SOLAR ORBITER ENERGETIC PARTICLE DETECTOR

EPT-HET EM EMC Test Report

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CHANGES RECORD

Issue	Revision	Date	Modified by	Section / Paragraph modified	Change implemented
1	0	07/04/2014		All	Initial release
1	1	04/07/2014	A.Ravanbakhsh after the internal DRB on 06.05.2014 and according to the RIDs received from EPD PO.	Sec. 3.3	Three reference documents are added.
				Sec. 4.6	Operative mode is added.
				Sec. 5.2	Table 5-2-1, the modifications applied to the PO LISN, is updated.
				Sec. 6.1.5	The bonding test conclusion was corrected according to the results in Table 6-1-3-2.
				Sec. 6.2.5	• I_{peak} is added. • Estimated dI/dt is added. • Total input charge is added.
				Sec. 6.3.5	Table 6-3-5-1 is added indicating the frequencies in which the peaks appears during CE-CM-FD test.
				Sec. 6.5.5	Table 6-5-5-1 is added indicating the frequencies in which the peaks appears during CE-DM-FD test.
				Annex A	Missed letters have been corrected.

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Purpose

The aim of this document is to report the EPT-HET EM EMC test as-run procedure and results. This test is performed to verify the EPT-HET EMC characteristics.

The tests indicated in Table 1-1-1 are performed on EPT-HET EM.

Table 1-1-1. Planned tests for the EPT-HET EM EMC test campaign.

Test	Reference name	Subsection
Bonding and grounding	Bonding and grounding	6.1
Conducted emission, inrush current on power leads	Inrush current	6.2
Conducted emission on power leads, common mode, 30 Hz to 100 MHz, frequency domain	CE-CM-FD	6.3
Conducted emission on power leads, common mode, 30 Hz to 100 MHz, time domain	CE-CM-TD	6.4
Conducted emission on power leads differential mode, 30 Hz to 100 MHz, frequency domain	CE-DM-FD	6.5
Conducted emission on power leads differential mode, 30 Hz to 100 MHz, time domain	CE-DM-TD	6.6
Conducted susceptibility on power leads in differential mode, 30 Hz to 100 kHz, frequency domain	CS-DM-FD	6.7
Conducted susceptibility on power leads in differential mode, 30 Hz to 100 kHz, transient	CS-DM-Transient	6.8
Conducted susceptibility on power leads in common mode, 50 kHz to 100 MHz, frequency domain	CS-CM-FD	6.9

Annex A: includes the facility test report on the EMC test which was performed on March 17-19, 2014.

1.2 Scope

This document applies to all activities related to EPT-HET EM EMC test campaign performed by all institutions and personnel involved in the test.

Important note

In this test procedure some requirements from EIDA-i4 [AD-1] have been generated with the same number plus some letters and the termination-DFU (Derivate For Units) to trace easily their parent requirements. These DFU requirements are referenced from “EPD EMC Control Plan”, [AD-02].

2 GLOSARY AND DEFINITIONS

2.1 Acronyms and abbreviations

BOB	Break Out Board
CAU	Christian-Albrechts-Universität zu Kiel
CE	Conducted Emission
CM	Common Mode
CS	Conducted Susceptibility
DFU	Derivate For Unit
DM	Differential Mode
EGSE	Electrical Ground Support Equipment
EIDA	Experiment Interface Document-Part A
EPD PO	Energetic Particles Detector Project Office
EPT	Electron, Proton Telescope
EUT	Equipment Under Test
FD	Frequency Domain
HET	High Energy Telescope
ICU	Instrument Control Unit
LCL	Latching Current Limiter
LISN	Line Impedance Stabilization Network
LVPS	Low Voltage Power Supply
N/A	Not applicable
NCR	Nonconformance Report
PA	Product Assurance
PI	Principal Investigator
QA	Quality Assurance
S/C	Spacecraft
TBC	To Be Confirmed
TD	Time Domain
TREO	EMC test facility planned for EPT-HET EM

3 APPLICABLE AND REFERENCE DOCUMENTS

3.1 Applicable documents

ID.	Title	Reference	Iss./Rev.	Date
AD-1	Experiment Interface Document part A	SOL-EST-RCD-0050	4	13/06/2013
AD-2	EPD EMC Control Plan	SO-EPD-PO-PL-0004	4/0	25/07/2013
AD-3	EPT-HET EM EMC Test Plan and Procedure	SO-EPD-KIE-TP-0008	1/1	14/03/2014
AD-4	Electrical Assembly Procedures EPT-HET EM (logbook)	SO-EPD-KIE-LB-0003	1/0	07/04/2014

3.2 Normative documents

ID.	Title	Reference	Iss./Rev.	Date
NR-09	Electromagnetic compatibility	ECSS-E-ST-20-07C	Rev.1	07/02/2012
NR-08	Spacecraft charging	ECSS-E-ST-20-06C		31/08/2008

3.3 Reference documents

ID.	Title	Reference	Iss./Rev.	Date
RD-1	Harness Specification	SOL-EPD-PO-RS-0005	1/0	22/07/2012
RD-2	Configuration Item Data List (CIDL) and As Built Configuration List (ABCL)	SO-EPD-KIE-LI-0008	1/0	07/04/2014
RD-3	Email Subject: Clarification of EIDA R-165 dI/dt less than 2A/usec	Alfonso Muñoz alfonso.munoz@sener.es		01/06/2014
RD-4	Email with attachment Subject: Clarification of EIDA R-165 dI/dt less than 2A/usec	Björn Schuster schuster@physik.uni-kiel.de		16/06/2014
RD-5	Email Subject: EPD/EPT-HET inrush current	Alfonso Muñoz alfonso.munoz@sener.es		19/03/2014

4 TEST OVERVIEW

4.1 Test objectives

The objectives of the different EPT-HET EM EMC tests are to:

- Verify electromagnetic compatibility and electromagnetic interference of the EPT-HET.

The results of EPT-HET EM EMC tests are being used as the unit level EMC verification prior to the EPD suite level integration and EMC test campaign.

4.2 Test facility

The EPT-HET EM EMC tests are conducted in TREO EMC test facility.

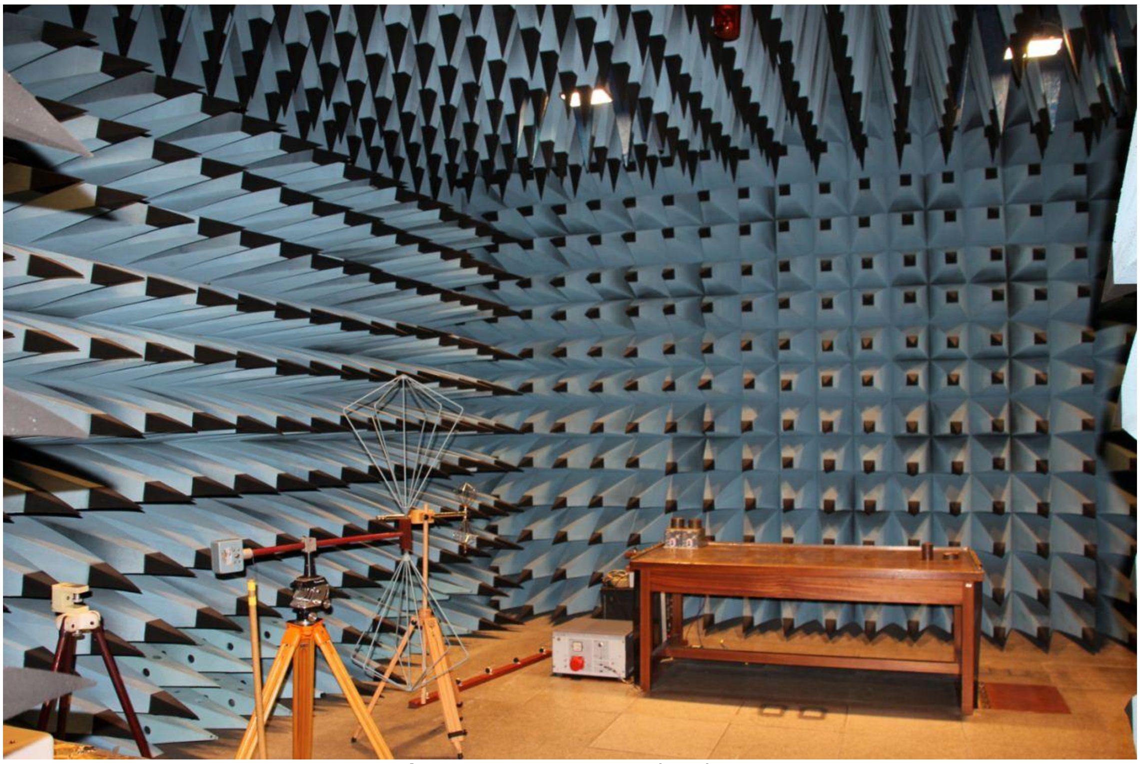


Fig. 4-2-1. TREO EMC chamber.

4.3 Environmental conditions

- Temperature: 21.3 °C
- Relative humidity: 38.6 %

4.4 Participants

The test participants and their responsibilities are defined in Table 4-5-1.

Table 4-5-1. Test participants and their responsibilities.

#	Name	Responsibility
1	Alfonso Muñoz (EPD EMI engineer)	Technical review
2	Robert Wimmer (Principal Investigator)	Final Approval
3	Michael Richards (Product Assurance)	QA Approval
4	César Martín (Project Manager)	Final release
5	Shri Kulkarni (Instrument lead)	Set-up, monitoring
6	Stephan Böttcher (Electronics, Test engineer)	Set-up, monitoring, analysis, reporting
7	Björn Schuster (Electronics, Test engineer)	Set-up, monitoring, analysis, reporting
9	Mahesh Yadla (Electronics)	Set-up, monitoring, analysis
10	Ali Ravanbakhsh (AIVT)	Monitoring, reporting
TREO (test facility)		
#	Name	Responsibility
1	Mr. Peter Sell	Test facility responsible, test conductor, reporting

4.5 Safety

Handling, mounting and testing shall be performed by qualified personnel from CAU with support of TREO personnel in accordance with safety requirements of TREO.

4.6 Item under test

The EPT-HET unit consist of two sensor heads and one Ebox. As seen in Fig. 4-7-1, the EPT and HET share a common Ebox which includes the analog board, digital board, power board and two preamp boards for each of the two sensor heads.

The only available operative mode at the time of the test was STF (Sensor Transfer Frame) steaming mode.

More details on the Item under test can be found in [AD-4].

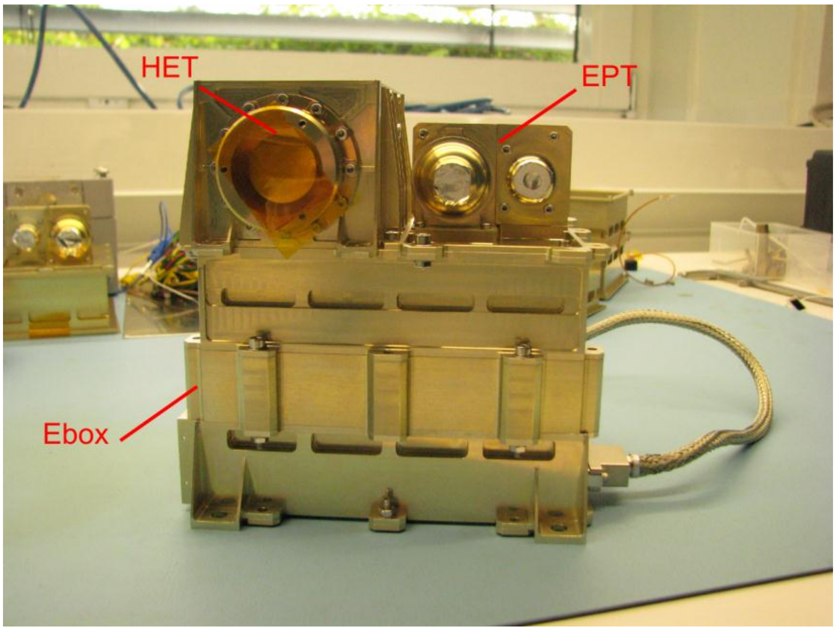


Fig. 4-7-1. EPT-HET EM for unit level EMC test campaign.

4.6.1 Item under test build standard requirement

The following table summarizes the build standard of the EPT-HET EM compared with the EIDA R-554 from [AD-1]:

Table 4-7-1-1. EPT-HET EM build standard compared to EIDA R-544 from [AD-1].

EIDA R-544: The PI shall ensure that the instrument EM units have the following minimum build standard:	**EPT-HET EM build standard** For detailed information see [RD-2]
• electronics flight standard except for parts quality	Non-compliant
• commercial parts have to be of same technology, same supplier as FM parts	Partially compliant
• mechanisms flight representative for electrical actuators	N/A
• structure flight representative for mounting and shape	Partially compliant
• electrically representative as needed for conducted EMC tests (emissions and susceptibility).	Partially compliant
• software flight standard as needed for all command/ control/ data interactions with the spacecraft.	Compliant
• harness flight representative	Compliant

5 TEST PARAMETERS

5.1 General set-up requirements

In addition to the specific test set up for each type of EMC test, the following requirements from [AD-1] should be respected for all these tests.

EIDA R-460: The PI shall ensure that the tests shall be performed in an ambient electromagnetic environment which is at least 6 dB below the performance levels required in chapter 4 of [AD-1].

Note: The performance level is between 30 Hz and 100 MHz.

EIDA R-463: The PI shall ensure that, in the cases where real electrical/electronic loads cannot be used, these loads are simulated by dummy loads with similar characteristics.

EIDA R-464: The PI shall not take the interface wires to ground if not done in the actual/final installation in the spacecraft.

EIDA R-465: The PI shall ensure that the power sources used for the tests have well defined impedance below 10 MHz.

EIDA R-466: The PI shall ensure that the test harnesses are flight representative.

EIDA R-467: The PI shall ensure that the grounding of interfaces is in accordance with flight installation.

EIDA R-468: The PI shall ensure that bonding of units, unit tester, etc to the ground plane are verified by a bonding test.

EIDA R-469: The PI shall ensure that the unit bonds are similar to that specified for the actual installation.

EIDA R-470: The PI shall ensure that all equipment used for emission and susceptibility tests are calibrated.

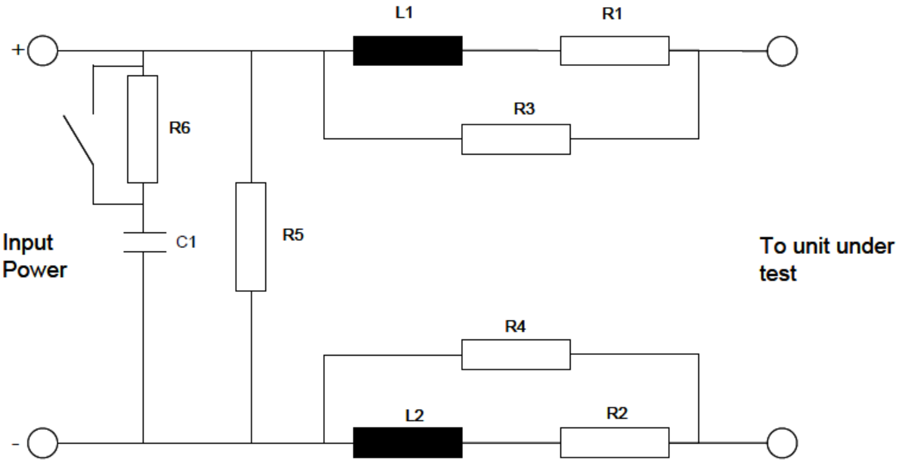
EIDA R-471: The PI shall ensure that passive equipment, such as antennas, current probes etc. have calibration curves from the manufacturer.

5.2 LISN (Line Impedance Stabilization Network)

EIDA R-168: The PI shall ensure that the unit are powered by using the Line Impedence Stabilisation Network (LISN) 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, as shown in figure below. D: The Prime Contractor will specify the LISN characteristics. The LISN will be provided by the PI.

EIDA R-176: The PI shall ensure that for all conducted emission and susceptibility tests on subsystem and unit level a LISN is used, simulating the Solar Orbiter primary power bus impedance.

LISN definition can be seen in Fig. 5-2-1. This LISN shall be used for all the conducted emission and susceptibility test at unit level and EPD level [AD-2].



R1,R2 = 0.3 Ohm +/-5% for regulated power bus
= 0.1 Ohm +/-5% for unregulated power bus
R3,R4 = 50 Ohm +/-5%
R5 = 50kOhm +/-5%
R6 = 10 Ohm precharge resistor (tbc by contractor)
C1 = 20mF +/-5%
L1,L2 = 2µH +/-5%

Fig. 5-2-1. LISN definition.

CAU used the modified LISN received from EPD PO for EPT-HET EM EMC test campaign, see Fig. 5-2-2. The list of modifications can be seen in Table 5-2-1.

Fig. 5-2-2. LISN used for EPT-HET EM EMC test campaign.

The circuit layout can be seen in Fig. 5-2-3.

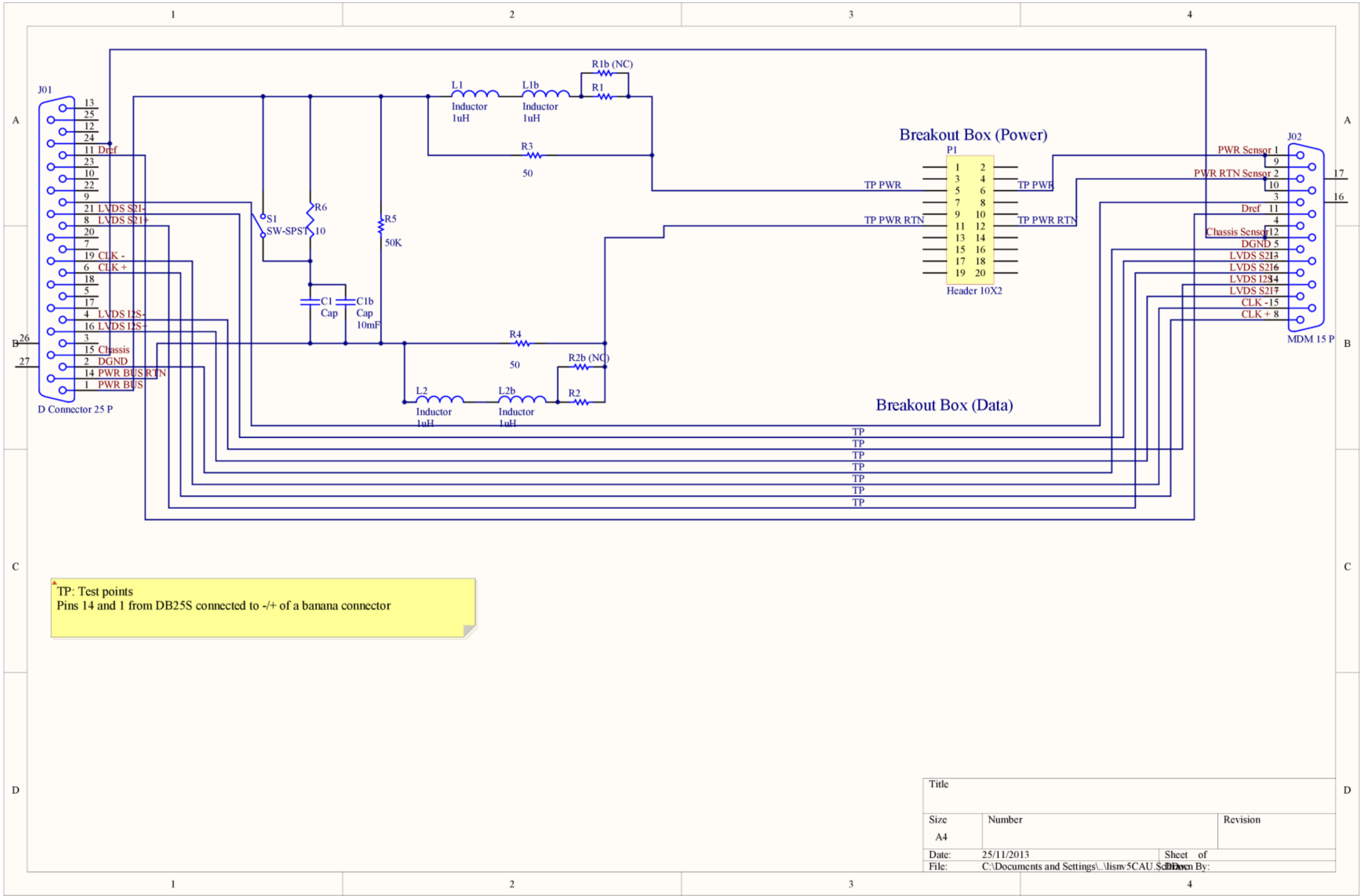


Fig. 5-2-3. LISN circuit layout.

Table 5-2-1. List of changes CAU applied to the LISN received from PO.

#	Applied change
1	A new label was printed and attached for charging the capacitors.
2	The MDM connector has been changed to one with appropriate mounting screws.
3	On the D-25 connector, the wires for +28V and return were swapped (pins 1 and 14). These wires were resoldered from the connector and returned back to the right order.
4	The top plate of the LISN was modified to let the BOB access from the outside of the LISN. See Fig. 5-2-2.
5	An electronic switch was used for connection with BOB. See the small box in the right side of Fig. 5-2-2.

5.3 Test harness

For the EPT-HET EM, there were two harnesses available. This is because of existence of two identical units on the S/C, EPT-HET1 and EPT-HET2. These harnesses have the same characteristics except for the length; see Table 5-3-1. These harnesses are received from the EPD PO, see Fig. 5-3-1 (a-d). **Cable 2** in the EPT-HET EM unit level EMC test is used.

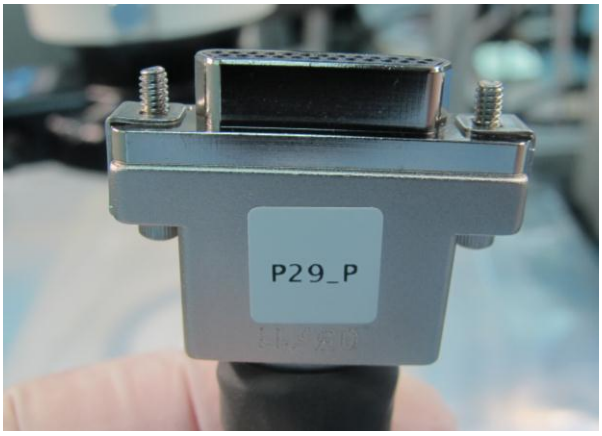
Table 5-3-1. EPT-HET EM harnesses available for EMC tests [RD-1].

Cable	Description	Connector End A		Connector End D		Labelling	Total Lenght (m)
		Number	Type	Number	Type		
1	HET/EPT 2	P13_S	MDM15	P33_P	MDM25	EPD.HAR.EM 320720.EM	7,18
2	HET/EPT 1	P09_S	MDM15	P29_P	MDM25	EPD.HAR.EM 320730.EM	2

(a) Cable 1, see Table 5-3-1.

(b) Cable 2, see Table 5-3-1.

(c) MDM 15 S which goes to LISN.



(d) MDM 25 P which goes to EUT.

Fig. 5-3-1 (a-d). Harnesses available for EPT-HET EM EMC tests.

The harness pin out and grounding connections can be seen in Fig. 5-3-2.

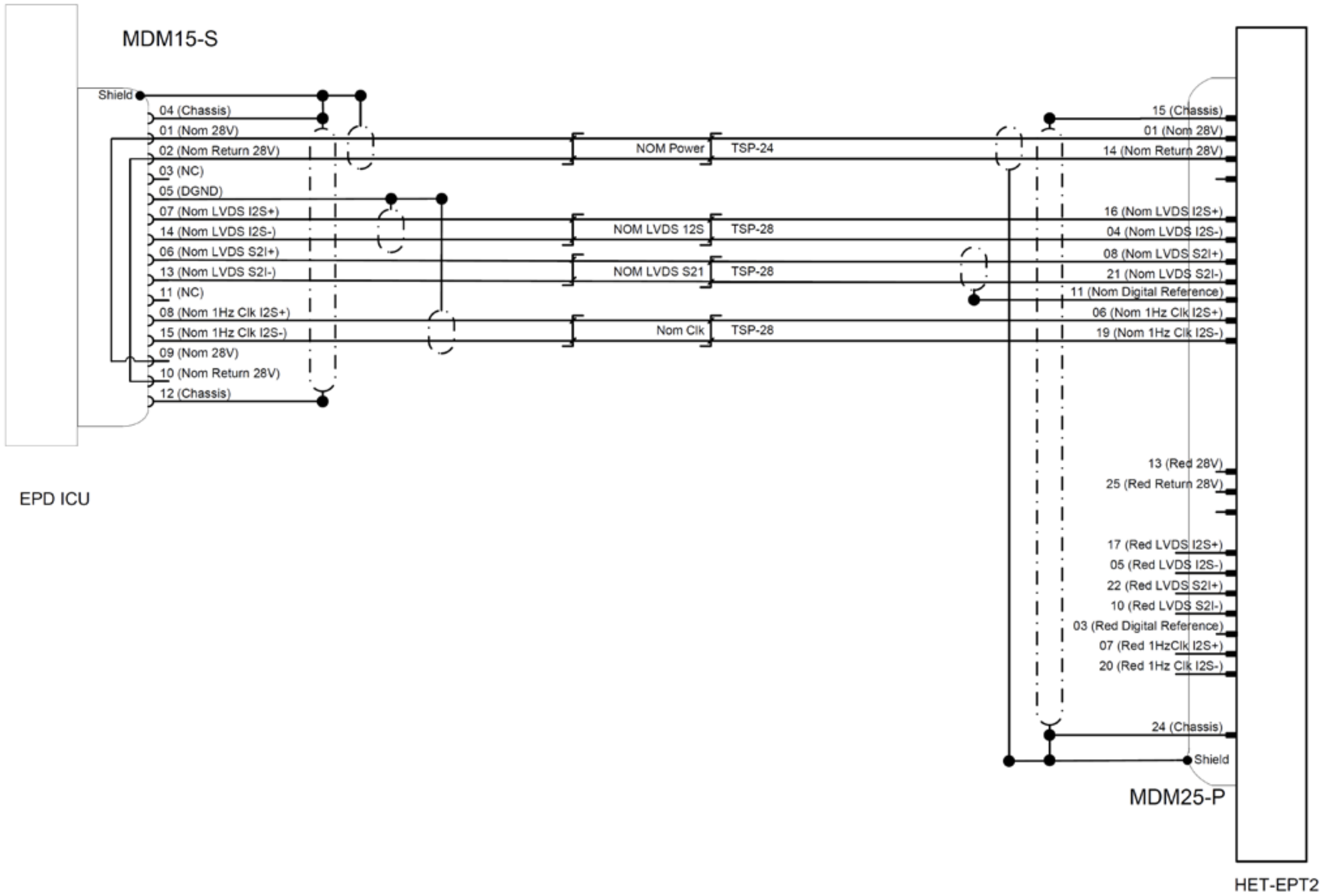


Fig. 5-3-2. ICU (LISN in unit level EMC tests) to HET_EPT1&2 pinouts and grounding for EPT-HET EM [RD-1].

5.4 Abortion criteria

The test abortion is possible according to the test facility TREO considerations during the EPT-HET EM EMC test campaign.

5.5 Test tolerances

EIDA R-440: The PI shall respect the following test tolerances, unless otherwise specified. According to **EIDA R-440** the relevant test level tolerances are as below:

- Voltage Amlplitude: ±5% of the peak value
- Current Amplitude: ±5% of the peak value
- Frequency: ±2%
- Distance: ±5% of specified distance or ±5 cm, whichever is greater

6 STEP EM EMC TESTS

The tests indicated in Table 1-1-1 in the introduction are planned for EPT-HET EM EMC test campaign.

Conducted emission bandwidth and measurement time are indicated in Table 6-1.

Table. 6-1. Bandwidth and measurement time, paragraph 5.2.9 from [NR-09].

Frequency Range	6 dB bandwidth	Dwell time	Minimum measurement time (analogue measurement receiver)
30 Hz - 1 kHz	10 Hz	0.15 s	0.015 s/Hz
1 kHz - 10 kHz	100 Hz	0.015 s	0.15 s/kHz
10 kHz - 150 kHz	1 kHz	0.015 s	0.015 s/kHz
150 kHz - 30 MHz	10 kHz	0.015 s	1.5 s/MHz
30 MHz - 100 MHz	100 kHz	0.015 s	0.15 s/MHz

Conducted susceptibility scanning requirements are indicated in Table 6-2.

Table. 6-2. Susceptibility scanning.

Frequency range	Analog scans Maximum scan rates	Stepped scans Maximum step size
30 Hz - 1 MHz	0.0333 f_0/sec	0.05 f_0
1 MHz - 30 MHz	0.00667 f_0/sec	0.01 f_0
30 MHz – 100 MHz	0.00333 f_0/sec	0.005 f_0

Note: f_0 is the tuned frequency of the signal source.

6.1 Bonding and grounding

6.1.1 Requirements

EIDA R-308: The PI and Prime Contractor shall comply with the relevant requirements, as defined in paragraph 4.2.10 in ECSS-E-ST-20-07C [NR-09].

EIDA R-777: The PI shall ensure that each electrical equipment chassis can be bonded to structure with a resistance of less than 5mOhm.

EIDA R-309: The PI and Prime Contractor shall comply with the relevant requirements, as defined in paragraph 4.2.11 of ECSS-E-ST-20-07C [NR-09] and Paragraph 6.3 of ECSS-E-ST-20-06C [NR-08].

EIDA R-779: For the purpose of electrostatic protection, the PI shall ensure that all external/internal metallic parts without area consideration (such as metallic labels, baseplates, straps, insulated electrical circuits, etc), and intrinsically conductive parts (like carbon) that do not perform any electrical function, are grounded to the main structure by a DC resistance lower than 1kOhm. Floating metallic parts are strictly prohibited without any area consideration.

Note: For EPT-HET EM a provisional grounding stud is foreseen which provides grounding connection between the EUT and the EMC test ground table.

Due to the fact that the grounding strap is currently under definition/design with regard to thermal and electrical aspects, the solid grounding strap used for the EMC tests is not fully flight representative from the thermal point of view. From the electrical point of view which is important for the following tests we consider it representative.

6.1.2 Bonding and grounding test set up

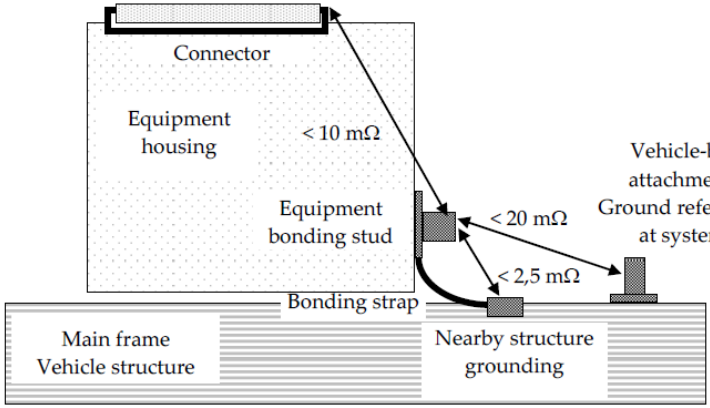
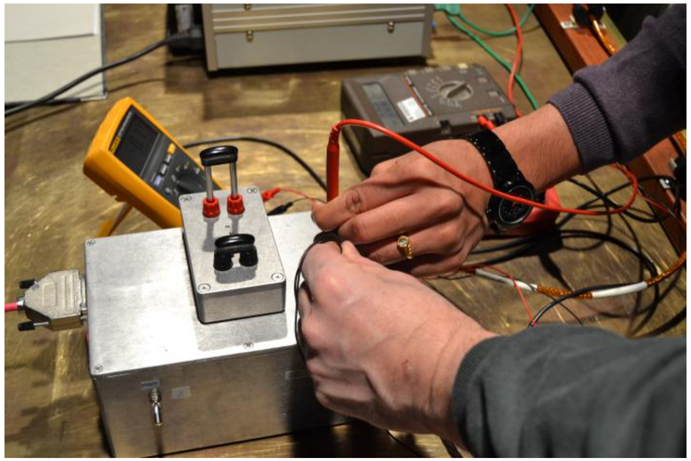
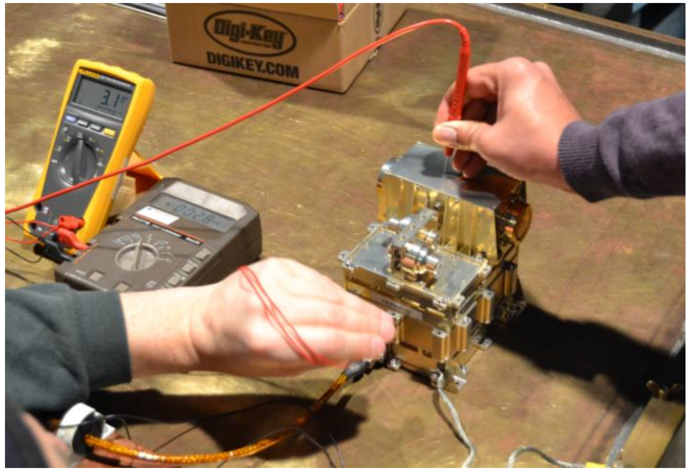


Fig. 6-1-2-1. Bonding test set up, page 22 of [NR-09].



(a)



(b)

Fig. 6-1-2-2. (a),(b): Bonding test set up at the time of the test.

6.1.3 Bonding and grounding step-by-step test procedure

Table 6-1-3-1: Step-by-step test procedure for bonding and grounding.

