SOLAR ORBITER ENERGETIC PARTICLE DETECTOR

STEP EM EMC Test Report

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CHANGES RECORD

Issue	Revision	Date	Modified by	Section / Paragraph modified	Change implemented
1	0	04/04/2014		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. 6.2.5	• 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 STEP EM EMC test as-run procedure and results. This test is performed to verify the STEP (old STEIN) EMC characteristics.

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

Table 1-1-1. Planned tests for the STEP 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

Annex A: includes the facility test report on the EMC test which was performed on March 24, 2014.

Note: No conducted susceptibility test was performed on STEP EM. See deviation #1 in Table 8-2-1.

1.2 Scope

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

Important note

In this as-run test report 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
EUT	Equipment Under Test
FD	Frequency Domain
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
STEP	Supra Thermal Electrons and Protons
STEIN	Supra Thermal Electrons Ions and Neutrals
TBC	To Be Confirmed
TD	Time Domain
TREO	EMC test facility planned for STEP 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	STEP EM EMC Test Plan and Procedure	SO-EPD-KIE-TP-0009	1/0	06/03/2014
AD-4	Electrical Assembly Procedures STEP EM (logbook)	SO-EPD-KIE-LB-0004	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 STEP EM EMC tests are to:

- Verify electromagnetic compatibility and electromagnetic interference of STEP.

The results of STEP 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 STEP EM EMC tests are conducted in TREO EMC test facility.

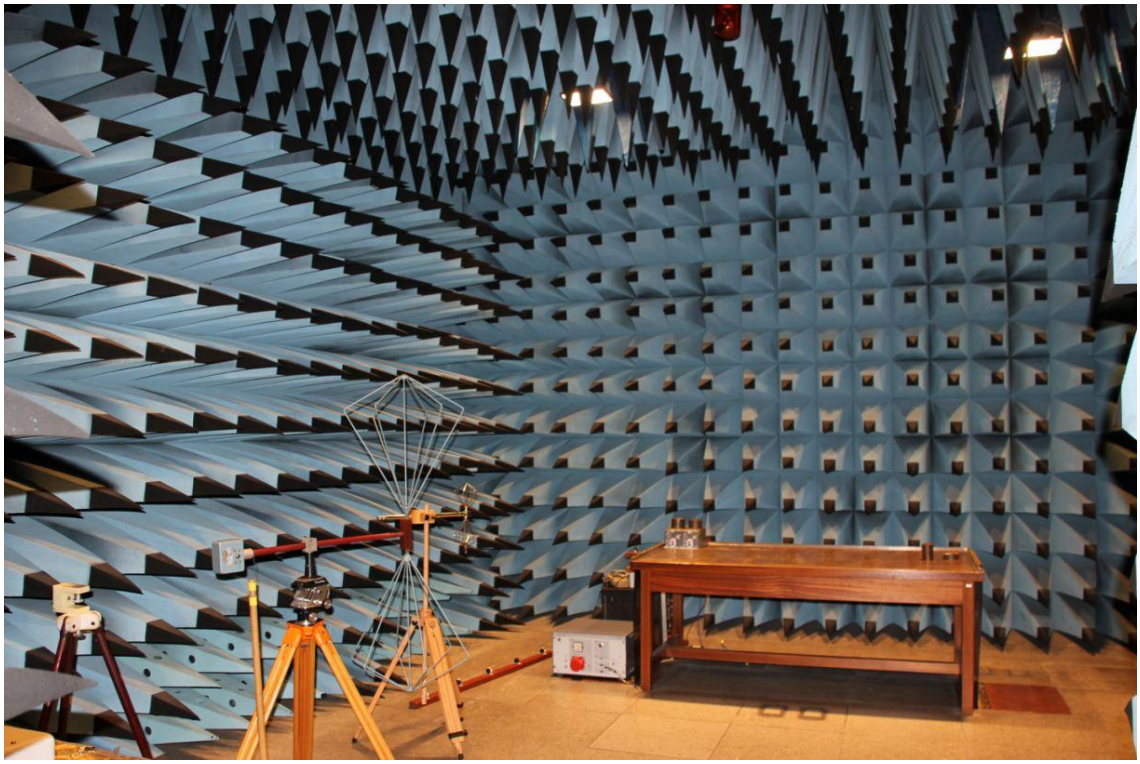


Fig. 4-2-1. TREO EMC chamber.

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	Lauri Panitzsch (Instrument lead)	Set-up, monitoring
6	Christoph Terasa (Instrument Scientist)	Set-up, monitoring
7	Stephan Böttcher (Electronics, Test engineer)	Set-up, monitoring, analysis, reporting
8	Björn Schuster (Electronics, Test engineer)	Set-up, monitoring, analysis, reporting
9	Alexander Kulemzin (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 STEP unit under test is represented by the STEIN unit (as seen in Fig. 4-7-1). The Ebox of the unit (upper box in the figure) contains the LVPS and the digital board. The Idef-X ASIC is installed on a test board without the silicon detector in the lower box of the housing.

The only available operative mode at the time of the test was idle mode, no data streaming.

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

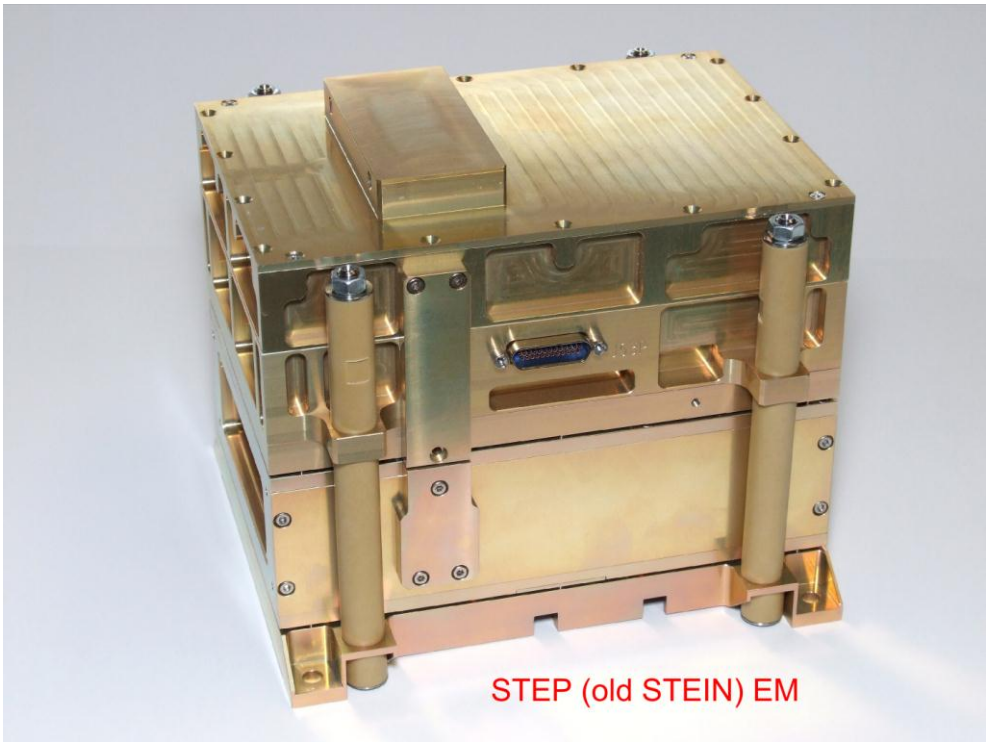


Fig. 4-7-1. STEP EM for unit level EMC test campaign.

4.6.1 Item under test build standard requirement

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

Table 4-7-1-1. STEP 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:	**STEP 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	Non-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.

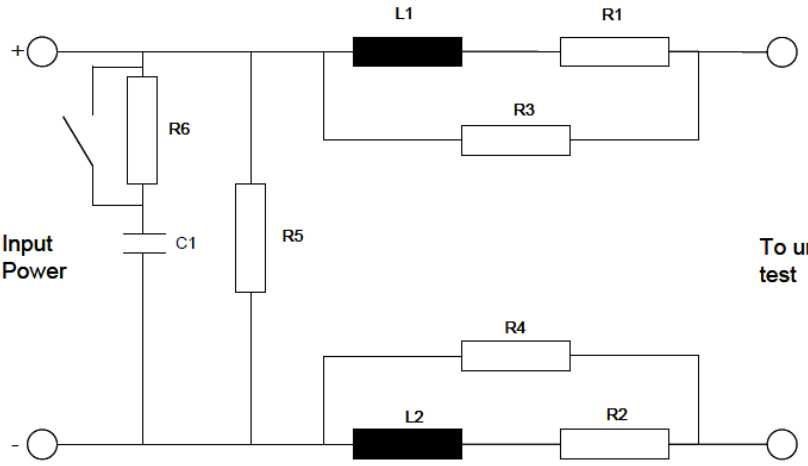
EIDA R-471: The PI shall ensure that passive equipment, such as antennas, current probes etc. have calibration curves from the manufacturer.

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 STEP 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 STEP EM EMC test campaign.

The circuit layout can be seen in Fig. 5-2-3, for modifications please see Table 5-2-1**.**

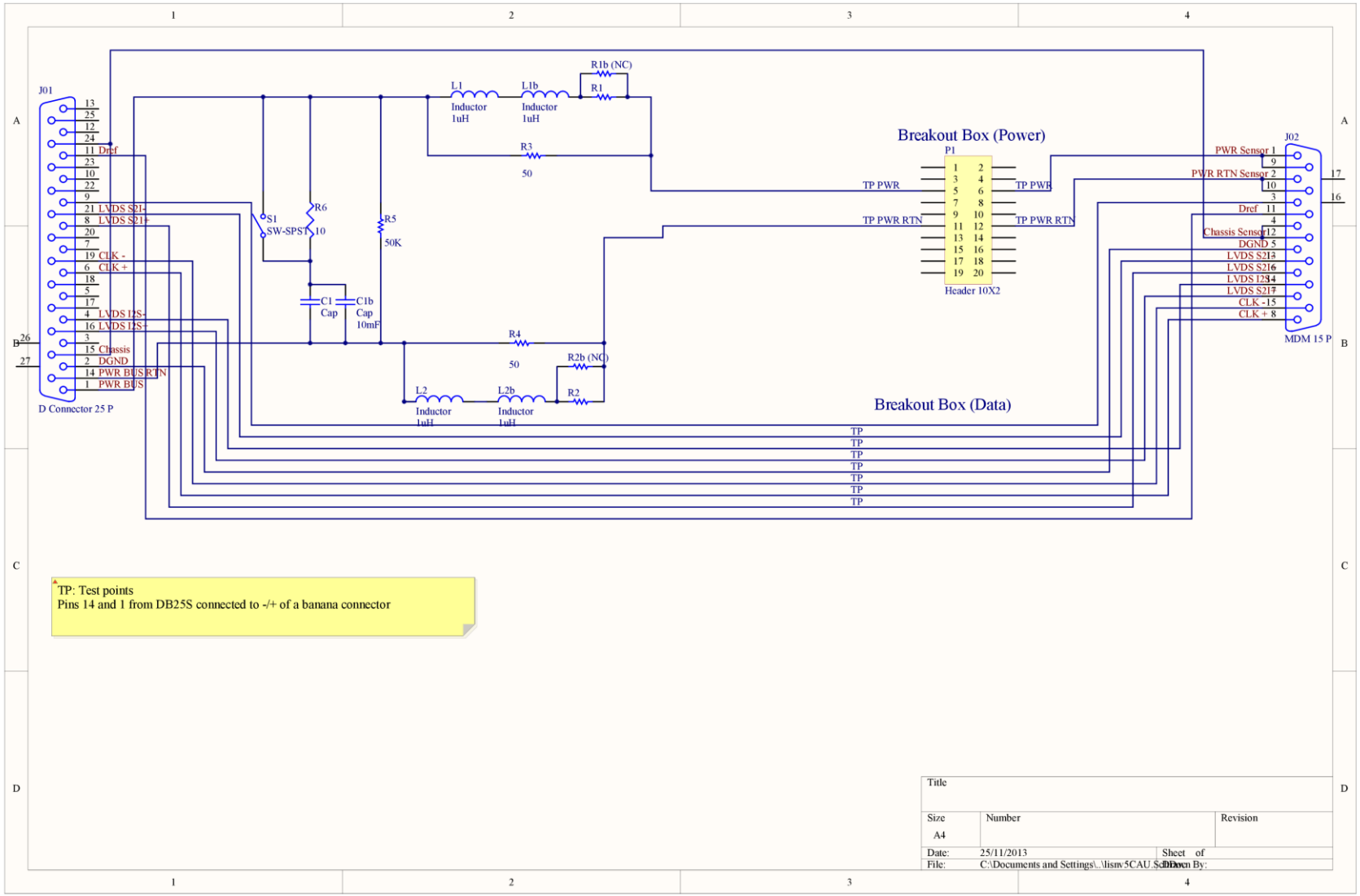


Fig. 5-2-3. LISN circuit layout.

