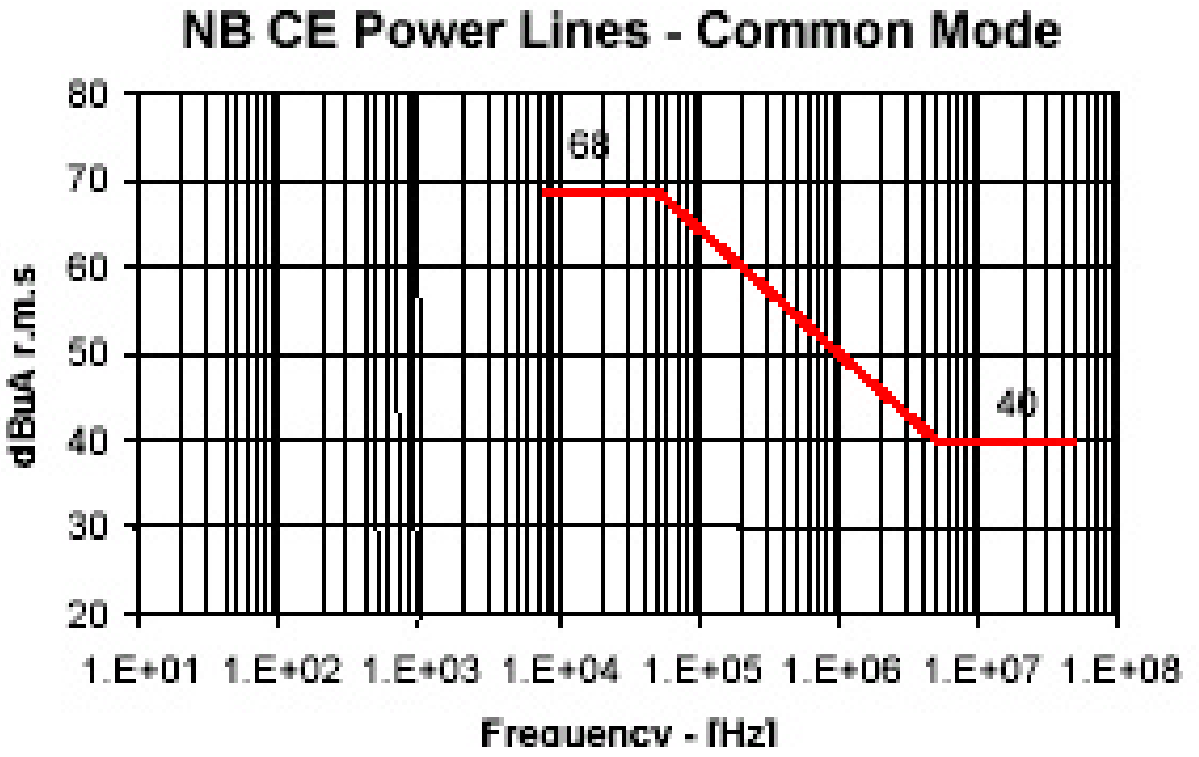

Figure 9.1-3 Narrow Band Conducted Emission Current- Common Mode

9.2 Current Ripple, Time Domain, Differential Mode

9.2.1 Measurements on Primary Power Bus

Differential mode, time domain current ripple and spikes on the primary power bus of the DPU shall be:

A. For nominal DC input current less than 1 A:

Ripple: less than 20 mApp.
Spikes, including ripple: less than 60 mApp.

B. For nominal DC input current greater than 1 A:

Ripple: relax 20 mApp by a factor vI (A), I (A) being the nominal input current in Ampere.
Spikes, including ripple: relax 60 mApp by a factor vI (A), I (A) being the nominal input current in Ampere.

Ripple and spikes shall be measured on both the primary and return lines with at least 50 MHz bandwidth.

9.3 Conducted Emission Common Mode Current on Signal Bundles

The Conducted Emission Common Mode on individual Signal Bundles of the subsystem shall be measured from 10 kHz to 50 MHz**. Measurement shall be used to establish the limits for Conducted Susceptibility Common Mode current injection on the same bundles (see section 10.5).**
The following signal bundles are identified for the DPU:

9.3.1 DPU PRIME PACS case:

1. the 1553B wires of nominal and redundant channel: **connectors J03 and J04**
2. Command and HK to DEC/MEC1: **connector J07**
3. Command and HK to SPU1: **connector J09**
4. Command and HK to SPU2: **connector J10**

9.3.2 DPU REDUNDANT PACS case:

5. the 1553B wires of nominal and redundant channel: **connectors J05 and J06**
6. Command and HK to DEC/MEC1: **connector J08**
7. Command and HK to SPU1: **connector J11**
8. Command and HK to SPU2: **connector J12**

9.3.3 DPU PRIME SPIRE case:

9. the 1553B wires of nominal and redundant channel: **connectors J03 and J04**
10. Command and HK to DCU: **connector J07**
11. Command and HK to MCU**: connector J08**

12. Command and HK to SCU**: connector J09**

9.3.4 DPU REDUNDANT SPIRE case:

13. the 1553B wires of nominal and redundant channel: **connectors J05 and J06**
14. Command and HK to DCU: **connector J10**
15. Command and HK to MCU**: connector J11**
16. Command and HK to SCU**: connector J12**

10 Conducted Susceptibility Tests

10.1 Conducted Susceptibility Power Lines . Differential Mode . Steady State

The DPU shall not exhibit any malfunction, degradation of performance or deviation beyond the tolerance indicated in its specification when sinusoidal voltages with amplitude specified in Fig.10-1 are injected into the subsystem equipment power leads in the frequency range 30Hz-50MHz. The frequency sweep rate shall not be faster than 5 min/decade.