Step	Description	Expected results	Measured value	Date/time	Sign	Comment
00	Preparation of the test item according to Fig. 6-1-2-1.			17.03.2014 09:30-10:40 10:50-11:20	S. Böttcher B. Schuster S. Kulkarni M. Yedla	EUT EGSE was not the correct one and the EUT needed minor modification. See deviation #1.
05	Measure the resistance between different housing parts and EUT chassis.	R<5mOhm	Please see Table 6-1-3-2.	11:20-11:30	S. Böttcher B. Schuster S. Kulkarni M. Yedla	The measurement was done as follow: Applying a small voltage difference (0.5V) with a current limitation of about 1A between the two points which are about to be checked. Then, by measuring the voltage the resistance was deduced.
10	Verification of grounding by measurement.				S. Böttcher	Appropriate grounding was checked.

Table 6-1-3-2: Resistance measurement between different housing parts of the EUT.

Input current (A)		The resistance between different parts, R (mΩ)						
		HET housing-top to GND stud	EPT housing-top to GND stud	EPT baseplate to GND stud	EPT top to EPT baseplate	Ebox data module to GND stud	Ebox power module to GND stud	Ebox baseplate to GND stud
Set up Fig. 6-1-2-2 (a-b)	0.999	3.5	6.5	3.6	3.0	3.2	2.0	1.4

6.1.4 Bonding and grounding test success criteria

- The EUT grounding scheme shall be verified by measurement.
- The resistance between the chassis and the structure should be less than 5mOhm.

6.1.5 Conclusion

According to the measured results indicated in Table 6-1-3-2, even though not all of the screws in the subassemblies were not fastened, the bonding requirements are satisfied except for the EPT housing-top to GND stud which is 6.5 mΩ and slightly more than the requirement.

6.2 Inrush current

6.2.1 Requirements

EIDA R-318: The PI and Prime Contractor shall comply with the relevant requirements, as defined in Annex A, paragraph A.3 of ECSS-E-ST-20-07C, [NR-09].

According to [AD-2]:
Taking to account the characteristics of the LCL include in the ICU the units shall meet the following values (EIDA R-318a-DFU):

Inrush current duration (in ms): <4 ms. (trip-off time of ICU LCL 5-10ms)
Total Charge: 1.6 mC
Maximum Current during LCL reaction time (15-20 us) shall be less than 5A.

The power bus input interface shall be designed to be compatible with this requirement and a test will be performed to verify the inrush current.

EIDA R-166: The PI shall measure the Ipeak, the dI/dt and inrush charge considering the maximum and the minimum bus voltage to the loads.

EIDA R-847: The PI shall measure the Ipeak, the dI/dt and inrush charge for the following cases:

- When the instrument is connected to a LISN and switched on using an external (test) relay.
- If the instrument includes an internal power-on switch, when the instrument is connected to a LISN and this internal switch is operated.
- When any other significant transient is expected to be generated, as per PI's assessment.

EIDA R-167: The PI shall measure the inrush current according to the following set-up

- positive power line of each user connected to LCL.
- current probe connected near the load
- load connections with a limited length.
- voltage measure performed near the LISN outlet; performed for engineering analysis /investigation.

EIDA R-477: The PI shall abide by paragraph 5.4.4 of ECSS-E-ST-20-07C, [NR-09].
EIDA R-152: The PI shall ensure that the instruments operate with nominal performance within the following steady state voltage limits provided by the PCDU:

• Power Bus Voltage = 28 V:
o Min: 26 V
o Max: 29 V

D: This applies for both Main and Redundant Lines.

6.2.2 Inrush current test set up

EIDA R-168: The PI shall ensure that the unit is powered by using a Line Impedence Stabilisation Network (LISN) with an external bounce-free relay (e.g. laboratory mercury relay) installed between the LISN and the user on the positive power line, as shown in Figure 4.7-1 below.

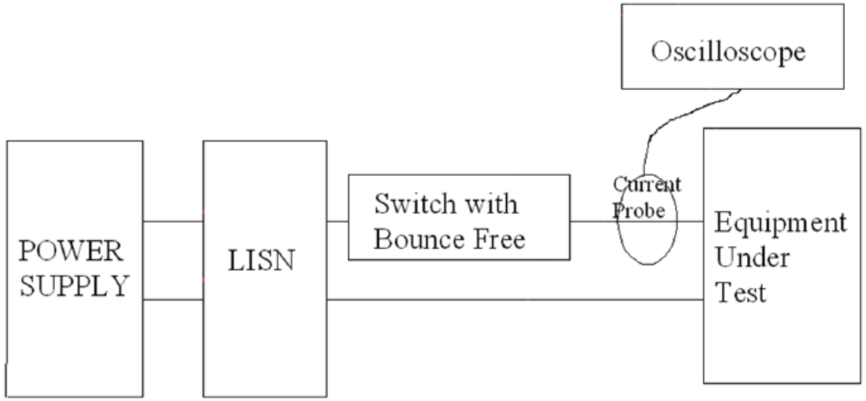


Fig. 6-2-2-1. Inrush current test set up, Figure 4.7-1 of [AD-1].

Fig. 6-2-2-2. Inrush current test set up at the time of the test.

6.2.3 Inrush current step-by-step test procedure

Table 6-2-3-1: Step-by-step test procedure for inrush current, paragraph 5.4.4 of [NR-09].

Step	Description	Expected results	Measured value	Date/time	Sign	Comment
00	Preparation of test set up according to Fig. 6-2-2-1.			17.03.2014 11:40-11:50	S. Böttcher P. Sell	See Fig. 6-2-2-2.
05	Turn on the measurement equipment and allow a sufficient time for stabilization.			11:50-12:10	P. Sell	
10	Measurement system checks by the facility responsible.			11:50-12:10	P. Sell	
15	Test the EUT by determining the conducted emission from the EUT input power leads, as follows: (a) Select the positive lead for testing and clamp the current probe into position. (b) Perform measurement by application of power on the EUT using a mercury relay. **Note:** “Inrush current “ should be measured at the minimum and maximum bus voltage as specified at **EIDA R-166**. Whether significant power transient is expected at mode change, the inrush current shall be measured in the change mode. The voltage evolution during the inrush test has to be recorded. See **EIDA R-167**.			12:10-12:40	S. Böttcher P. Sell	The inrush current measurement was performed in three different time scales, and 5 min waiting time between each measurement to make sure of discharge of residual charge inside the EUT. Instead of a mercury relay a bounce-free relay has been used. The results can be seen in Fig.4 to Fig.8 of Annex A.

6.2.4 Inrush current test success criteria

- Inrush current duration (in ms): <4 ms. (trip-off time of ICU LCL 5-10ms).
- Total Charge: 1.6 mC.
- Maximum Current during LCL reaction time (15-20 us) shall be less than 5A.

Note: Once the current measured using mercury relay as shown in Fig. 6-2-2-1, the total charge shall be calculated during the inrush and the current shall be calculated during the reaction time.

6.2.5 Conclusion

The durations of the current inrushes for both operating voltages (26V and 29V) are around 1ms and thus smaller than 4ms which defines one requirement.

According to Fig.7 of Annex A, the I_{peak} is around 10.2 A.

According to Fig.7 of Annex A and also clarification from [RD-3], the dI/dt is around 4A/μs. Based on the requirement (EIDA R-165) the dI/dt should be less than 2A/μs with a power bus raised to 28 V at a rate of 600 V/msec. Due to the fact that during inrush current test on EPT-HET EM, the power bus raised much faster than 600 V/msec, the obtained dI/dt as around 4A/μs can be considered as a worst case. According to [RD-3], applying the bus raise a rate of 600 V/msec will help to be compliant with the EIDA R-165.

In addition, an analysis can be found in [RD-4] showing that with enhanced input filter in LVPS board, this requirement will be fully met in the future models.

The maximum input charge during the first 1msec is calculated based on the test data and can be seen in Fig. 6-2-5-1. As seen the maximum input charge during 1msec is around 2.4 mC which is less than 3.68 mC as is required in [RD-5].

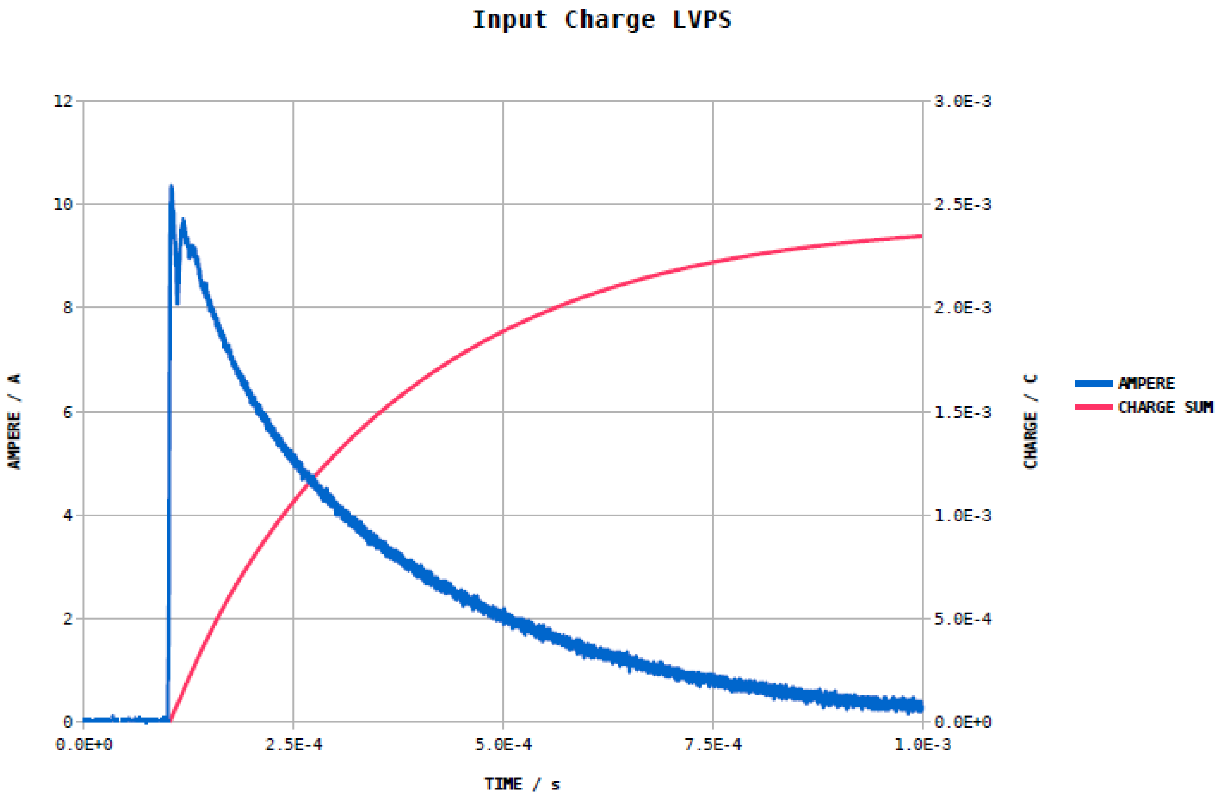


Fig. 6-2-5-1. The input charge of the EPT-HET EM LVPS.

6.3 CE-CM-FD test

6.3.1 Requirements

EIDA R-473: The PI shall abide by paragraph 5.4.3 of ECSS-E-ST-20-07C, [NR-09].

EIDA R-708: The PIs shall ensure that Common Mode (CM) current characterization will be performed at unit level to obtain reference information relevant to the RPW desired performance with maximum background noise levels as below and as shown in Figure 9.1-4 (Common mode level):

- 60dBuV/m over the frequency range 100Hz to 20kHz,
- Reducing to 50dBuV/m over the frequency range 10kHz to 20kHz,
- Reducing to 20dBuV/m over the frequency range 20kHz to 2MHz,
- 20dBuV/m over the frequency range 2MHz to 100MHz

Figure 9.1-4 of [AD-1] is shown in 6-3-1-1.

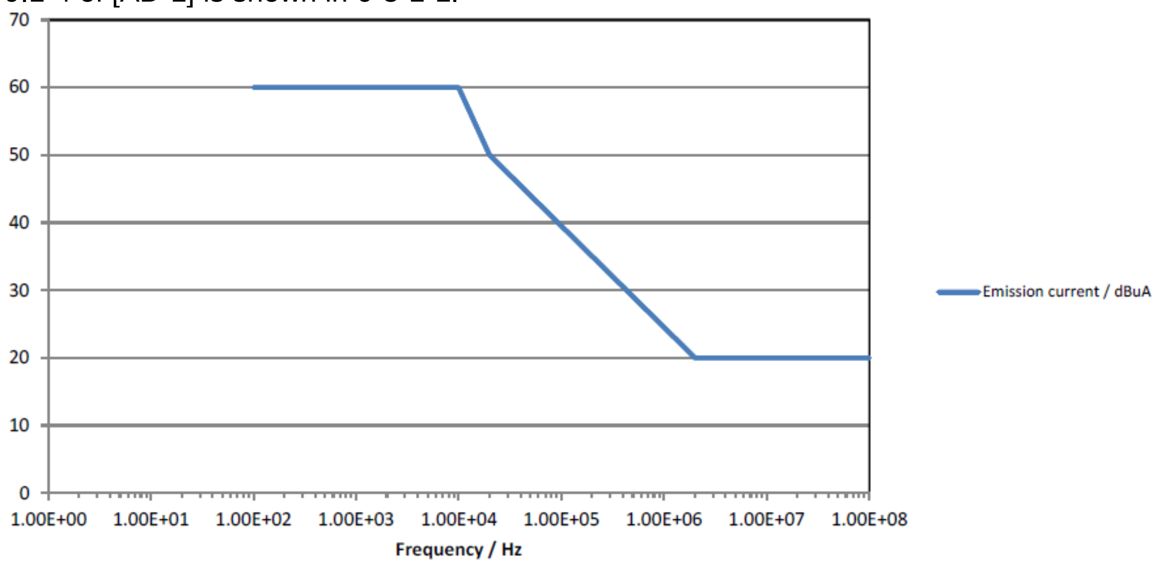


Fig. 6-3-1-1. Maximum background noise level for current emissions from equipments.

According to [AD-2]:

EIDA R-314a-DFU: The PI and Prime contractor shall ensure that the conducted narrow band current emissions (common mode) in the frequency range 30 Hz - 50 MHz appearing on the unit's primary power lines does not exceed the following limits:

- 60dBuA rms in the frequency range 30Hz to 100kHz,
- Reducing at 15dB per decade to 30dBuA rms in the frequency range 100kHz to 10MHz
- 30dBuA rms in the frequency range 10MHz to 50MHz

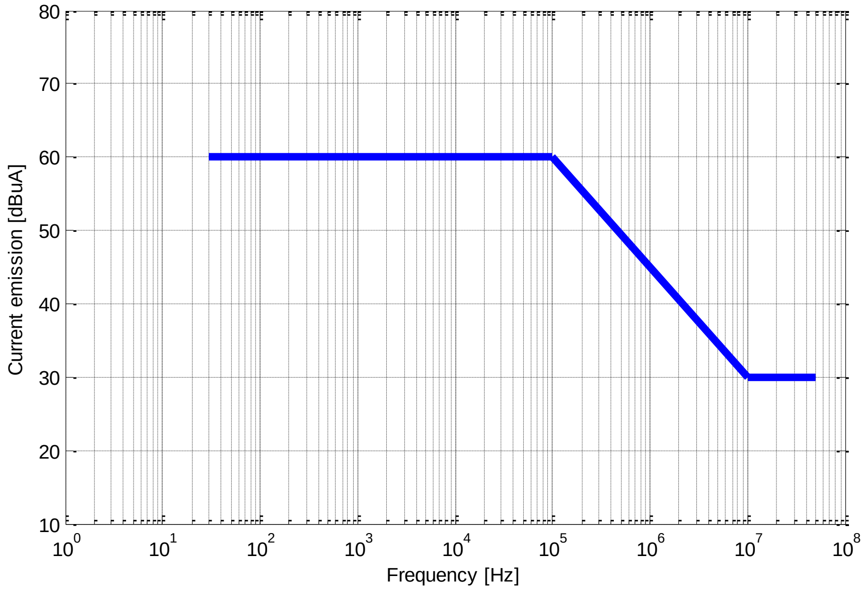


Fig. 6-3-1-2. EIDA R-314a-DFU graphical representation.

These limits are applicable to units demanding up to 1A. For units demanding more than 1A the levels may be scaled proportionally to the current demand over the whole frequency range with an increase in dB given by 20 log (I_DC).

EIDA R-845-a-DFU (TBD): The EPD units shall measure the conducted emission (common mode) up to 100MHz. The range 50MHz to 100MHz is for information only.
The design has to be done taking into account the requirement at EPD sensor interface. (DFU requirements).

6.3.2 CE-CM-FD test set up

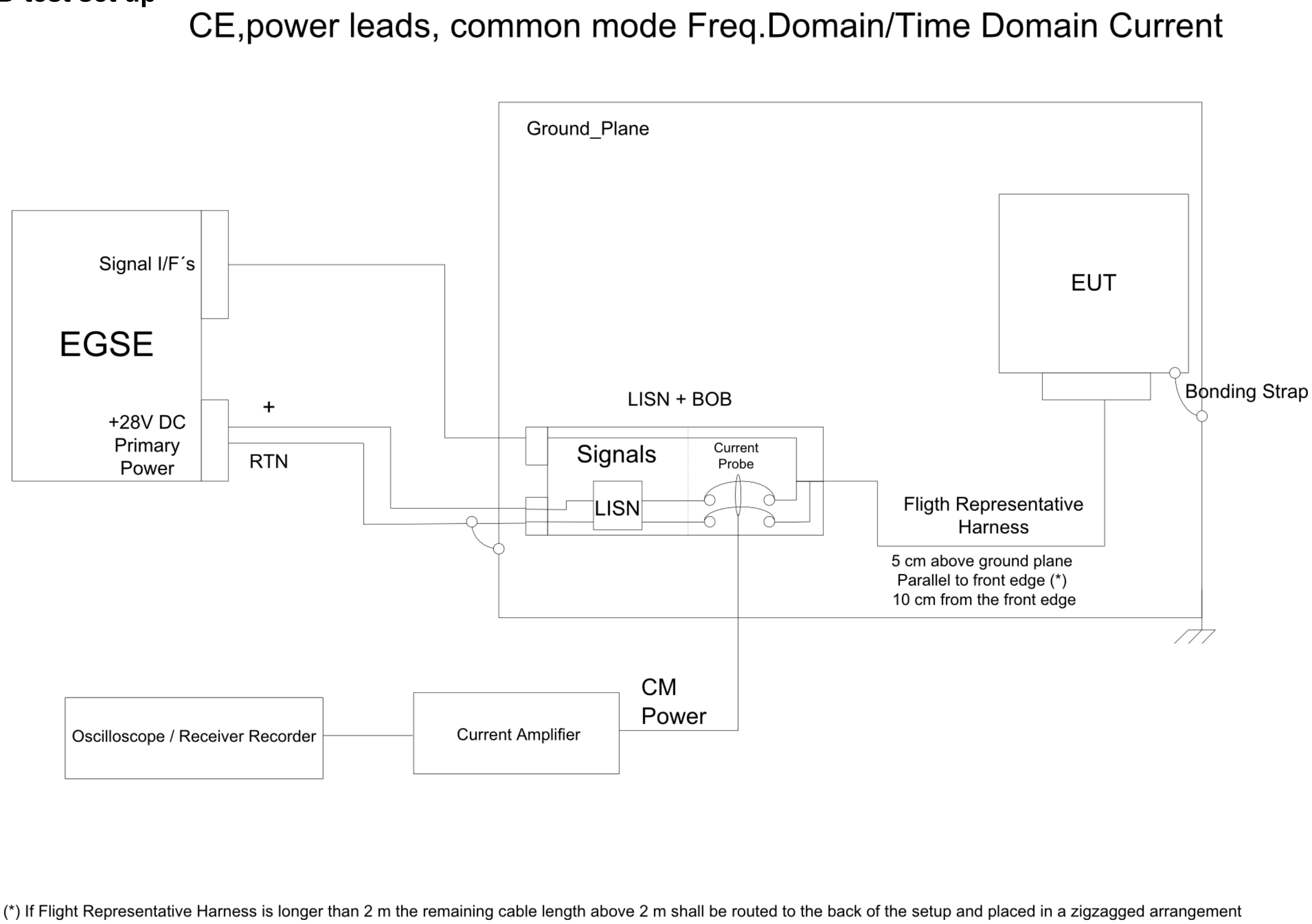
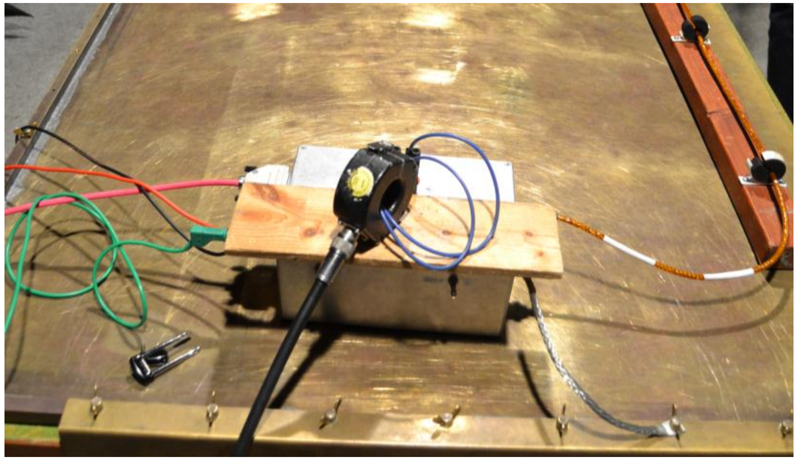


Fig. 6-3-2-1. Test setup for CE-CM-FD.

(a)



(b)

Fig. 6-3-2-2. Test setup for CE-CM-FD at the time of the test, (a) CE-CM-FD measurement, (b) back ground noise measurement prior to the test.

6.3.3 CE-CM-FD step-by-step test procedure

Table 6-3-3-1: Step-by-step test procedure for CE-CM-FD, paragraph 5.4.3 of [NR-09].

Step	Description	Expected results	Measured value	Date/time	Sign	Comment
00	Preparation of test set up according to Fig. 6-3-2-1.			17.03.2014 13:25-13:45	P. Sell S. Böttcher B. Schuster S. Kulkarni M. Yedla A. Ravanbakhsh	See Fig. 6-3-2-2 (a).
05	Turn on the measurement equipment and allow a sufficient time for stabilization.			13:45-15:30	P. Sell	
10	Measurement system checks by the facility responsible.			13:45-15:30	P. Sell S. Böttcher B. Schuster	
20	Test the EUT by determining the conducted emission from Vbus and VbusRTN lines together (Fig. 6-3-2-1) (a) Turn on the EUT and wait until it is stabilized. (b) Select a lead or a bundle for testing and clamp the current probe into position. (c) Scan the measurement receiver over the frequency range, using the bandwidths and minimum measurement times specified in Table 6-1. **Note:** The background noise should be recorded in the test report and this should be in accordance with **EIDA R-708** (see Fig. 6-3-1-1) and **EIDA R-460** (6dB below the requirement).			15:30-16:15	P. Sell S. Böttcher B. Schuster S. Kulkarni M. Yedla A. Ravanbakhsh	Back ground noise was measured according to Fig.6-3-1-1, but starting from 30 Hz instead of 100 Hz. The background noise can be seen in Fig.11 of Annex A. The measurement results can be seen in Fig.12 of Annex A.

6.3.4 CE-CM-FD test success criteria

The conducted narrow band current emissions (common mode) in the frequency range 30 Hz - 50 MHz appearing on the unit's primary power lines does not exceed the following limits, Fig. 6-3-1-1:

- 60dBuA rms in the frequency range 30Hz to 100kHz,
- Reducing at 15dB per decade to 30dBuA rms in the frequency range 100kHz to 10MHz
- 30dBuA rms in the frequency range 10MHz to 50MHz

6.3.5 Conclusion

The results shown in Fig. 11 and Fig. 12 of the Annex A show that both, the background noise and the contribution generated by the EUT are well below the particular requirements.

In Table 6-3-5-1 the frequencies in which the peaks appear and the relation with the design frequencies are indicated.

Table 6-3-5-1: The frequencies in which the peaks appear, see Fig. 12 of the Annex A.

Frequencies in which peak appears	Identified source
125 kHz	Fly back convertor PWMLVPS
125 kHz	Harmonics power supply
250 kHz	Harmonics power supply
375 kHz	Harmonics power supply
500 kHz	Harmonics power supply
625 kHz	Harmonics power supply
750 kHz	Harmonics power supply
1 MHz	clock DC/DC secondary side switching convertor

6.4 CE-CM-TD test

6.4.1 Requirements

EIDA R-473: The PI shall abide by paragraph 5.4.3 of ECSS-E-ST-20-07C, [NR-09]

EIDA R-317: The PI and Prime Contractor shall ensure that current ripple and spikes are ≤ 5 mApp when measured with at least 50 MHz bandwidth.

According to [AD-2]:

EIDA R-317a-DFU: The EPD Sensors shall ensure that current ripple and spikes are ≤ 1 mApp when measured with at least 50 MHz bandwidth at Sensor/ICU interface. The test at ICU interface will be performed with simulate sensor load.

EIDA R-317b-DFU: The EPD ICU shall ensure that current ripple and spikes are ≤ 1 mApp when measured with at least 50 MHz bandwidth at ICU interface using Sensor simulated load.

EIDA R-317c-DFU: ICU shall design the common mode filter to ensure that the current ripple and spikes at the VBUS interface is less than 5 mApp taking into account the limit given to the EPD sensors limits (R-317a-DFU) and the common mode emission of the ICU itself.

6.4.2 CE-CM-TD test set up

The test set up is the same as CE-CM-FD test set up and can be seen in Fig. 6-3-2-1.

Fig. 6-4-2-1. Test setup for CE-CM-TD at the time of the test.

6.4.3 CE-CM-TD step-by-step test procedure

Table 6-4-3-1: Step-by-step test procedure for CE-CM-TD, paragraph 5.4.3 of [NR-09], the same as CE-CM-FD procedure.

Step	Description	Expected results	Measured value	Date/time	Sign	Comment
00	Preparation of test set up according to Fig. 6-3-2-1			17.03.2014 16:20-16:25	P. Sell S. Böttcher	
05	Turn on the measurement equipment and allow a sufficient time for stabilization			16:25-16:30	P. Sell	
10	Measurement system checks by the facility responsible.			16:25-16:30	P. Sell S. Böttcher	
20	Test the EUT by determining the conducted emission from Vbus and VbusRTN lines together (Fig. 6-3-2-1) (a) Turn on the EUT and wait until it is stabilized. (b) Select a lead or a bundle for testing and clamp the current probe into position. **Note:** The noise level before the test should be recorded at the test report.			16:30-16:50	P. Sell S. Böttcher	The Current ripple noise can be seen in Fig.14 of Annex A. The current ripple measurement can be seen in Fig. 15 and fig. 17 of Annex A.

6.4.4 CE-CM-TD test success criteria

- The current ripple and spikes are ≤ 1 mApp when measured with at least 50 MHz bandwidth at sensor/ICU interface. The test at ICU interface will be performed with simulate sensor load.

6.4.5 Conclusion

As seen in in Fig.15 and Fig.17, the current ripples and spikes in common mode recorded in the time domain are in the order of 1mApp or just below.
As seen in Fig. 17, there is a signal modulation at around 60 MHz which its source is under investigation.

6.5 CE-DM-FD test

6.5.1 Requirements

EIDA R-472: The PI shall abide by paragraph 5.4.2 of ECSS-E-ST-20-07C [NR-09].

EIDA R-844: The PI and Prime contractor shall measure the conducted emission (differential mode) up to 100MHz. The range 50MHz to 100MHz is for information only.

According to [AD-2]:

EIDA R-313a-DFU: The EPD units shall ensure that the conducted narrowband current emissions (differential mode) in the frequency range 30 Hz - 50 MHz appearing on the unit's primary power lines does not exceed the following limits:

- 60dBuA rms in the frequency range 30Hz to 100kHz.
- Reducing at 20dB per decade to 20dBuA rms in the frequency range 100kHz to 10MHz.
- 20dBuA rms in the frequency range 10MHz to 50MHz

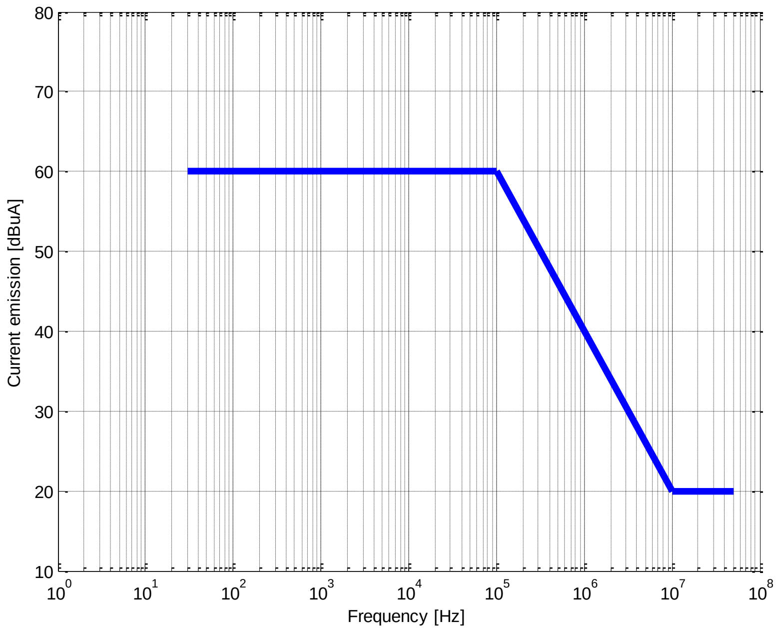


Fig. 6-5-1-1. EIDA R-313a-DFU graphical representation.

These limits are applicable to units demanding up to 1A. For units demanding more than 1A the levels may be scaled proportionally to the current demand over the whole frequency range with an increase in dB given by 20 log (I_DC).

EIDA R-844-DFU: The PI and Prime contractor shall measure the conducted emission (differential mode) up to 100MHz. The range 50MHz to 100MHz is for information only.