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.

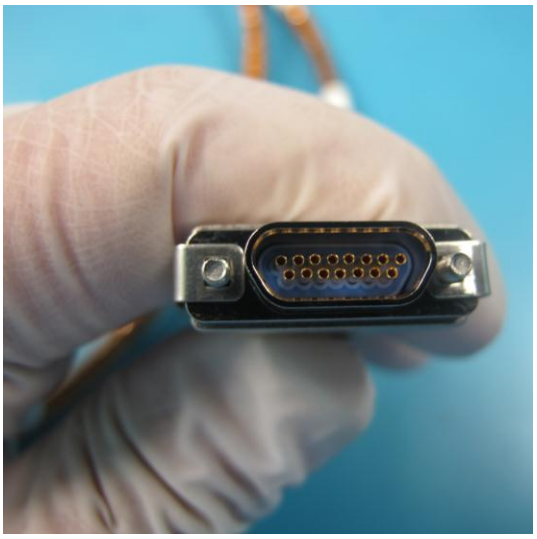
5.3 Test harness

For the STEP EM, there is one harness available. This harness was received from the EPD PO, see Fig. 5-3-1 (a-c).

Table 5-3-1. STEP EM harness for EMC tests [RD-1].

Cable	Description	Connector End A		Connector End D		Labelling	Total Lenght (m)
		Number	Type	Number	Type		
4	STEP	P05_S	MDM15	P25_P	MDM25	EPD.HAR.EM 320770.EM	1,16

(a) Cable 4, see Table 5-3-1.



(b) MDM 15 S which goes to LISN.

(c) MDM 25 P which goes to EUT.

Fig. 5-3-1 (a-c). Harness for STEP EM EMC tests.

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

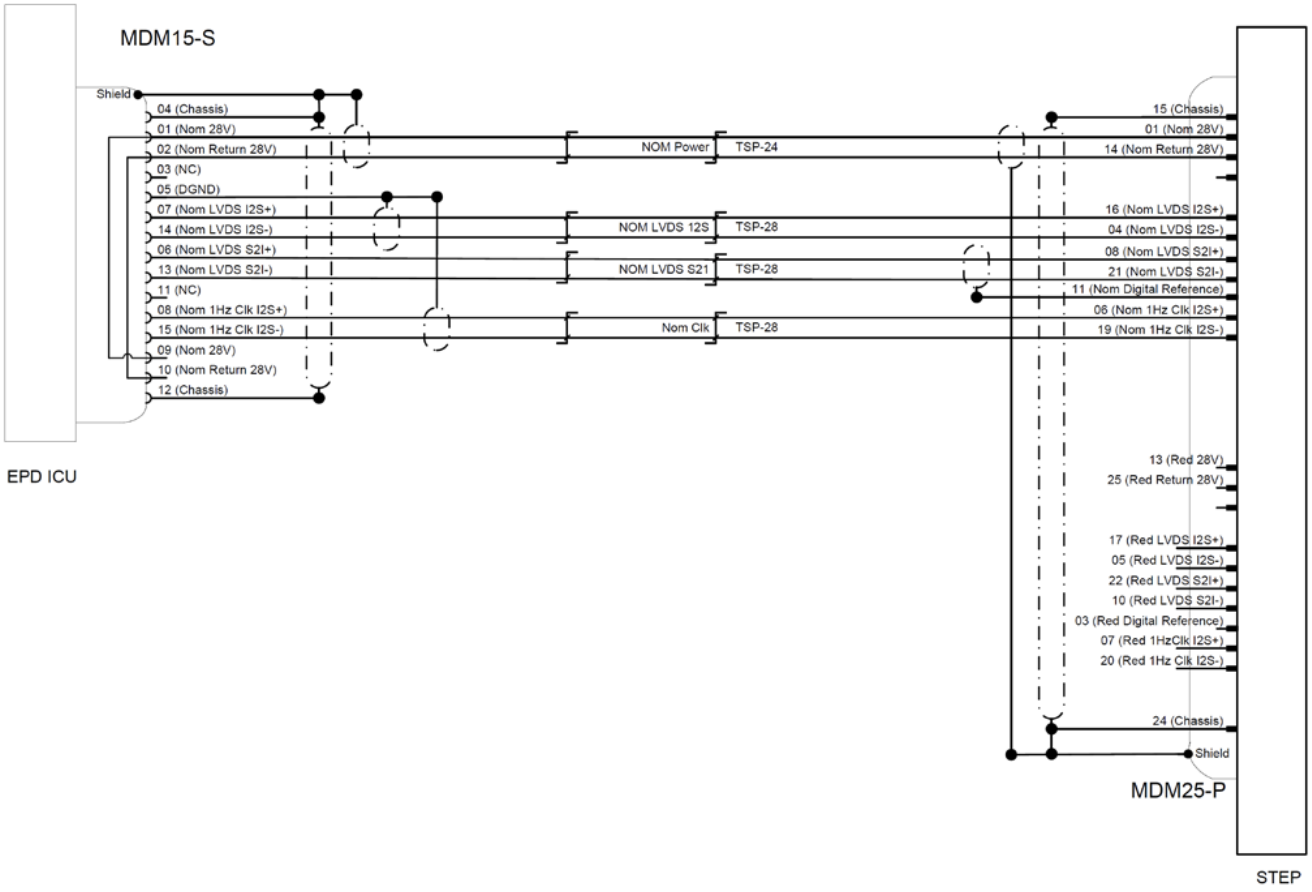


Fig. 5-3-2. ICU (LISN in unit level EMC tests) to STEP pinouts and grounding for STEP EM [RD-1].

5.4 Abortion criteria

The test abortion is possible according to the test facility TREO considerations during the STEP 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

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

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 STEP EM a provisional grounding stud is foreseen which provides grounding connection between the EUT and the EMC test ground table.

But, due to the fact that the definition of the grounding strap is currently under definition between the units and S/C, the grounding test is not fully flight representative.

6.1.2 Bonding and grounding test set up

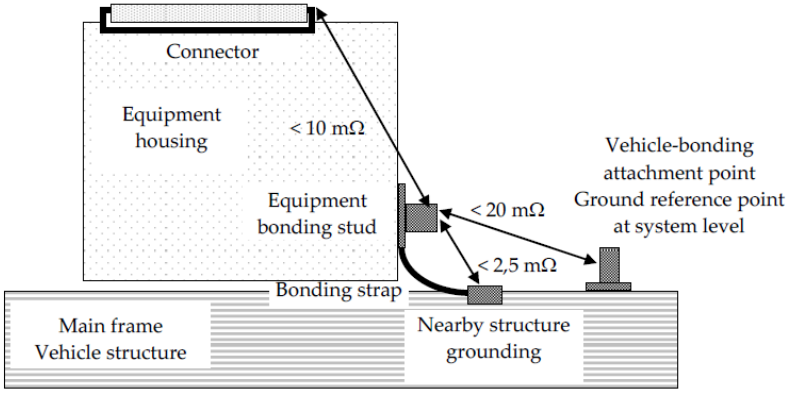


Fig. 6-1-2-1. Bonding test set up, page 22 of [NR-09].

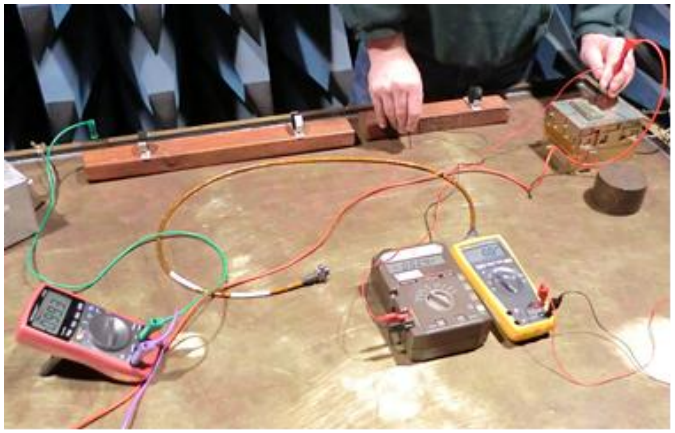


Fig. 6-1-2-2. Bonding test set up at the time of the test.

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.			24.03.2014 09:05-09:20	S. Böttcher L. Panitzsch C. Terasa A. Kulemzin	
05	Measure the resistance between different housing parts and EUT chassis.	R<5mOhm	Please see Table 6-1-3-2.	09:20-09:30	S. Böttcher L. Panitzsch C. Terasa A. Kulemzin	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)		
		Top plate and STEP GND stud	Ebox (side plate) and STEP GND stud	LISN housing and GND table
Set up Fig. 6-1-2-2	0.995	2.4	2.0	1.3

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

As verified by the test the resistance between the unit and the grounding table is around 2.4mOhm or less and thus well within the requirements. Thus, this test is passed.

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.

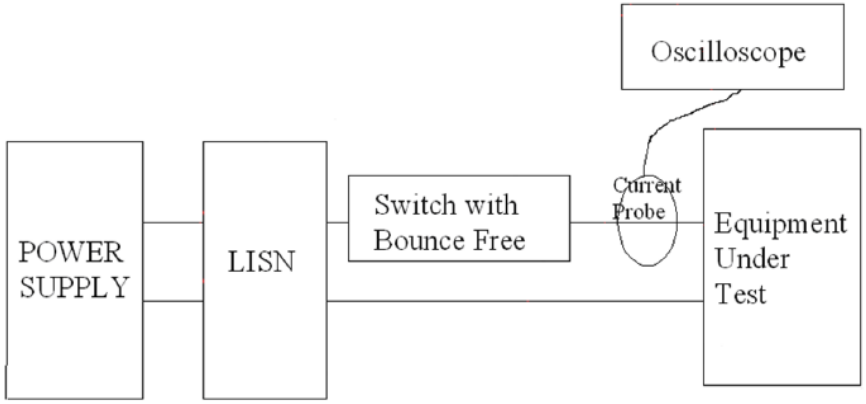


Fig. 6-2-2-1. Inrush current test set up, Figure 4.7-1 of [AD-1].

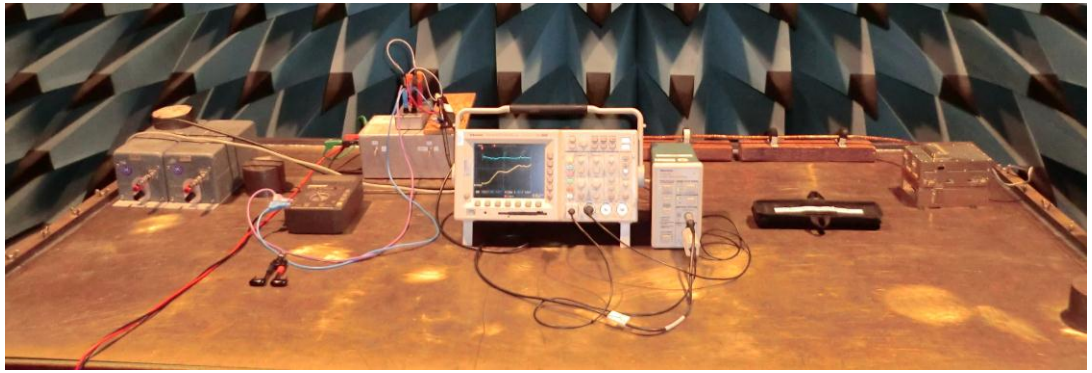


Fig. 6-2-2-2. Inrush current test set up at the time of the test.

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.			24.03.2014 09:30-09:40	S. Böttcher P. Sell	See Fig. 6-2-2-2. See Fig. 29 of Annex A.
05	Turn on the measurement equipment and allow a sufficient time for stabilization.			09:40-09:45	P. Sell	
10	Measurement system checks by the facility responsible.			09:40-09:45	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**.			10:50-11:25	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.9 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 as seen in the Fig. 6 and Fig. 9 in the Annex A and thus smaller than 4ms which defines one requirement.

According to Fig.6 of Annex A, the I_{peak} is around 10 A.

According to Fig.5 of Annex A and also clarification from [RD-3], the dI/dt is around 1A/µs. The obtained dI/dt can be considered as a worst case which is well below the required limit.

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 2.5 mC which is less than 3.68 mC as is required in [RD-5].