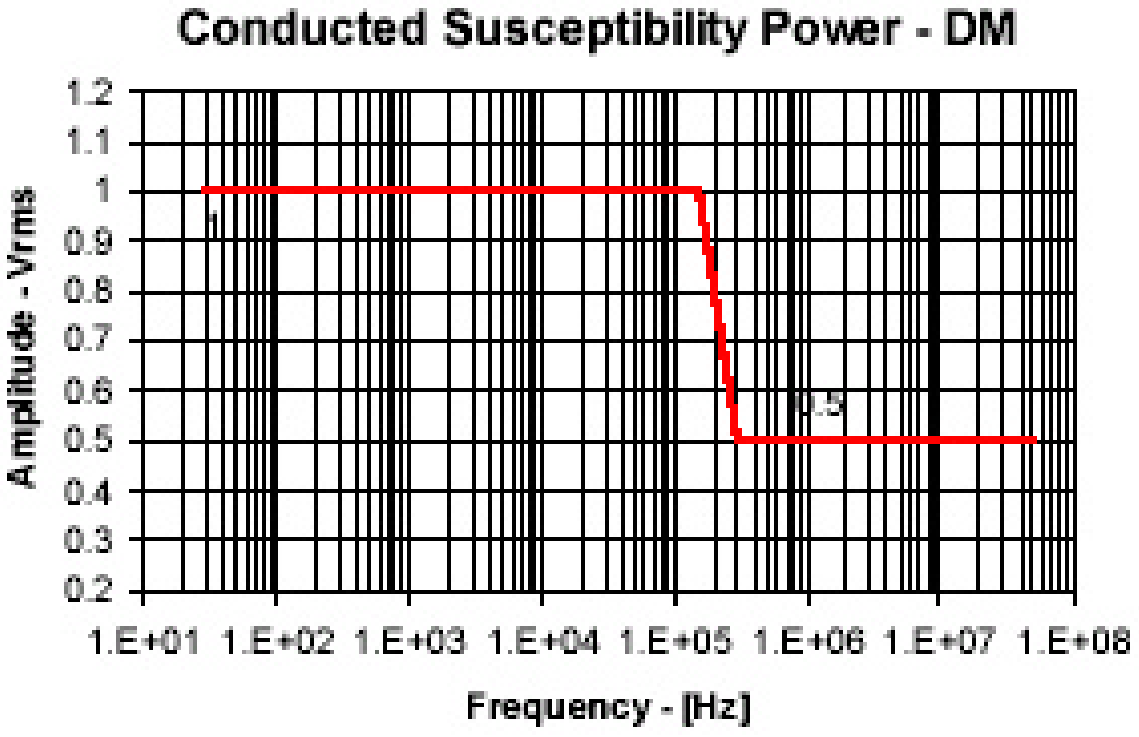

Figure 10-1 Conducted Susceptibility Power Lines- Differential Mode

In the frequency range 50 kHz-50 MHz, the applied sinusoidal voltage shall be 1 kHz amplitude modulated (30% AM).

The requirement shall be considered to have been met when:

1) Frequency range 30 Hz-50 kHz:

the specified test voltage level cannot be generated but the injected current has reached 1 Arms and the DPU is still operating without malfunctions within its specified tolerances.

2) Frequency range 50 kHz -50 MHz:

a power source of 1 Watt, 50 ? impedance cannot develop the required voltage at the equipment power input terminals and the DPU is still operating without malfunctions within its specified tolerances.

10.2 Conducted Susceptibility Tests Set-Up: Differential Mode Steady State

The test set-up for differential mode susceptibility on primary power lines is shown in Figure 10-2 for frequencies up to 50KHz. For the frequency range 50KHz-50MHz then the test set-ups shown in Figure 10-3 or Figure 10-4 should be used. The injected voltage relevant to the susceptibility threshold shall be monitored and recorded. The injected current shall be limited to **3 Arms** on the input power lines.