6.5.2 CE-DM-FD test set up

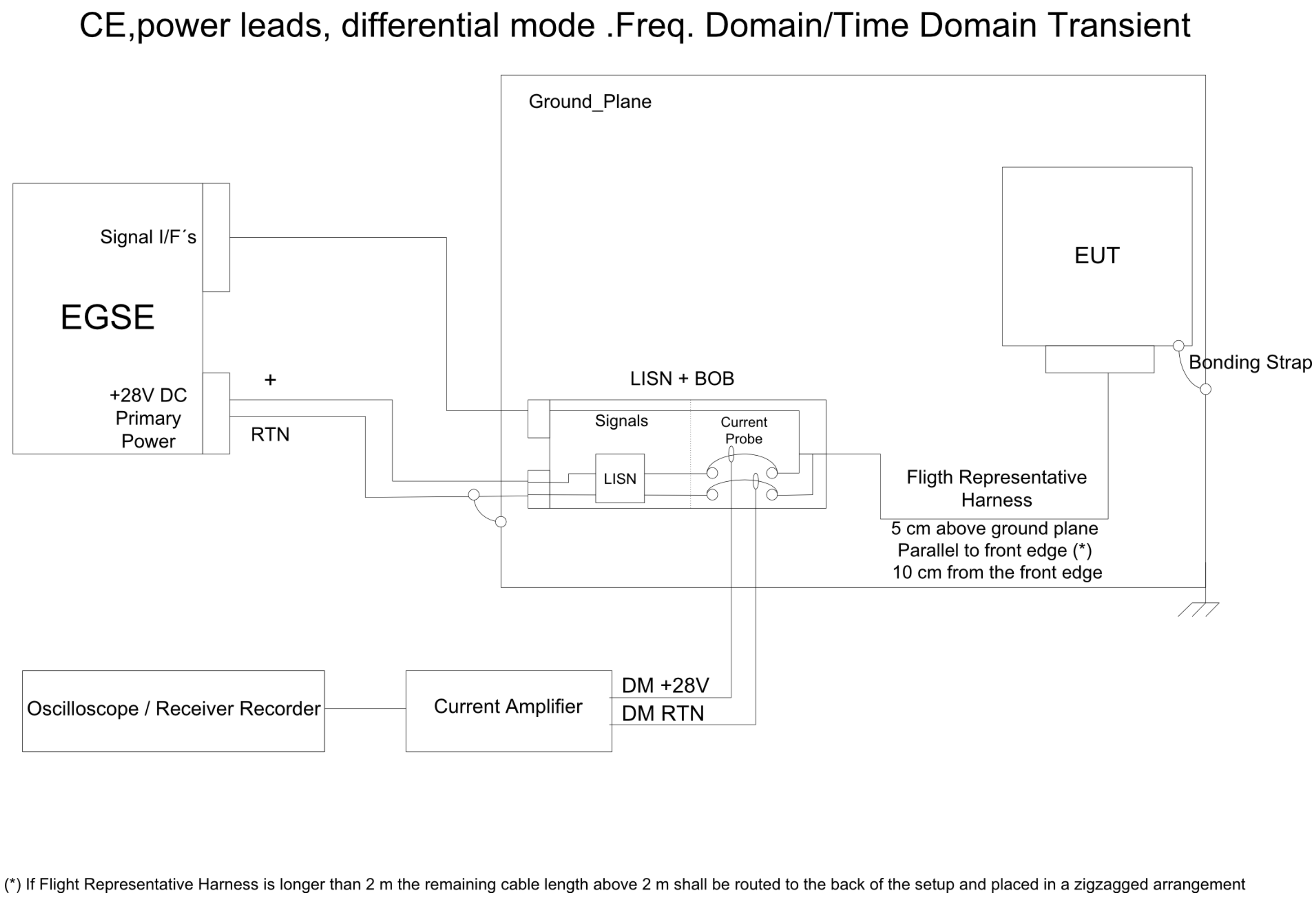
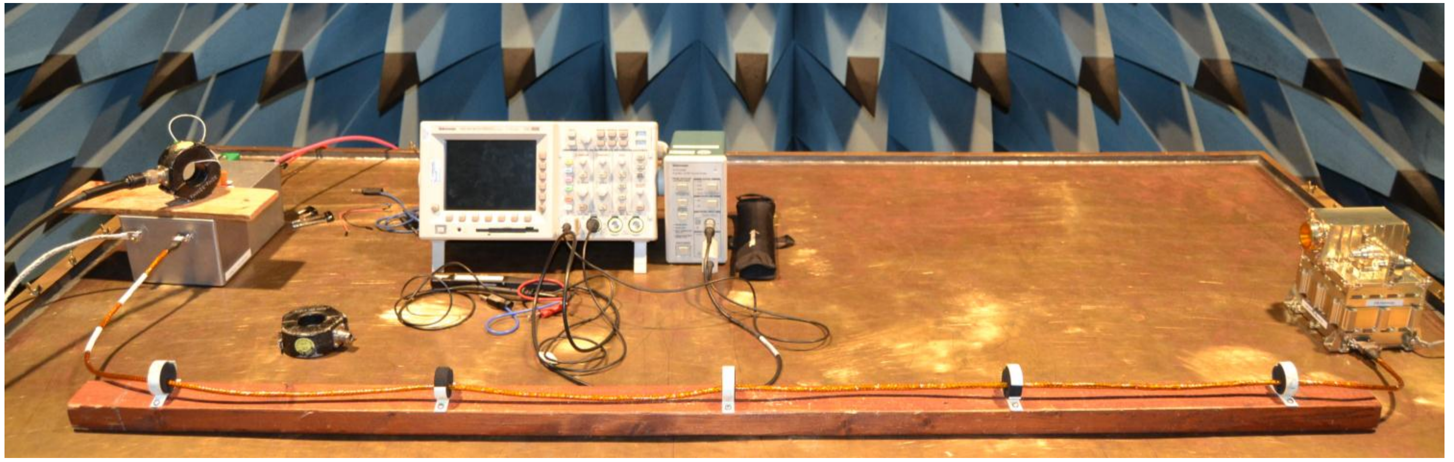
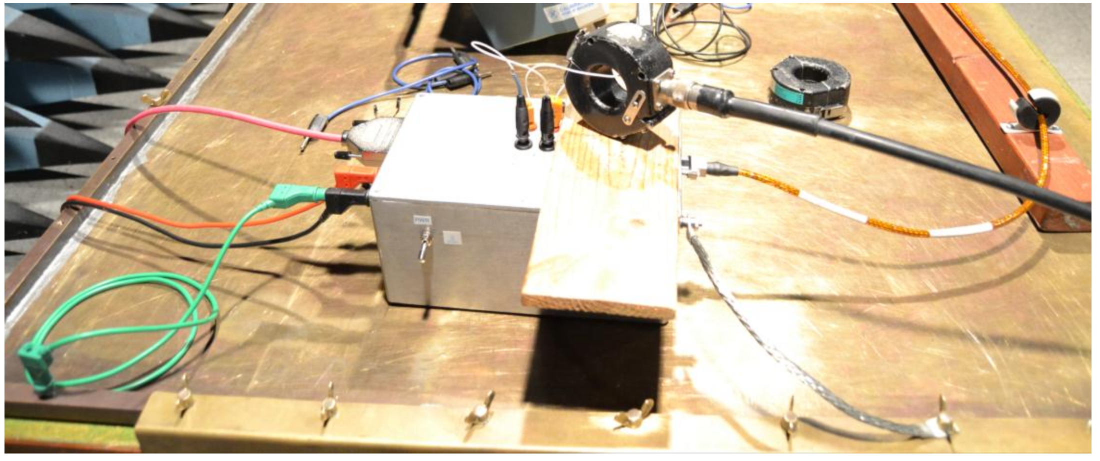


Fig. 6-5-2-1. Test setup for CE-DM-FD.



(a)



(b)

Fig. 6-5-2-2. Test setup for CE-DM-FD at the time of the test, (a) CE-DM-FD measurement, (b) back ground noise measurement prior to the test.

6.5.3 CE-DM-FD step-by-step test procedure

Table 6-5-3-1: Step-by-step test procedure for CE-DM-FD, paragraph 5.4.2 of [NR-09].

Step	Description	Expected results	Measured value	Date/time	Sign	Comment
00	Preparation of test set up according to Fig. 6-5-2-1.			18.03.2014 09:15-09:40	P. Sell S. Böttcher B. Schuster S. Kulkarni M. Yedla A. Ravanbakhsh	
05	Turn on the measurement equipment and allow a sufficient time for stabilization.			09:40-09:50	P. Sell	
10	Measurement system checks by the facility responsible.			09:40-09:50	P. Sell S. Böttcher	
20	Test the EUT by determining the conducted emissions from the EUT input power leads, hot line and return, and measure the conducted emission separately on the power lead as follows: (a) Turn on the EUT and wait for its stabilization. (b) Select a lead or a bundle for testing and clamp the current probe into position. (c) Scan the measurement receiver over the frequency range, using the bandwidths and minimum measurement times specified in Table 6-1. **Note:** The background noise should be recorded in the test report.			09:50-10:30	P. Sell S. Böttcher B. Schuster S. Kulkarni M. Yedla A. Ravanbakhsh	Noise measurement on both lines: +28 V and RTN. Back ground noise was measured according to Fig.6-3-1-1, but starting from 30 Hz instead of 100 Hz. The background noise can be seen in Fig.18 and Fig.19 of Annex A. The measurement results can be seen in Fig. 20 and Fig. 21 of Annex A.

6.5.4 CE-DM-FD test success criteria

The conducted narrowband current emissions (differential mode) in the frequency range 30 Hz - 50 MHz appearing on the unit's primary power lines does not exceed the following limits, Fig. 6-5-1-1:

- 60dBuA rms in the frequency range 30Hz to 100kHz
- Reducing at 20dB per decade to 20dBuA rms in the frequency range 100kHz to 10MHz
- 20dBuA rms in the frequency range 10MHz to 50MH

6.5.5 Conclusion

The results shown in Fig. 20 and Fig.21 of the Annex A show that both, the background noise and the contribution generated by the EUT are well below the particular requirements.

In Table 6-5-5-1 the frequencies in which the peaks appear and the relation with the design frequencies are indicated.

Table 6-5-5-1: The frequencies in which the peaks appear, see Fig. 20, Fig. 21 of the Annex A.

Frequencies in which peak appears	Identified source
125 kHz	Fly back convertor PWMLVPS
125 kHz	Harmonics power supply
250 kHz	Harmonics power supply
375 kHz	Harmonics power supply
500 kHz	Harmonics power supply
625 kHz	Harmonics power supply
750 kHz	Harmonics power supply
1 MHz	clock DC/DC secondary side switching convertor

6.6 CE-DM-TD test

6.6.1 Requirements

EIDA R-472: The PI shall abide by paragraph 5.4.2 of ECSS-E-ST-20-07C [NR-09].

EIDA R-474: The PI shall measure current ripple and spikes according to the test set-up in fig. 5-8 of ECSS-E-ST-20-07C, [NR-09] with current probe and oscilloscope with the required bandwidth.

EIDA R-475: The PI shall measure voltage ripple/spike on the primary power bus inputs of the units according to the test set-up in fig. 5-8 ECSS-E-ST-20-07C, [NR-09] where a differential voltage probe (instead of a current probe) is connected to the power lines wires and the data recorder is an oscilloscope.

EIDA R-315: The PI and Prime Contractor shall ensure that current ripple and spikes on the primary power bus inputs of the units, measured on positive and return lines, are ≤ 20 mApp when measured with at least 50 MHz bandwidth.

EIDA R-316: The PI and Prime Contractor shall ensure that voltage ripple / spikes on the primary power bus inputs of the units, measured between positive and return lines, are ≤ 150 mVpp (ripple) and ≤ 280 mVpp (spikes) when measured with at least 50 MHz bandwidth.

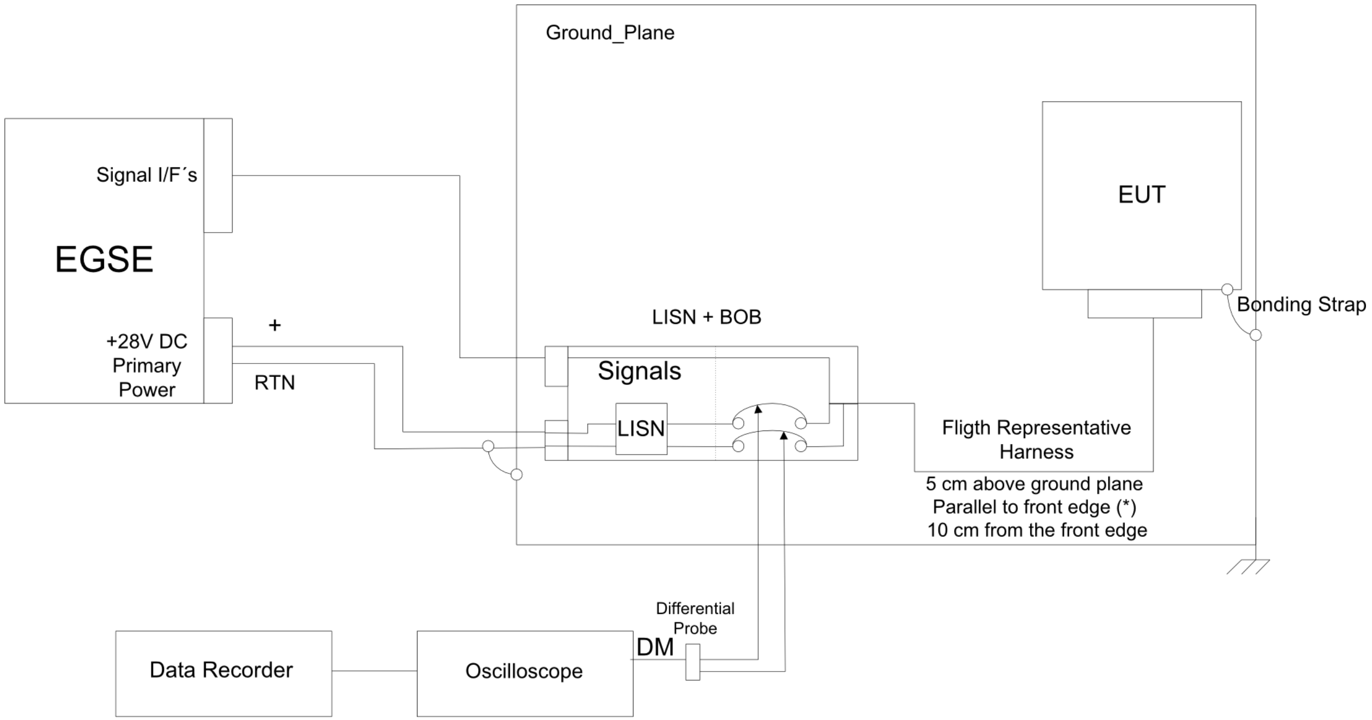
According to [AD-2]:

EIDA R-315a-DFU: The EPD units shall ensure that current ripple and spikes on the primary power bus inputs of the units, measured on positive and return lines, are ≤ 3 mApp when measured with at least 50 MHz bandwidth.

EIDA R-316a-DFU: The EPD units shall ensure that voltage ripple / spikes on the primary power bus inputs of the units, measured between positive and return lines, are ≤ 25 mVpp (ripple) and ≤50 mVpp (spikes) when measured with at least 50 MHz bandwidth.

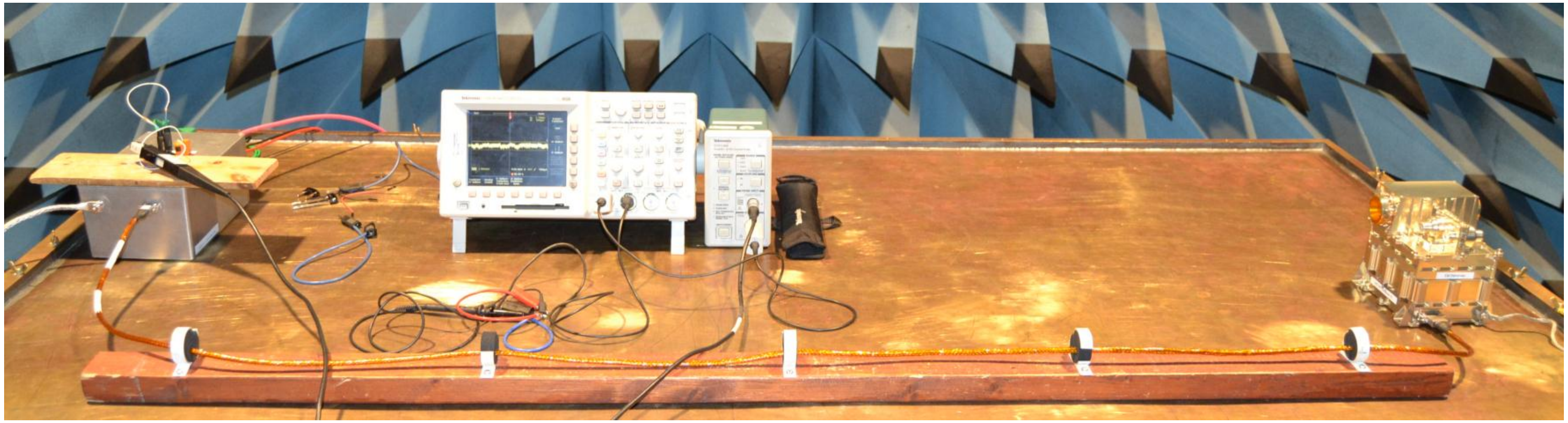
6.6.2 CE-DM-TD test set up

CE,power leads, differential mode .Time Domain Voltage Transient

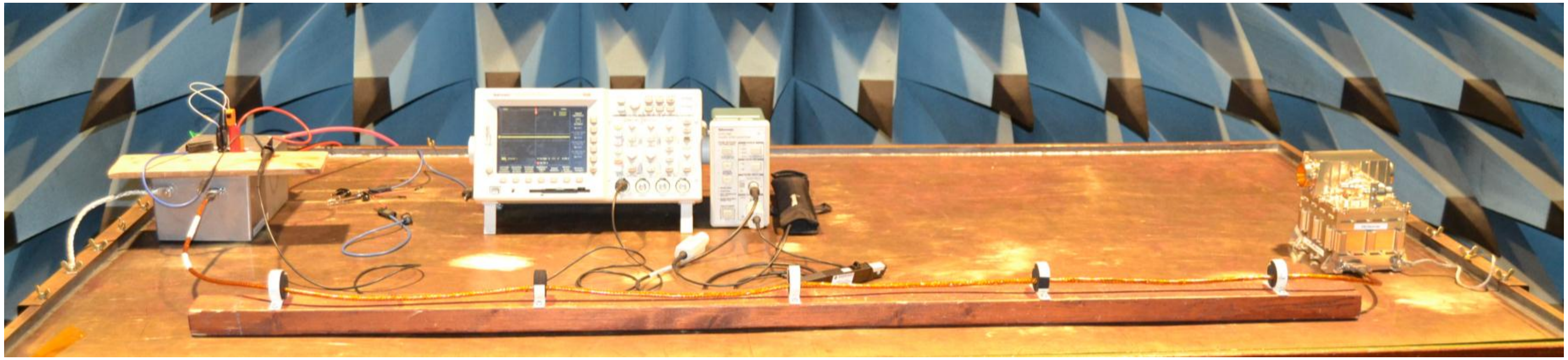


(*) If Flight Representative Harness is longer than 2 m the remaining cable length above 2 m shall be routed to the back of the setup and placed in a zigzagged arrangement

Fig. 6-6-2-1. Test setup for CE-DM-TD voltage transient.



(a)



(b)

Fig. 6-6-2-2. Test setup for CE-DM-TD at the time of the test, (a) current ripple measurement, (b) voltage ripple measurement.

6.6.3 CE-DM-TD step-by-step test procedure

Table 6-6-3-1: Step-by-step test procedure for CE-DM-TD, paragraph 5.4.2 of [NR-09].

Step	Description	Expected results	Measured value	Date/time	Sign	Comment
00	Preparation of test set up according to Fig. 6-6-2-1 for voltage transient.			18.03.2014 11:25-11:40	P. Sell S. Böttcher	This step (step 00) was started after the step 25.
05	Turn on the measurement equipment and allow a sufficient time for stabilization.			11:40-11:50	P. Sell	
10	Measurement system checks by the facility responsible.			11:40-11:50	P. Sell S. Böttcher	
20	Test the EUT by determining the conducted emissions from the EUT Vbus against Vbus Return: (a) Turn on the EUT and wait for its stabilization. (b) Select a lead or a bundle for testing and clamp the differential voltage probe into position. **Note:** It is recommended that the noise level before the test should be recorded at the test report.			11:50-12:25	P. Sell S. Böttcher B. Schuster S. Kulkarni M. Yedla A. Ravanbakhsh	The measured noise level for both: +28V and RTN lines can be seen in Fig.26 of Annex A. The measured voltage ripples and spikes can be seen in Fig. 27 and Fig. 28 of Annex A.

25	Preparation of test set up according to Fig. 6-5-2-1 for current transient. Test the EUT by determining the conducted emissions from the EUT in each power line Vbus and VbusRtn: (a) Turn on the EUT and wait for its stabilization. (b) Select a lead or a bundle for testing and clamp the current probe into position. **Note:** It is recommended that the noise level before the test should be recorded at the test report.			18.03.2014 10:20-11:20	P. Sell S. Böttcher B. Schuster S. Kulkarni M. Yedla A. Ravanbakhsh	This step (step 00) was started after the step 25. The measured noise level for +28V line can be seen in Fig.23 of Annex A. The measured current ripples and spikes can be seen in Fig. 24 and Fig. 25 of Annex A.

6.6.4 CE-DM-TD test success criteria

- The current ripple and spikes on the primary power bus inputs of the units, measured on positive and return lines, are ≤ 3 mApp when measured with at least 50 MHz bandwidth.

- The voltage ripple / spikes on the primary power bus inputs of the units, measured between positive and return lines, are ≤ 25 mVpp (ripple) and ≤50 mVpp (spikes) when measured with at least 50 MHz bandwidth.

6.6.5 Conclusion

The current ripples and spikes recorded in two different time domains as shown in Fig. 24 and Fig. 25 are well below the requirement. As shown in the Annex that ripples are in the range of 1mApp. Thus, the EUT passes this criterion.

The voltage ripples and spikes are illustrated in Fig. 27 and Fig. 28. The ripples stay within the envelope of 25mVpp. Most of the spikes are also within the 50mVpp requirement. After several attempts we were able to trigger a ripple exceeding that requirement. The reason for those strong spikes needs to be investigated. The EUT can be declared to partially pass that requirement.

6.7 CS-DM-FD test

6.7.1 Requirements

EIDA R-479: The PI shall abide by paragraph 5.4.7 of ECSS-E-ST-20-07C, [NR-09]

EIDA R-320: The PI and Prime Contractor shall comply with the relevant requirements, as defined in Annex A, paragraph A.10 with limit in fig. A-4 and not A-5 of ECSS-E-ST-20-07C [NR-09].

The following specifications are proposed for the susceptibility test on the power leads:

- the injected voltage level is equal or larger than the level shown in Fig. 6-7-1-1
- a limitation of the injected current before the specified voltage is reached is applied:
  - the limit of current is 1 A_{rms}
  - the voltage level when the current limit is reached is measured and reported.

The current applied is reported.

Independent power lines are tested separately.

NOTE Independent means “connected to separate power sources”.

Except in the case of structure return, for each power line, hot and return wires are tested separately.

NOTE In case of structure return, the test is only applied to hot wires.

The test signal covers the [30 Hz-100 kHz] frequency range.

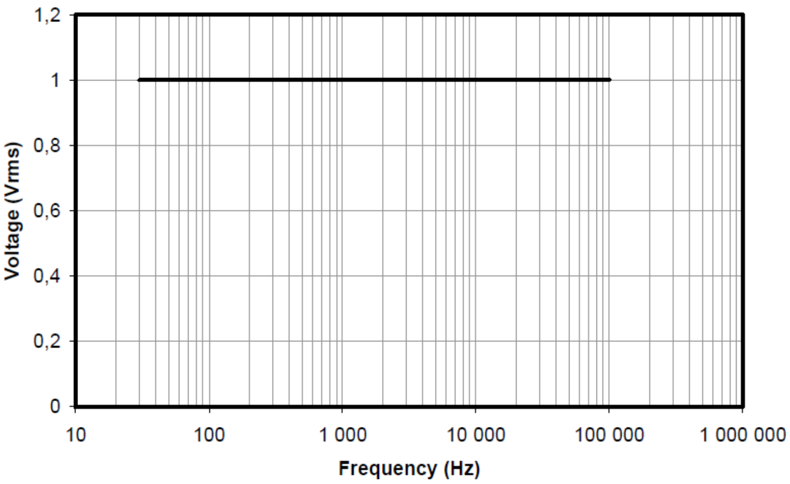


Fig. 6-7-1-1. Conducted susceptibility limit, frequency domain, page 86 of [NR-09].

According to [AD-2]:
EIDA R-320a-DFU: The ICU LCL's can transmit the injected signal at ICU input to the LCL output during this test but no amplification of injected signal is allowed. The LCL state shall not be modified during the injection of the interference signal specified at EIDA R-320. Sensors Simulated load shall be used during this test.

6.7.2 CS-DM-FD TEST SET UP

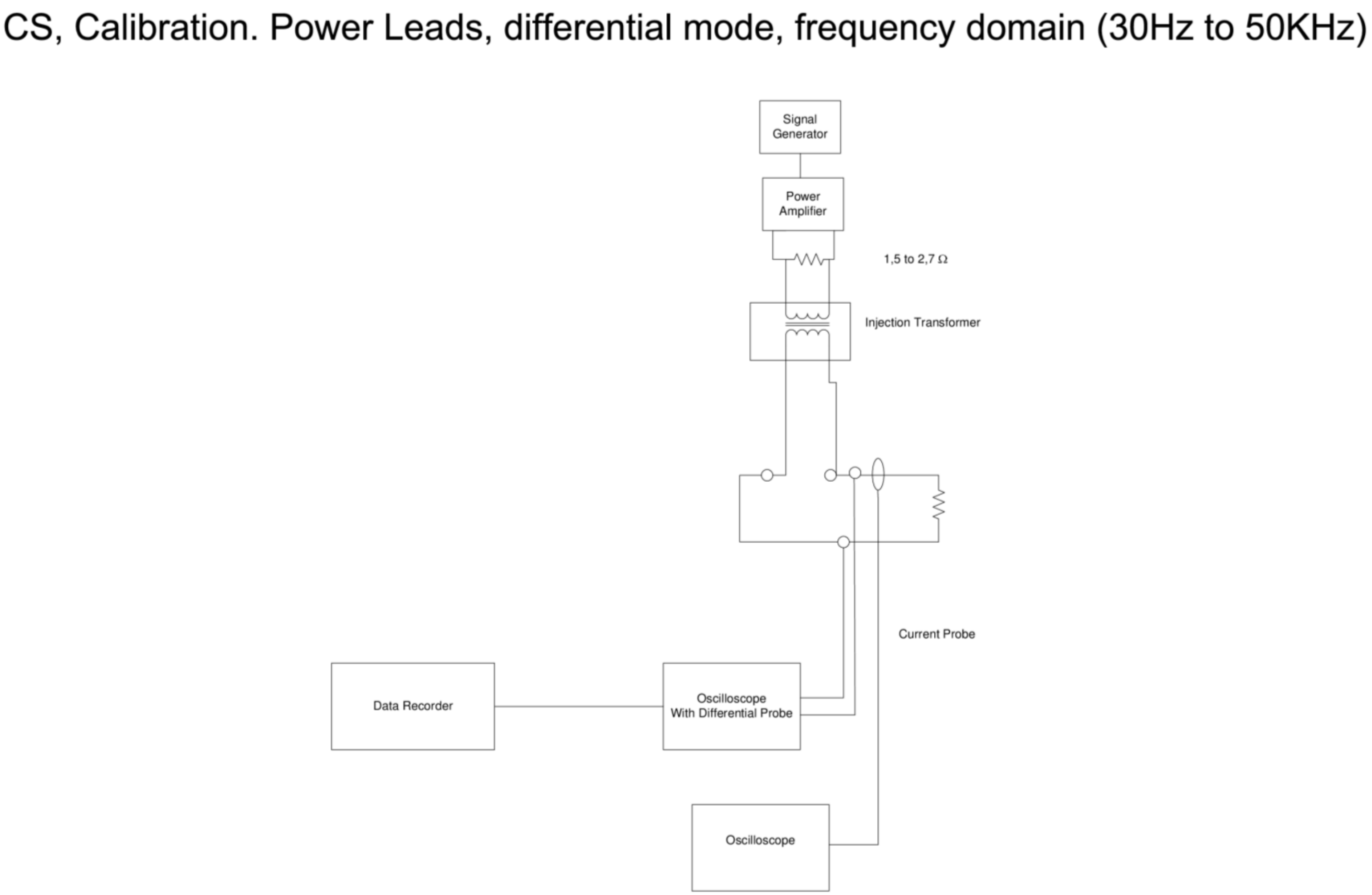
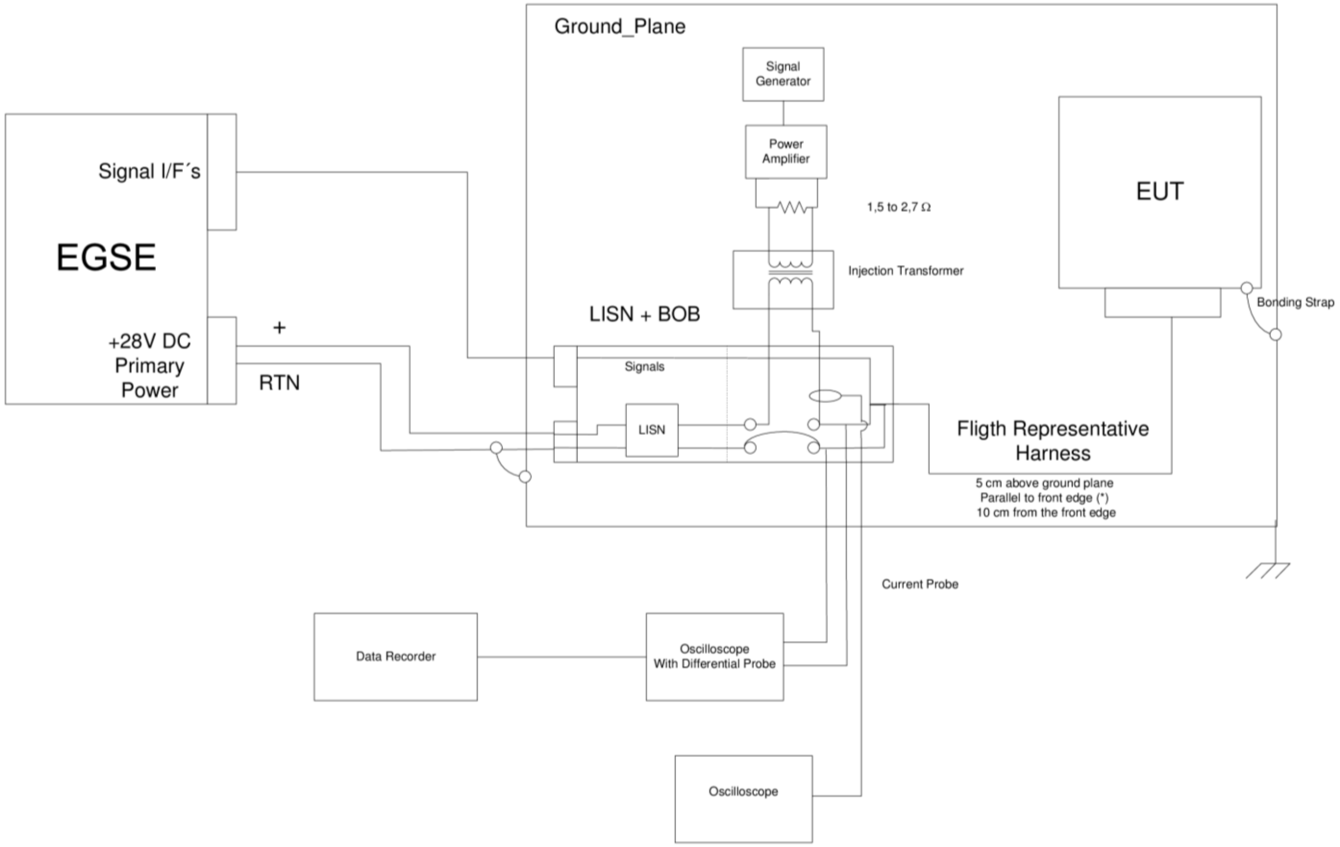


Fig. 6-7-2-1. Calibration setup for CS-DM-FD, 30 Hz to 50 kHz.

CS, Power Leads, differential mode, frequency domain(30Hz to 50KHz)



(*) If Flight Representative Harness is longer than 2 m the remaining cable length above 2 m shall be routed to the back of the setup and placed in a zigzagged arrangement

Fig. 6-7-2-2. Test setup for CS-DM-FD, 30 Hz to 50 kHz.

CS, Calibration Power Leads, Calibration differential mode, frequency domain(50kHz to 100KHz)

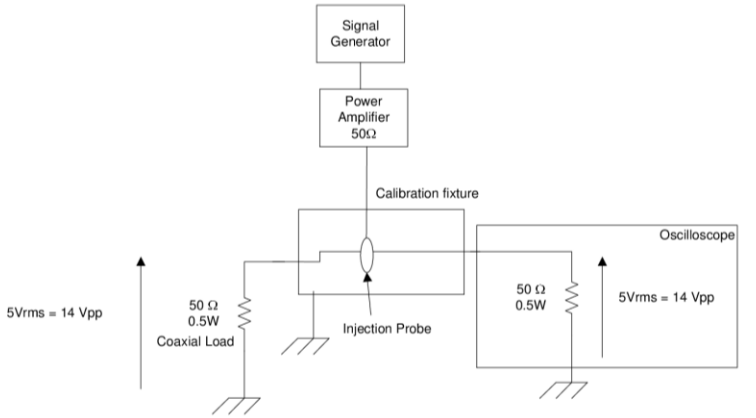


Fig. 6-7-2-3. Calibration setup for CS-DM-FD, 50 kHz to 100 kHz.