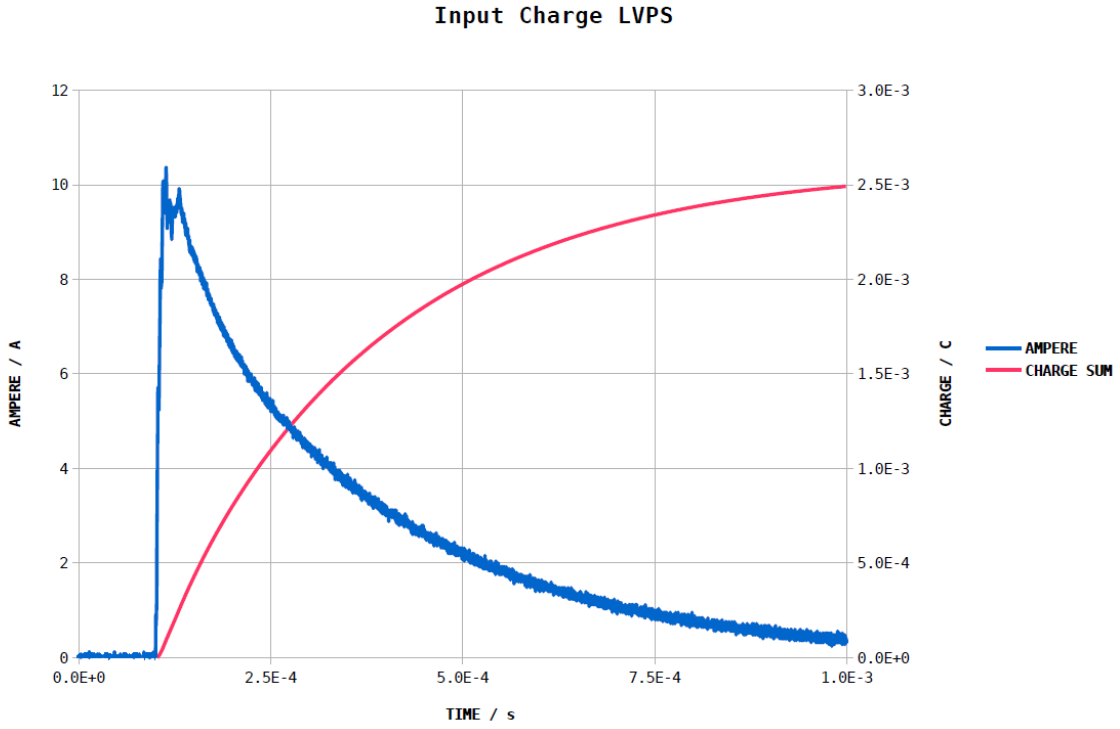


Fig. 6-2-5-1. The input charge of the STEP EM LVPS.

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.

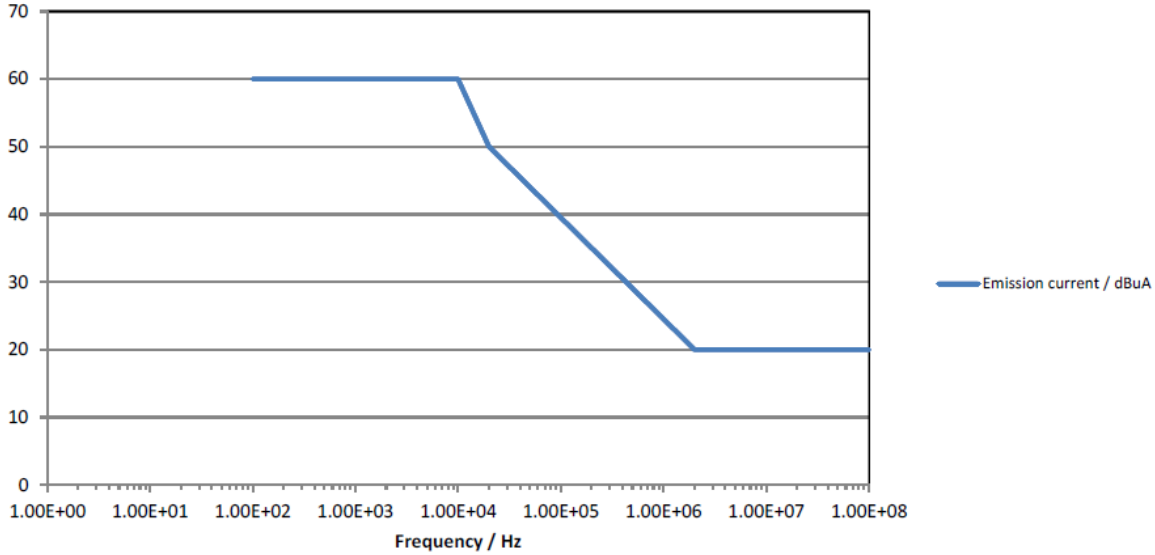


Fig. 6-3-1-1. Maximum background noise level for current emissions from equipments.

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

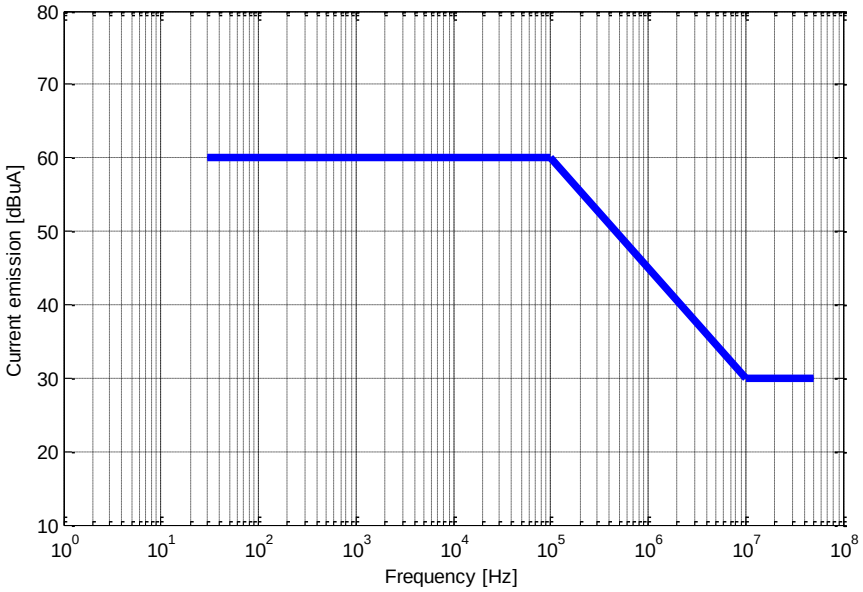
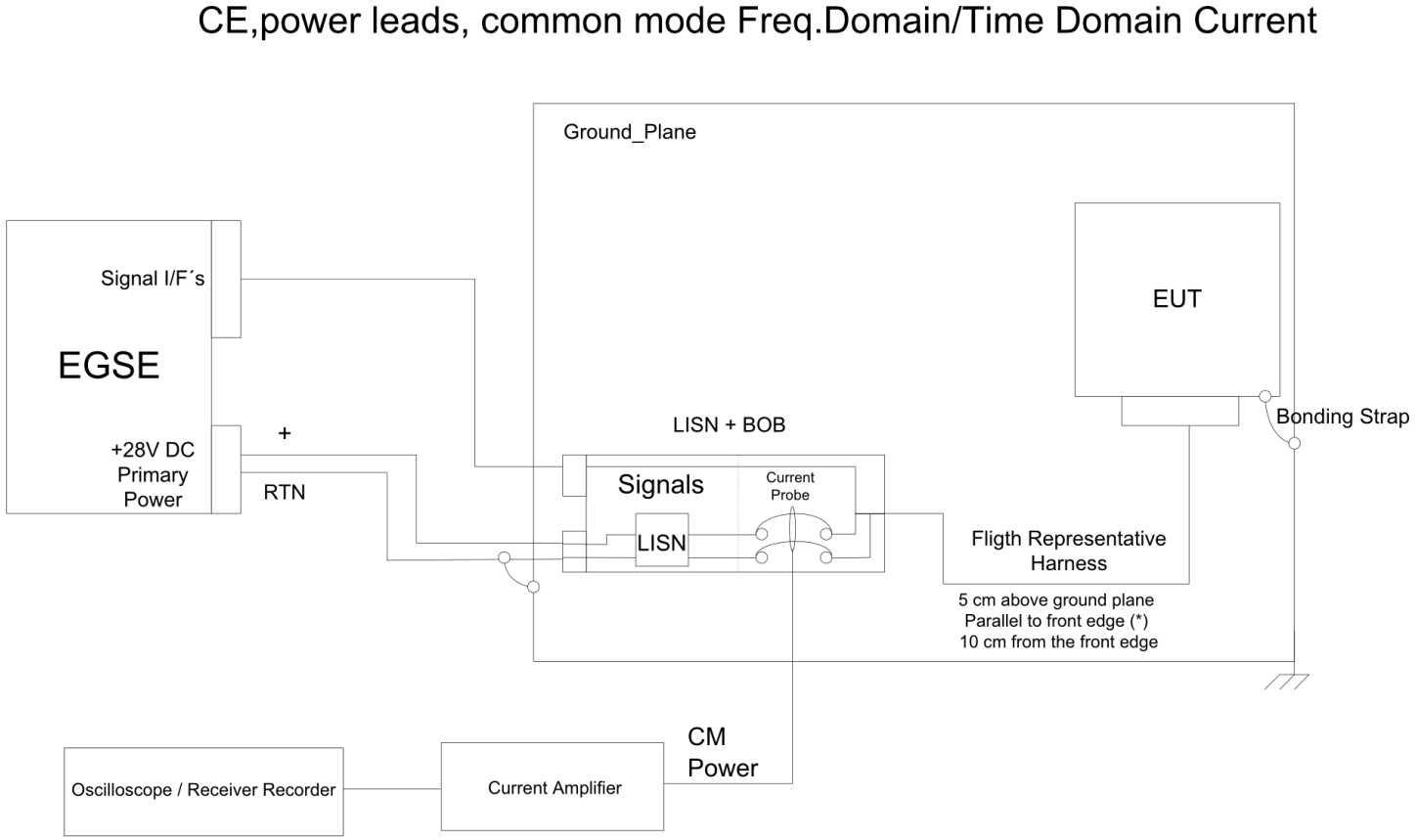


Fig. 6-3-1-2. EIDA R-314a-DFU graphical representation.

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).

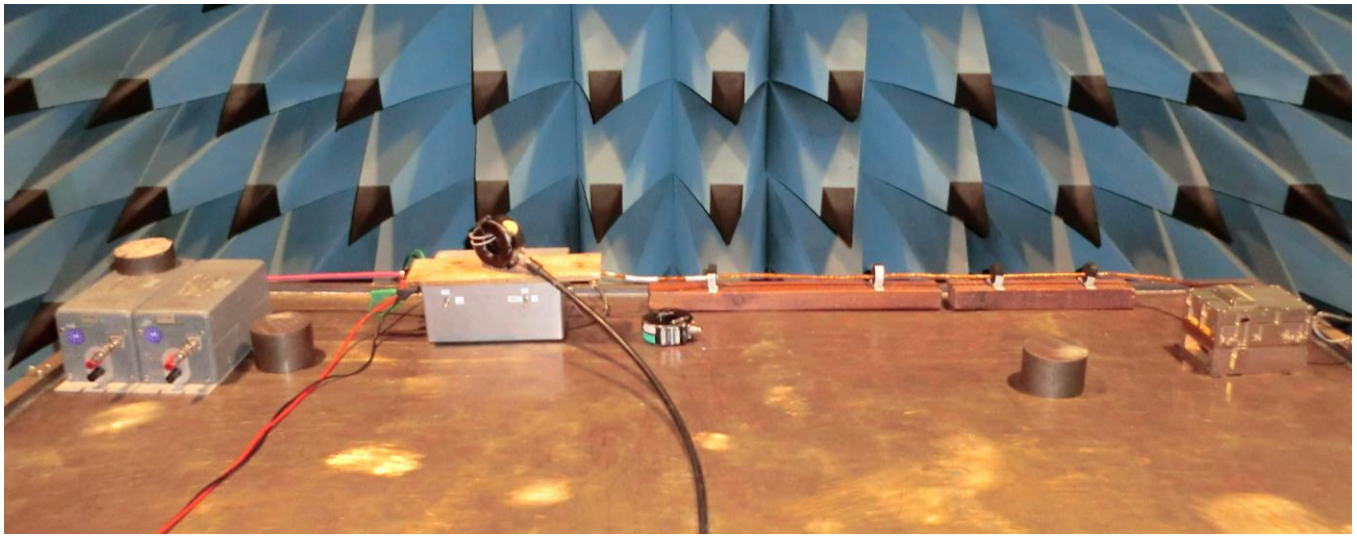
EIDA R-845-a-DFU (TBD): The EPD units shall measure the conducted emission (common mode) up to 100MHz. The range 50MHz to 100MHz is for information only.
The design has to be done taking into account the requirement at EPD sensor interface. (DFU requirements).