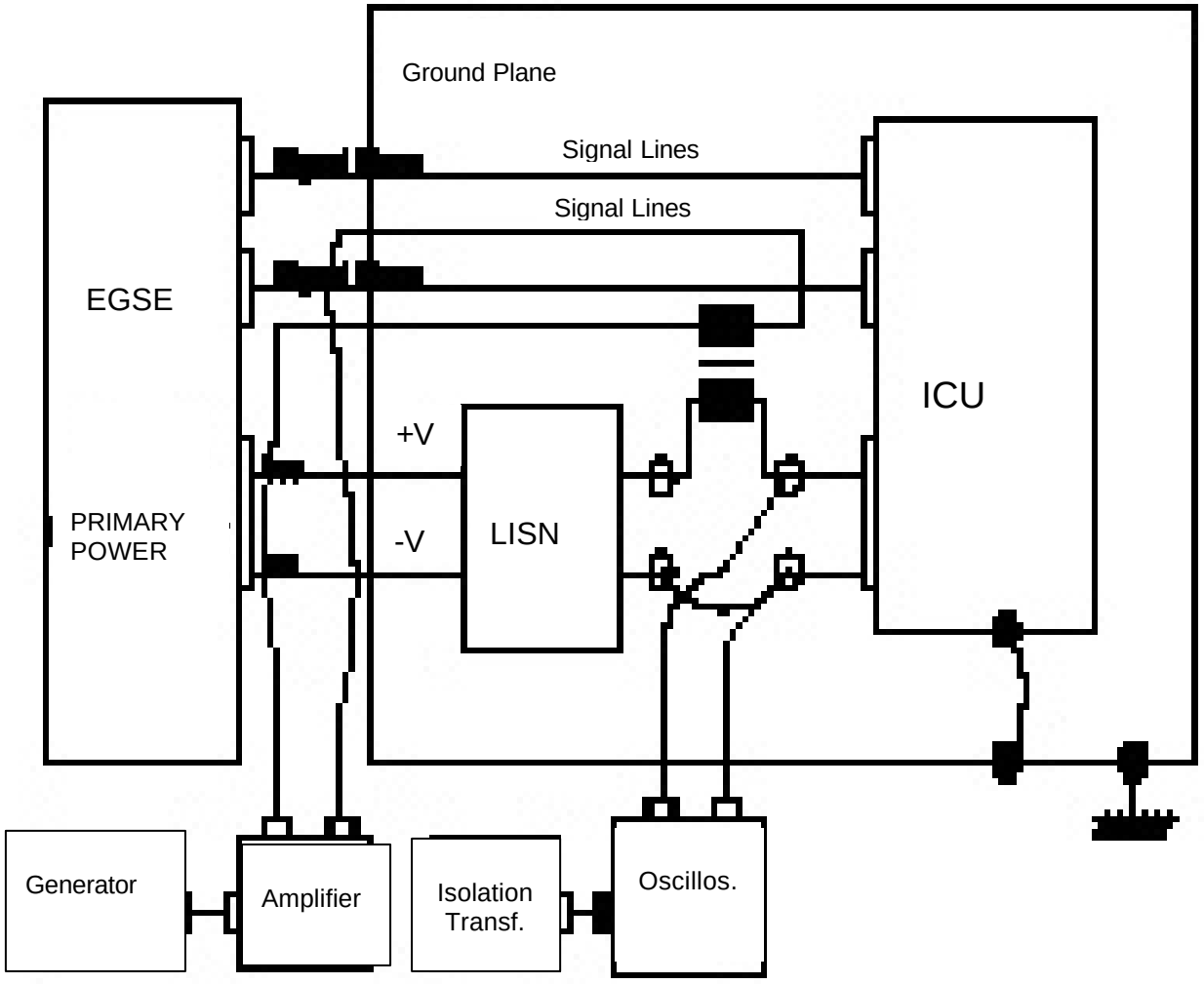

Figure 10-2 Conducted Susceptibility Power Lines- Differential Mode: 30 Hz-50 kHz

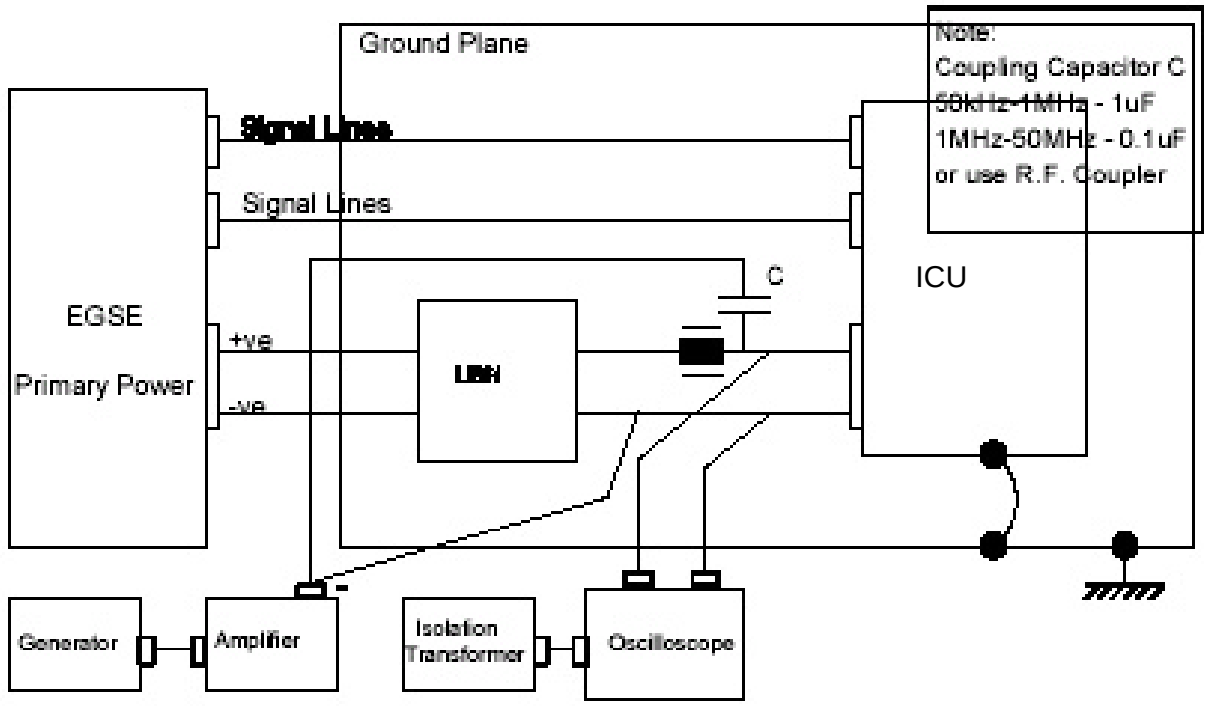

Figure 10-3 Conducted Susceptibility Power Lines- Differential Mode: 50 kHz-50 MHz