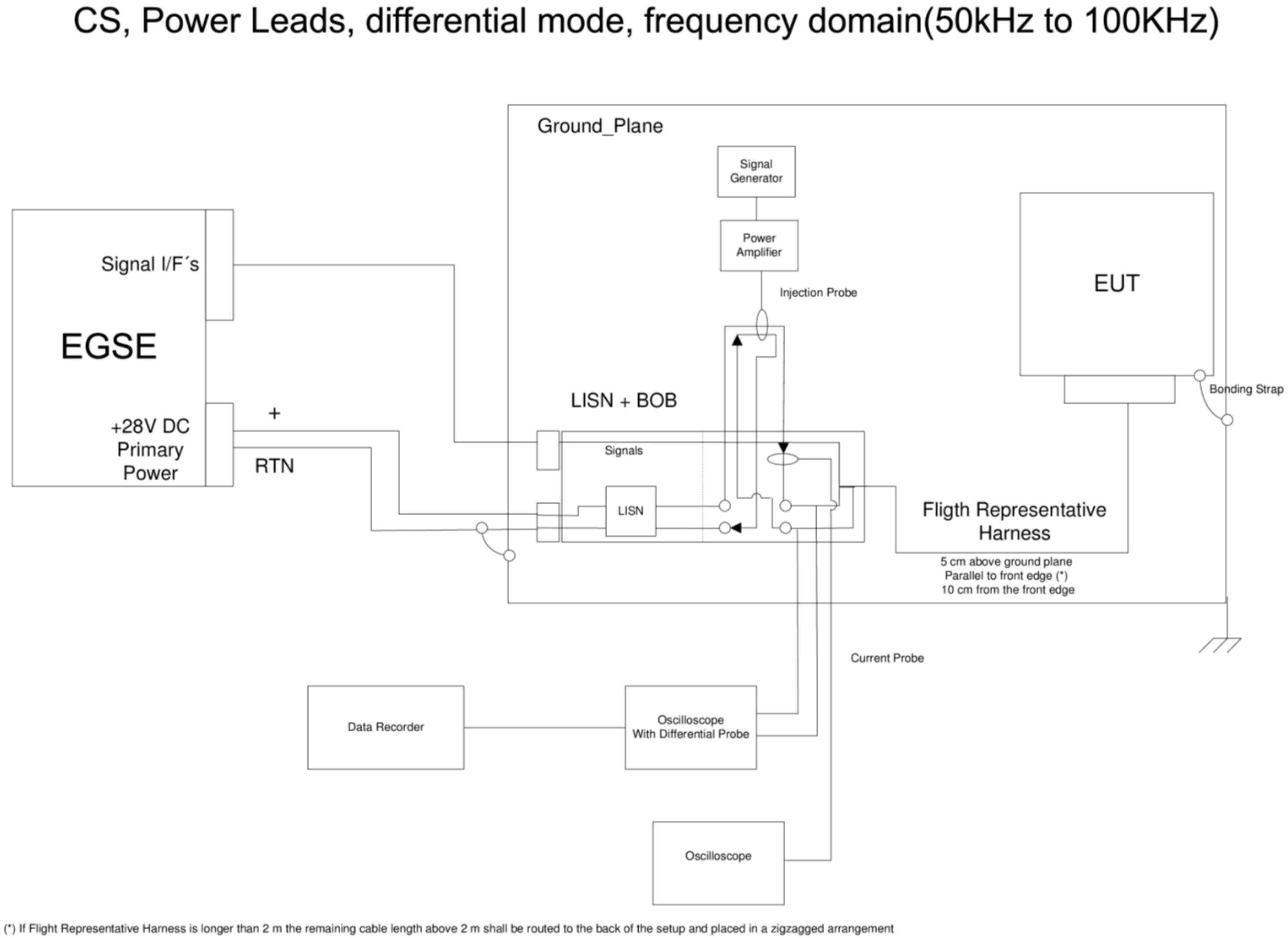
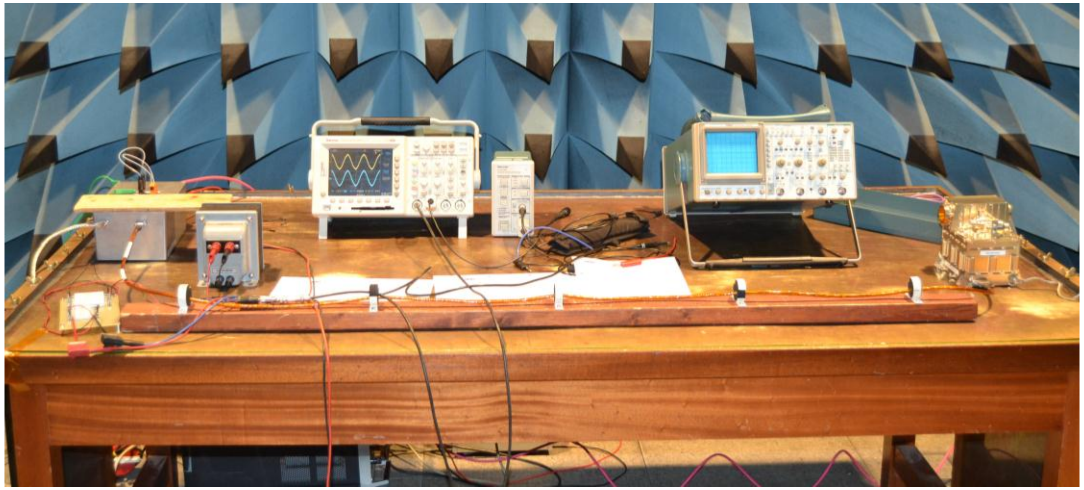
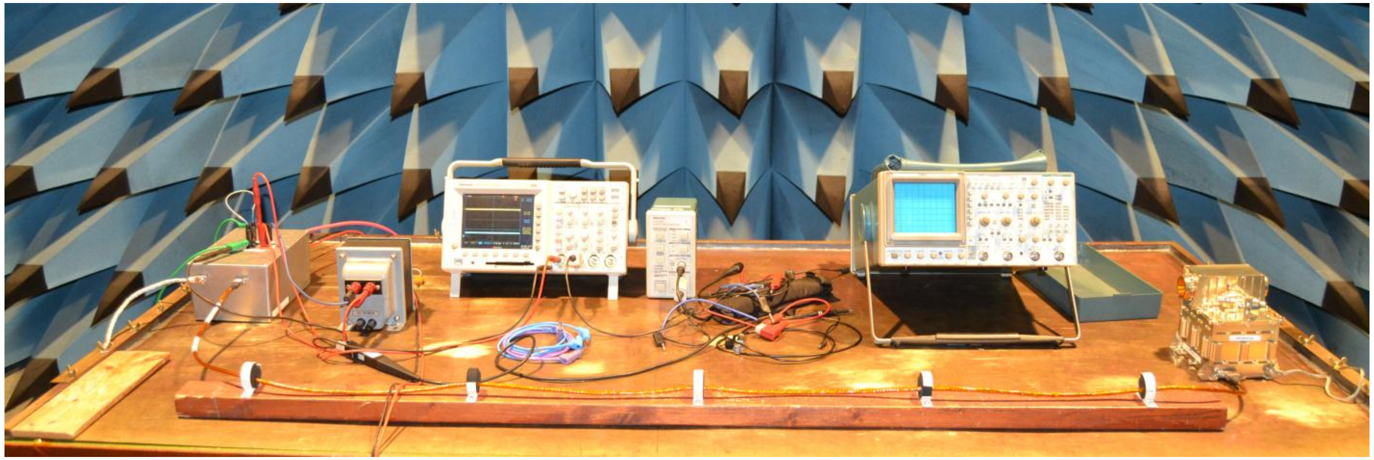


Fig. 6-7-2-4. Test setup for CS-DM-FD, 50 kHz to 100 kHz.

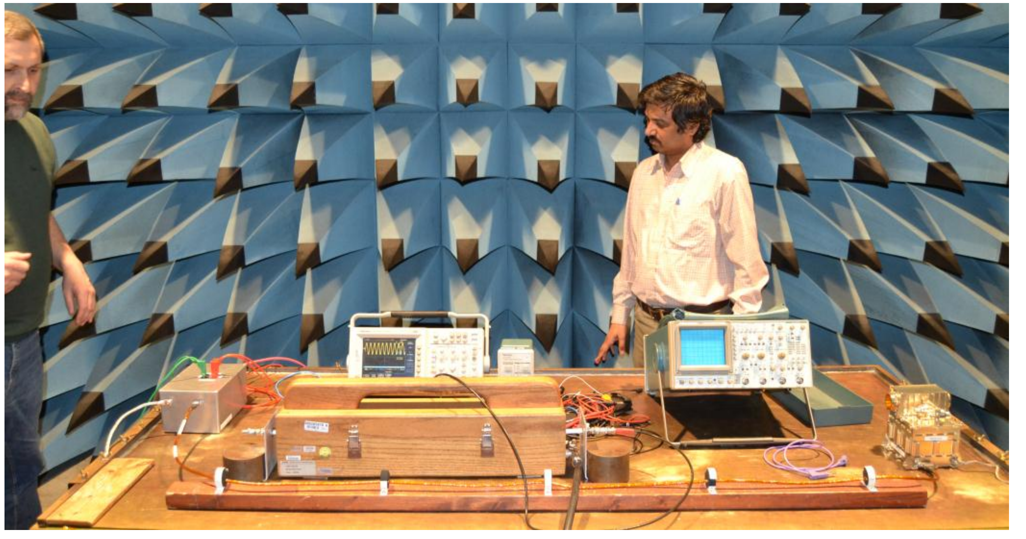


(a)

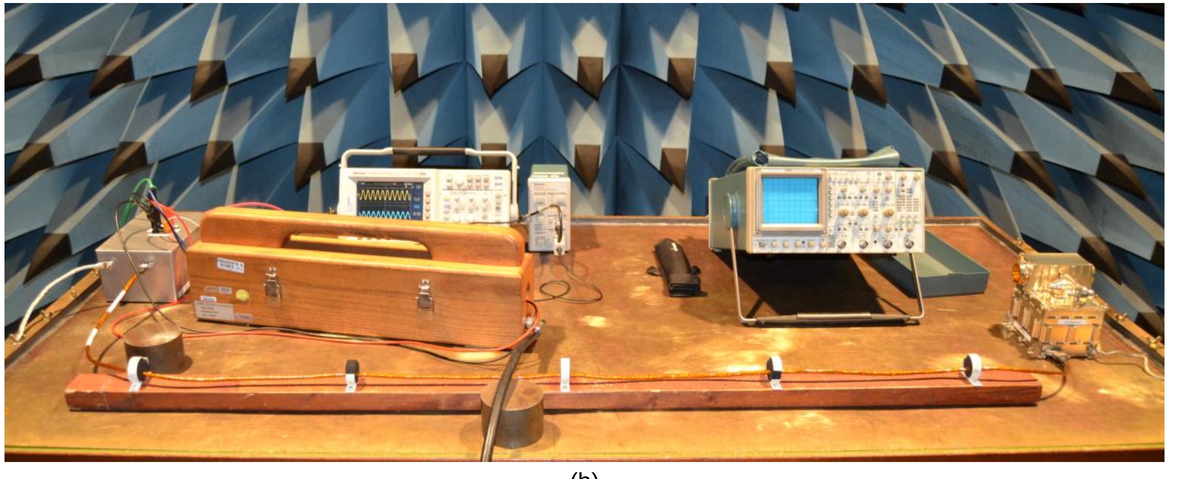


(b)

Fig. 6-7-2-5. CS-DM-FD, 30 Hz to 50 kHz at the time of the test, (a) Calibration setup, (b) Test setup.



(a)



(b)

Fig. 6-7-2-6. CS-DM-FD, 50 kHz to 100 kHz at the time of the test, (a) Calibration setup, (b) Test setup.

6.7.3 CS-DM-FD STEP-BY-STEP TEST PROCEDURE

Table 6-7-3-1: Step-by-step test procedure for CS-DM-FD, paragraph 5.4.7 of [NR-09].

Step	Description	Expected results	Measured value	Date/time	Sign	Comment
00	Preparation of calibration set up according to Fig. 6-7-2-1 [30 Hz to 50 kHz].			18.03.2014 14:00-14:10	P. Sell S. Böttcher	
05	The measurement equipment shall be turned on and waited until it is stabilized.			14:10-14:25	P. Sell S. Böttcher	
10	The measurement system shall be checked using the measurement system check set up for waveform verification as follows: 1. Set the signal generator to the lowest test frequency. 2. Increase the applied signal until the oscilloscope indicates the voltage level specified by application of clause 4.2.8, verify that the output waveform is sinusoidal, and verify that the indication given by the current probe is within 3 dB of the expected level derived from the 1 Ω resistor voltage. 3. Repeat step 10 (2) by setting the signal generator to the highest test frequency.			14:10-14:25	P. Sell S. Böttcher	
15	Preparation of test set up according to Fig. 6-7-2-2 [30 Hz to 50 kHz].			14:30-14:40		
20	Turn on EUT and wait until it is stabilized.			14:30-14:40		

25	Set the signal generator to the lowest test frequency, and increase the signal level until the testing voltage seen in Fig. 6-7-1-1, is reached on the power lead. **Note:** The settings during the injection on the EUT do not exceed the settings recorded during the calibration (see **EIDA R-480** in [AD-1]).			14:40-14:50		
30	Repeat step 25 at all frequency steps through the testing frequency range 30 Hz to 50 kHz. Susceptibility scanning according to Table 6-2.			14:50-15:20		Dwell time: 10 Sec
35	Evaluate the susceptibility as follows: Monitor the EUT for degradation of performance (TBD before the test, mainly house keeping data monitoring). When susceptibility indications are noted in EUT operation, a threshold level shall be determined as follows where the susceptible condition is no longer present: (1) When a susceptibility condition is detected, reduce the interference signal until the EUT recovers.					No susceptibility observed. Mainly the data stream was monitored during the CS test. The data structure remained unchanged.

	(2) Reduce the interference signal by an additional 6 dB. (3) Gradually increase the interference signal until the susceptibility condition reoccurs; the resulting level is the threshold of susceptibility. (4) Record this level, frequency range of occurrence, frequency and level of greatest susceptibility, and the other test parameters.					
40	Preparation of calibration set up according to Fig. 6-7-2-3 [50 kHz to 100 kHz]			15:20-15:30		
45	The measurement equipment shall be turned on and waited until it is stabilized.			15:20-15:30		
50	The measurement system shall be checked using the measurement system check set up for waveform verification as follows: 1. Set the signal generator to the lowest test frequency. 2. Increase the applied signal until the oscilloscope indicates the voltage level specified by application of clause 4.2.8, verify that the output waveform is sinusoidal, and verify that the indication given by the current probe is within 3 dB of			15:30-15:45		There is not any current probe in the calibration set up. Typo in step 50.

	the expected level derived from the 50 Ω resistor voltage. Repeat step 50 (2) by setting the signal generator to the highest test frequency.					
55	Preparation of test set up according to Fig. 6-7-2-4 [50 kHz to 100 kHz]			15:45-16:00		
60	Turn on EUT and wait until it is stabilized.			15:45-16:00		
65	Set the signal generator to the lowest test frequency, and increase the signal level until the testing voltage seen in Fig. 6-7-1-1, is reached on the power lead. **Note:** The settings during the injection on the EUT do not exceed the settings recorded during the calibration (see **EIDA R-480** in [AD-1]).			16:00-16:10		
70	Repeat step 65 at all frequency steps through the testing frequency range 50 kHz to 100 kHz. Susceptibility scanning according to Table 6-2.			16:00-16:10		
75	Evaluate the susceptibility as follows: Monitor the EUT for degradation of performance (TBD before the test, mainly house keeping data monitoring).					No susceptibility observed. Mainly the data stream was monitored during the CS test. The data

	When susceptibility indications are noted in EUT operation, a threshold level shall be determined as follows where the susceptible condition is no longer present: (1) When a susceptibility condition is detected, reduce the interference signal until the EUT recovers. (2) Reduce the interference signal by an additional 6 dB. (3) Gradually increase the interference signal until the susceptibility condition reoccurs; the resulting level is the threshold of susceptibility. (4) Record this level, frequency range of occurrence, frequency and level of greatest susceptibility, and the other test parameters.					structure remained unchanged.

6.7.4 CS-DM-FD TEST SUCCESS CRITERIA

The CS-DM-FD test success criteria are mainly proper communication between the EUT and the EGSE based on designated data structure.

6.7.5 CONCLUSION

No susceptibility was witnessed.

6.8 CS-DM-Transient test

6.8.1 REQUIREMENTS

EIDA R-482: *The PI shall abide by paragraph 5.4.9 of ECSS-E-ST-20-07C, [NR-09]*

EIDA R-322: *The PI and Prime Contractor shall comply with the relevant requirements, as defined in Annex A, paragraph A.12 of ECSS-E-ST-20-07C [NR-09].*

The following specifications are proposed for the susceptibility test on the power leads:

- a series of positive spikes, then a series of opposite spikes superposed on the power voltage shall be applied,
- at any time step, the voltage spike amplitude is:
    - +100 % or -100 % of the actual line voltage if the nominal bus voltage is lower than 100 V, Fig. 6-8-1-1.
    - +50 % or -100 % of the actual line voltage if the nominal bus voltage is equal or larger than 100 V
    - Level 0 in Fig. 6-8-1-1 represents the DC bus voltage.
    - Only the positive spike is represented in Fig. 6-8-1-1.
    - When a negative spike is applied, the absolute instantaneous transient voltage goes down to 0, never negative.
- tests are performed with two spike durations, the first zero-crossing is at T=150 ns and at T=10 µs.
- Independent power lines are tested separately.
- Independent means “connected to separate power sources”.

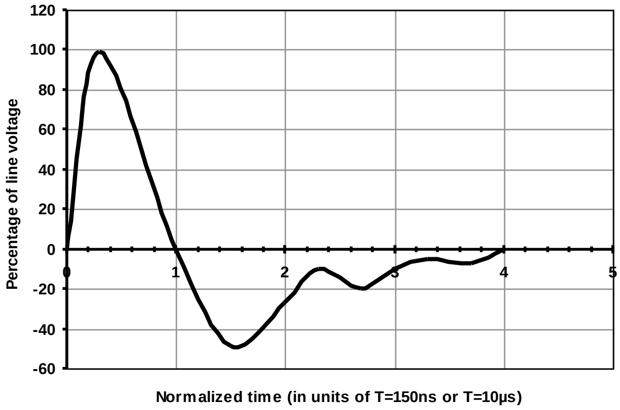


Fig. 6-8-1-1. CS, voltage spike in percentage of test bus voltage, page 88 of [NR-09].

According to [AD-2]:

This conducted susceptibility shall be applied at the input of each EPD unit. Owing to the fact that the ICU includes LCL’s for each EPD sensor.

6.8.2 CS-DM-TRANSIENT TEST SET UP

CS, Calibration. Power Leads, differential mode, Time domain. Series/Parallel Injection.

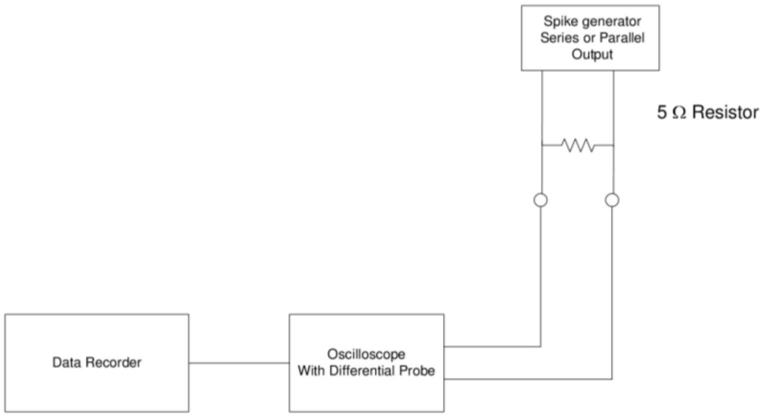
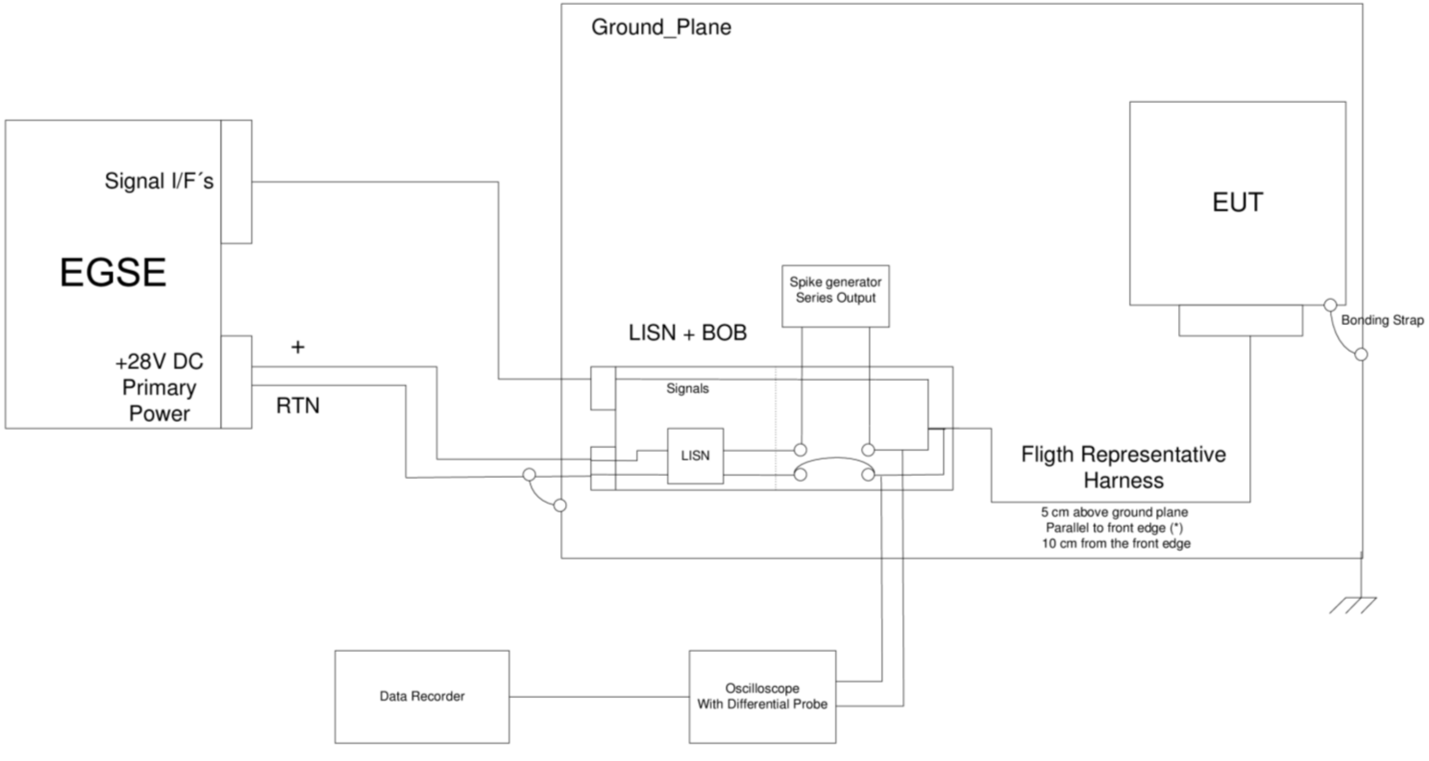


Fig. 6-8-2-1. Calibration setup for CS-DM-Transient, series/parallel injection.

CS, Power Leads, differential mode, Time domain. Series Injection.



(*) If Flight Representative Harness is longer than 2 m the remaining cable length above 2 m shall be routed to the back of the setup and placed in a zigzagged arrangement

Fig. 6-8-2-2. Test setup for CS-DM-Transient, series injection.

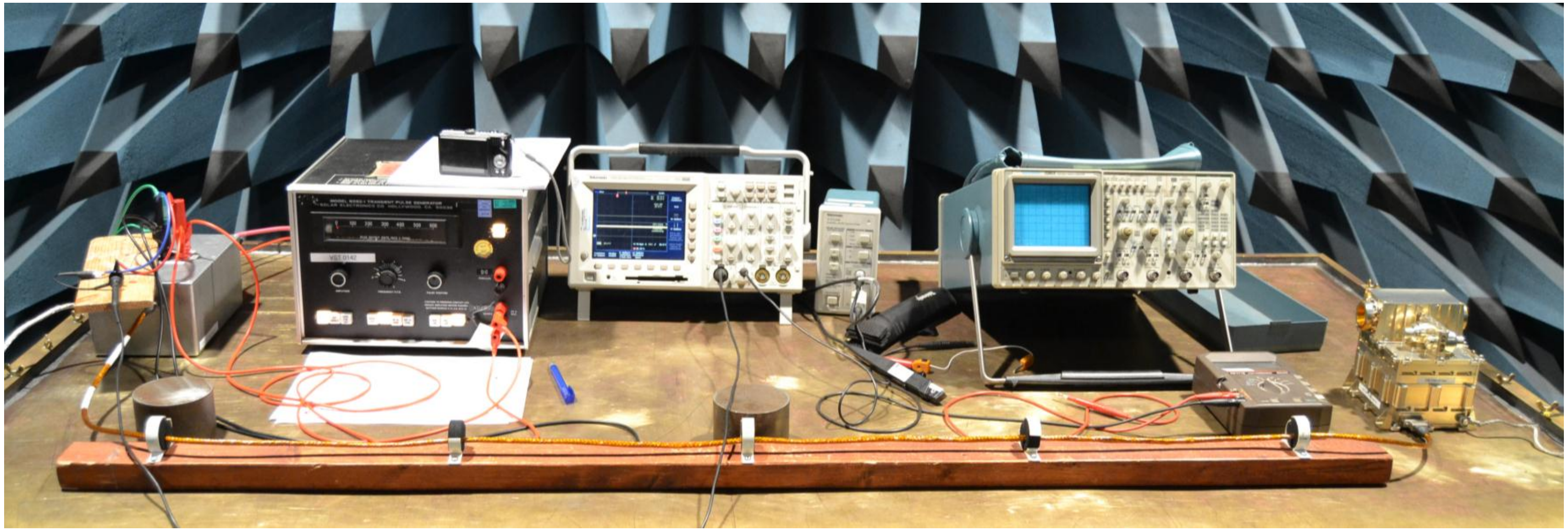


Fig. 6-8-2-3. CS-DM-Transient test set up at the time of the test, series injection.

6.8.3 CS-DM-Transient step-by-step test procedure

Table 6-8-3-1: Step-by-step test procedure for CS-DM-Transient, paragraph 5.4.9 of [NR-09].

Step	Description	Expected results	Measured value	Date/time	Sign	Comment
00	Preparation of calibration set up according to Fig. 6-8-2-1.			18.03.2014 16:20-16:30		
05	The measurement equipment shall be turned on and waited until it is stabilized.			16:20-16:30		
10	For calibration: (a) Configure the test equipment in accordance with Fig. 6-8-2-1 for verification of the waveform. (b) Set up the oscilloscope to monitor the voltage across the 5 Ω resistor.			16:20-16:30		
15	Turn on the measurement equipment and wait until it is stabilized.			16:20-16:30		
20	Perform the following procedure using the calibration set up: a) Adjust the pulse generator for the pulse width, and pulse repetition rate. b) Adjust the amplitude of the signal to the level specified in associated limit. c) Verify that the waveform complies with the requirements, if not, correct accordingly.			16:20-16:30		

	d) Record the pulse generator amplitude setting.					
25	Preparation of test set up according to Fig. 6-8-2-2 (series test method) or Fig. 6-8-2-3 (parallel test method) NOTE 1 With series injection, the internal LISN capacitor at the input power side is protecting the source. NOTE 2 With parallel injection, the internal inductance is protecting the source, so a minimum value is needed as specified in 5.4.9.2a.6.			16:30-16:55		Series injection is selected.
30	(a) Turn on the EUT and wait until it is stabilized. (b) Adjust the spike generator to a pulse duration. (c) Apply the test signal to each power lead and increase the generator output level to provide the specified voltage without exceeding the pulsed amplitude setting recorded during calibration. (d) Apply repetitive (6 to 10 pulses per second) positive spikes to the EUT ungrounded input lines for a period not less than 2 minutes in duration, and if the equipment employ gated circuitry, trigger the spike to occur within the time frame of the gate.			16:55-17:10		The test just performed with T=10 µs spike duration and no T=150 ns duration was performed. See deviation #2.

	(e) Repeat step 30(d) with negative spikes. (f) Monitor the EUT for degradation of performance.					
35	When susceptibility indications are noted in EUT operation, a threshold level shall be determined as follows where the susceptible condition is no longer present: (1) When a susceptibility condition is detected, reduce the interference signal until the EUT recovers. (2) Reduce the interference signal by an additional 6 dB. (3) Gradually increase the interference signal until the susceptibility condition reoccurs; the resulting level is the threshold of susceptibility. (4) Record this level, frequency range of occurrence, frequency and level of greatest susceptibility, and the other test parameters.					No susceptibility observed. Mainly the data stream was monitored during the CS test. The data structure remained unchanged. After studying in detail the facility test report (see Fig. 36 of Annex A), it is found that the applied voltage spike amplitudes were exceeding the 100% limit required in EIDA-322. See deviation #3.
40	Record the peak current as indicated on the oscilloscope.					

6.8.4 CS-DM-Transient test success criteria

The CS-DM-FD test success criteria are mainly proper communication between the EUT and the EGSE based on designated data structure.

6.8.5 CONCLUSION

No susceptibility was witnessed.

6.9 CS-CM-FD test

6.9.1 REQUIREMENTS

EIDA R-481: The PI shall abide by paragraph 5.4.8 of ECSS-E-ST-20-07C, [NR-09]

EIDA R-321: The PI and Prime Contractor shall comply with the relevant requirements, as defined in Annex A, paragraph A.11 of ECSS-E-ST-20-07C [NR-09].

The following specifications are proposed for the susceptibility test on the power leads:

- the common mode level of 3 volts peak to peak or larger is applied,
- the limit of the current induced on the bundle is 3 A peak-to-peak,
- the test signal is pulse modulated,

NOTE Square wave modulation is a particular case of pulse modulation.

- the duty cycle is depending on the carrier frequency, according to Table 6-9-1-1.
- The same level is applied to all cables together or to bundles taken separately.
- The common mode induced current on the bundle is reported.
- The test signal covers the [50 kHz-100 MHz] frequency range.

- **Table 6-9-1-1:** Equipment: susceptibility to conducted interference, test signal.

Frequency range	Pulse repetition frequency	Duty cycle
50 kHz-1 MHz	1 kHz	50 % (squarewave)
1 MHz-10 MHz	100 kHz	20 %
10 MHz-100 MHz	100 kHz	5 %

According to [AD-2]:

This test will be performed at all the cable between the ICU and sensors and at the cable that connect the ICU with the platform.

6.9.2 CS-CM-FD TEST SET UP

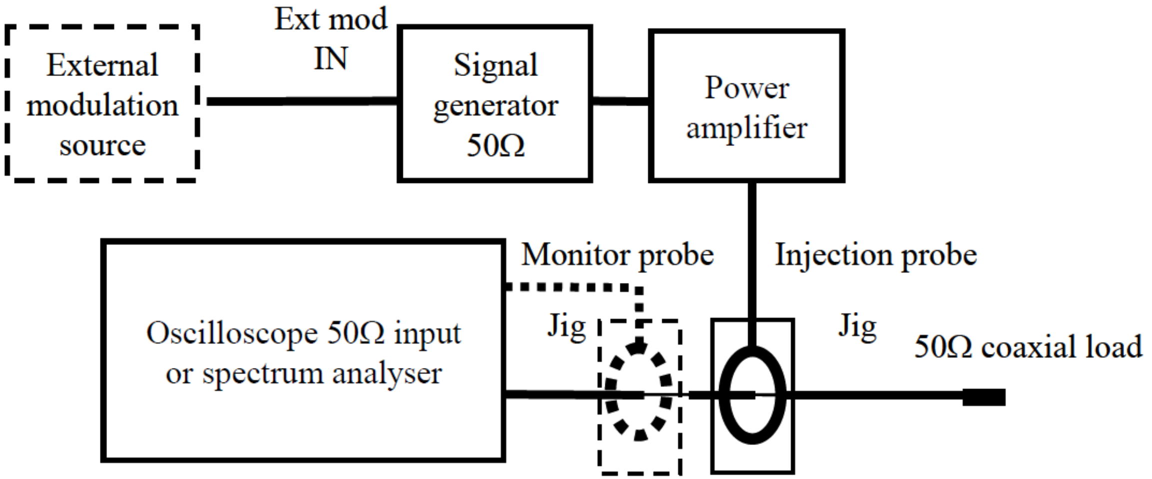


Fig. 6-9-2-1. Calibration setup for CS-CM-FD, see deviation #3.

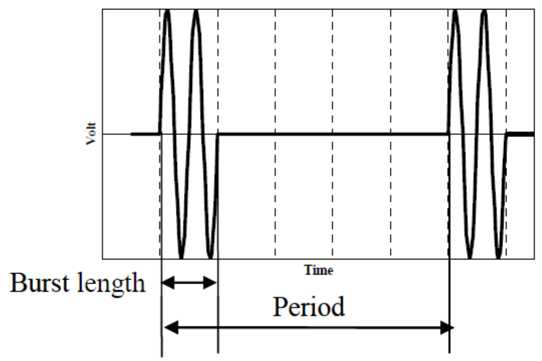


Fig. 6-9-2-2. Signal test wave form.

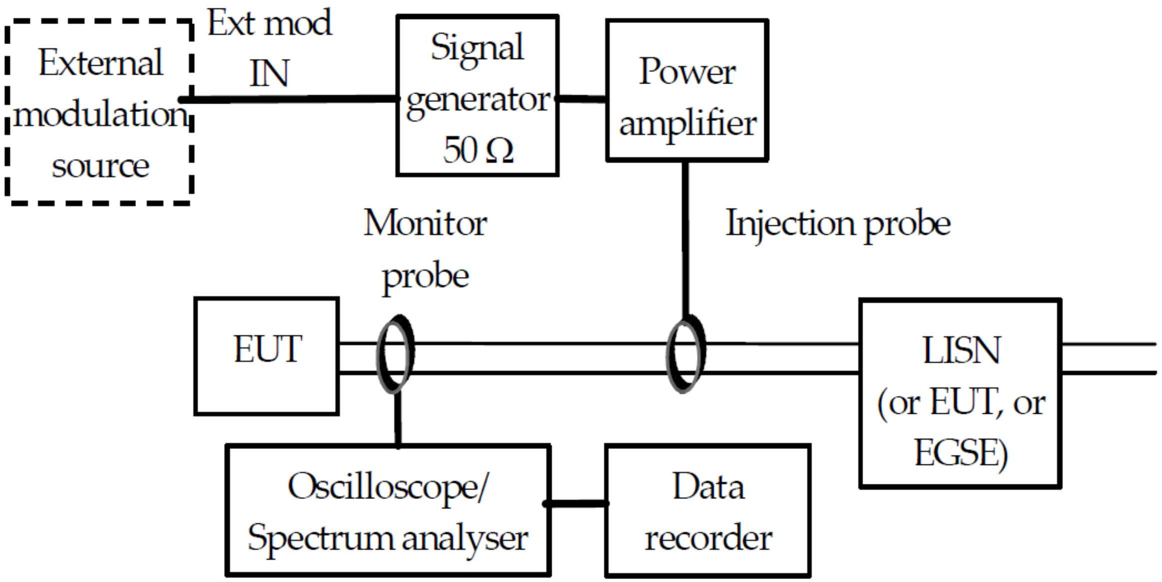
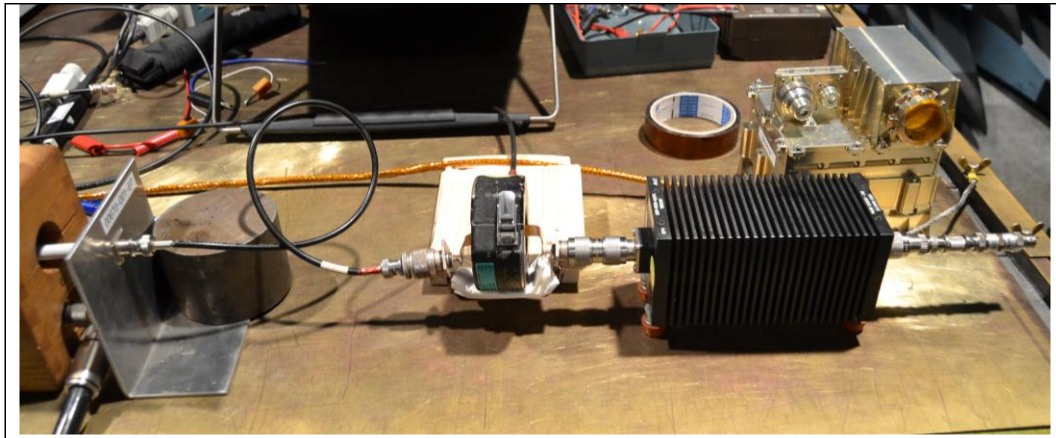
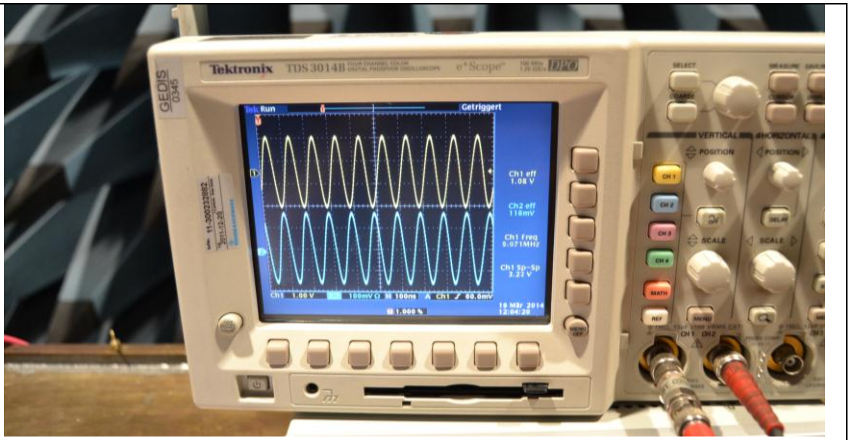


Fig. 6-9-2-3. Test setup for CS-CM-FD, see deviation #3.