6.3.2 CE-CM-FD test set up

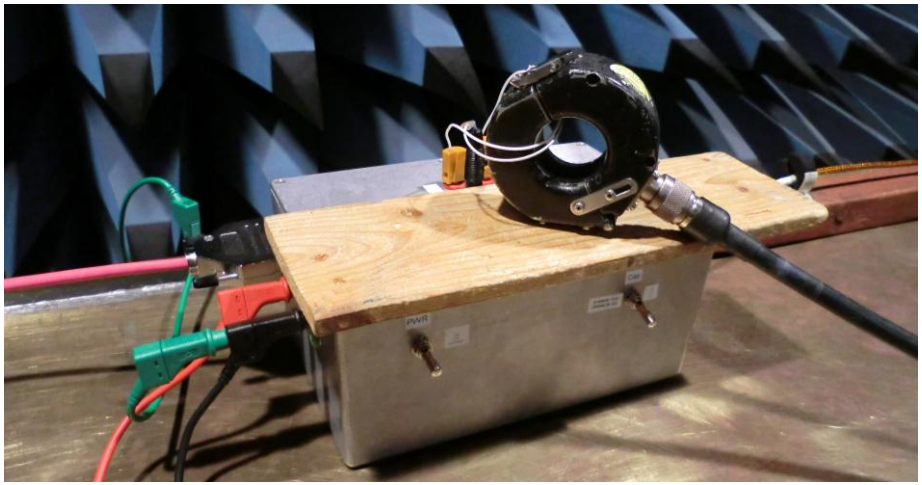


(*) If Flight Representative Harness is longer than 2 m the remaining cable length above 2 m shall be routed to the back of the setup and placed in a zigzagged arrangement

Fig. 6-3-2-1. 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.			24.03.2014 11:45-11:55	S. Böttcher P. Sell	See Fig. 6-3-2-2 (a).
05	Turn on the measurement equipment and allow a sufficient time for stabilization.			11:55-12:05	P. Sell	
10	Measurement system checks by the facility responsible.			11:55-12:05	P. Sell	
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).			12:05-12:20 13:10-13:25	S. Böttcher P. Sell	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. The unit generates some prominent structures in the frequency range mainly from 100 kHz up to 1MHz which need further investigation but with the current performance the EUT passes the requirement.

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.

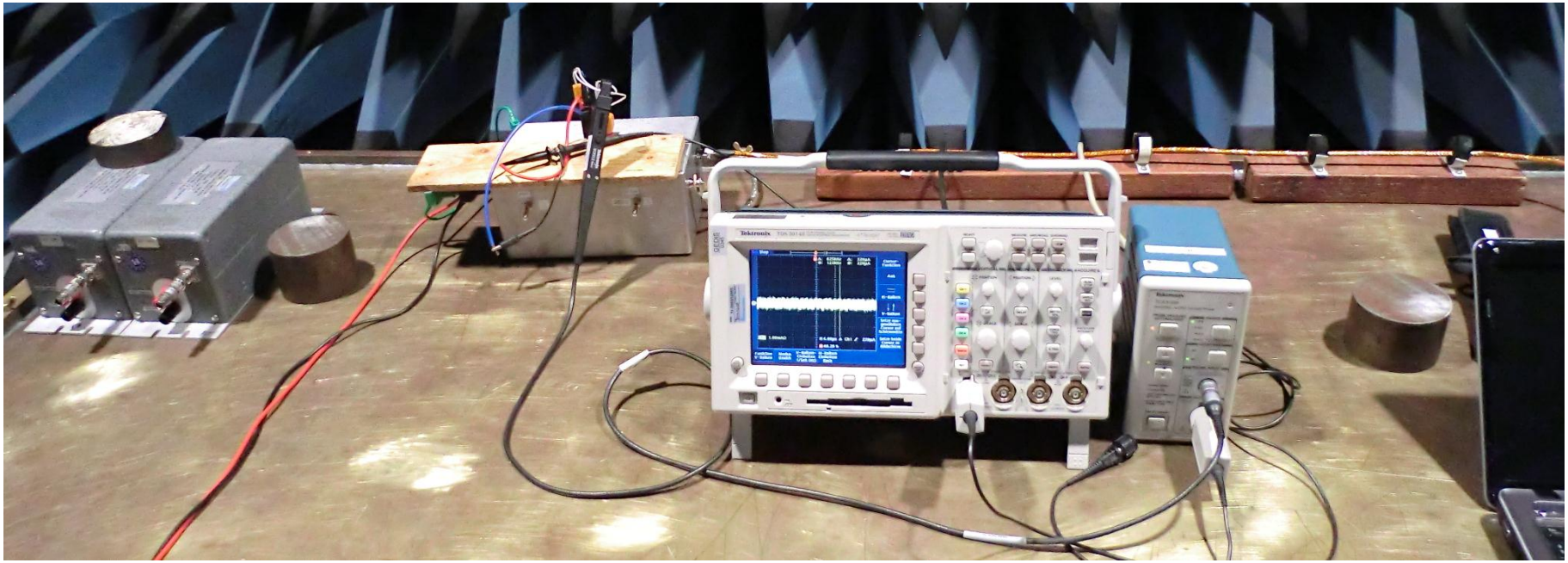


Fig. 6-4-2-1. Test setup for CE-CM-TD at the time of the test.

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			24.03.2014 14:40-15:00	P. Sell L. Panitzsch C. Terasa A. Ravanbakhsh M. Richards	This test was started after the CE-DM-FD indicated in section 6.5.
05	Turn on the measurement equipment and allow a sufficient time for stabilization			15:00-15:30	P. Sell	
10	Measurement system checks by the facility responsible.			15:00-15:30	P. Sell	
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.			15:30-16:00	P. Sell L. Panitzsch C. Terasa A. Ravanbakhsh M. Richards	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. 16 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.16, the current ripples and spikes in common mode recorded in the time domain are in the order of 1mApp or just below.

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

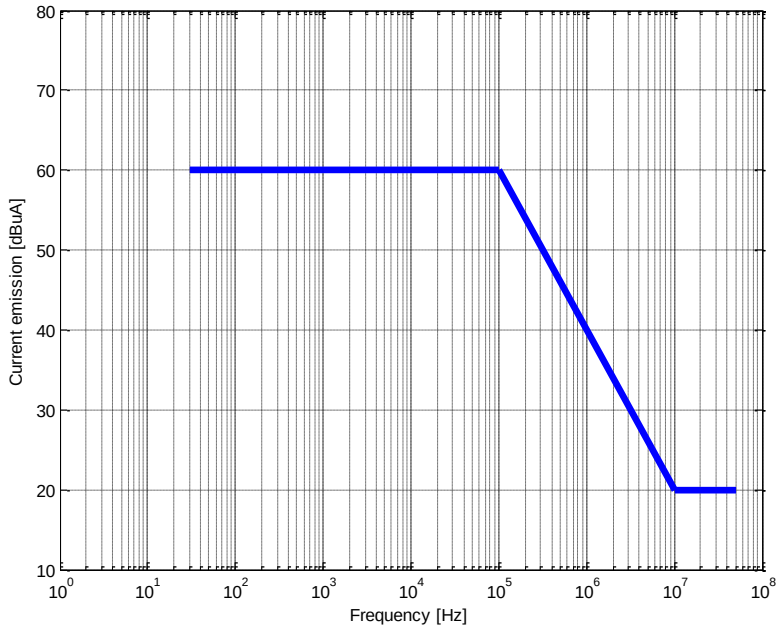
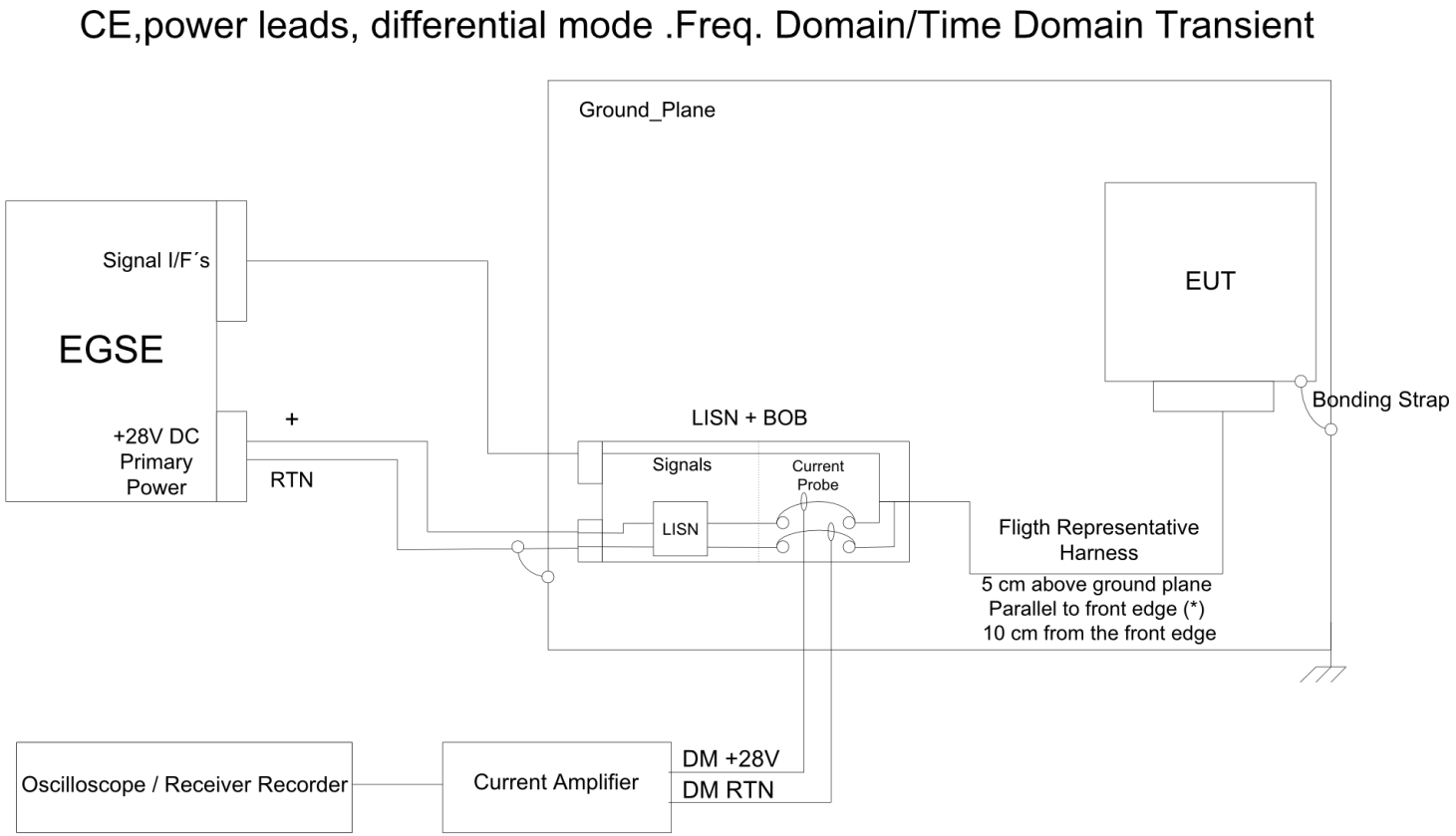


Fig. 6-5-1-1. EIDA R-313a-DFU graphical representation.

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).