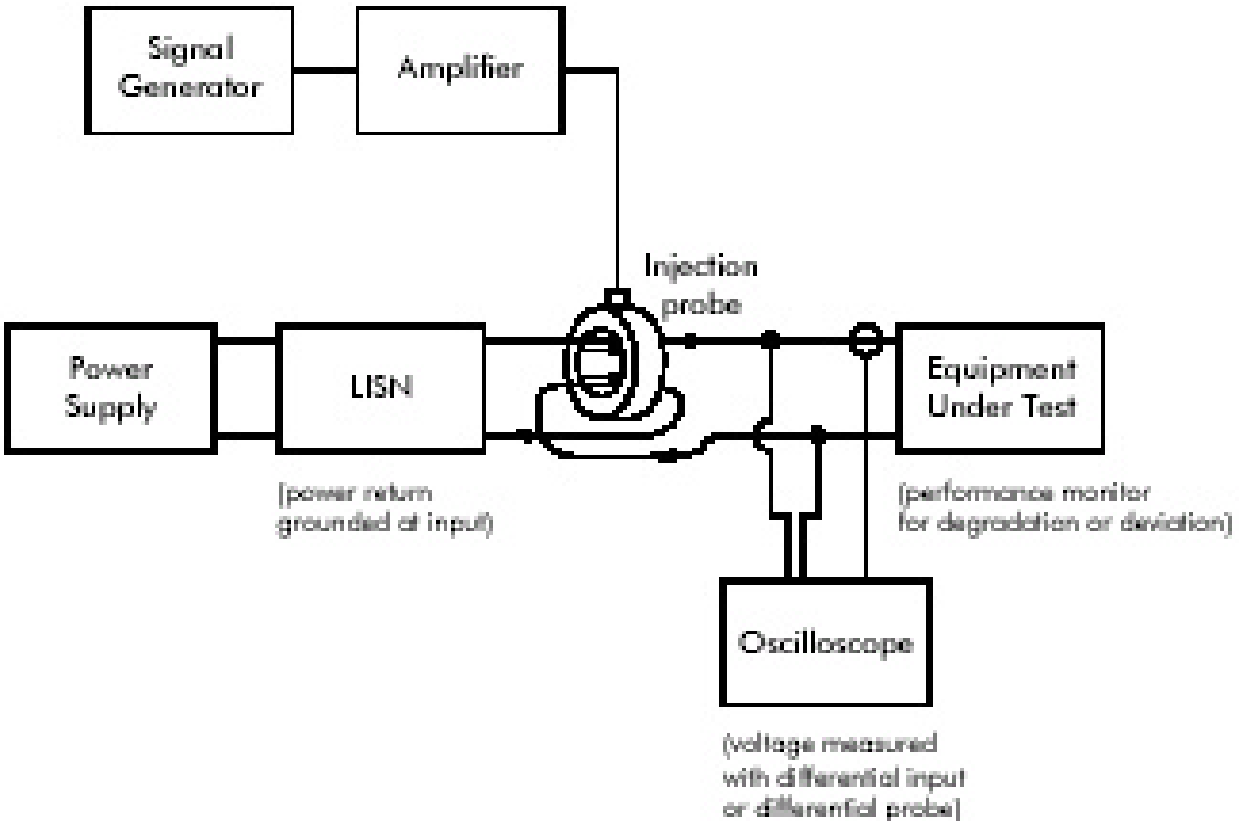

Figure 10-4 Conducted Susceptibility Power Lines- Differential Mode: 50 kHz-50 MHz

10.3 Conducted Susceptibility Power Lines Test Set-Up: Common Mode Steady State

The DPU shall not exhibit any malfunction, degradation of performance or deviation beyond the tolerance indicated in its individual specification when a sinusoidal common mode signal is injected in both the DPU power leads via Bulk Current Injection (BCI) until:

A) 2 Vpp is achieved between return line and chassis.

B) A maximum of 1 App is achieved

The text set-up for common mode susceptibility on primary power lines **and on signal bundles** is shown in Figure 10-5. The signal lines shall be loaded with electrical simulators of the interfacing circuits.

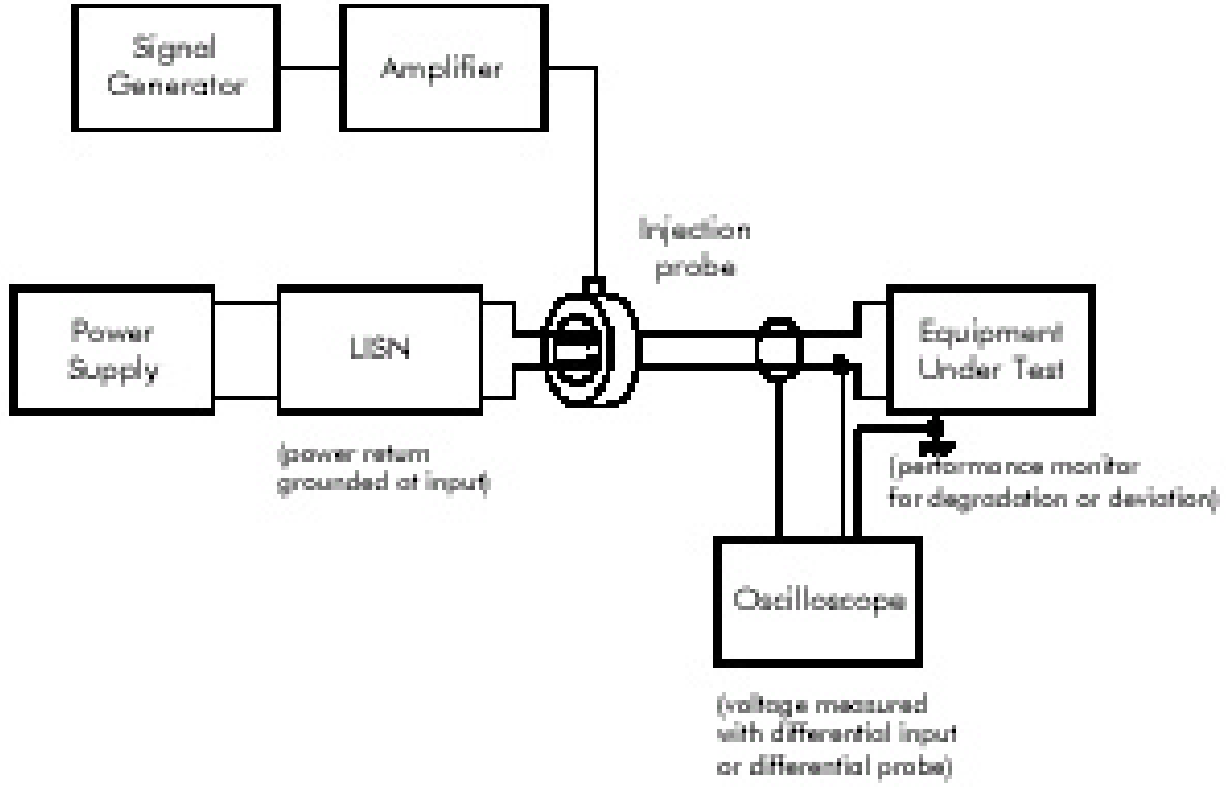

Figure 10-5 Conducted Susceptibility Power Lines & Signal Bundles- Common Mode: 10 kHz-50 MHz

10.4 Conducted Susceptibility on Power Lines . Transients

10.4.1 Conducted Susceptibility Tests on Power Lines. Transient Differential Mode

The DPU shall not exhibit any malfunction, degradation of performance or deviation beyond the tolerance indicated in its individual specification **when transient voltages typically shaped as shown in Fig. 10-6 are superimposed on the steady state bus voltage at the unit input power leads.** With reference to Fig. 10-6 the peak amplitude shall be ±2.5V, the rise time between 10µs and 100µs, the flat portion of the pulse 300µs and the time constant 2ms. The pulse repetition frequency of the waveform shall range from 5 Hz to 10 Hz and the test duration shall be at least 5 minutes.