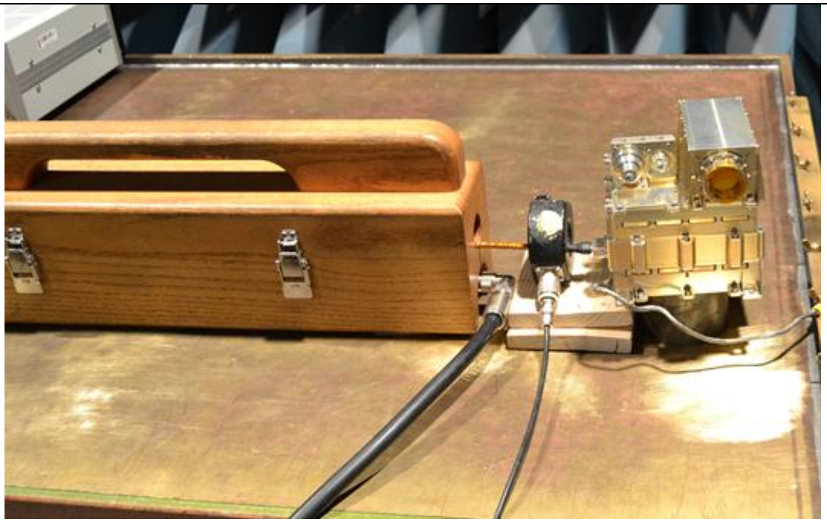


(a)



(b)

(c)



(d)

Fig. 6-9-2-4. CS-CM-FD at the time of the test, (a-b) Calibration setup, (c-d) Test setup, see deviation #1.

6.9.3 CS-CM-FD STEP-BY-STEP TEST PROCEDURE

Table 6-9-3-1: Step-by-step test procedure for CS-CM-FD, paragraph 5.4.8 of [NR-09].

Step	Description	Expected results	Measured value	Date/time	Sign	Comment
00	Preparation of calibration set up according to Fig. 6-9-2-1.			19.03.2014 09:15-09:40		Due to the EUT damage risk, both the calibration and test set up has been assumed according to Fig. 6-9-2-1. See deviation #4.
05	The measurement equipment shall be turned on and waited until it is stabilized.			10:35-11:00		
10	The measurement system shall be calibrated by performing the following procedures using the calibration setup: 1. Set the frequency of the generator to 50 kHz and apply the pulse modulation, Fig. 6-9-2-2. 2. Increase the applied signal until the oscilloscope indicates the voltage Fig. 6-7-1-1. 3. Verify that both inputs of the oscilloscope, voltage monitored on 50 Ω and current monitored by the current probe, are consistent within 3 dB. This is applicable only if a current probe is used during calibration			11:00-11:45		The calibration details can be seen in section 8.8 of Annex A.

	4. Record the generator settings. 5. Repeat step 10(2) through step 10(4) for each measurement frequency.					
15	Preparation of test set up according to Fig. 6-9-2-3			11:00-11:45		
20	Turn on the EUT and wait until it is stabilized.			11:00-11:45		
25	Select a bundle for testing and clamp the current probes into position. (a) Set the modulated sine generator to a test frequency, at low output level. (b) Adjust the modulation in duty cycle and frequency. (c) Increase the generator output to the level determined during calibration, without exceeding the current limit specified by application of clause 4.2.8 and record the peak current obtained. (TBD)			11:45-12:20 13:20-14:45		No susceptibility observed. Mainly the data stream was monitored during the CS test. The data structure remained unchanged.
30	When susceptibility indications are noted in EUT operation, a threshold level shall be determined as follows where the susceptible condition is no longer present: (1) When a susceptibility condition is detected, reduce the interference signal until the EUT recovers.					

	(2) Reduce the interference signal by an additional 6 dB. (3) Gradually increase the interference signal until the susceptibility condition reoccurs; the resulting level is the threshold of susceptibility. (4) Record this level, frequency range of occurrence, frequency and level of greatest susceptibility, and the other test parameters.					
35	Repeat step 25 and step 30 for each test frequency. Susceptibility scanning according to Table 6-2.					
40	Repeat step 25-30-35 applying the test signals to each bundle interfacing with each connector or all bundles taken together. The calibration need not be re-performed before testing each EUT bundle.			15:10 Test finish.		The EUT has just one bundle.

6.9.4 CS-CM-FD TEST SUCCESS CRITERIA

The CS-DM-FD test success criteria are mainly proper communication between the EUT and the EGSE based on designated data structure.

6.9.5 CONCLUSION

No susceptibility was witnessed.

7 GSE

The complete list of EGSE items to be used during the test is indicated in Table 8-1.

Also the list of test equipment provided by the test facility, TREO, can be seen in Table 2 of Annex A.

Table 7-1: EGSE items.

#	Item	Manufacturer	Serial Number	Calibration status
1	Multimeter 177 True RMS	Fluke	N/A	Not calibrated.
2	Multimeter True RMS	Voltcraft	N/A	Not calibrated.
3	Power supply 8733	Toellner	N/A	Not calibrated.
4	Pulse generator 33220A	Agilent	N/A	Not calibrated.
5	Modified LISN from PO	EPD PO/modified by CAU. See Table 5-2-1.	N/A	N/A
6	GND strap for LISN	EPD PO		N/A
7	MDA Harness for EM EPT-HET1, 2.0 m	Axon Cable S.A.S. Received from EPD PO.	N/A	N/A
8	Laboratory connectors and probes		N/A	N/A
9	Appropriate mechanical tools for connectors mounting		N/A	N/A
10	etsolo1 computer, with GSE software svn revision r2644	HW: Lenovo SW: CAU	N/A	N/A
11	EMI test harness between GSE and LISN, pink 10m cat5, with shield at the last 2m.	CAU	N/A	N/A
12	FET (Field Effect Transistor) switch for the inrush current test.	CAU	N/A	N/A

8 SPECIAL REMARKS

8.1 Anomalies

There was not any anomaly during the test.

8.2 Test deviations

Test deviations are indicated in the Table 8-2-1.

Table 8-2-1: List of test deviations.

#	Test deviation	Comment
1	At the first date of the test, 17.03.2014, the test was stopped before any measurement and some rework has been performed on EUT between 09:30-10:40.	A capacitor has been removed from LVPS board in order to improve inrush current characteristics based on some previous verification done prior to the test date. See [AD-4] for details.
2	At the time of test, the spike generator of the facility could not provide the spike duration of T=150 ns as required in EIDA-R322.	Even though before the TRR, the test requirements were agreed by the facility, but accidentally at the time of the test the spike generator was not capable to provide T=150 ns spike duration.
3	After studying in detail the facility test report on CS-DM-Transient (see Fig. 36 of Annex A), it is found that the applied voltage spike amplitudes were exceeding the 100% limit required in EIDA-322.	During and after this over testing the EUT did not demonstrate any susceptibility. Also, the analysis of the circuit did not show any suspected damage to EUT due to this over testing.
4	At the time of the test “CS-CM-FD”, performing the test based on the set up shown in Fig.6-9-2-3, the damage risk of EUT was detected. Reviewing the relevant requirements, this test was performed based on the set up suggested in [NR-09] paragraph 5.4.8.	After the test, the used set up has been checked by A. Muñoz (EPD EMI engineer) and his technical approval of the used set up was received. The main difference between the not-used test set up from [AD-3] and used set up from [NR-09] was: Injecting the signal waves on the whole bundle (including shielding and signal lines) instead of injecting just on power lines from BOB.

Annex A

TREO
LABOR FÜR UMWELTSIMULATION

Treo - Labor für Umweltsimulation GmbH
Edisonstraße 3
24145 Kiel
Tel: +49 (0) 431/ 71971 47
Fax: +49 (0) 431/ 71948 86

Deutscher Akkrediti erungs Rat
DAR

DAT-PL-175/94-03

TEST REPORT	Version 001
Document No.:	066-14
Device:	SOLAR ORBITER ENERGETIC PARTICLE DETECTOR EPT-HET
Assignment no.:	4010726
Product no.:	320401.3 (Ref: EPD-Kiel CDR product tree)
Serial no.:	EPTHET-EM1
Client:	Institut für Experimentelle und Angewandte Physik Christian-Albrechts-Universität zu Kiel. Leibnizstraße 11 D-24118, Kiel
Tests:	Inrush current(6.2)*, CE-CM-FD(6.3)*, CE-CM-TD(6.4)*, CE-DM-FD(6.5)*, CE-DM-TD(6.6)*, CS-DM-FD(6.7)*, CS-DM-Transient(6.8)* and CS-CM-FD(6.9)* acc. to SO-EPD-KIE-TP-0008, Issue 1, Revision 1, date 14.03.2014
Date:	04.04.2014

Treo – Labor für Umweltsimulation GmbH
Accredited test laboratory for environmental simulation and electromagnetic compatibility – www.treo.de

Prepared by: ....

Dipl.-Ing. P. Sell
Head of EMC Laboratory

Reviewed by: ....

C. Möller, B. Sc.
Test Engineer

List of Revisions

Issue	Date	Effected		Reasons for Revision
		Page	Section	
1	2014-04-04	all	all	Initial Release

1 Index

2 Description of Unit(s) Under Test

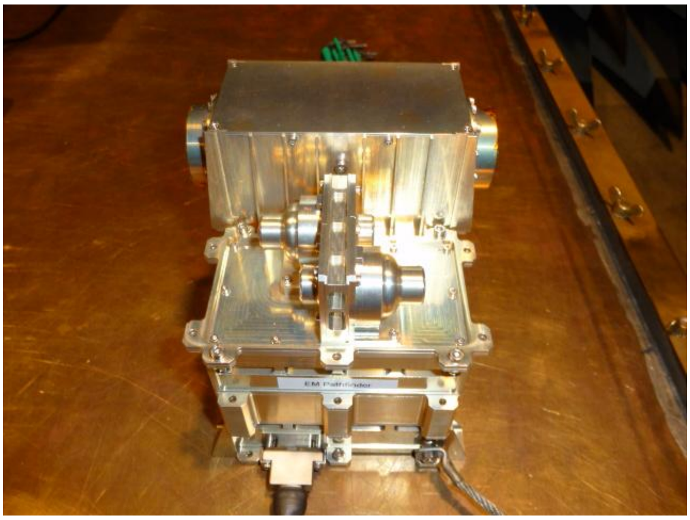


Fig. 1: Unit under test

2.1 Entrance Examination

The test unit was checked after arrival by visual inspection. No external damage could be detected.

3 Test Overview and Results

Table 1: Results

Sec.	Test	Date	Result	Executive person
8.1	Inrush current(6.2)* Conducted emission, inrush current on power leads	17.03.2014	passed	P. Sell
8.2	CE-CM-FD(6.3)* Conducted emission on power leads, common mode, 30 Hz to 100 MHz, frequency domain	17.03.2014	passed	P. Sell
8.3	CE-CM-TD(6.4)* Conducted emission on power leads, common mode, 30 Hz to 100 MHz, time domain	17.03.2014	passed	P. Sell
8.4	CE-DM-FD(6.5)* Conducted emission on power leads differential mode, 30 Hz to 100 MHz, frequency domain	18.03.2014	passed	P. Sell
8.5	CE-DM-TD(6.6)* Conducted emission on power leads differential mode, 30 Hz to 100 MHz, time domain	18.03.2014	passed	P. Sell
8.6	CS-DM-FD(6.7)* Conducted susceptibility on power leads in differential mode, 30 Hz to 100 kHz, frequency domain	18.03.22014	passed	P. Sell
8.7	CS-DM-Transient(6.8)* Conducted susceptibility on power leads in differential mode, 30 Hz to 100 kHz, transient	19.03.2014	passed	P. Sell
8.8	CS-CM-FD(6.9)* Conducted susceptibility on power leads in common mode, 50 kHz to 100 MHz, frequency domain	19.03.2014	passed	P. Sell

4 Test Equipment

Table 2: Test Equipment

Unit Type	Properties	Model	ID	cal.due
Generator	1mHz-2MHz	PM 5190	0179	Dez.15
Oscilloscope	4Kanal,100MHz	TDS3014B	0345	Dez.15
Current clamp	DC-100MHz	Tektronix TCPA 300	0346	Dez.15
Current clamp/ampl.	DC-100MHz	Tektronix TCP 312	0347	Dez.15
Coupling clamp	10kHz-1GHz	FCC, F-2031	0170	Dez.14
EMI Receiver	5Hz-1GHz	R&S ESS	500-070	Dec.15
Current clamp	100kHz-1GHz	Ailtech 94111-1	0056	Dec.14
Current clamp	10kHz-100MHz	EATON 91550-1	0058	Dec.14
Generator	9kHz-2080MHz	R&S SMY 02	102066	Dez.15
Amplifier	1MHz-1GHz, 10W	AR 10W1000	0130	Dez.15
Amplifier	30Hz-200kHz, 100W	SOLAR6552-1A	0126	Dez.15
Amplifier	35kHz-15MHz,100W	AR 100A15	0128	Dez.15
Amplifier	1MHz-1GHz,100W	AR 100W1000B	0400-048	Dez.15
Current clamp	30Hz-30MHz	Singer 93511	0057	Dec.14
EMI Receiver	10Hz-40GHz	GAUSS TDEMIX	0100-001	Dez.14
Thermo-/ Hygrometer		EASY Log 80CL	10712	Nov.14

The above mentioned test equipment can be traced back to certified standards and are calibrated at regulated intervals.

The accuracy of tests and of test equipment itself is according to the requirements of the applied standards.

5 General identification of appliance, clients, data

5.1 Representative of client during test

Dr. Stephan Boettcher
Dr. Shri Kudkarni
Mr. Björn Schuster
Mr. Makesh Yedla
Mr. Ali Ravanbakhsh

5.2 Dimensions of equipment under test

max width = 136 mm
max length = 148 mm
max height = 147 mm (including rtax-adapter and excluding thermal stand-offs)

5.3 Overview, specs of device

The EPT-HET unit consist of two sensor heads and one Ebox. As seen in Fig. 4-7-1, the EPT and HET share a common Ebox which includes the analog board, digital board, power board and two preamp boards for each of the two sensor heads.

5.4 Software

N/A

5.5 Connections

Table 3: Connections

Cable	Description	Connector End A		Connector End D		Labelling	Total Lenght (m)
		Number	Type	Number	Type		
1	HET/EPT 2	P13_S	MDM15	P33_P	MDM25	EPD.HAR.EM 320720.EM	7.18
2	HET/EPT 1	P09_S	MDM15	P29_P	MDM25	EPD.HAR.EM 320730.EM	2

5.6 Housing, material

Aluminum

6 Test procedures and conditions

6.1 Operation mode

STF streaming mode

6.2 Criteria for immunity tests

N/A

6.3 Test software

emissiont EMIS Version 1.0

susceptibilityt Compliance 3,Version 1.0.

6.4 Power voltage

28V DC

6.5 Arrangement of the device

See pictures

6.6 Environmental parameters

Temperature:	21.3° C
Humidity:	38.6 % rel hum
Altitude:	101.17 kPa

6.7 Safekeeping of EMI in the customers operating instruction

The operating instruction of the customers product must describe the operation of the equipment regarding the EMI regulations for use, installation and service.

7 Test configuration

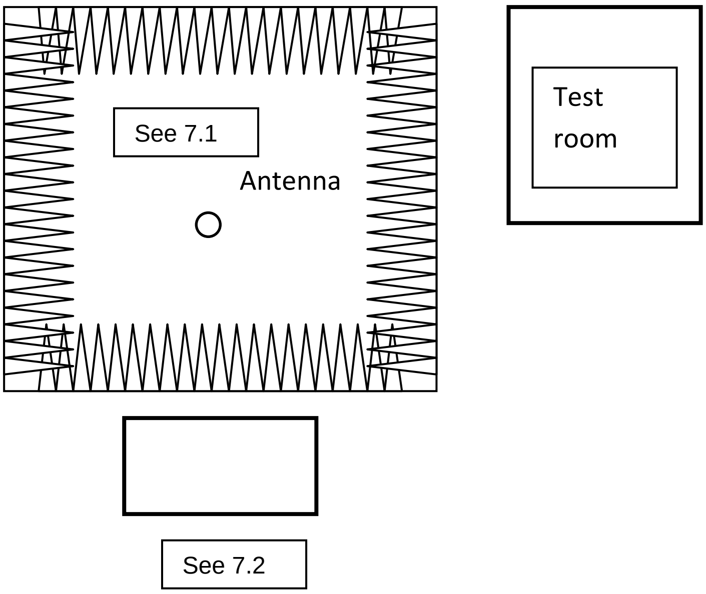


Fig. 2: Test configuration

7.1 Configuration EUT within test chamber

- SOLAR ORBITER ENERGETIC PARTICLE DETECTOR HET-EPT EM1, composed of:
  - HET-EPT LVPS V2, with 94µF input filter capacitance and 16.8µH differential inductance before the first capacitor.
  - HETEPTDIG EM1 with aldec flash FPGA.

    bitfile: heteptdig em/v03, options 24MHz, 115200baud, mem16ee
  - HETEPTANA EM1 with BGA in a socket FPGA

    bitfile: heteptana em/v01
  - EM1 sensor heads
- EM harness, het-ept1, 2m
- LISN as provided by the EPD Project Office:
  - with proper MDM mounting hardware
  - fixed power pins on D25
  - Breakout box connected to 4mm banana sockets in the lid.

- FET switch for the inrush current test.

7.2 Configuration EUT outside test chamber

- sologse 2, firmware svn revision r2615
- etsolo1 computer, with GSE software svn revision r2644
- EMI test harness between GSE and LISN, pink 10m cat5, with shield at the last 2m.

8 Testplan and Result of individual tests

8.1 Conducted emission, inrush current on power leads(6.2)*

According to SO-EPD-KIE-TP-0008, Issue 1, Revision 1, date 14.03.2014:

Taking to account the characteristics of the LCL include in the ICU the units shall meet the following values (EIDA R-318a-DFU):

Inrush current duration (in ms):	<4 ms. (trip-off time of ICU LCL 5-10ms)
Total Charge:	1.6 mC

Maximum Current during LCL reaction time (15-20 us) shall be less than 5A.

The unit is powered by using a Line Impedance Stabilisation Network (LISN) with an external bounce-free relay (e.g. laboratory mercury relay) installed between the LISN and the user on the positive power line, as shown in Figure below.

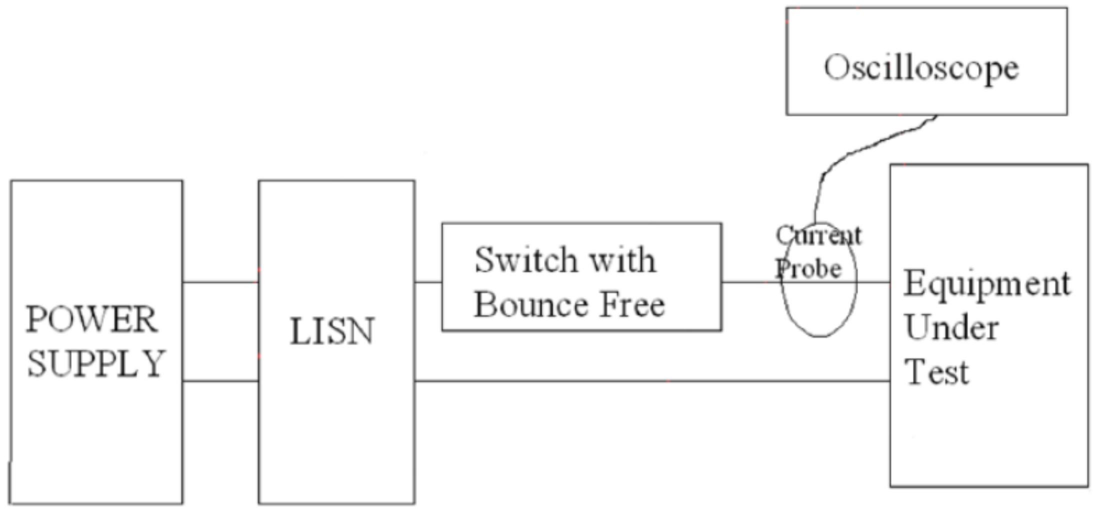


Fig. 3: Schematic of Test Set-Up for inrush current

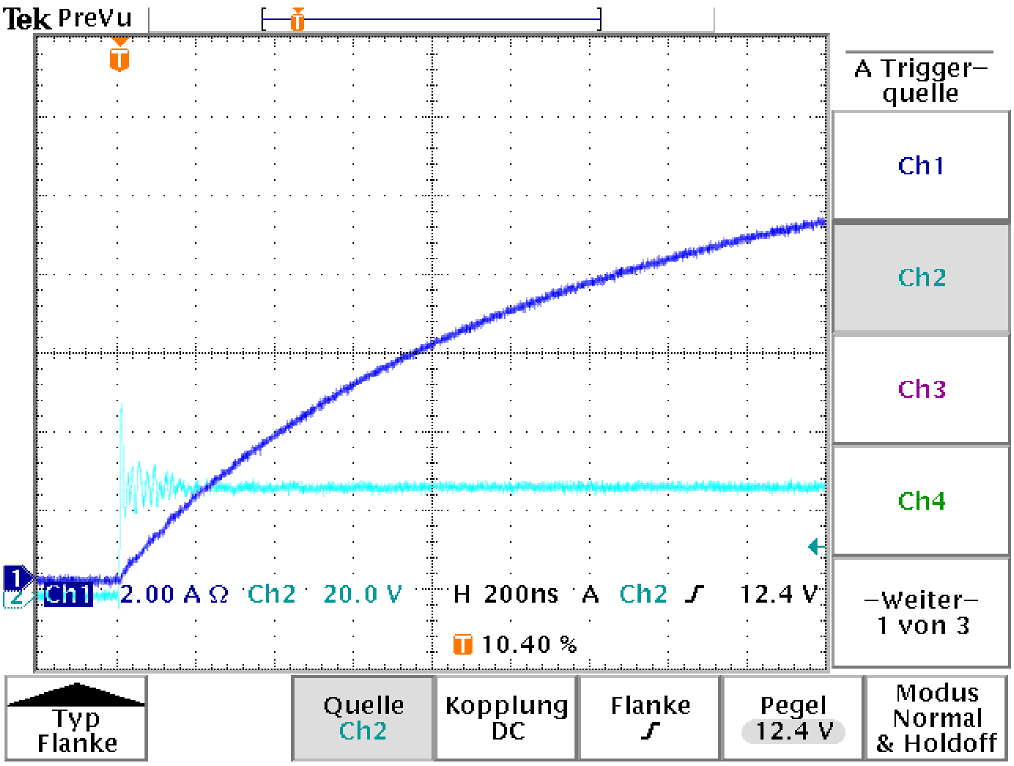


Fig. 4: dI/dt <= 2A/µs

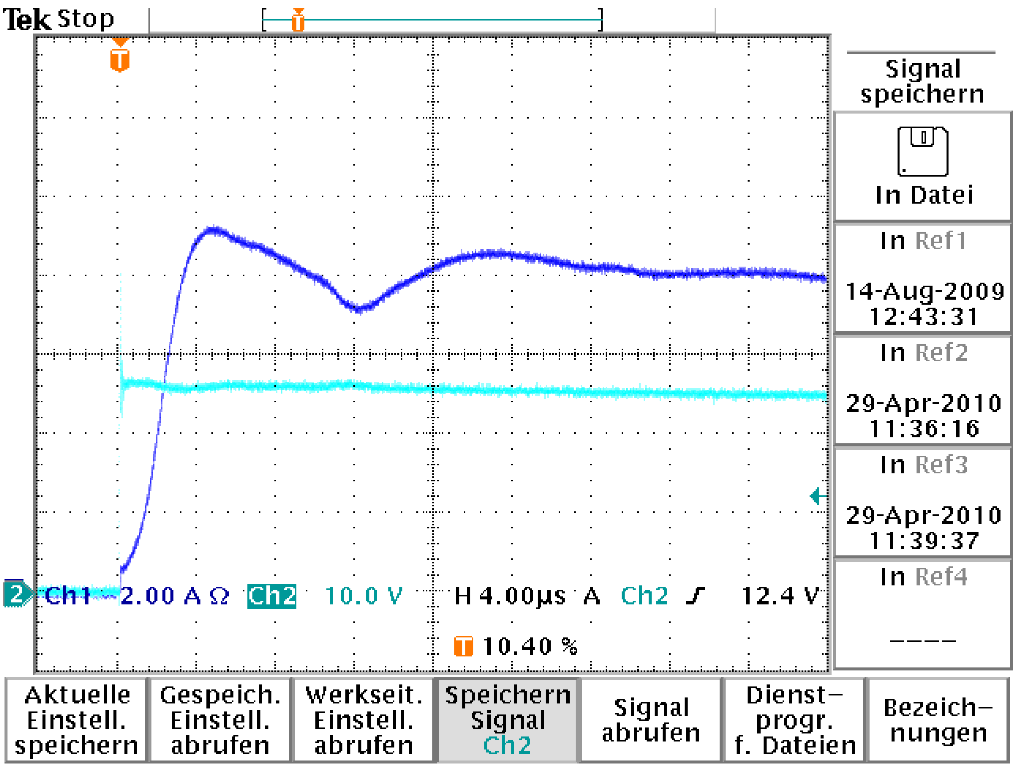


Fig. 5: dI/dt <= 2A/µs min. voltage 26V 4µs

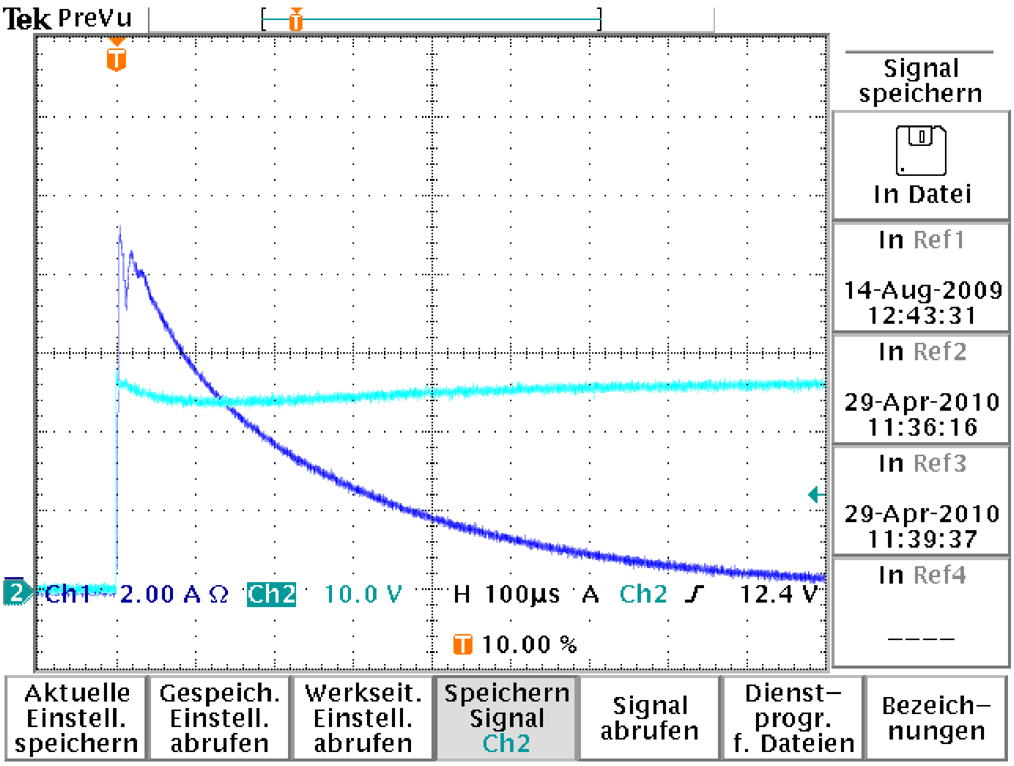


Fig. 6: dI/dt <= 2A/µs min. voltage 26V 100µs

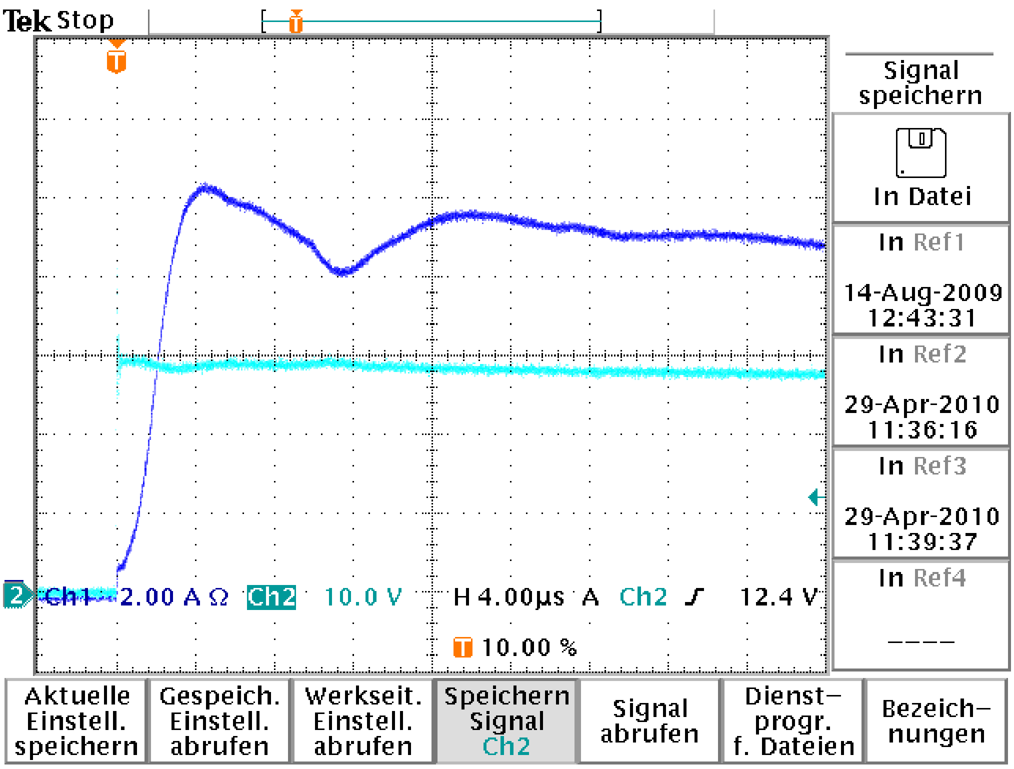


Fig. 7: dI/dt <= 2A/µs max. voltage 29V 4µs

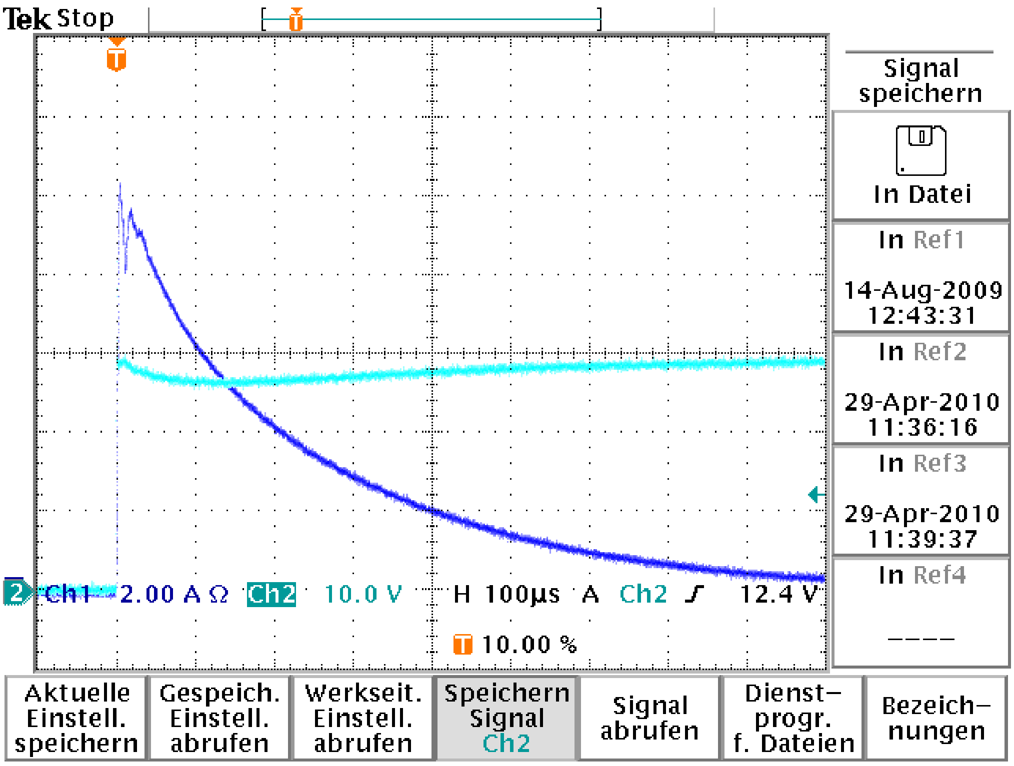


Fig. 8: dI/dt <= 2A/µs max. voltage 29V 100µs

8.2 Conducted emission on power leads, common mode, 30 Hz to 100 MHz, frequency domain(6.3)*

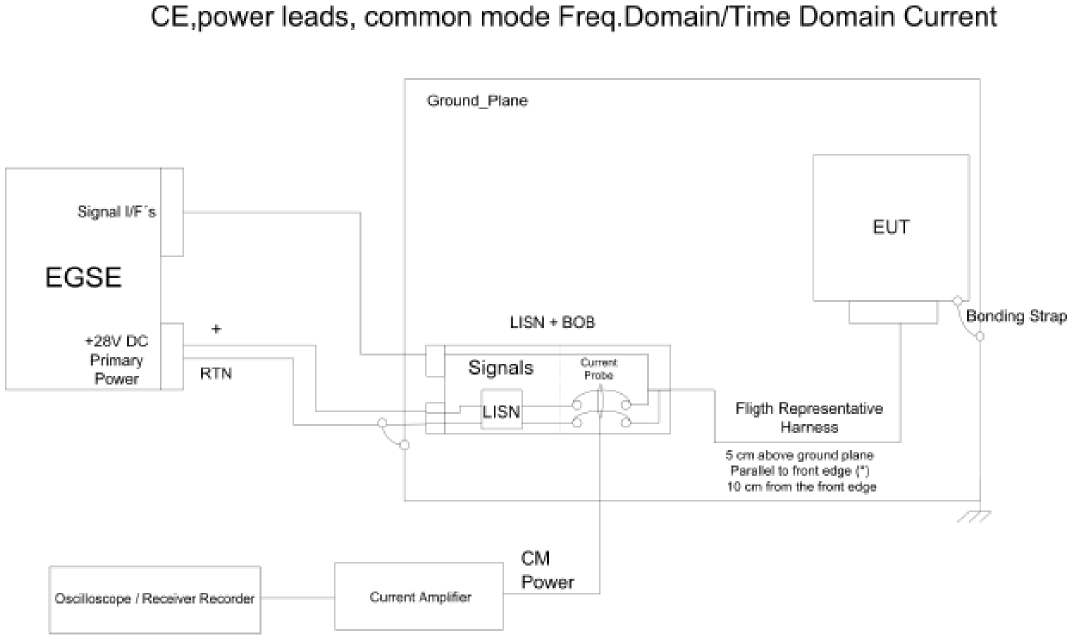


Fig. 9: Schematic of Test Set-Up for CE-CM-FD

The uncertainty of the emission measurements is max. 3.0 dB

8.2.1 Conducted Emission 100Hz – 100MHz Noise CM

E.U.T. : SOLAR ORBITER ENERGETIC PARTICLE DETECTOR EPT-HET

Test Procedure : SO-EPD-KIE-TP-0008, Issue 1, Revision 1, date 14.03.2014

Comment : Limit curve for noise limit

Test Engineer : P.Sell

Receiver : ESS

Start Freq.	Stop Freq.	Bandw.	Step	Detector	Transducer
100.000 Hz	1.000 kHz	10 Hz	0.003 kHz	PEAK	0057
1.000 kHz	10.000 kHz	100 Hz	0.020 kHz	PEAK	0057
10.000 kHz	150.000 kHz	1 kHz	0.200 kHz	PEAK	0057
150.000 kHz	30.000 MHz	10 kHz	5.000 kHz	PEAK	0058
30.000 MHz	100.000 MHz	100 kHz	50.000 kHz	PEAK	0058