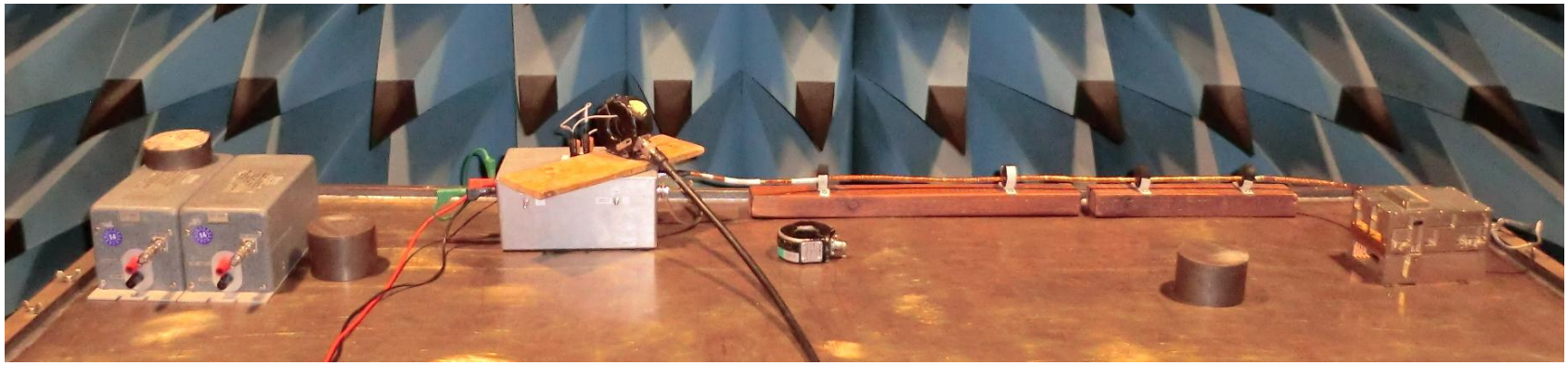
EIDA R-844-DFU: The PI and Prime contractor shall measure the conducted emission (differential mode) up to 100MHz. The range 50MHz to 100MHz is for information only.

6.5.2 CE-DM-FD test set up

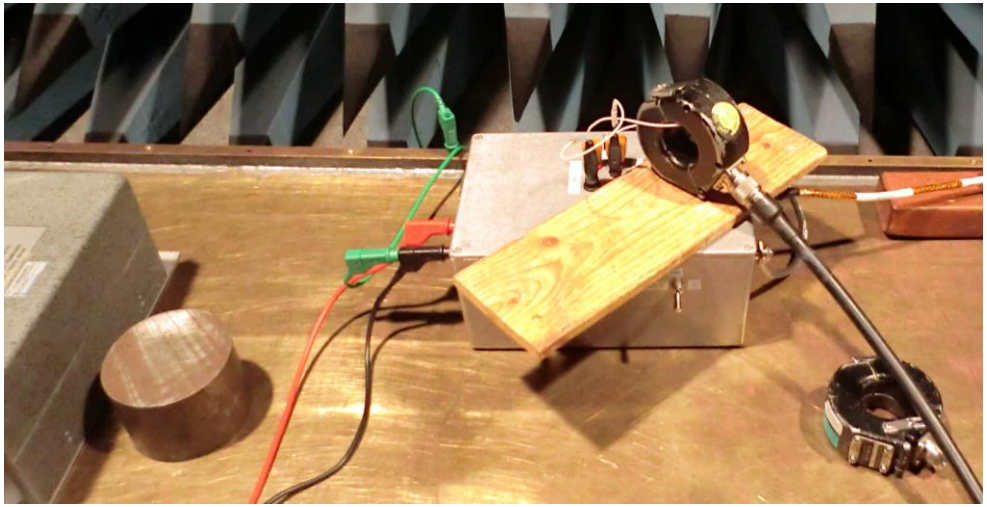


(*) If Flight Representative Harness is longer than 2 m the remaining cable length above 2 m shall be routed to the back of the setup and placed in a zigzagged arrangement

Fig. 6-5-2-1. 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.			24.03.2014 13:30-13:35	P. Sell L. Panitzsch C. Terasa A. Ravanbakhsh M. Richards	This test was started after the CE-CM-FD indicated in section 6.2.
05	Turn on the measurement equipment and allow a sufficient time for stabilization.			13:35-13:45	P. Sell	
10	Measurement system checks by the facility responsible.			13:35-13:45	P. Sell	
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.			13:45-14:35	P. Sell L. Panitzsch C. Terasa A. Ravanbakhsh M. Richards	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.17 and Fig.18 of Annex A. The measurement results can be seen in Fig.19 and Fig.20 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. 19 and Fig.20 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. 19, Fig. 20 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.

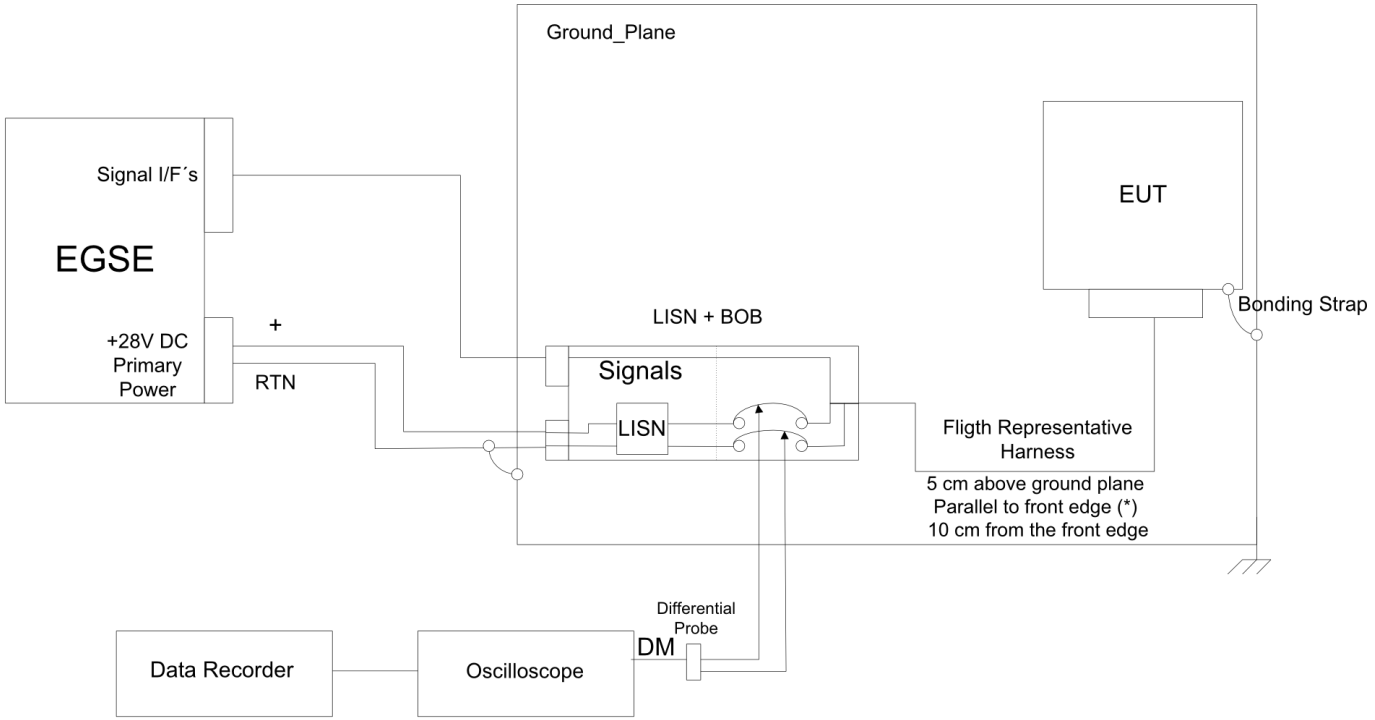
According to [AD-2]:

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.

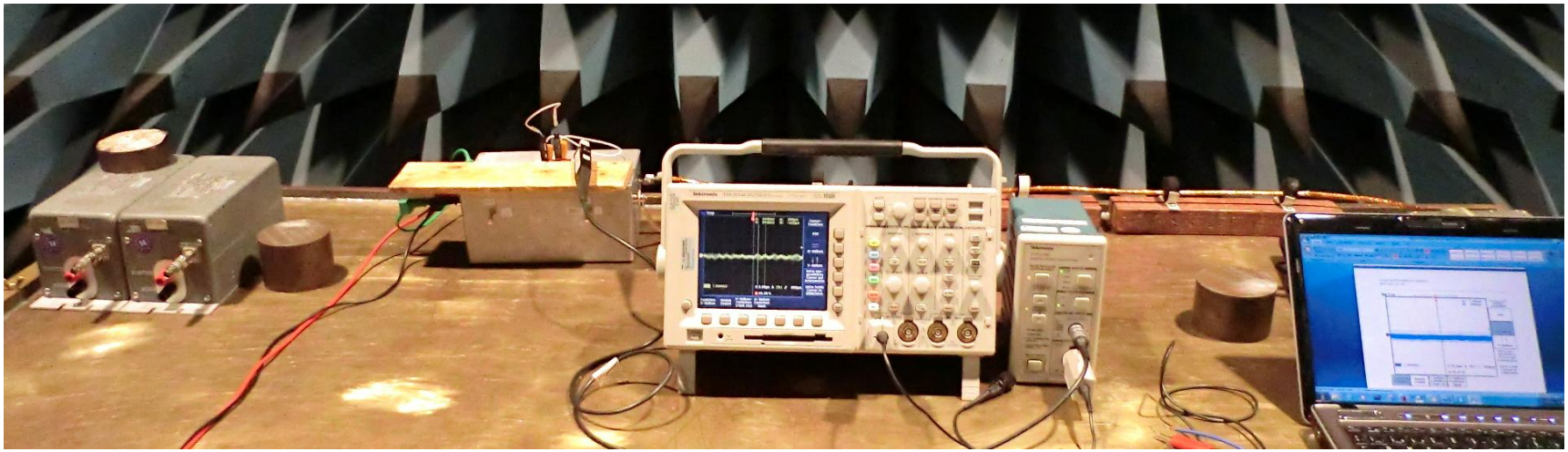
6.6.2 CE-DM-TD test set up

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

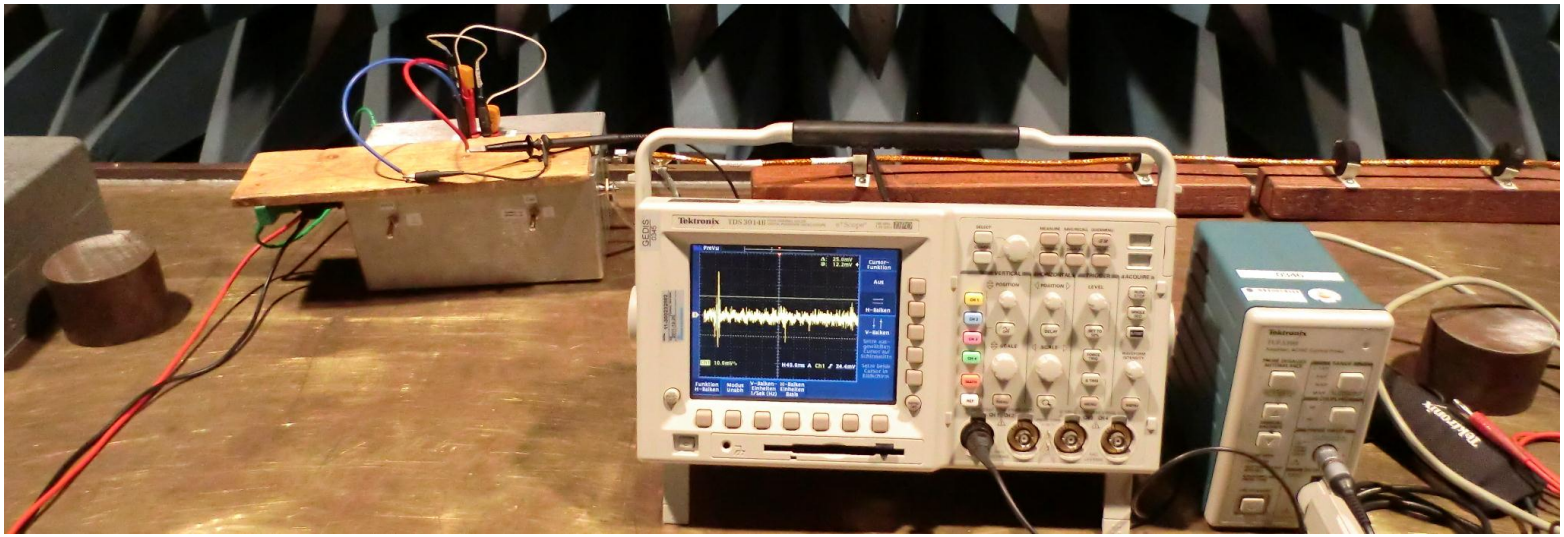


(*) If Flight Representative Harness is longer than 2 m the remaining cable length above 2 m shall be routed to the back of the setup and placed in a zigzagged arrangement

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.			24.03.2014 16:30-16:40	P. Sell L. Panitzsch C. Terasa A. Ravanbakhsh M. Richards	This step (step 00) was started after the step 25.
05	Turn on the measurement equipment and allow a sufficient time for stabilization.			16:40-16:50	P. Sell	
10	Measurement system checks by the facility responsible.			16:40-16:50	P. Sell	
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.			16:50-17:00	P. Sell L. Panitzsch C. Terasa A. Ravanbakhsh M. Richards	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.			17:00-17:15	P. Sell L. Panitzsch C. Terasa A. Ravanbakhsh M. Richards	This step (step 00) was started after the step 25. The measured noise level for +28V line can be seen in Fig. 22 and Fig. 23 of Annex A. The measured current ripples and spikes can be seen in 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.