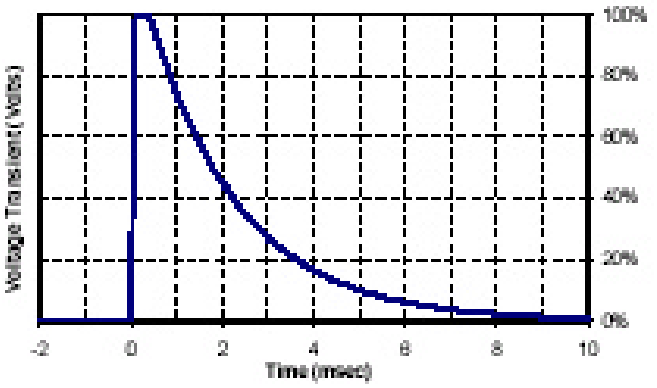

Figure 10-6 Typical transient waveform for DM Transient on Power Lines

10.4.2 Conducted Susceptibility Tests on Power Lines. Transient Common Mode

The DPU shall not exhibit any malfunction, degradation of performance or deviation beyond the tolerance indicated in its individual specification **when transient voltages shaped as shown in Fig. 10-7 are applied between the power return line and the unit case.** With reference to Fig. 10-7 the peak amplitude shall be 28 V, the rise time less than 100ns and the length (Td) at least 5µs. Repetition rate shall range from 5 Hz to 10 Hz and the test duration shall be at least 5 minutes

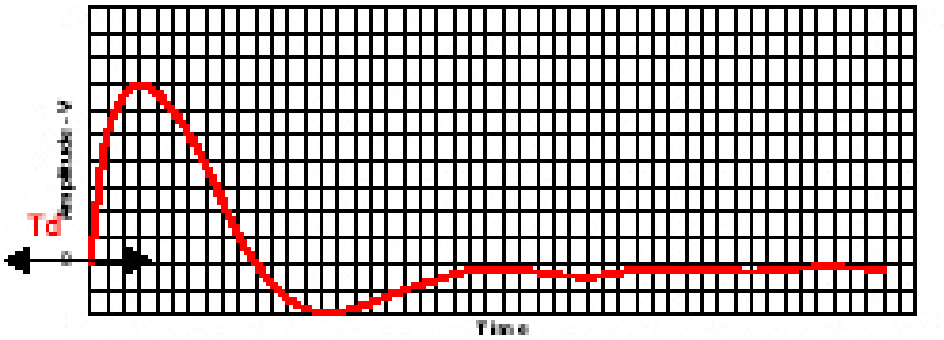

Figure 10-7 Typical transient waveform for CM Transient on Power Lines

10.5 Conducted Susceptibility Common Mode Current on Signal Bundles

The DPU shall not exhibit any malfunction, degradation of performance or deviation beyond the tolerance indicated in its individual specification when a sinusoidal common mode current of amplitude 6 dB higher than the common mode measurement (specified in the paragraph 9.3) is injected into the signal bundles.

The following signal bundles are identified for the DPU:

10.5.1 DPU PRIME PACS case:

17. the 1553B wires of nominal and redundant channel: **connectors J03 and J04**
18. Command and HK to DEC/MEC1: **connector J07**
19. Command and HK to SPU1: **connector J09**
20. Command and HK to SPU2: **connector J10**

10.5.2 DPU REDUNDANT PACS case:

21. the 1553B wires of nominal and redundant channel: **connectors J05 and J06**
22. Command and HK to DEC/MEC1: **connector J08**
23. Command and HK to SPU1: **connector J11**
24. Command and HK to SPU2: **connector J12**

10.5.3 DPU PRIME SPIRE case:

25. the 1553B wires of nominal and redundant channel: **connectors J03 and J04**
26. Command and HK to DCU: **connector J07**
27. Command and HK to MCU**: connector J08**
28. Command and HK to SCU**: connector J09**

10.5.4 DPU REDUNDANT SPIRE case:

29. the 1553B wires of nominal and redundant channel: **connectors J05 and J06**
30. Command and HK to DCU: **connector J10**
31. Command and HK to MCU**: connector J11**
32. Command and HK to SCU**: connector J12**

10.6 Conducted Susceptibility Common Mode Voltage on Signal Reference - Steady State

The DPU shall not exhibit any malfunction, degradation of performance or deviation beyond the tolerance indicated in its individual specification when sinusoidal voltages with 2 Vpp amplitude are applied between the DPU signal reference and the ground plane in the frequency range 50 kHz - 50 MHz. The sweep rate shall not be faster than 5 min/decade.

10.7 Conducted Susceptibility Common Mode Voltage on Signal Reference -Transient

The DPU shall not exhibit any malfunction, degradation of performance or deviation beyond the tolerance indicated in its individual specification when transient voltages typically shaped as shown in fig 10-7 are applied between the equipment signal reference and the ground plane. With reference to Fig. 10.7, the peak amplitude shall be calibrated to ± 3 V and Td shall be between 150 ns and 250 ns when the source having output impedance of 50 ? is connected to a 50 ? resistor. Then the source is applied to the equipment after it is detached from the ground plane. The pulse repetition frequency of the waveform shall range from 5 Hz to 10 Hz and the test duration shall be at least 5 minutes

The test set-up for common mode conducted susceptibility between the DPU signal reference and the ground plane (transient and steady state) is shown in Figure 10-8 (no accessible ground wire).