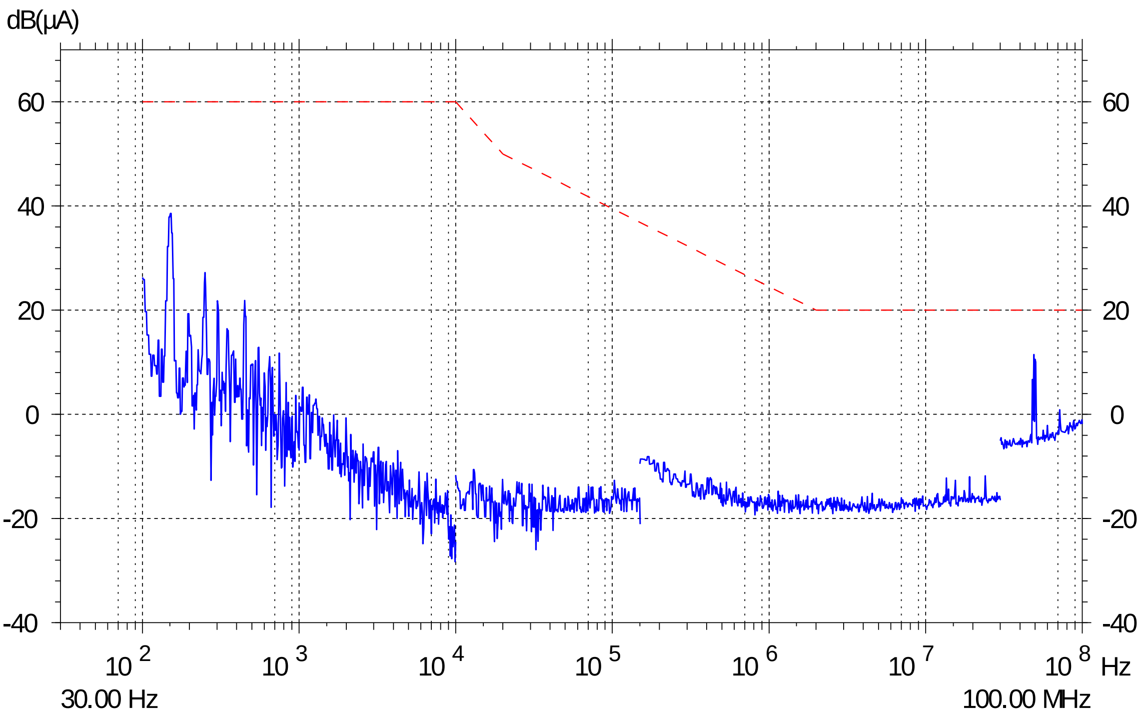


Fig. 10: Conducted Emission 100Hz – 100MHz Noise CM

8.2.2 Conducted Emission 30Hz – 100MHz Noise CM

E.U.T. : SOLAR ORBITER ENERGETIC PARTICLE DETECTOR EPT-HET

Test Procedure : SO-EPD-KIE-TP-0008, Issue 1, Revision 1, date 14.03.2014

Comment : limit line for noise limit, limit line for measured values

Test Engineer : P.Sell

Receiver : ESS

Start Freq.	Stop Freq.	Bandw.	Step	Detector	Transducer
30.000 Hz	1.000 kHz	10 Hz	0.003 kHz	PEAK	0057
1.000 kHz	10.000 kHz	100 Hz	0.020 kHz	PEAK	0057
10.000 kHz	150.000 kHz	1 kHz	0.200 kHz	PEAK	0057
150.000 kHz	30.000 MHz	10 kHz	5.000 kHz	PEAK	0058
30.000 MHz	100.000 MHz	100 kHz	50.000 kHz	PEAK	0058

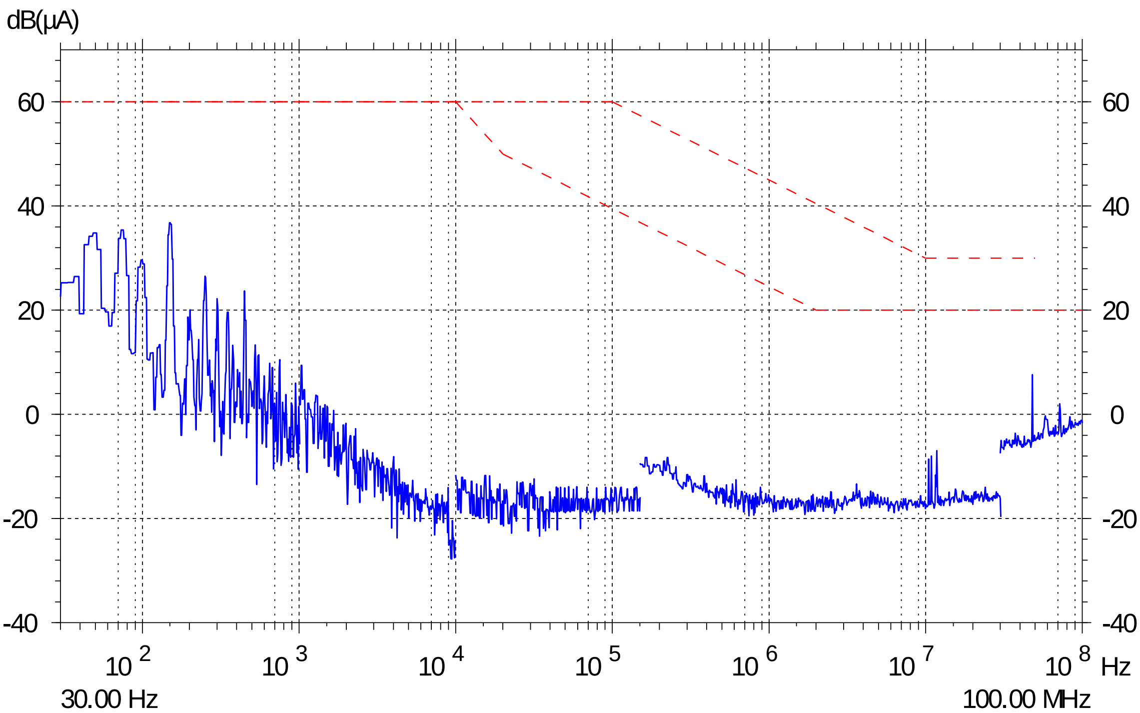


Fig. 11: Conducted Emission 30Hz – 100MHz Noise CM

8.2.3 Conducted Emission 30Hz – 100MHz CM

E.U.T. : SOLAR ORBITER ENERGETIC PARTICLE DETECTOR EPT-HET

Test Procedure : SO-EPD-KIE-TP-0008, Issue 1, Revision 1, date 14.03.2014

Comment : limit line for measured values, frequency range 50MHz -100MHz for information only

Test Engineer : P.Sell

Receiver : ESS

Start Freq.	Stop Freq.	Bandw.	Step	Detector	Transducer
30.000 Hz	1.000 kHz	10 Hz	0.003 kHz	PEAK	0057
1.000 kHz	10.000 kHz	100 Hz	0.020 kHz	PEAK	0057
10.000 kHz	150.000 kHz	1 kHz	0.200 kHz	PEAK	0057
150.000 kHz	30.000 MHz	10 kHz	5.000 kHz	PEAK	0058
30.000 MHz	100.000 MHz	100 kHz	50.000 kHz	PEAK	0058

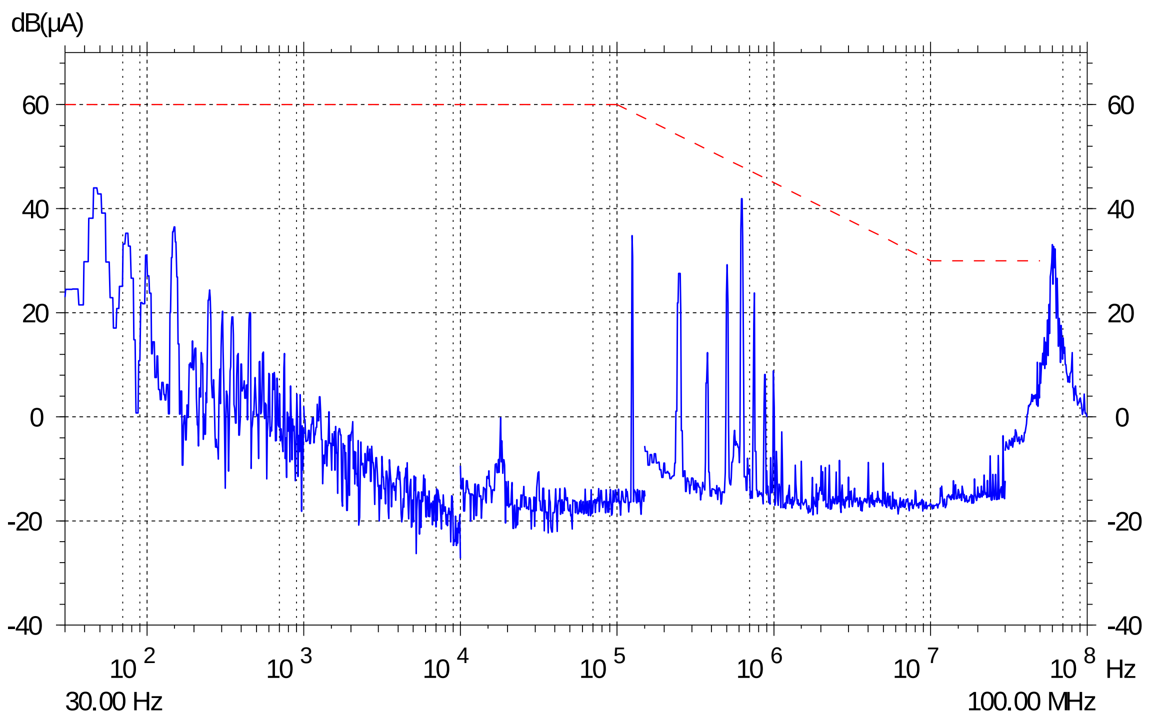


Fig. 12: Conducted Emission 30Hz – 100MHz CM

8.3 Conducted emission on power leads, common mode, 30 Hz to 100 MHz, time domain(6.4)*

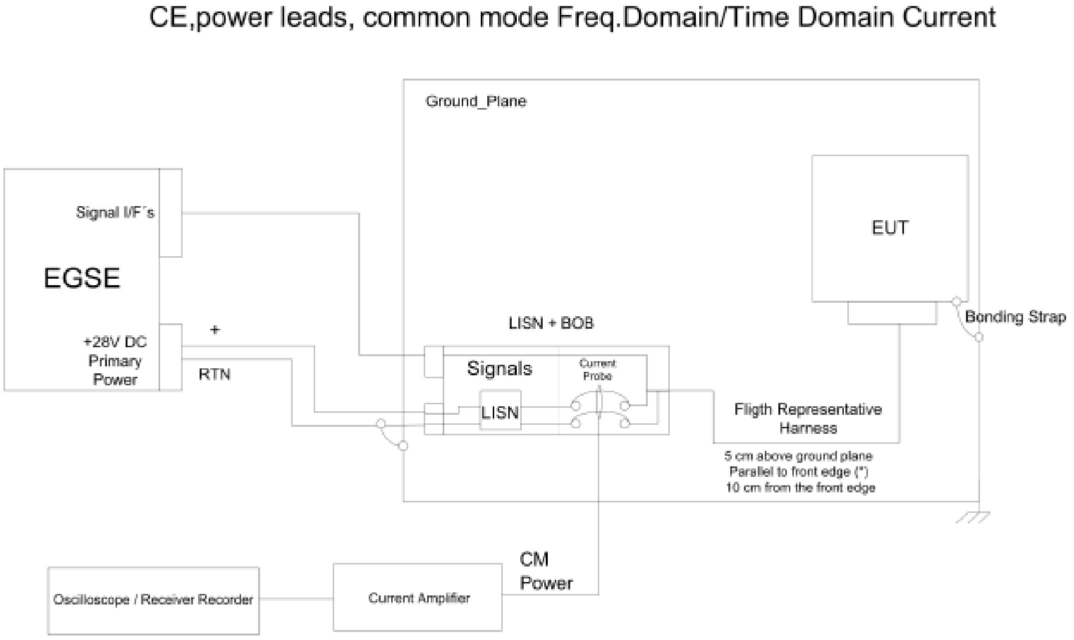


Fig. 13: Schematic of the Test Set-Up for CE-CM-TD

According to SO-EPD-KIE-TP-0008, Issue 1, Revision 1, date 14.03.2014:

EIDA R-317: The PI and Prime Contractor shall ensure that current ripple and spikes are ≤ 5 mApp when measured with at least 50 MHz bandwidth.

According to [AD-2]:

EIDA R-317a-DFU: The EPD Sensors shall ensure that current ripple and spikes are ≤ 1 mApp when measured with at least 50 MHz bandwidth at Sensor/ICU interface. The test at ICU interface will be performed with simulate sensor load.

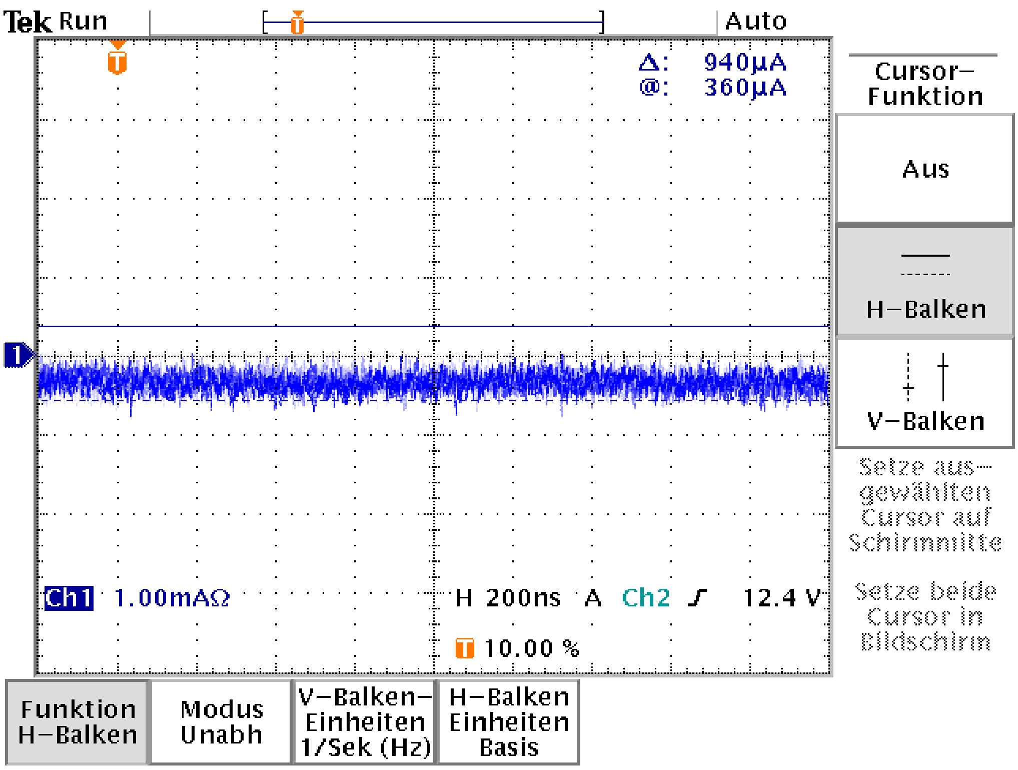


Fig. 14: Current ripple noise CM

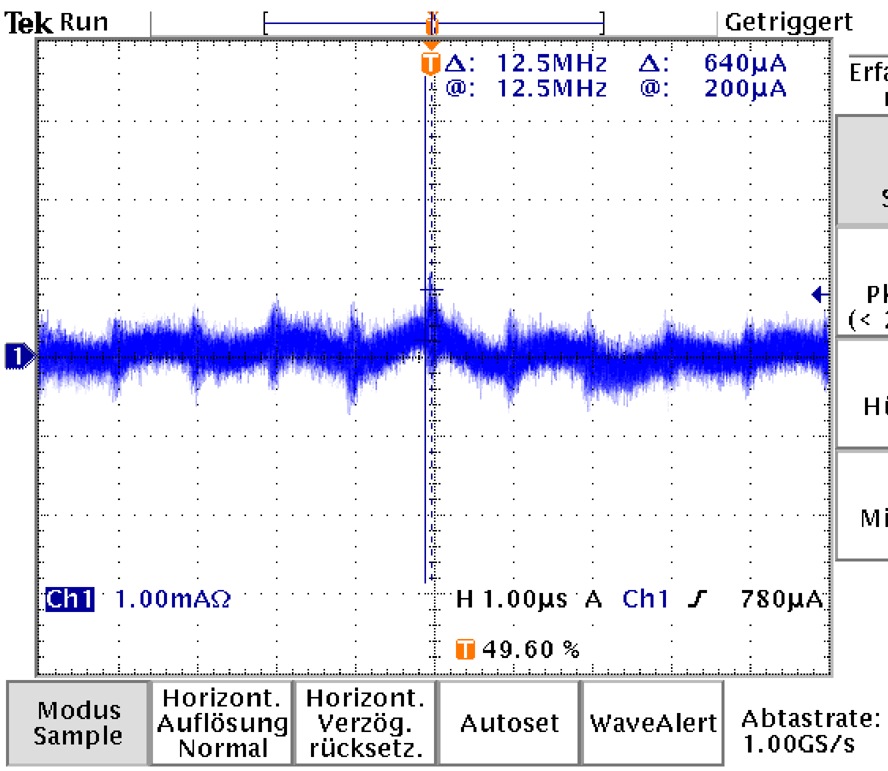


Fig. 15:Current ripple 40ns Signal at 1 MHz CM

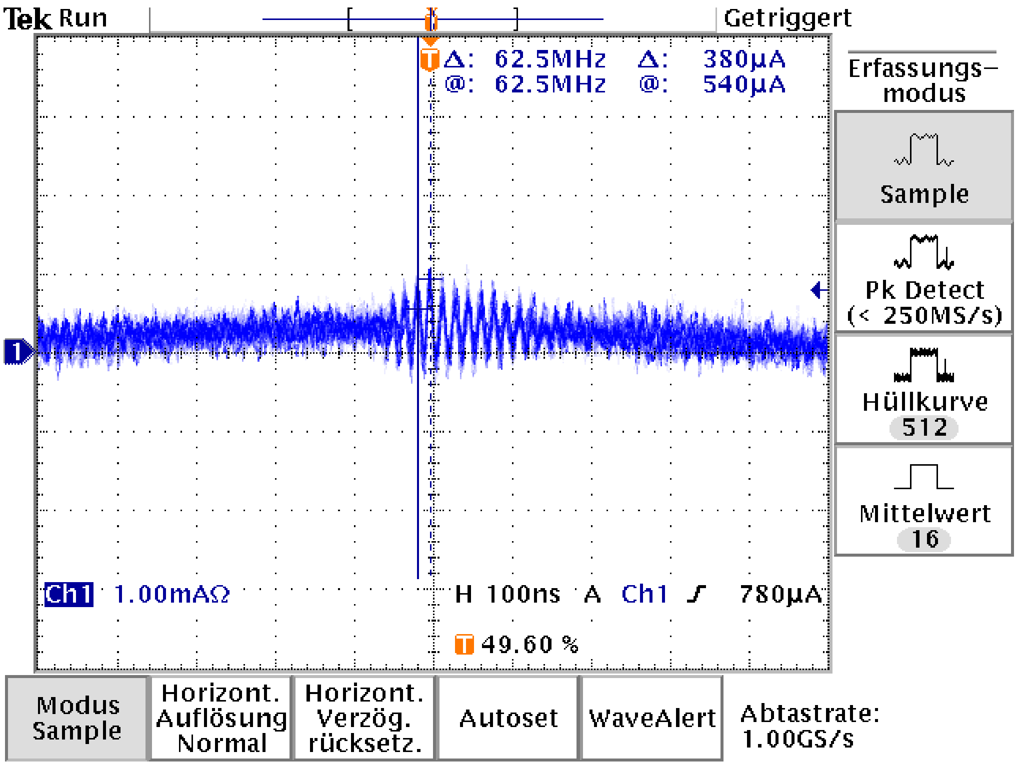


Fig. 16: Current ripple 40ns Signal at 1 MHz CM

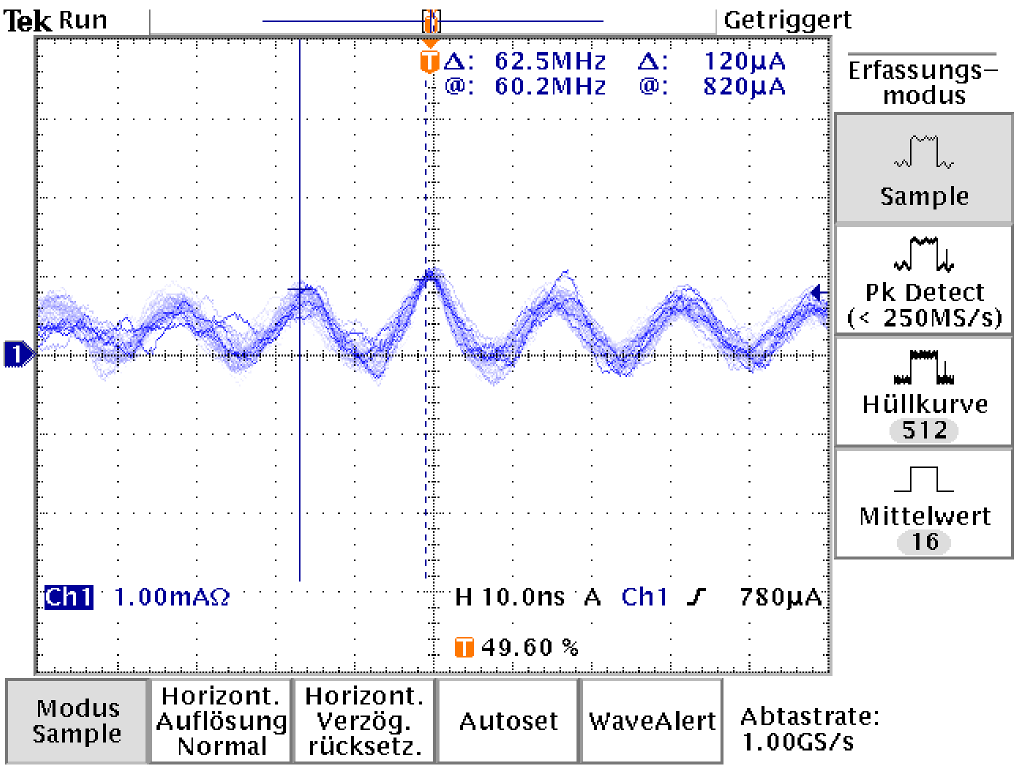


Fig. 17: Current ripple 40ns Signal at 62 MHz CM

8.4 Conducted emission on power leads differential mode, 30 Hz to 100 MHz, frequency domain(6.5)*

8.4.1 Conducted emission 30Hz – 100MHz NOISE DM +28V DC

E.U.T. : SOLAR ORBITER ENERGETIC PARTICLE DETECTOR EPT-HET

Test Procedure : SO-EPD-KIE-TP-0008, Issue 1, Revision 1, date 14.03.2014

Comment : limit line for measured values, frequency range 50MHz -100MHz for information only

Test Engineer : P.Sell

Receiver : ESS

Start Freq.	Stop Freq.	Bandw.	Step	Detector	Transducer
30.000 Hz	1.000 kHz	10 Hz	0.003 kHz	PEAK	0057
1.000 kHz	10.000 kHz	100 Hz	0.020 kHz	PEAK	0057
10.000 kHz	150.000 kHz	1 kHz	0.200 kHz	PEAK	0057
150.000 kHz	30.000 MHz	10 kHz	5.000 kHz	PEAK	0058
30.000 MHz	100.000 MHz	100 kHz	50.000 kHz	PEAK	0058

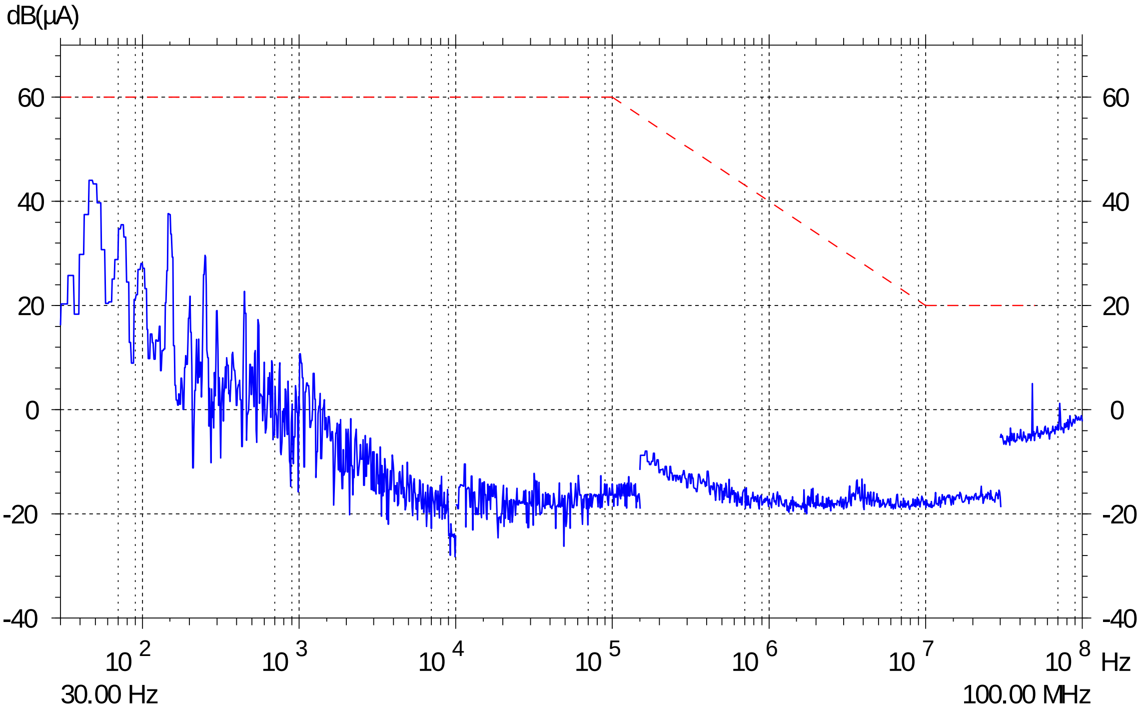


Fig. 18: Conducted emission 30Hz – 100MHz NOISE DM +28V DC

8.4.2 Conducted emission 30Hz – 100MHz NOISE DM 0V DC

E.U.T. : SOLAR ORBITER ENERGETIC PARTICLE DETECTOR EPT-HET

Test Procedure : SO-EPD-KIE-TP-0008, Issue 1, Revision 1, date 14.03.2014

Comment : limit line for measured values, frequency range 50MHz -100MHz for information only

Test Engineer : P.Sell

Receiver : ESS

Start Freq.	Stop Freq.	Bandw.	Step	Detector	Transducer
30.000 Hz	1.000 kHz	10 Hz	0.003 kHz	PEAK	0057
1.000 kHz	10.000 kHz	100 Hz	0.020 kHz	PEAK	0057
10.000 kHz	150.000 kHz	1 kHz	0.200 kHz	PEAK	0057
150.000 kHz	30.000 MHz	10 kHz	5.000 kHz	PEAK	0058
30.000 MHz	100.000 MHz	100 kHz	50.000 kHz	PEAK	0058

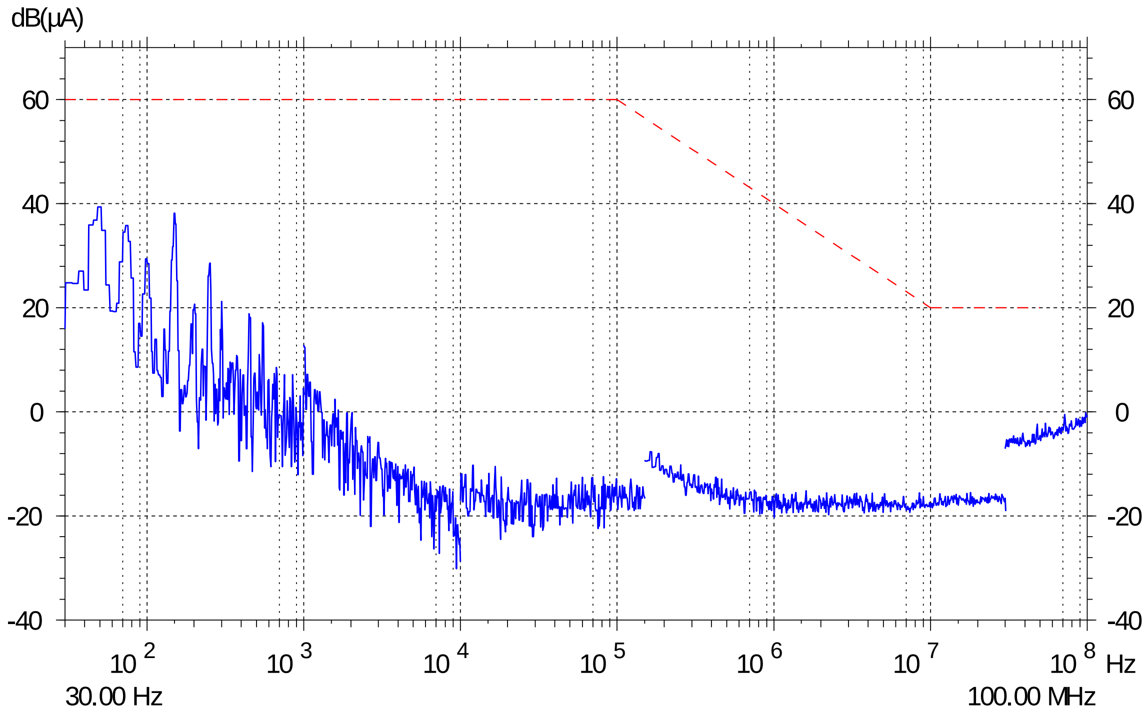


Fig. 19: Conducted emission 30Hz – 100MHz NOISE DM 0V DC

8.4.3 Conducted emission 30Hz – 100MHz DM +28V DC

E.U.T. : SOLAR ORBITER ENERGETIC PARTICLE DETECTOR EPT-HET

Test Procedure : SO-EPD-KIE-TP-0008, Issue 1, Revision 1, date 14.03.2014

Comment : limit line for measured values, frequency range 50MHz -100MHz for information only