7 GSE

The list of GSE items which CAU provided 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: GSE 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	Modified LISN from PO	EPD PO/modified by CAU. See Table 5-2-1.	N/A	N/A
5	GND strap for LISN	EPD PO		N/A
6	MDA Harness for EM STEP, 1.16 m	Axon Cable S.A.S. Received from EPD PO.	N/A	N/A
7	FET (Field Effect Transistor) switch for the inrush current test.	CAU	N/A	N/A
8	Laboratory connectors and probes		N/A	N/A
9	Appropriate mechanical tools for connectors mounting		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	The conducted susceptibility tests planned in [AD-3] were not performed.	This decision was made due to the maturity level of the STEP EM. The STEP detector assembly was not ready at the time of the test and the susceptibility tests could not give any valuable information about the EUT.

Annex A

LABOR FÜR UMWELTSIMULATION

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Deutscher Akkreditierungs Rat
DAR
DAT-PL-175/94-03

The change in part or duplication in extracts of this test report requires the written approval of the laboratory. The test report refers only to the indicated samples. Test reports are not valid without signature. This test report may contain test methods which are not part of our accredited test areas. These tests are marked with an asterisk (*). Tests implemented in an external laboratory are marked with two asterisks (**).

TEST REPORT	Version 001
Document No.:	070-14
Device:	SOLAR ORBITER ENERGETIC PARTICLE DETECTOR STEP EM
Assignment no.:	4010726
Product no.:	320301.3 (Ref: EPD-Kiel CDR product tree)
Serial no.:	STEP-EM
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)* and CE-DM-TD(6.6)* acc. to SO-EPD-KIE-TP-0009, Issue 1, Revision 1, date 20.03.2014
Date:	28.03.2014

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 EMV Laboratory

Reviewed by: .....
C. Möller, B. Sc.
Test Engineer

List of Revisions

Issue	Date	Effected		Reasons for Revision
		Page	Section	
1	2014-03-28	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	24.03.2014	passed	P. Sell
8.2	CE-CM-FD(6.3)* Conducted emission on power leads, common mode, 30 Hz to 100 MHz, frequency domain	24.03.2014	passed	P. Sell
8.3	CE-CM-TD(6.4)* Conducted emission on power leads, common mode, 30 Hz to 100 MHz, time domain	24.03.2014	passed	P. Sell
8.4	CE-DM-FD(6.5)* Conducted emission on power leads differential mode, 30 Hz to 100 MHz, frequency domain	24.03.2014	passed	P. Sell
8.5	CE-DM-TD(6.6)* Conducted emission on power leads differential mode, 30 Hz to 100 MHz, time domain	24.03.2014	passed	P. Sell

4 Test Equipment

Table 2: Test Equipment

Unit Type	Properties	Model	ID	cal.due
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
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
Current clamp	30Hz-30MHz	Singer 93511	0057	Dec.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. Lauri Panitzsch
Dr. Michael Richards
Mr. Björn Schuster
Mr. Alenande Kulemzin
Mr. Christoph Terasa
Mr. Ali Ravanbakhsh

5.2 Dimensions of equipment under test

max width = 126 mm
max length = 146 mm
max height = 113 mm

5.3 Overview, specs of device

The STEP unit under test is represented by the STEIN unit (as seen in Fig. 4-7-1). The Ebox of the unit (upper box in the figure) contains the LVPS and the digital board.

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		
4	STEP	P05_S	MDM15	P25_P	MDM25	EPD.HAR.EM 320770.EM	1.16

5.6 Housing, material

Aluminum

6 Test procedures and conditions

6.1 Operation mode

Idle 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

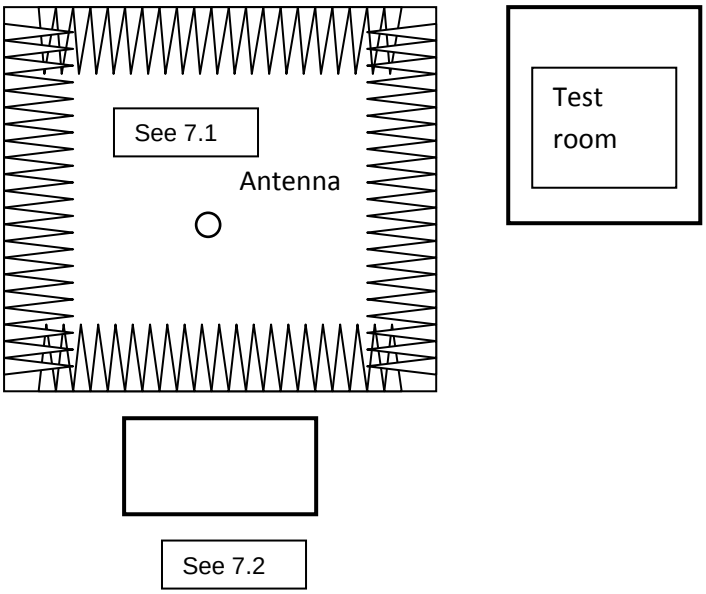

Fig. 2: Test configuration

7.1 Configuration EUT within test chamber

- SOLAR ORBITER ENERGETIC PARTICLE DETECTOR STEP EM, composed of:
  - STEP LVPS V2, with 94µF input filter capacitance and 16.8µH+10µH differential inductance before the first capacitor.
  - STEP DIGITAL (Altera)
  - IdeF-x test board
- EM harness, step, 1.16m
- 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

None

8 Testplan and Result of individual tests

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

According to SO-EPD-KIE-TP-0009, Issue 1, Revision 1, date 20.03.2014:

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

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.