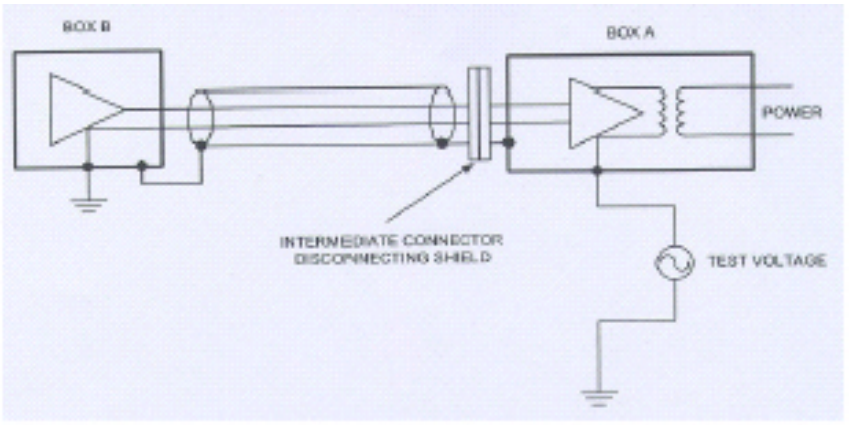

Figure 10-8 Conducted Susceptibility CM: between signal reference and GND, no accessible GND wire. Transient & Steady State

11 NB E-Field Radiated Emission (AD01)

Narrow-band electric fields generated by the DPU and measured at 1 m distance shall not exceed the limits shown in Fig. 11-1 in the frequency range 14kHz - 18GHz

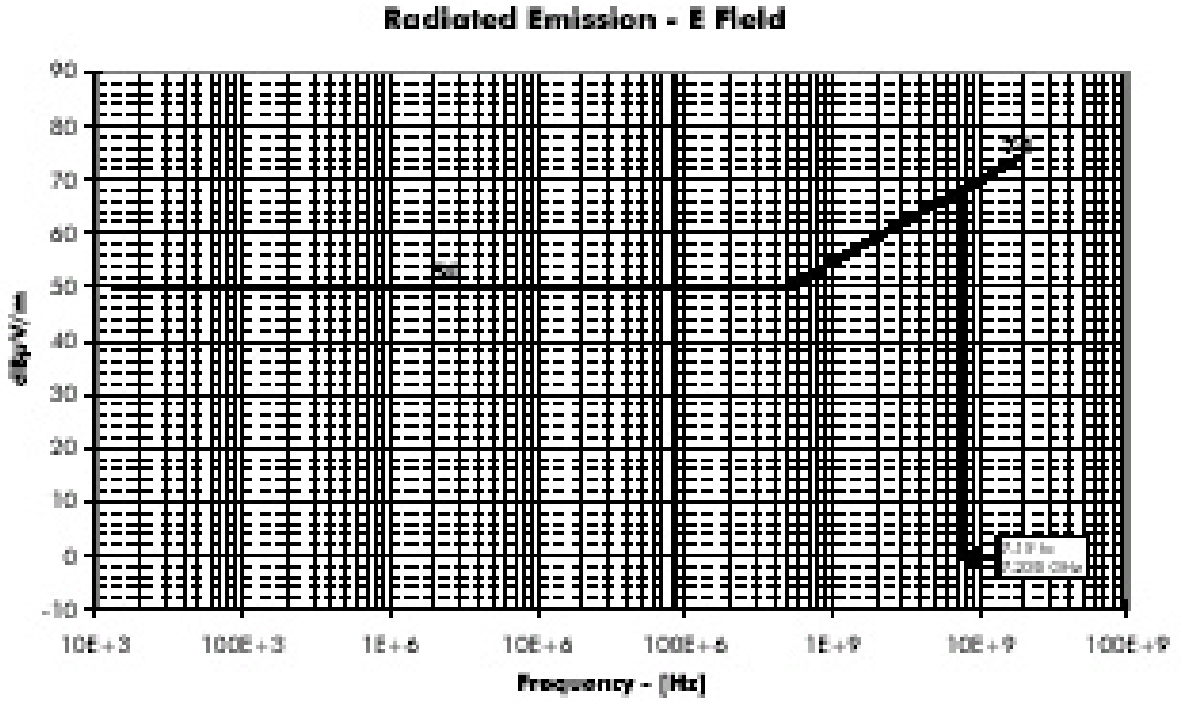

Figure 11-1 NB Radiated Emission Limit – E Field

The suggested test set-up is as shown in Figure 11-2. The emission at the antenna at one meter distance from the test object, which gives the highest reading, shall be the Radiated Electric Field Emission (REE). Above 25 MHz, the requirement shall be met for both horizontally and vertically polarized waves. The upper frequency range of the measurement shall be in accordance with the following Table.

Highest Frequency of Equipment	**Required Upper Limit**
< 1 GHz; **DPU Fmax: 20 MHz**	**To tenth Harmonic or 1 GHz whichever less** **=> 200 MHz**
1 - 10 GHz	To fifth Harmonic or 10 GHz whichever less