Test Engineer : P.Sell

Receiver : ESS

Start Freq.	Stop Freq.	Bandw.	Step	Detector	Transducer
30.000 Hz	1.000 kHz	10 Hz	0.003 kHz	PEAK	0057
1.000 kHz	10.000 kHz	100 Hz	0.020 kHz	PEAK	0057
10.000 kHz	150.000 kHz	1 kHz	0.200 kHz	PEAK	0057
150.000 kHz	30.000 MHz	10 kHz	5.000 kHz	PEAK	0058
30.000 MHz	100.000 MHz	100 kHz	50.000 kHz	PEAK	0058

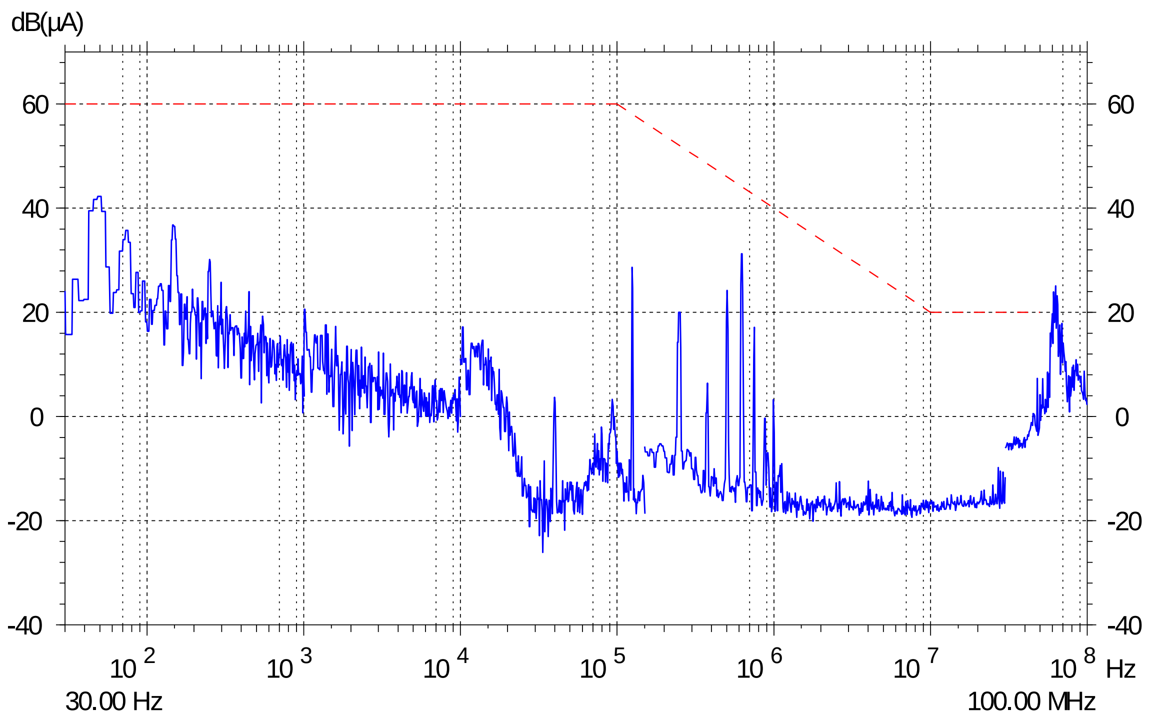


Fig. 20: Conducted emission 30Hz – 100MHz DM +28V DC

8.4.4 Conducted emission 30Hz – 100MHz DM 0V DC

E.U.T. : SOLAR ORBITER ENERGETIC PARTICLE DETECTOR EPT-HET

Test Procedure : SO-EPD-KIE-TP-0008, Issue 1, Revision 1, date 14.03.2014

Comment : limit line for measured values, frequency range 50MHz -100MHz for information only

Test Engineer : P.Sell

Receiver : ESS

Start Freq.	Stop Freq.	Bandw.	Step	Detector	Transducer
30.000 Hz	1.000 kHz	10 Hz	0.003 kHz	PEAK	0057
1.000 kHz	10.000 kHz	100 Hz	0.020 kHz	PEAK	0057
10.000 kHz	150.000 kHz	1 kHz	0.200 kHz	PEAK	0057
150.000 kHz	30.000 MHz	10 kHz	5.000 kHz	PEAK	0058
30.000 MHz	100.000 MHz	100 kHz	50.000 kHz	PEAK	0058

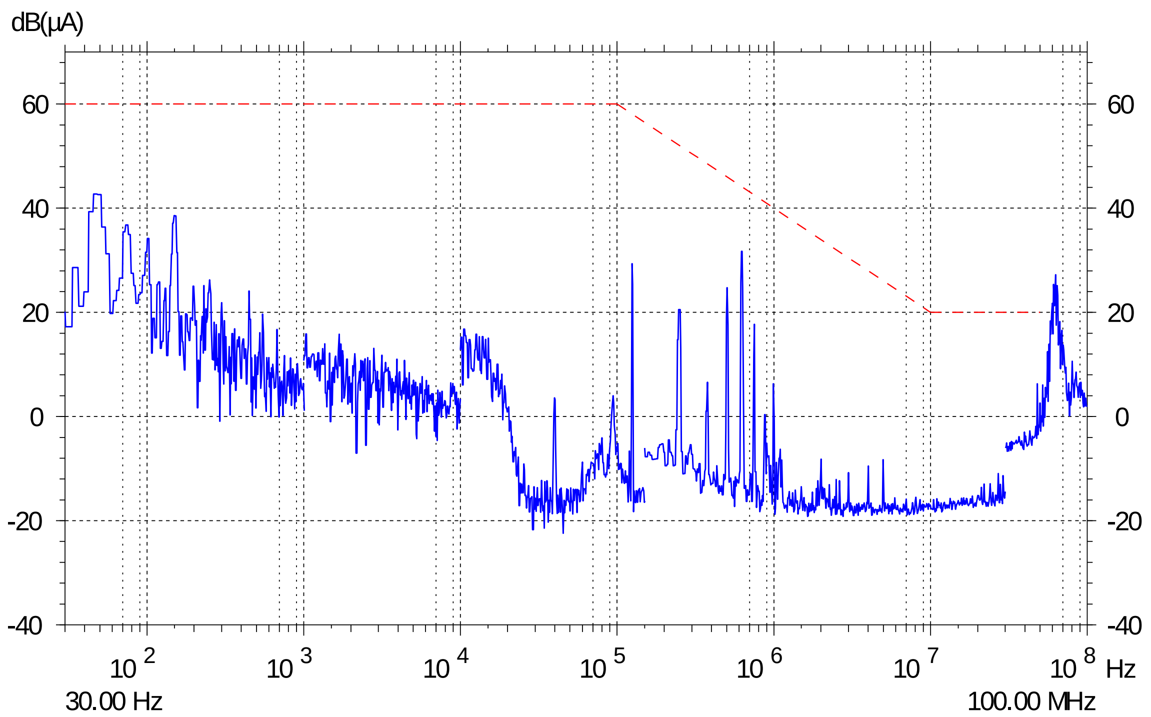


Fig. 21: Conducted emission 30Hz – 100MHz DM 0V DC

8.5 Conducted emission on power leads differential mode, 30 Hz to 100 MHz, time domain(6.6)*

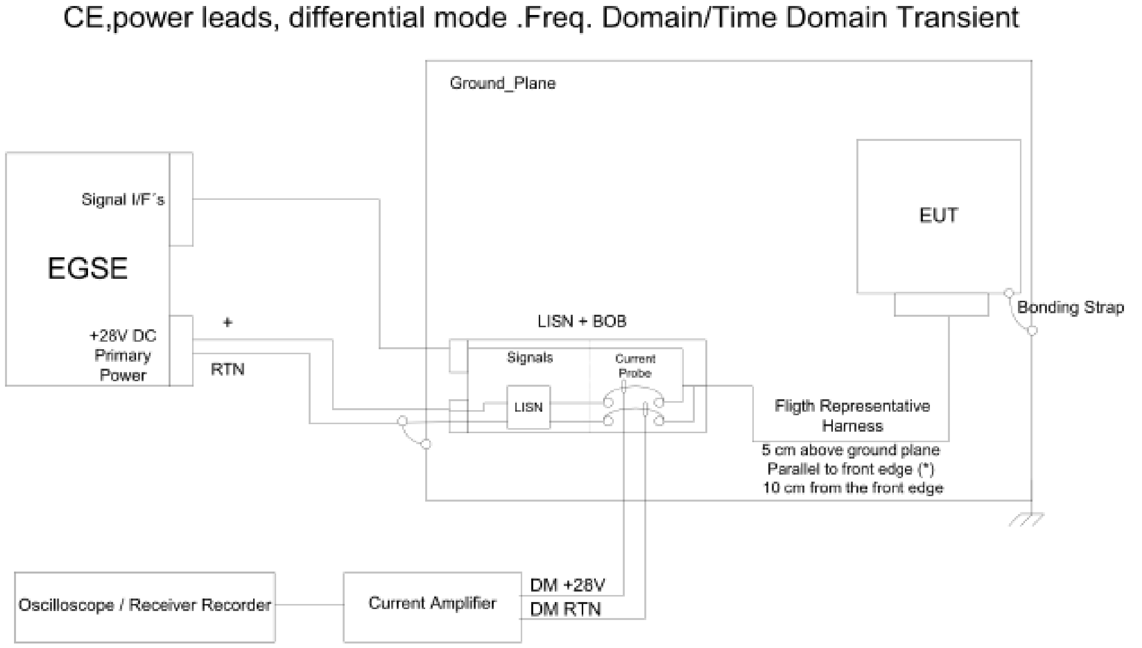


Fig. 22: Schematic of the Test Set-Up for CE-DM-TD

According to SO-EPD-KIE-TP-0008, Issue 1, Revision 1, date 14.03.2014:

EIDA R-315a-DFU: The EPD units shall ensure that current ripple and spikes on the primary power bus inputs of the units, measured on positive and return lines, are ≤ 3 mApp when measured with at least 50 MHz bandwidth.

EIDA R-316a-DFU: The EPD units shall ensure that voltage ripple / spikes on the primary power bus inputs of the units, measured between positive and return lines, are ≤ 25 mVpp (ripple) and ≤50 mVpp (spikes) when measured with at least 50 MHz bandwidth.

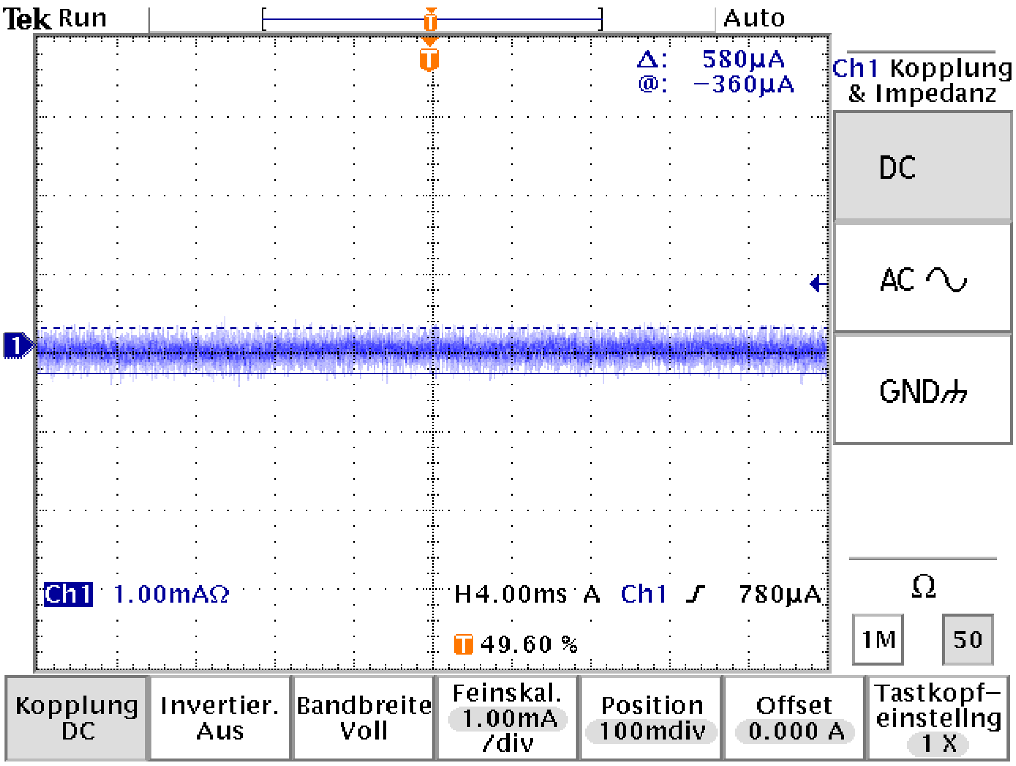


Fig. 23: Current ripple 4 ms DM +28V DC EUT off

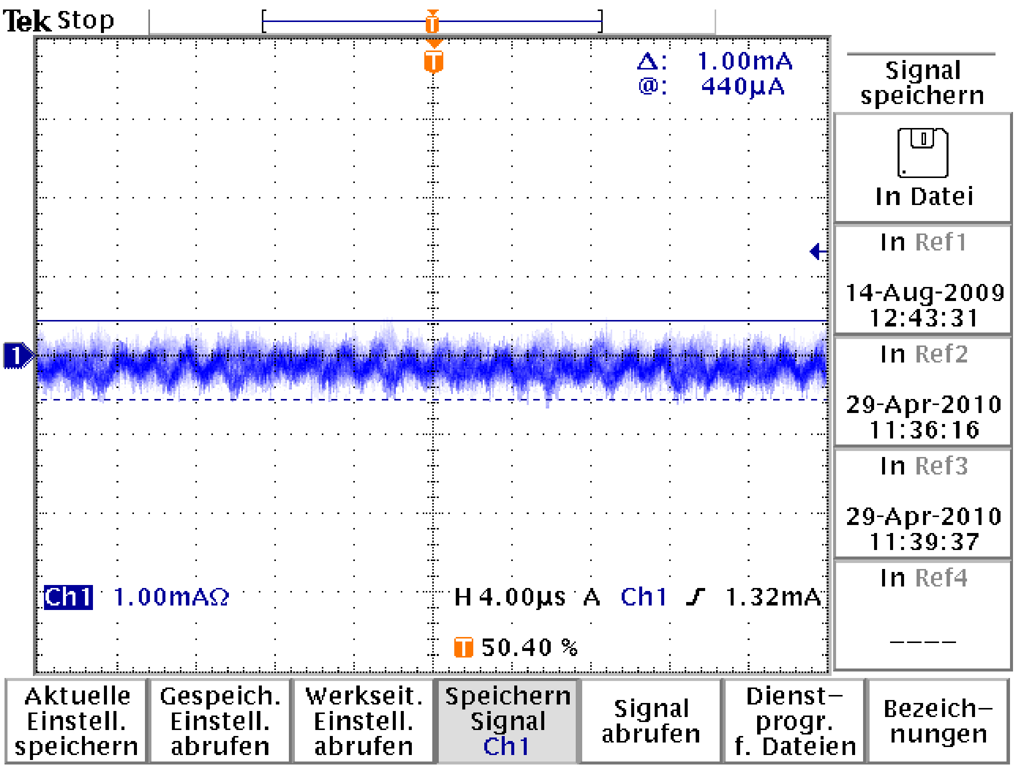


Fig. 24: Current ripple 4 µs DM +28V DC EUT on

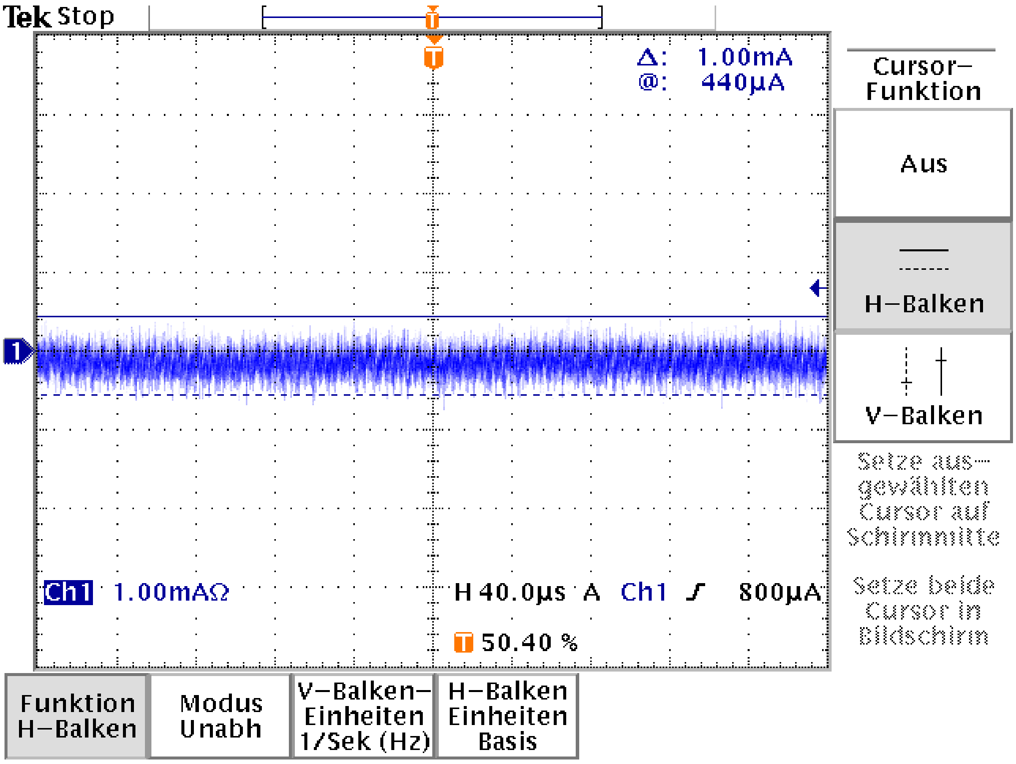


Fig. 25: Current ripple 40 µs DM 0V DC EUT on

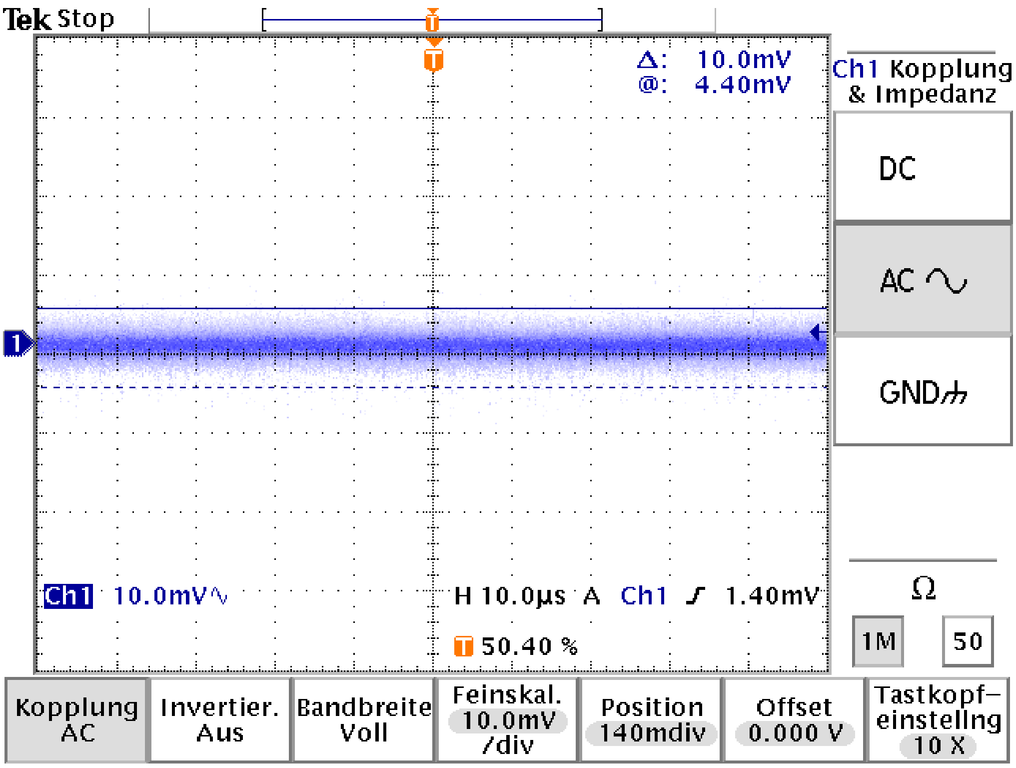


Fig. 26: Voltage ripple 10 µs DM DC EUT off

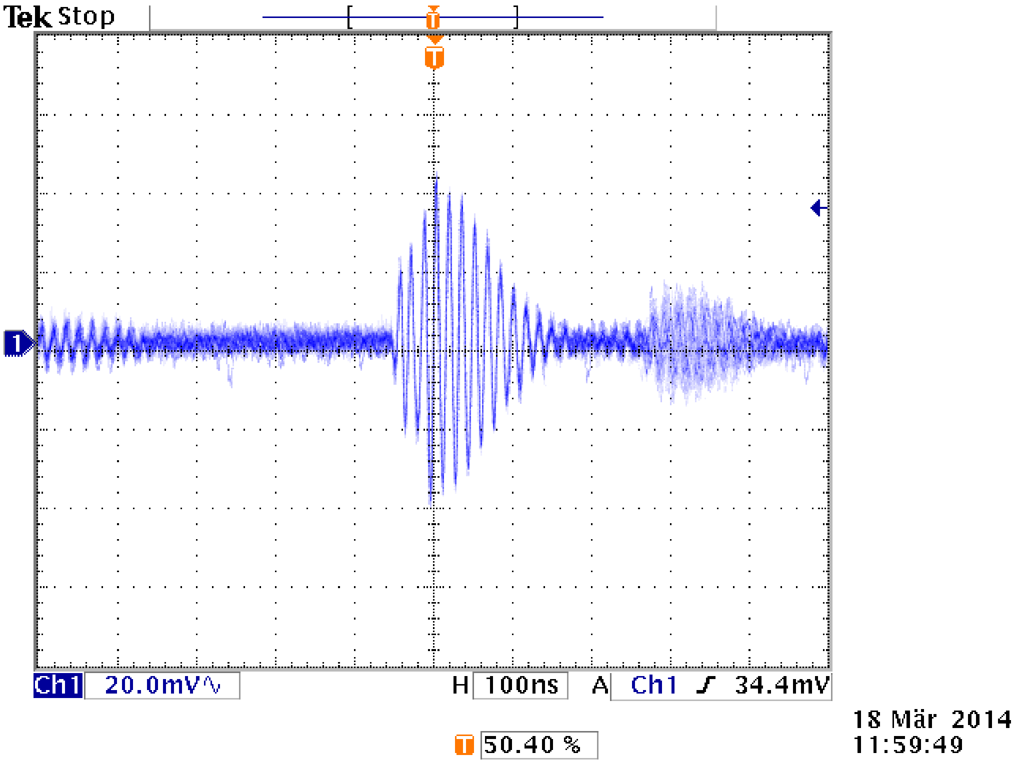


Fig. 27: Voltage ripple 100 ns, f = 62 MHz, 80mVpp, +28V DC EUT on

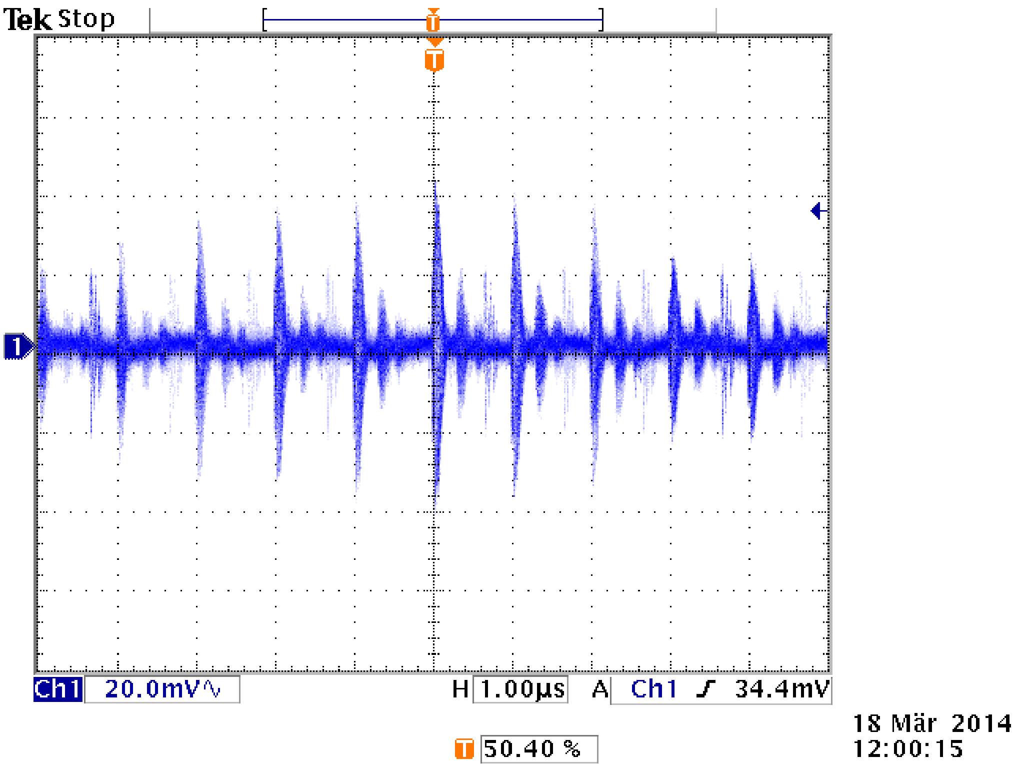


Fig. 28: Voltage ripple 1 µs, f = 1 MHz, 80mVpp, +28V DC EUT on

8.6 Conducted susceptibility on power leads in differential mode, 30 Hz to 100 kHz, frequency domain(6,7)*

CS, Calibration. Power Leads, differential mode, frequency domain (30Hz to 50KHz)

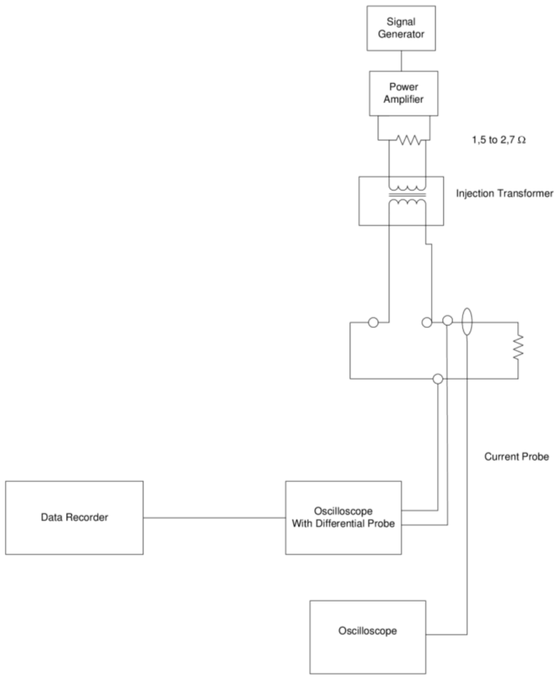


Fig. 29: System Calibration (30Hz – 50kHz)

CS, Power Leads, differential mode, frequency domain(30Hz to 50KHz)

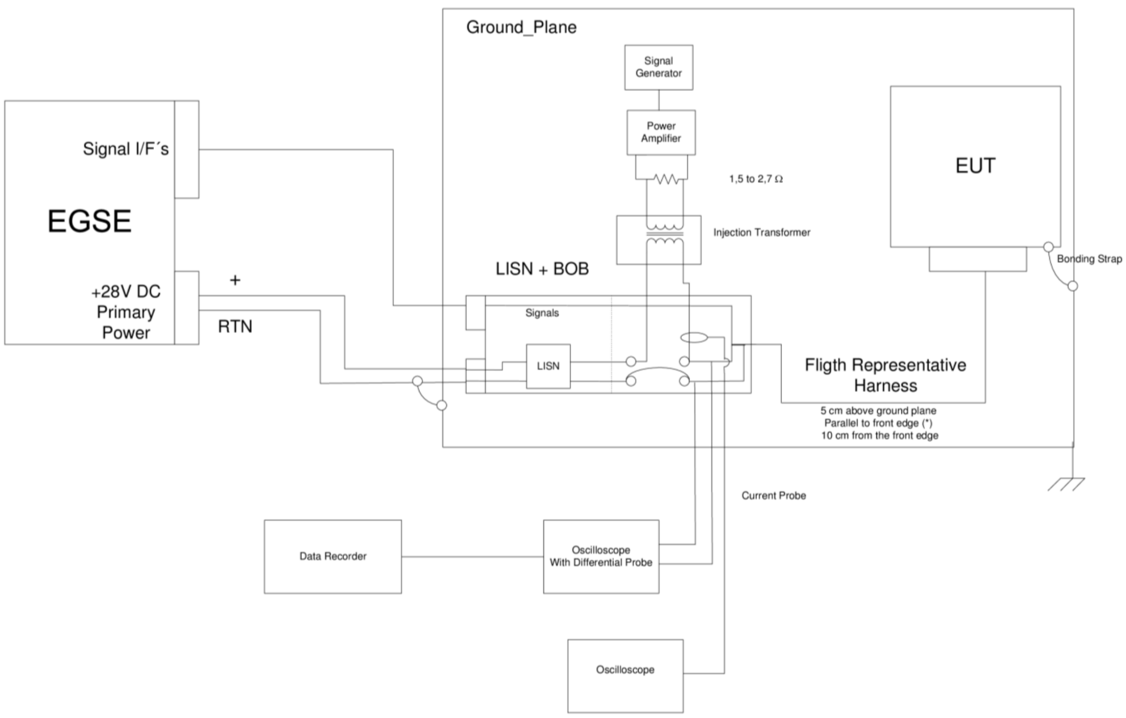


Fig. 30: Measuring set up(30Hz – 50kHz)

CS, Calibration Power Leads, Calibration differential mode, frequency domain(50kHz to 100KHz)

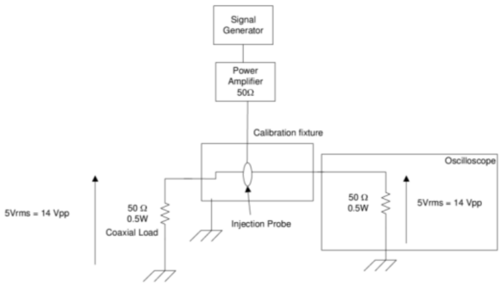


Fig. 31: System Calibration(50kHz-100kHz)

CS, Power Leads, differential mode, frequency domain(50kHz to 100KHz)

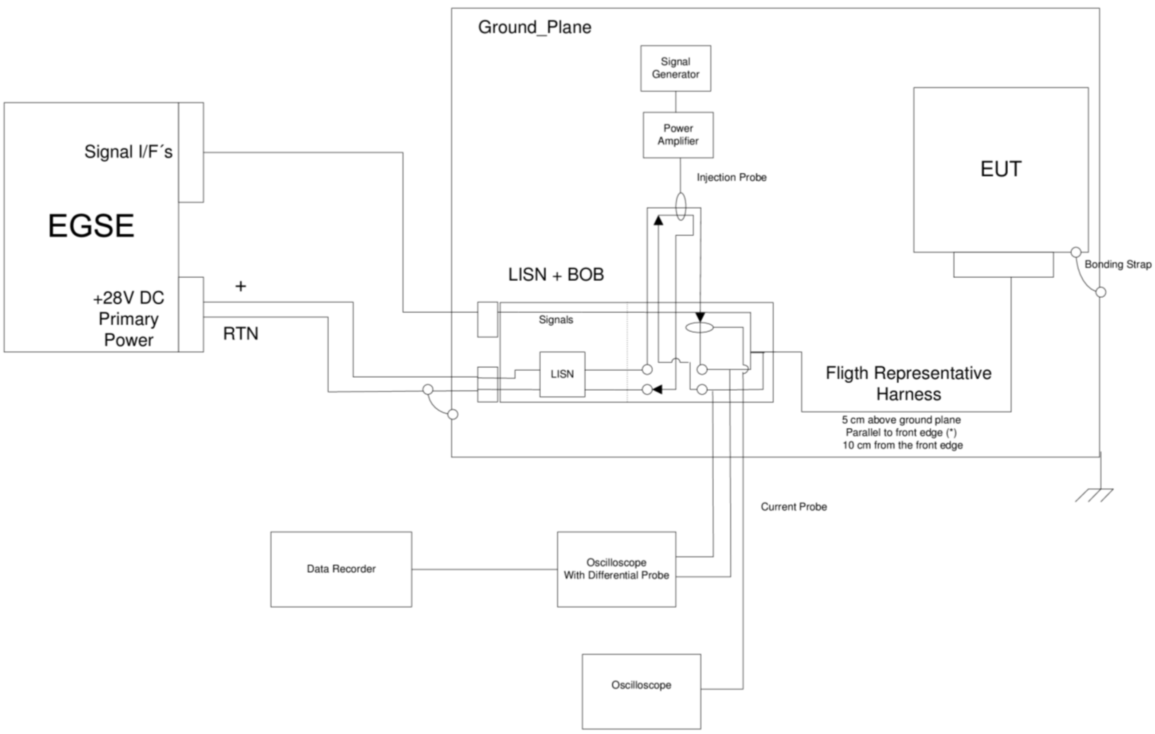


Fig. 32: Measuring set up(50kHz-100kHz)

The equipment under test was exposed to the following test signal:

Equipment Under Test supply 28 VDC

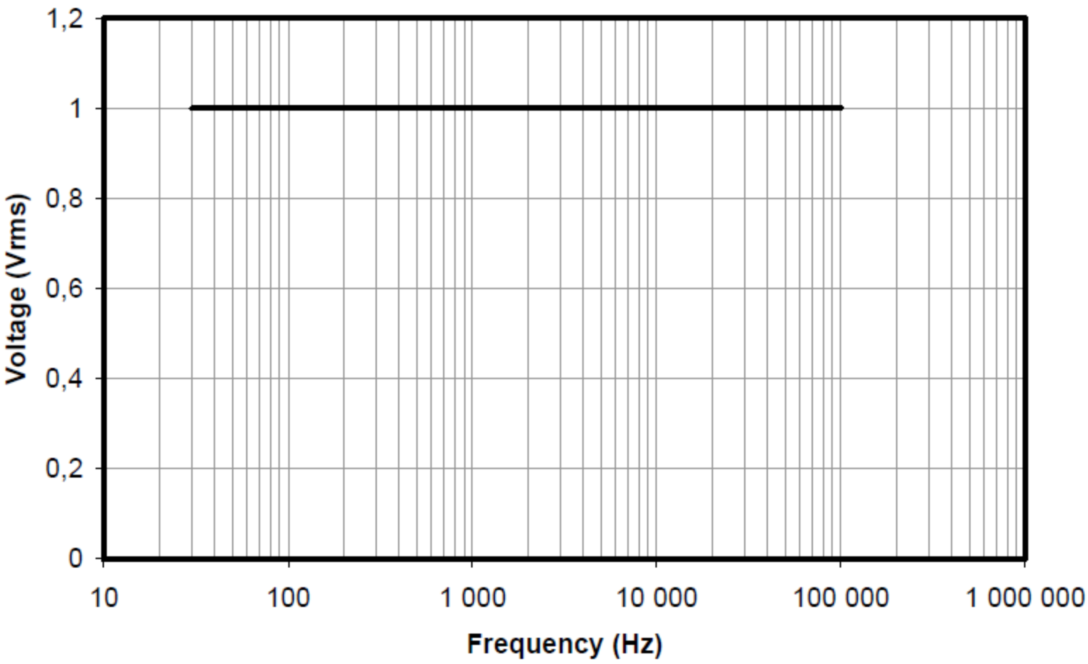


Fig. 33: Schematic of test signal

Measurement Uncertainty: 1 % of voltage range

Test result: Passed

8.7 Conducted susceptibility on power leads in differential mode, 30 Hz to 100 kHz, transient(6.8)*

CS, Calibration. Power Leads, differential mode, Time domain. Series/Parallel Injection.