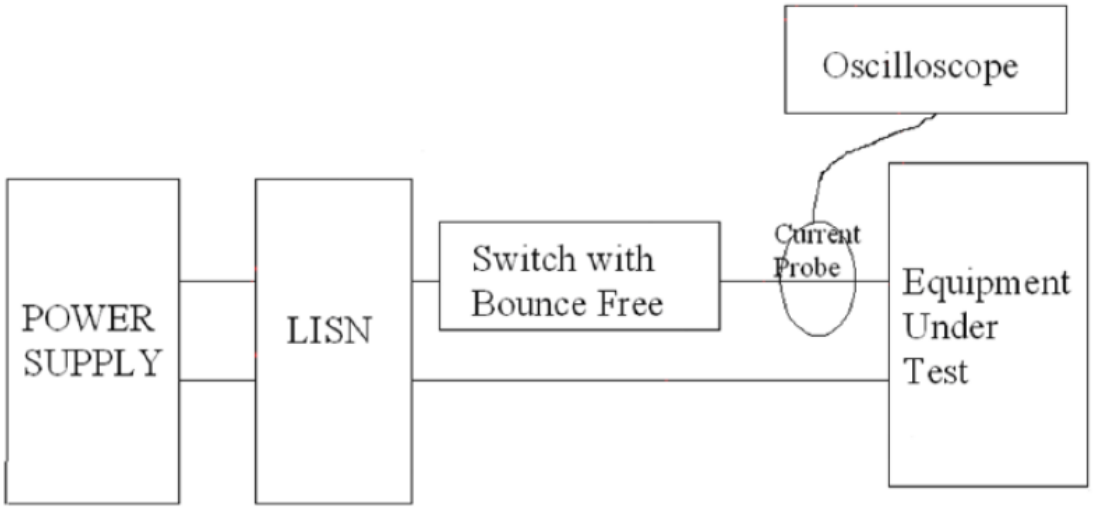

Fig. 3: Schematic of the Test Set-Up for inrush current

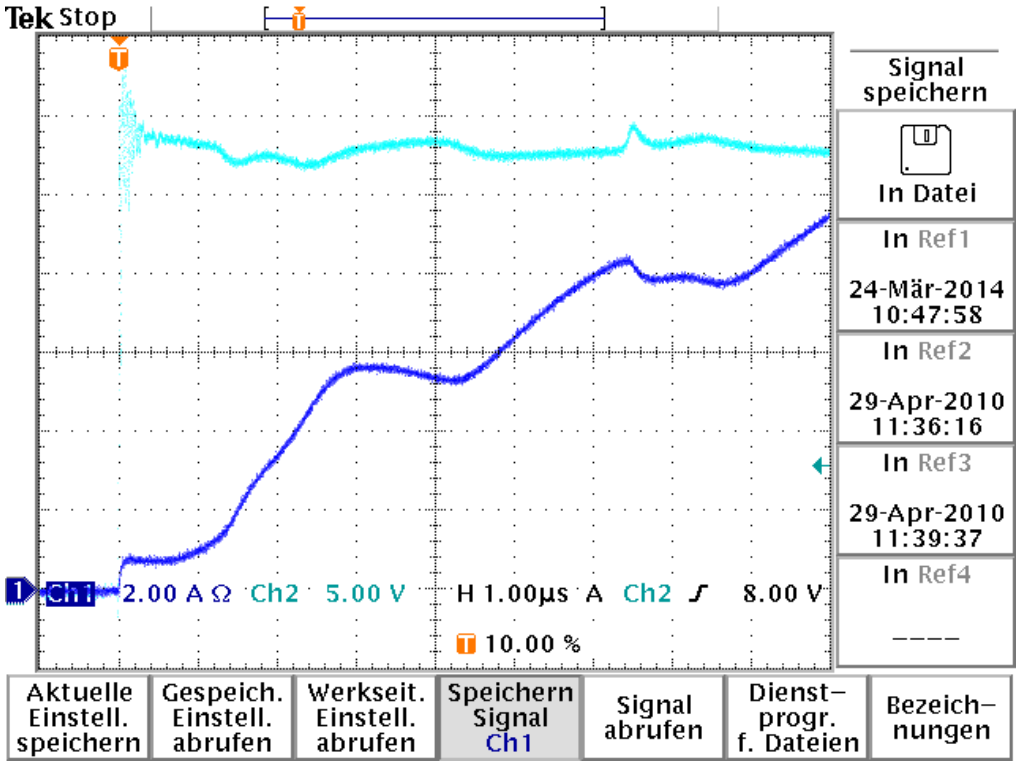

Fig. 4: dI/dt <= 2A/µs min. voltage 29V 10µs

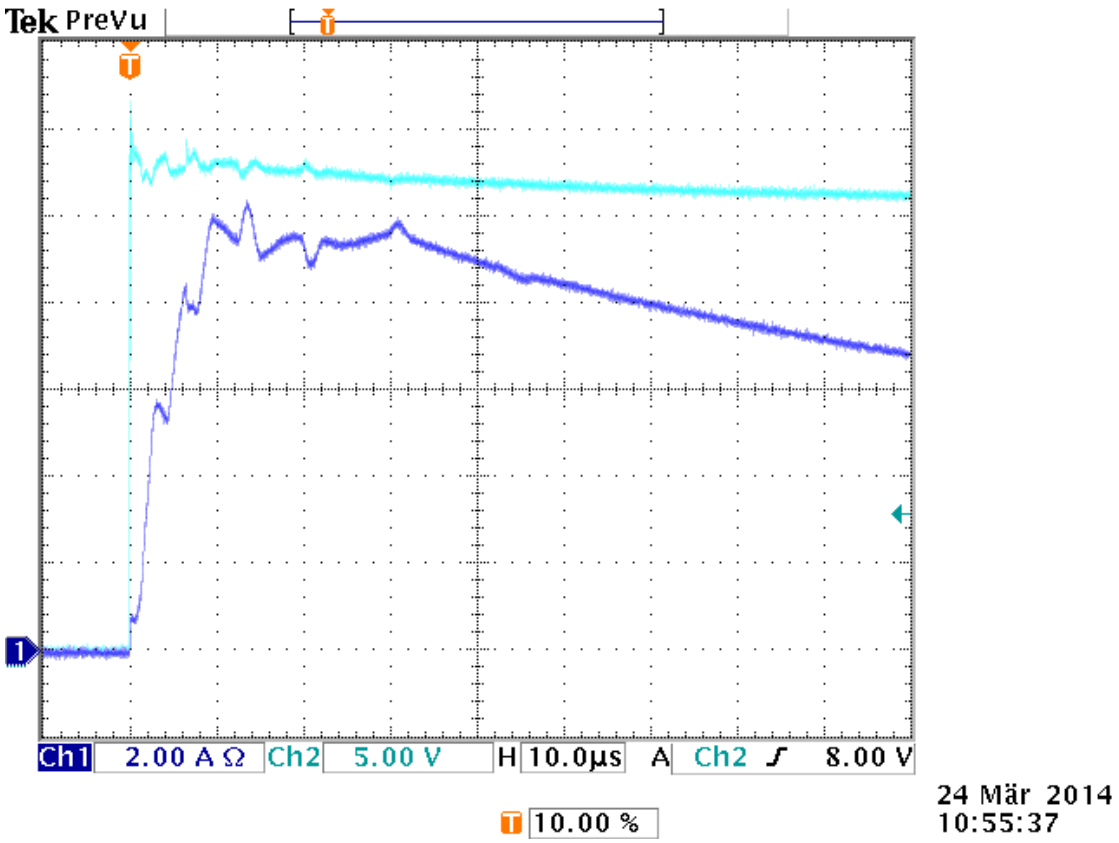

Fig. 5: dI/dt <= 2A/µs min. voltage 29V 100µs

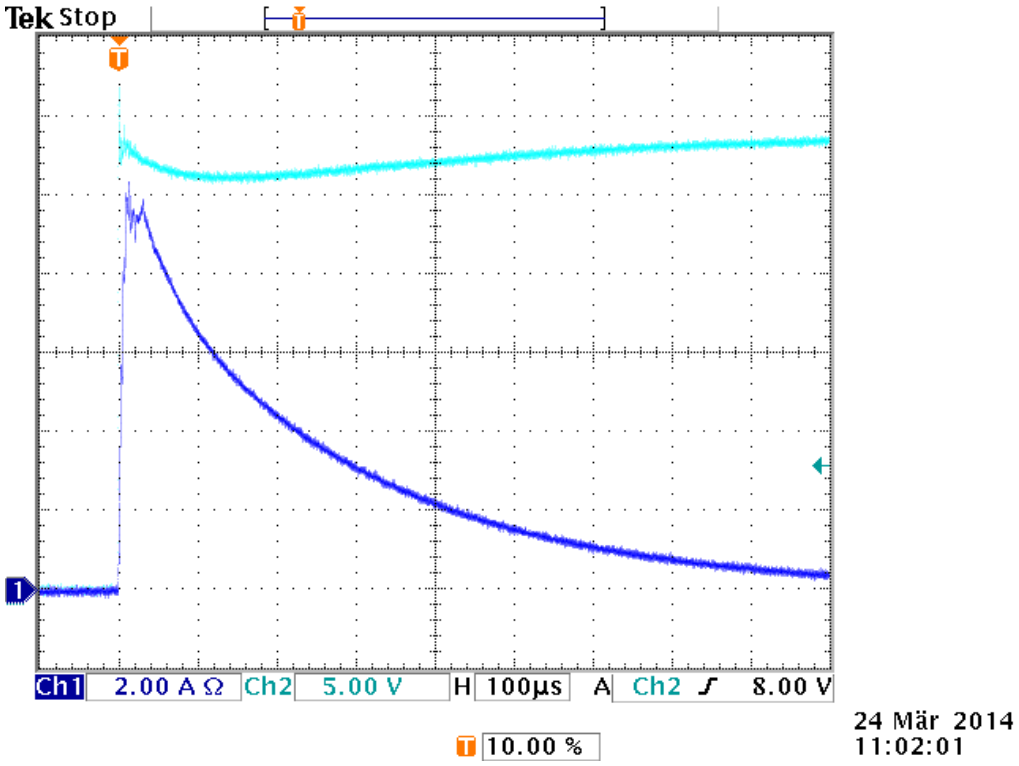

Fig. 6: dI/dt <= 2A/µs min. voltage 29V 1ms

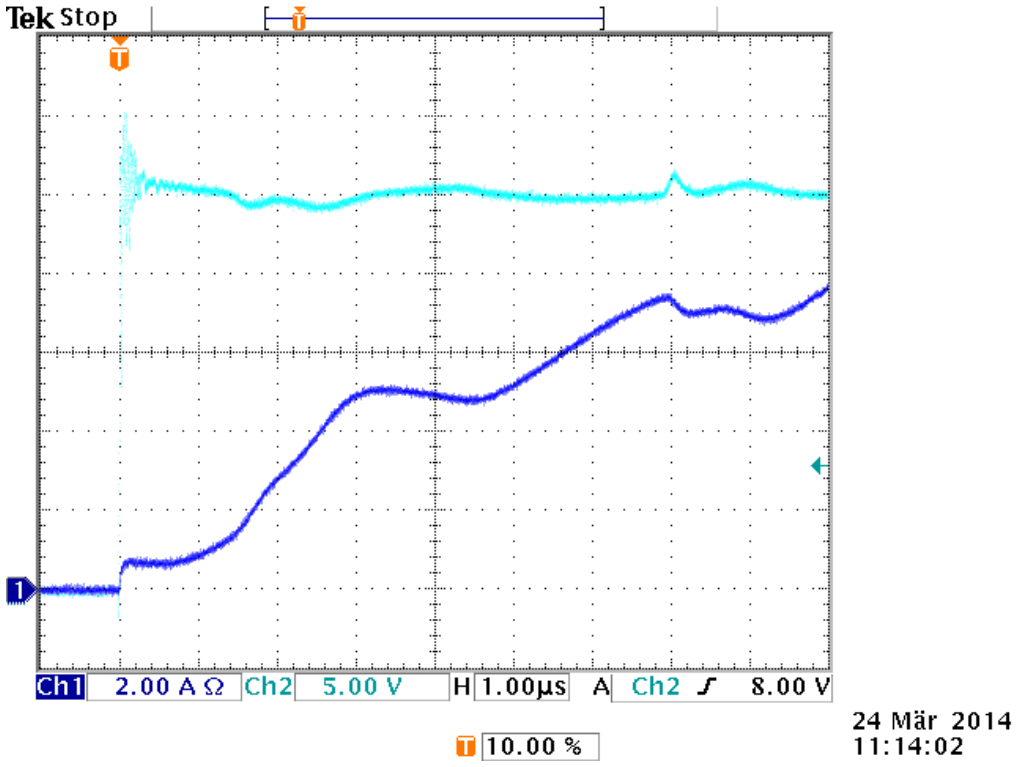

Fig. 7: dI/dt <= 2A/µs max. voltage 26V 10µs

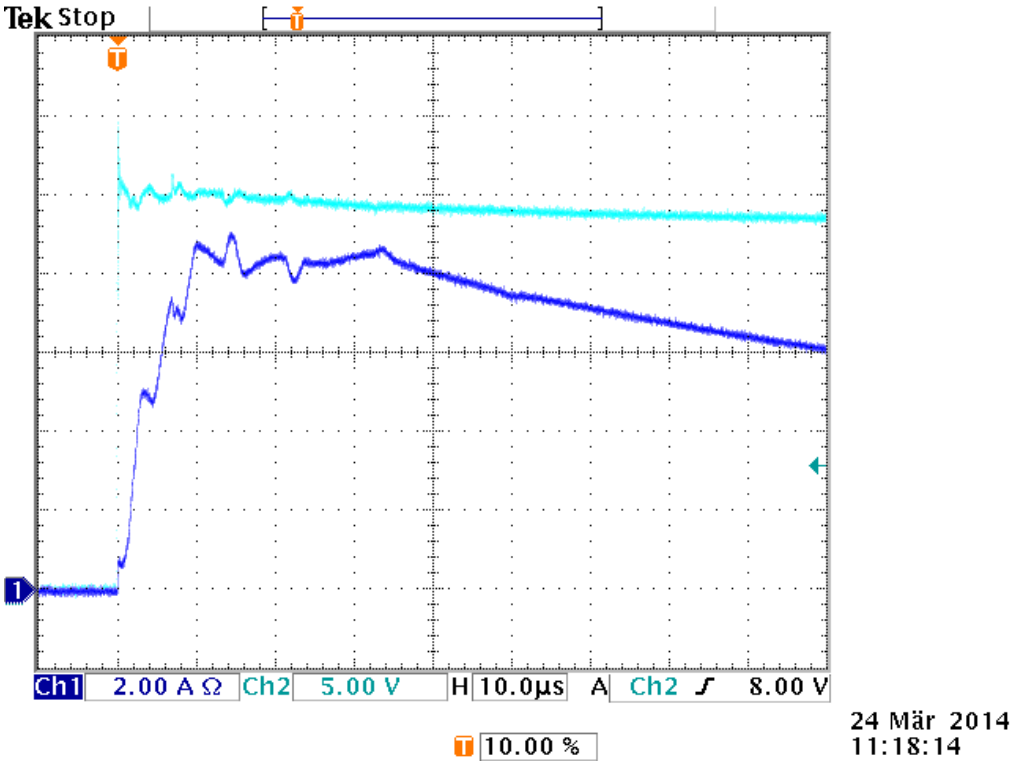

Fig. 8: dI/dt <= 2A/µs max. voltage 26V 100µs

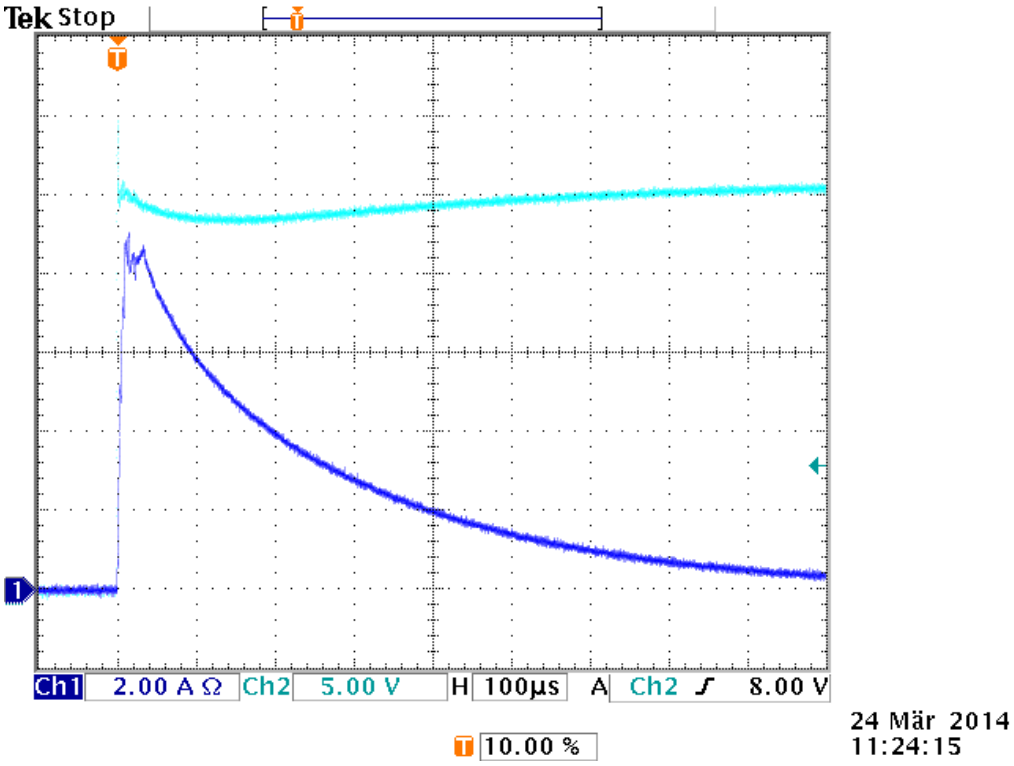

Fig. 9: dI/dt <= dI/dt <= 2A/µs max. voltage 26V 1ms

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

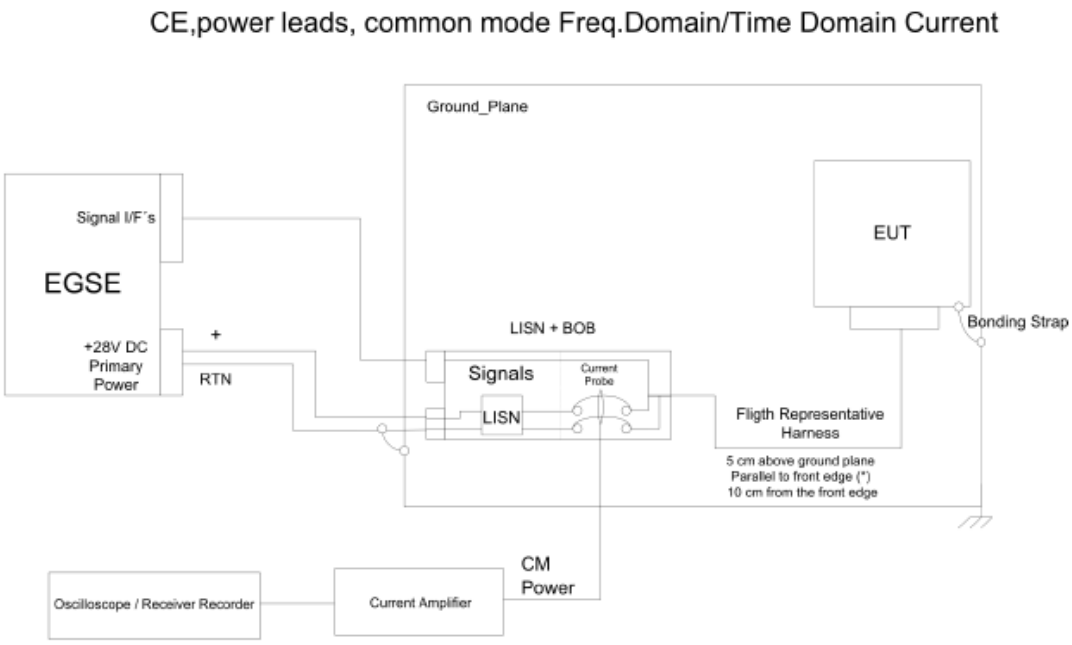

Fig. 10: Schematic of the Test Set-Up for CE-CM-FD

The uncertainty of the emission measurements is max. 3.0 dB

8.2.1 Conducted Emission 30Hz – 100MHz Noise CM

E.U.T. : SOLAR ORBITER ENERGETIC PARTICLE DETECTOR STEP EM

Test Procedure : SO-EPD-KIE-TP-0009, Issue 1, Revision 1, date 20.03.2014

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