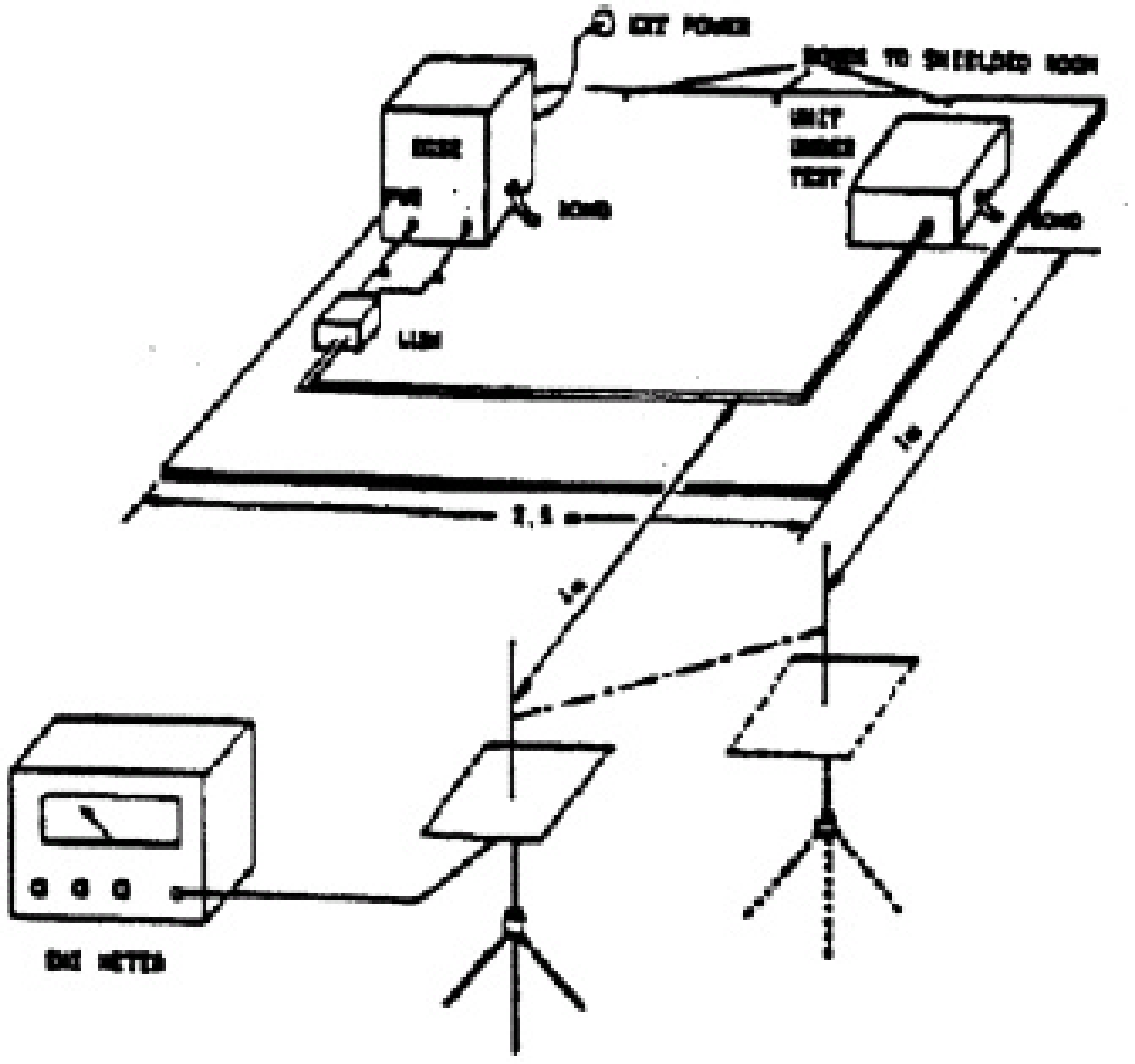

Figure 11-2 Radiated E-Field Frequency Range for Emission Test

12 NB E-Field Radiated Susceptibility (AD01)

The DPU shall not exhibit any malfunction, degradation of performance or deviation beyond the tolerance indicated in its individual specification when it is irradiated with 2 V/m, 1 kHz amplitude modulated (30% AM), in the frequency range 14 kHz - 18 GHz.

13 H Field Radiated Emission (AD01)

Narrow-band electric fields generated by the DPU and measured at 1 m distance shall not exceed the limits shown in Fig. 13-1 in the frequency range 30Hz - 50KHz

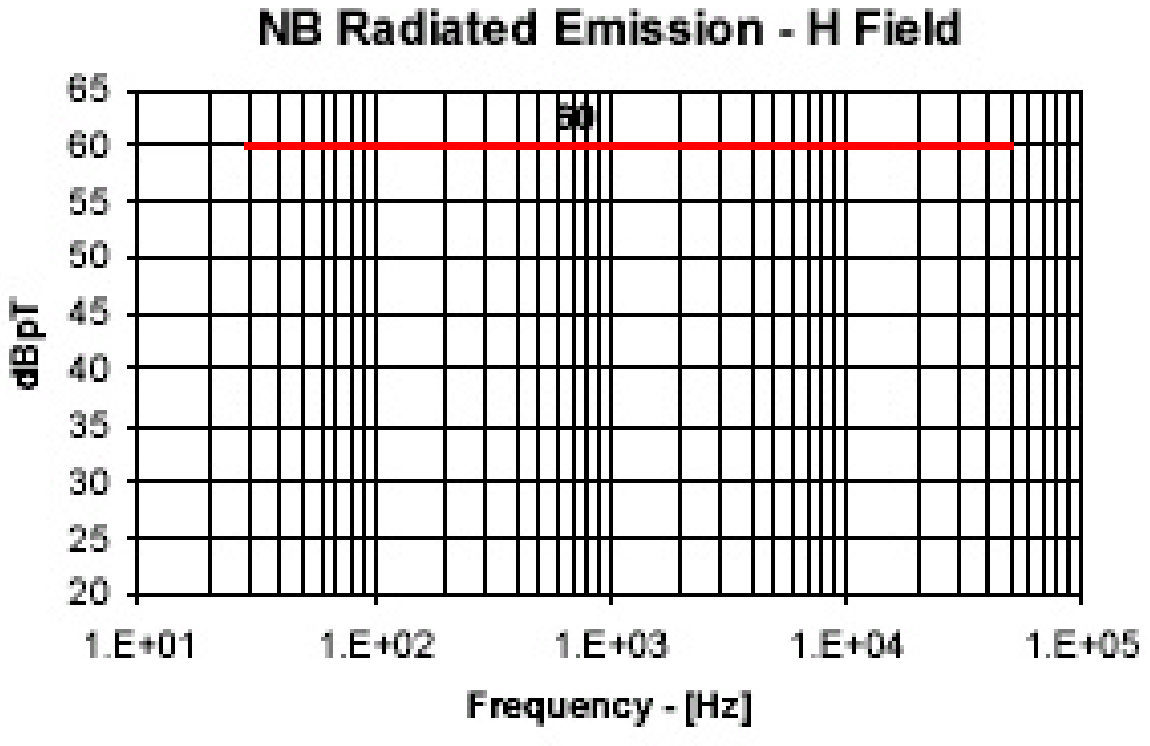

Figure 13-1 NB Radiated Emission Limit – H Field

14 H Field Radiated Susceptibility (AD01)

The DPU shall not exhibit any malfunction, degradation of performance or deviation beyond the tolerance indicated in its individual specification when it is irradiated with a magnetic field of 140dBpT in the frequency range 30Hz - 50kHz