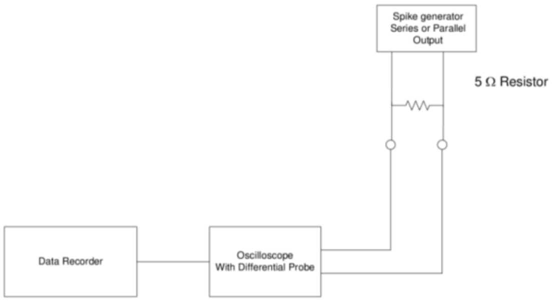


Fig. 34: System Calibration(30Hz – 100kHz)

CS, Power Leads, differential mode, Time domain. Series Injection.

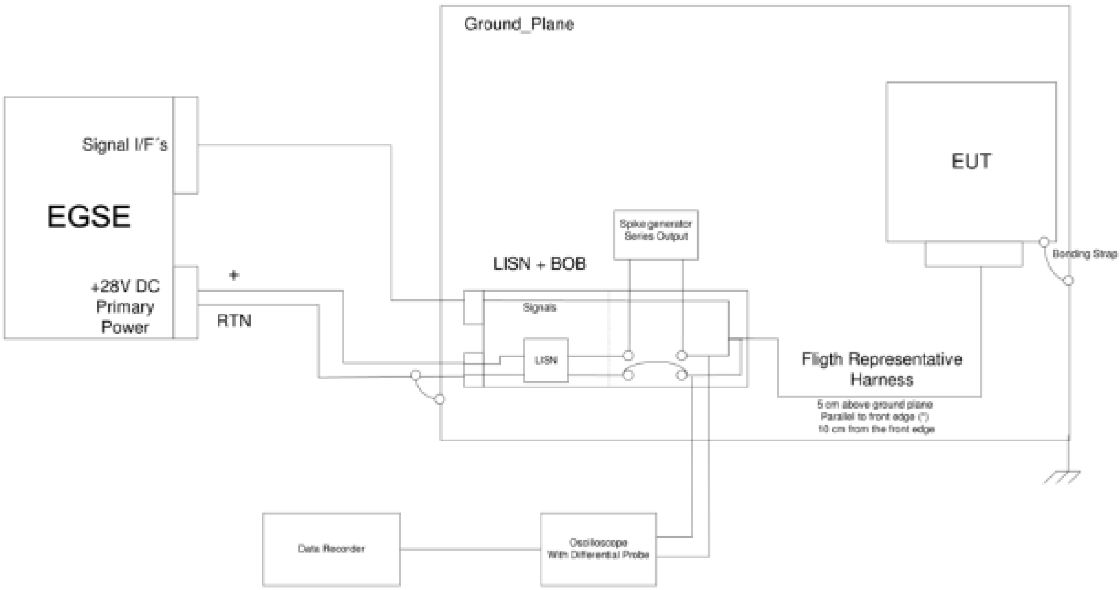


Fig. 35: Measuring set up(30Hz – 100kHz)

The equipment under test was exposed to the following test signal:

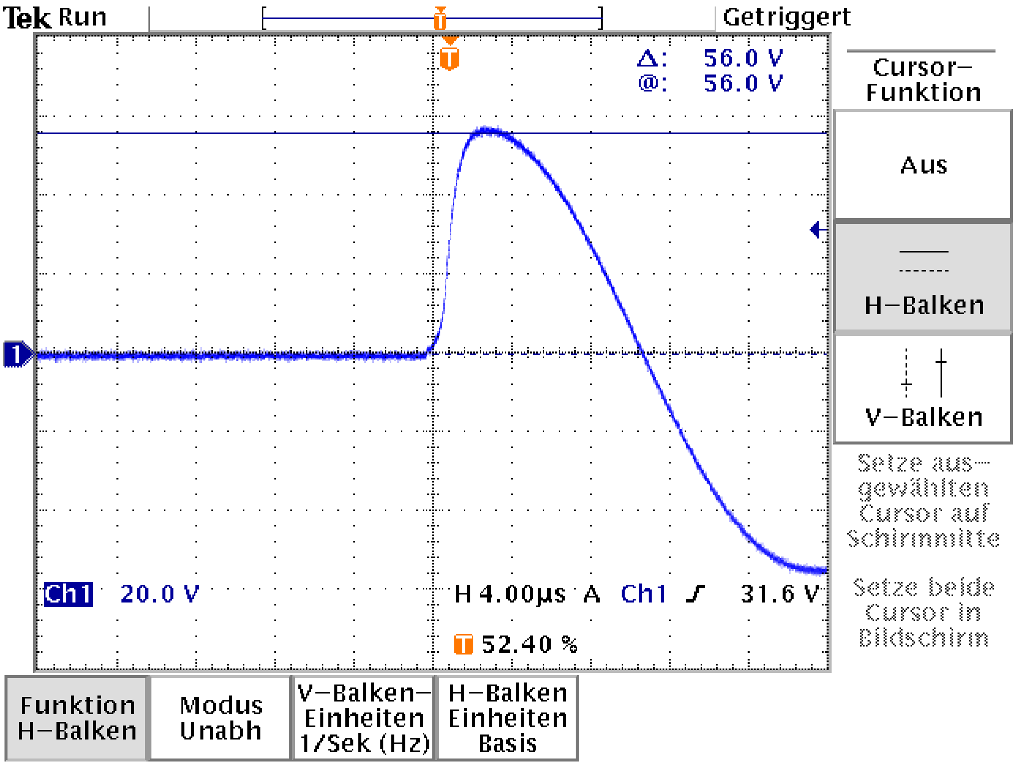


Fig. 36: Signal calibration at 5 Ω load

Measurement Uncertainty: 1 % of voltage range

Test result: Passed

8.8 Conducted susceptibility on power leads in common mode, 50 kHz to 100 MHz, frequency domain(6.9)*

The equipment under test was exposed to the following test signal: 50 kHz to 100 MHz.

Modulation:

Frequency range	Pulse repetition frequency	Duty cycle
50 kHz-1 MHz	1 kHz	50 % (squarewave)
1 MHz-10 MHz	100 kHz	20 %
10 MHz-100 MHz	100 kHz	5 %

Level:

the common mode level of 3 volts peak to peak or larger is applied

the limit of the current induced on the bundle is 3 A peak-to-peak

Data presentation for calibration and test

Range: 50 kHz – 1 MHz calibration (monitor probe 30 Hz – 30 MHz)

Frequency	Drive level of generator [dBm]	Vpp [Vpp]	Vrms [Vrms]	Irms x Z [mV]	Z [Ω]
50 kHz	-14.5 dBm	3.4 V	1.14 V	250 mV	1
100 kHz	-19.0 dBm	3.3 V	1.11 V	250 mV	1
200 kHz	-22.0 dBm	3.2 V	1.08 V	211 mV	1
500 kHz	-22.0 dBm	3.3 V	1.11 V	218 mV	1
1 MHz	-20.0 dBm	3.4 V	1.13 V	220 mV	1

Range: 50 kHz – 1 MHz test, achieved current (to be multiplied by 2 – modulation was 1kHz, 50% PM)

Frequency	Drive level of generator -20 dBm	Drive level of generator -17 dBm	Drive level of generator -14 dBm
50 kHz	64 mA	91 mA	128 mA
100 kHz	61 mA	86 mA	123 mA
200 kHz	66 mA	85 mA	120 mA
500 kHz	58 mA	81 mA	116 mA
1 MHz	58 mA	82 mA	117 mA

Range: 1 MHz – 10 MHz calibration (monitor probe 30 Hz – 30 MHz)

Frequency	Drive level of generator	Vpp	Vrms	Irms Calculated from transfer impedance Z of monitor probe	Z [Ω]
1 MHz	-23 dBm	3.2 V	1.07 V	20.9 mA	1
2 MHz	-20 dBm	3.3 V	1.11 V	20.5 mA	1
3 MHz	-19 dBm	3.2 V	1.06 V	22.7 mA	1
4 MHz	-18 dBm	3.3 V	1.12 V	24.6 mA	1
5 MHz	-19 dBm	3.1 V	1.04 V	21.9 mA	1
6 MHz	-20 dBm	3.1 V	1.05 V	21.5 mA	1
7 MHz	-21 dBm	3.2 V	1.09 V	22.0 mA	1
8 MHz	-21 dBm	3.3 V	1.12 V	22.2 mA	1
9 MHz	-20 dBm	3.3 V	1.10 V	21.1 mA	1
10 MHz	-19 dBm	3.1 V	1.05 V	19.8 mA	0.95

Range: 1 MHz – 10 MHz test, achieved current (modulation was 100kHz, 20% PM)

Frequency	Drive level of generator	Irms x Z [mV]	Ipp x Z [mV]	Z [Ω]
1 MHz	-38 dBm	11	50	1
2 MHz	-38 dBm	15	63	1
3 MHz	-38 dBm	27	117	1
4 MHz	-38 dBm	11	46	1
5 MHz	-38 dBm	7	30	1
7 MHz	-38 dBm	7.5	34	1
10 MHz	-38 dBm	5.2	25	0.95

Frequency	Drive level of generator	Irms x Z [mV]	Ipp x Z [mV]	Z [Ω]
1 MHz	-26 dBm		190	1
1.4 MHz	-26 dBm		206	1
2 MHz	-26 dBm		267	1
3 MHz	-26 dBm		482	1
4 MHz	-26 dBm		202	1
8 MHz	-26 dBm		211	1
9 MHz	-26 dBm		169	1
10 MHz	-26 dBm		100	0.95

Frequency	Drive level of generator	Irms x Z [mV]	Ipp x Z [mV]	Z [Ω]
1 MHz	-20 dBm		370	1
1.4 MHz	-20 dBm		394	1
2 MHz	-20 dBm		524	1
2.5 MHz	-20 dBm		692	1
3 MHz	-20 dBm		965	1
3.5 MHz	-20 dBm		668	1
4 MHz	-20 dBm		388	1
5 MHz	-20 dBm		246	1
6 MHz	-20 dBm		226	1
7 MHz	-20 dBm		274	1
8 MHz	-20 dBm		410	1
9 MHz	-20 dBm		324	1
10 MHz	-20 dBm		190	0.95

Range: 10 MHz – 100 MHz calibration (monitor probe 10 kHz – 100 MHz)

Frequency	Drive level of generator	Vpp	Vrms	Irms Calculated from transfer impedance Z of monitor probe
10 MHz	-19 dBm	3.0 V	1.01 V	108 mV / 5.4 Ω = 20 mA
20 MHz	-19 dBm	3.0 V	1.01 V	100 mV / 5.5 Ω = 18.1 mA
30 MHz	-21 dBm	3.15 V	1.06 V	87.2 mV / 5.5 Ω = 15.8 mA
40 MHz	-21 dBm	3.3 V	1.09 V	78.6 mV / 5.4 Ω = 14.5 mA
60 MHz	-17 dBm	3.2 V	1.07 V	88.1 mV / 4.8 Ω = 18.3 mA
80 MHz	-16 dBm	3.2 V	1.07 V	82.0 mV / 4.6 Ω = 17.8 mA
100 MHz	-19 dBm	3.3 V	1.12 V	67.7 mV / 3.9 Ω = 17.3 mA

Range: 10 MHz – 100 MHz test, achieved current (modulation was 100kHz, 5% PM)

Frequency	Drive level of generator	Irms [mA] Calculated from transfer impedance of monitor probe	Z [Ω]
10 MHz	-32 dBm	209	5.4
14 MHz	-32 dBm	317	5.45
20 MHz	-32 dBm	89	5.5
25 MHz	-32 dBm	14	5.5
30 MHz	-32 dBm	130	5.5
40 MHz	-32 dBm	388	5.4
50 MHz	-32 dBm	250	5.1
60 MHz	-32 dBm	118	4.8
70 MHz	-32 dBm	260	4.7
80 MHz	-32 dBm	230	4.6
90 MHz	-32 dBm	180	4.3
100 MHz	-32 dBm	146	3.9

Frequency	Drive level of generator	Irms [mA] Calculated from transfer impedance of monitor probe	Z [Ω]
10 MHz	-26 dBm	420	5.4
14 MHz	-26 dBm	648	5.45
20 MHz	-26 dBm	164	5.5
30 MHz	-26 dBm	238	5.5
40 MHz	-26 dBm	776	5.4
50 MHz	-26 dBm	430	5.1
60 MHz	-26 dBm	264	4.8
70 MHz	-26 dBm	530	4.7
80 MHz	-26 dBm	540	4.6
90 MHz	-26 dBm	365	4.3
100 MHz	-26 dBm	265	3.9

Frequency	Drive level of generator	Irms [mA] Calculated from transfer impedance of monitor probe	Z [Ω]
10 MHz	-20 dBm	800	5.4
14 MHz	-20 dBm	1260	5.45
20 MHz	-20 dBm	320	5.5
25 MHz	-20 dBm	30	5.5
30 MHz	-20 dBm	520	5.5
40 MHz	-20 dBm	1500	5.4
50 MHz	-20 dBm	1060	5.1
70 MHz	-20 dBm	1000	4.7
80 MHz	-20 dBm	980	4.6
90 MHz	-20 dBm	711	4.3
100 MHz	-20 dBm	602	3.9

Frequency	Drive level of generator	Irms [mA] Calculated from transfer impedance of monitor probe	Z [Ω]
10 MHz	-17 dBm	1180	5.4
14 MHz	-17 dBm	1820	5.45
20 MHz	-17 dBm	466	5.5
25 MHz	-17 dBm	27	5.5
30 MHz	-17 dBm	668	5.5
40 MHz	-17 dBm	2100	5.4
42 MHz	-17 dBm	4000	5.4
50 MHz	-17 dBm	1330	5.1
60 MHz	-17 dBm	720	4.8
70 MHz	-17 dBm	1520	4.7
80 MHz	-17 dBm	1500	4.6
90 MHz	-17 dBm	977	4.3
100 MHz	-17 dBm	920	3.9

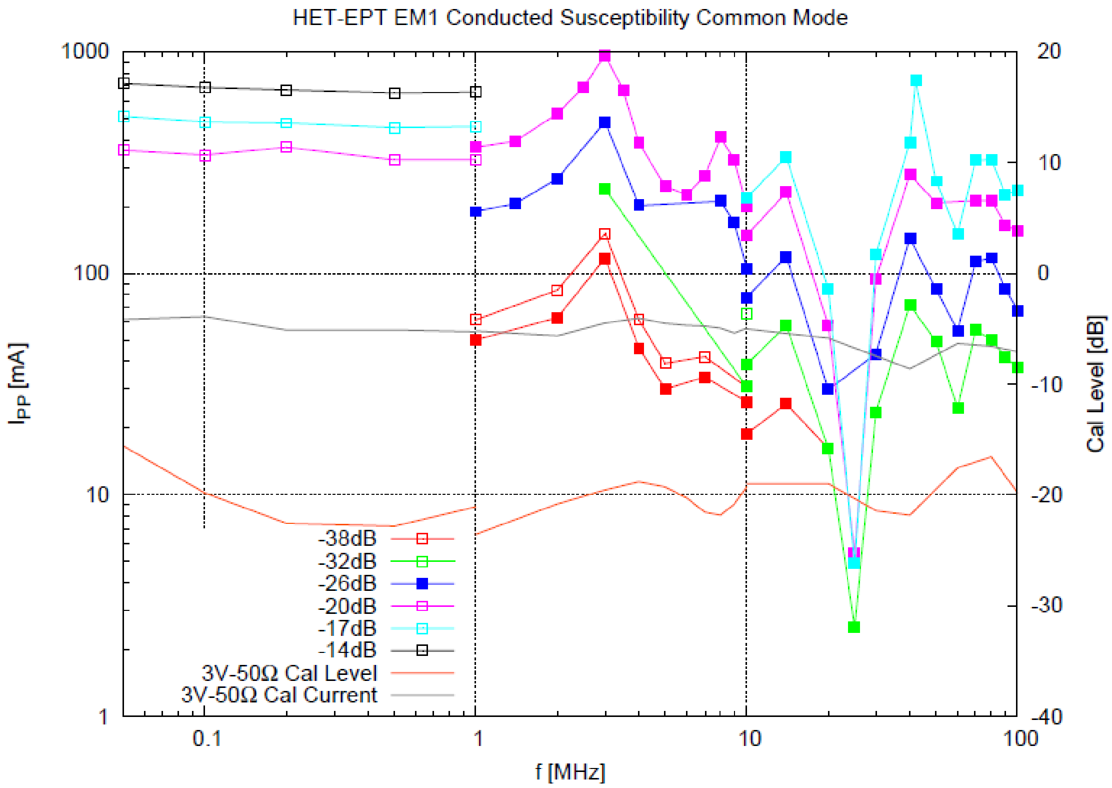


Fig. 37: (Figure caption see Text below)

The left y-axis show units of mA peak-to-peak for the current induced in the sensor harness. The lines with squares show the current induced at various excitation levels.
Open squares were measured with the oscilloscopes V_{RMS} function and corrected for duty cycle and RMS vs PP scale. These numbers are less reliable. Closed squares were measured with the oscilloscopes V_{PP} function, and should give a better picture.
The right y-axis shows units of dB, for the relative gain used in the HF generator, with arbitrary reference. Different HF power amplifiers were used below and above 1MHz. The orange line represents the excitation level required to obtain 3V peak-to-peak into 50Ω load. The gray line represents the peak-to-peak current (left axis) induced for that excitation level. Both lines were scaled to 3Vpp excitation from the actual calibration measurements, which were taken between 3Vpp and 3.4Vpp.
The test were performed in three frequency ranges with the specified duty cycles. In each range, repeated scans were performed with increasing excitation levels. From 50kHz to 1MHz, the highest excitation level was -14dB. From 1MHz to 10MHz the excitation with -20dB was sufficient to read 3Vpp equivalent. From 10MHz to 100MHz the last excitation level was -17dB.
Data was manually recorded, with full coverage only available for the highest excitation levels.
Sensor operation was at no point affected by the excitation.

uncertainty of the measurement is: 1.4 % of voltage

Test result: Passed

9 Photos of Test Set-Up

Fig. 38: Conducted emission, inrush current on power leads(6.2)

Fig. 39: Conducted emission on power leads, common mode, 30 Hz to 100 MHz, frequency domain

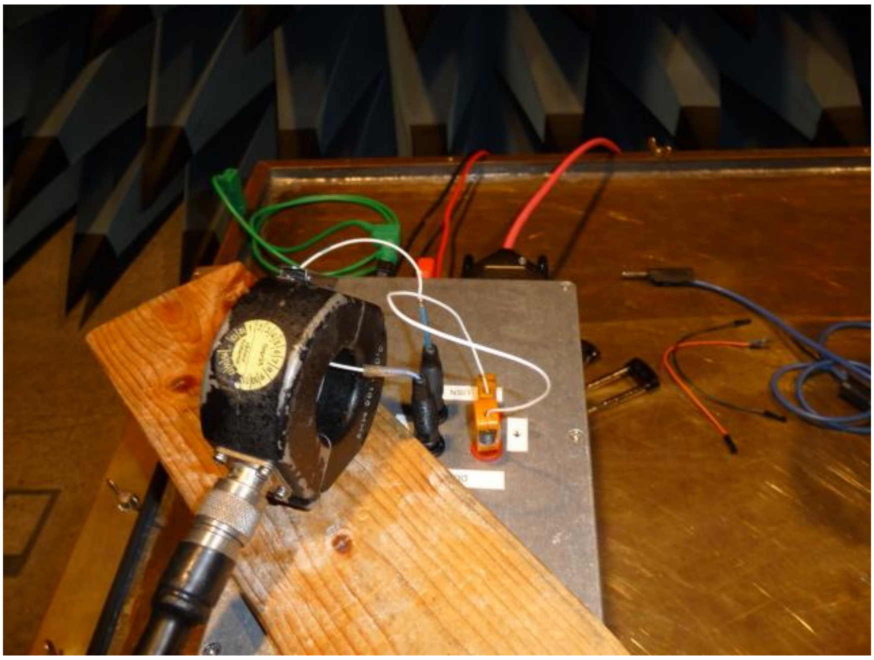


Fig. 40: Conducted emission on power leads differential mode, 30 Hz to 100 MHz, frequency domain

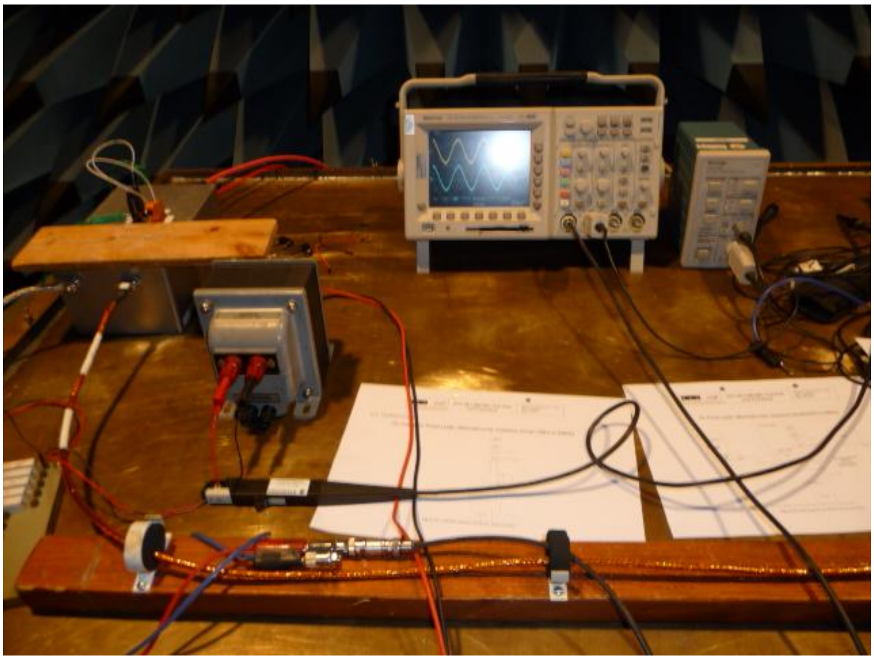


Fig. 41: Conducted susceptibility on power leads in differential mode, 30 Hz to 50 kHz, frequency domain

Fig. 42: Conducted susceptibility on power leads in differential mode, 50 kHz to 100 kHz, frequency domain

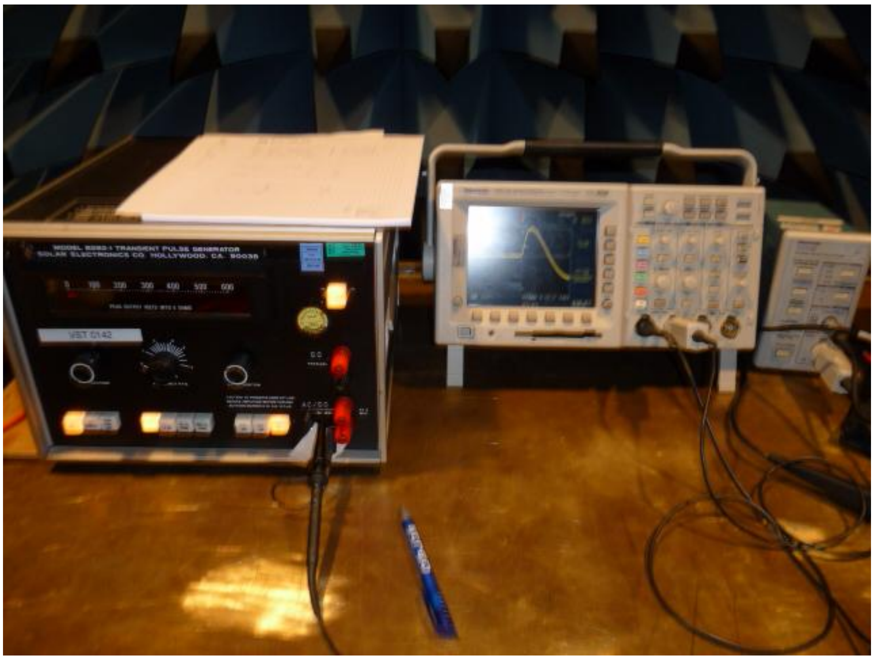


Fig. 43: Conducted susceptibility on power leads in differential mode, 30 Hz to 100 kHz, transient, calibration

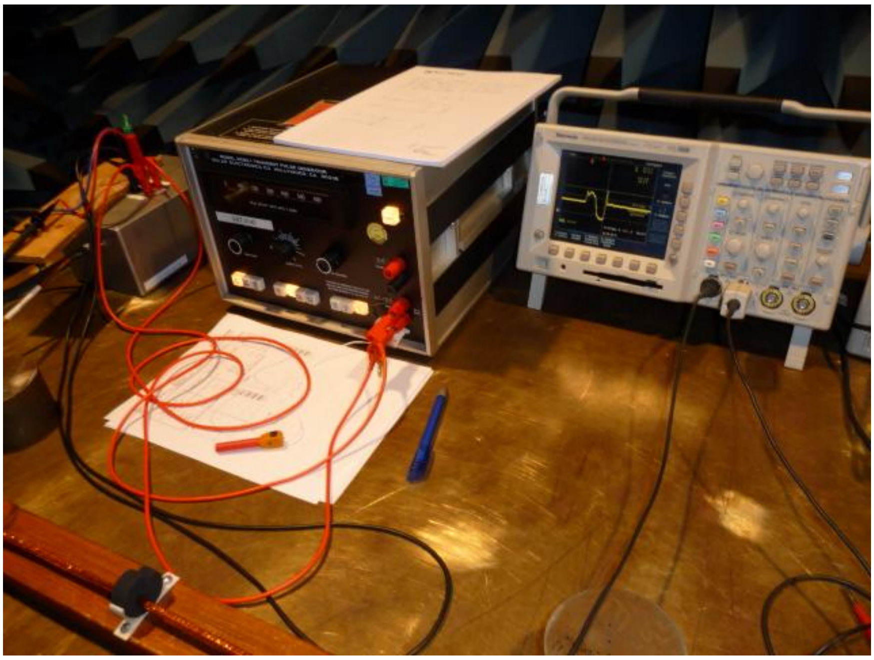


Fig. 44: Conducted susceptibility on power leads in differential mode, 30 Hz to 100 kHz, transient, test

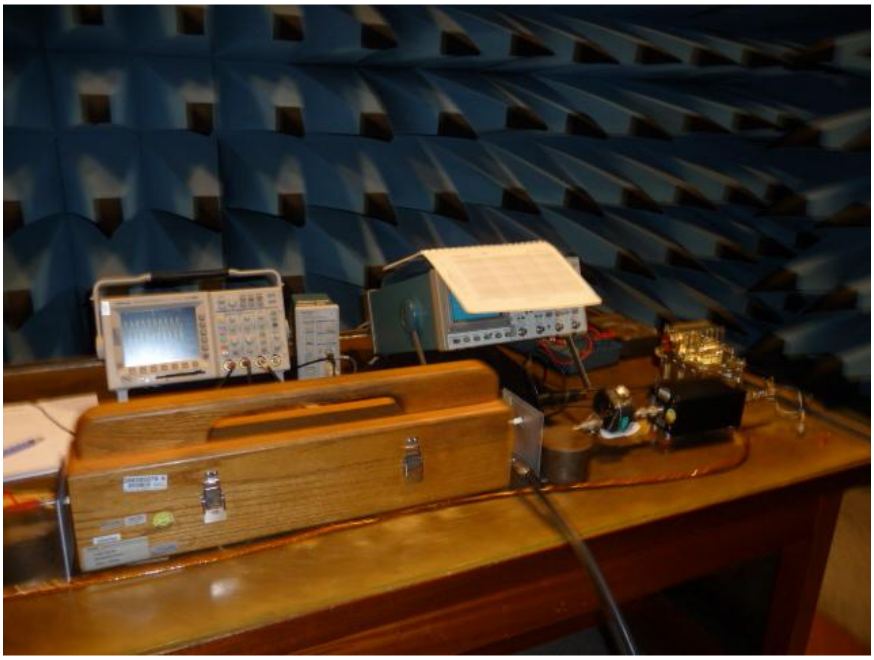


Fig. 45: Conducted susceptibility on power leads in common mode, 50 kHz to 100 MHz, frequency domain, calibration

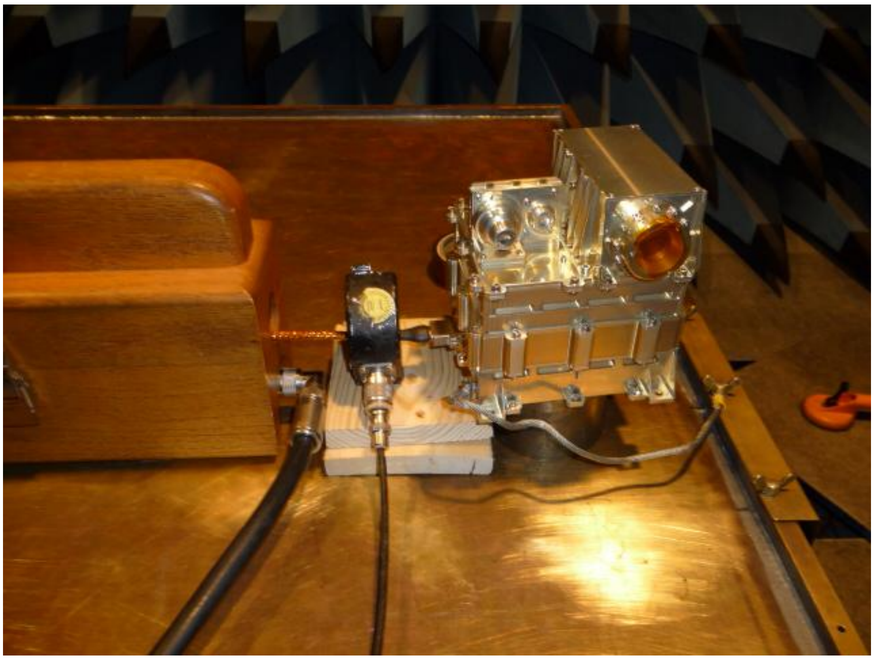


Fig. 46: Conducted susceptibility on power leads in common mode, 50 kHz to 100 MHz, frequency domain, test

END OF REPORT