15 Arc Discharge Susceptibility (AD01)

No malfunction, degradation of performance or deviation beyond the tolerance indicated in its individual specification shall occur when the DPU and its interface lines are exposed to a repetitive electrostatic arc discharge of at least 15 mJ energy/ 15 kV. The current rise time shall be less than 10 ns. If damage risks are envisaged for interface circuits, the voltage can be reduced down to 4 kV but the energy shall remain 15mJ. Figure 15-1 contains a suggested arc source schematic capable of establishing the required discharge. The discharge circuit must be adjusted in order to get the energy and the voltage specified above.
Any other equivalent type of circuitry (e.g. ESD simulator) can be used **and shall be fully described in the EMC report**. A minimum of 10 discharges shall be performed.

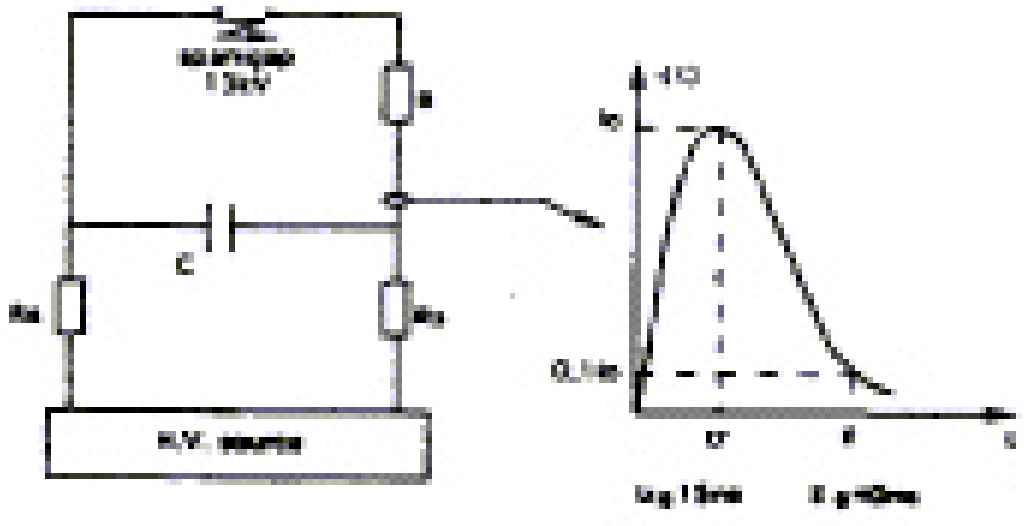

Figure 15-1: Arc source schematic capable of generating the discharge

The discharge shall be a direct discharge of current through the equipment chassis and shall be generated by putting the tip of the gun in contact with the chassis or/and by moving it closer to the chassis until the discharge occurs.

16 Plug-in and Inrush current measurement (AD01)

The inrush current shall be measured on the positive power line of the user connected to its 28V power supply through the LISN defined in § 3.8, when switching it ON with an external bounce-free relay (e.g. laboratory mercury relay) installed between the LISN and the user on the positive power line.
The recorded inrush current (measured with an oscilloscope in single shot mode) shall show the following 2 distinct aspects :

- A current transient corresponding to the charge of the primary filter capacitors
- A DC/DC converter start current transient.

The primary filter charge current transient shall be compliant with the following requirements:

- $S(I*dt) < 2$ mC
- $dI/dt < 2$ A/µs (TBC)
- I peak < 30 A (TBC)

The DC/DC converter start current transient :

- shall not exceed the user line LCL current limitation value for a total time higher than 5ms (TBC);
- shall comply with : $S(I*dt) <$ (LCL current limitation value)*5ms (TBC).

The test shall comply with the following mask :

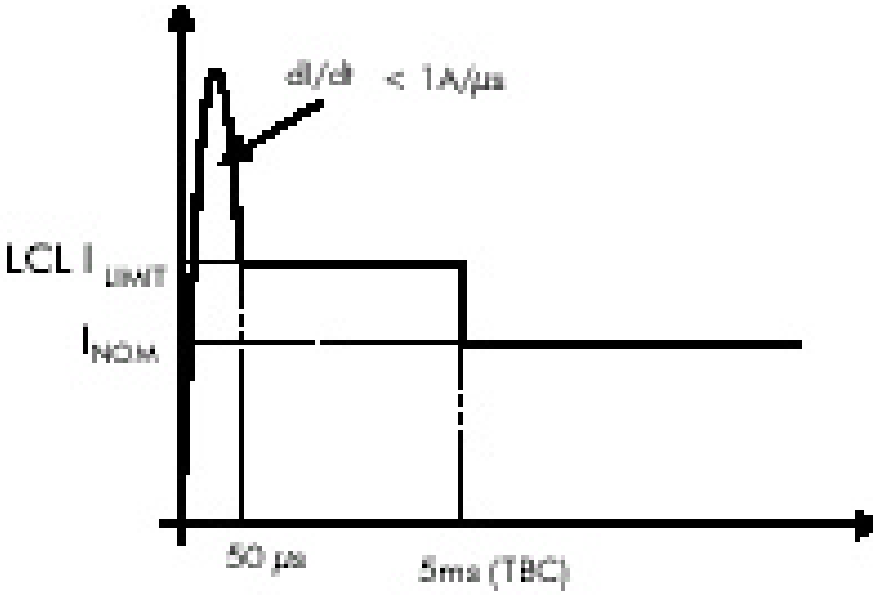

Figure 16-1 Inrush Current Mask