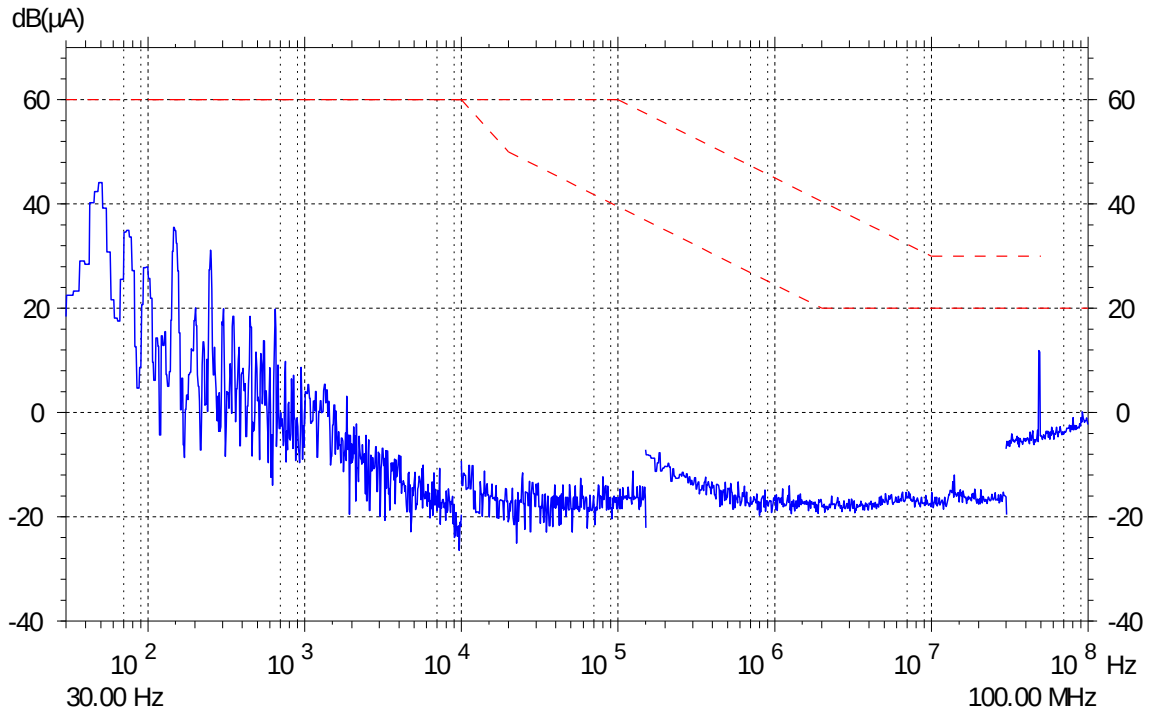

Fig. 11: Conducted Emission 30Hz – 100MHz Noise CM

8.2.2 Conducted Emission 30Hz – 100MHz CM

E.U.T. : SOLAR ORBITER ENERGETIC PARTICLE DETECTOR STEP EM

Test Procedure : SO-EPD-KIE-TP-0009, Issue 1, Revision 1, date 20.03.2014

Comment : limit line for noise limit (lower), limit line for measured values (upper), frequency range 50MHz -100MHz for information only. Noise floor = blue Actual measurement = green

Test Engineer : P.Sell

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

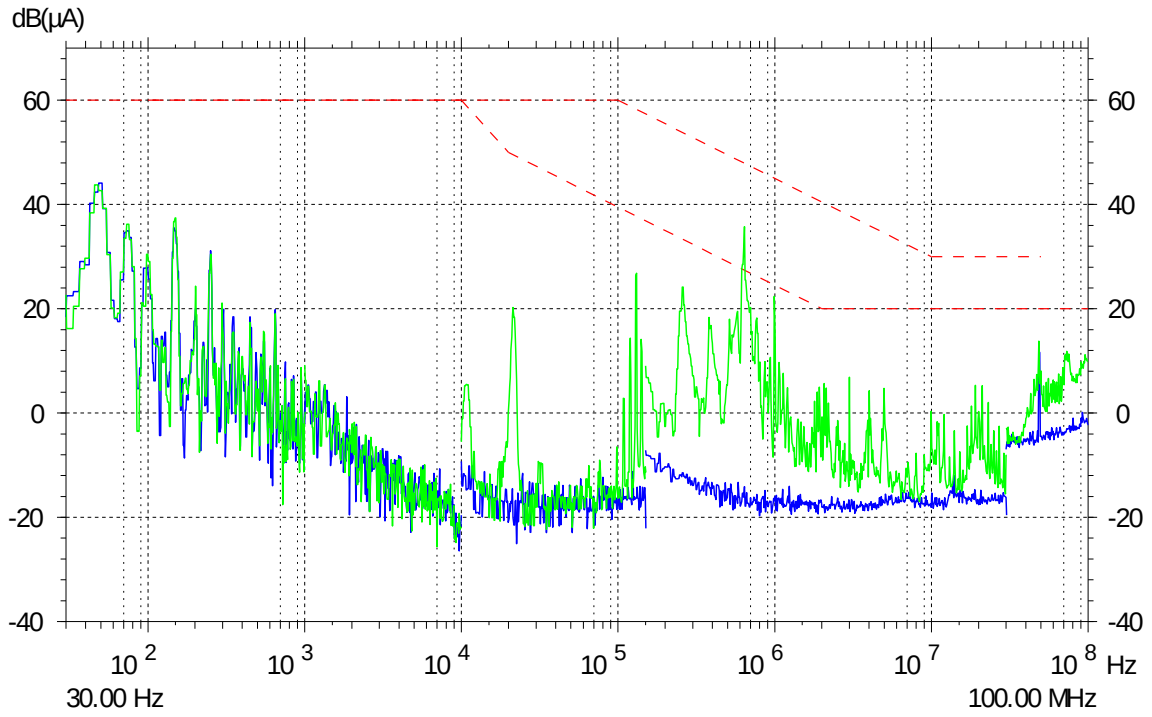

Fig. 12: Conducted Emission 30Hz – 100MHz CM(Green), Noise(Blue)

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

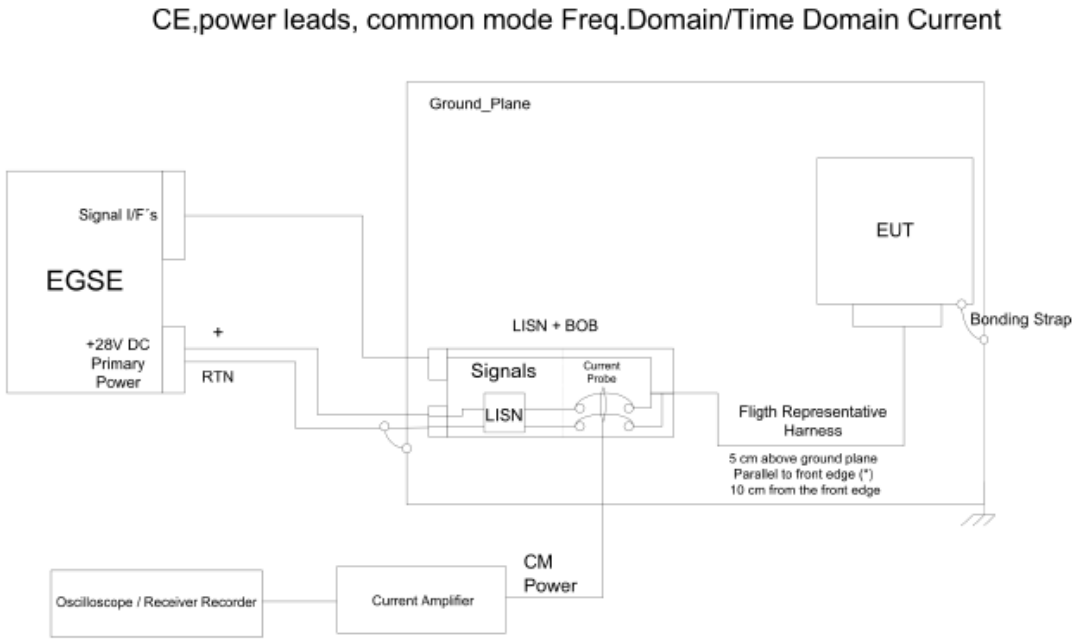

Fig. 13: Schematic of the Test Set-Up for CE-CM-TD

According to SO-EPD-KIE-TP-0009, Issue 1, Revision 1, date 20.03.2014:

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.

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.

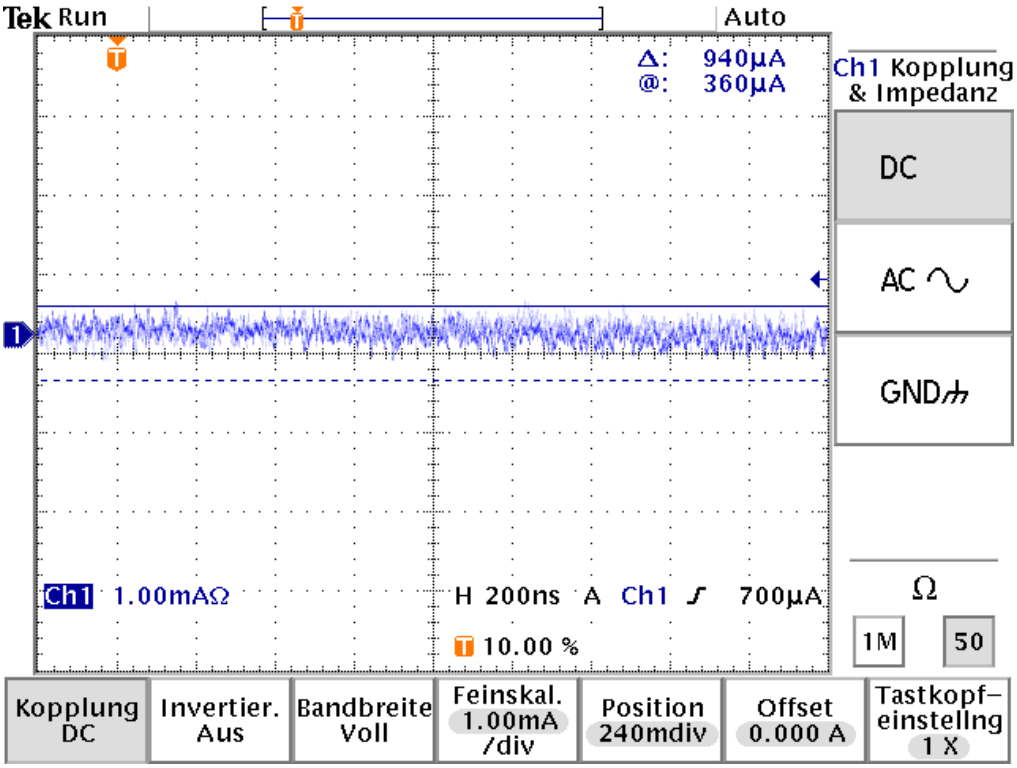

Fig. 14: Current ripple noise CM

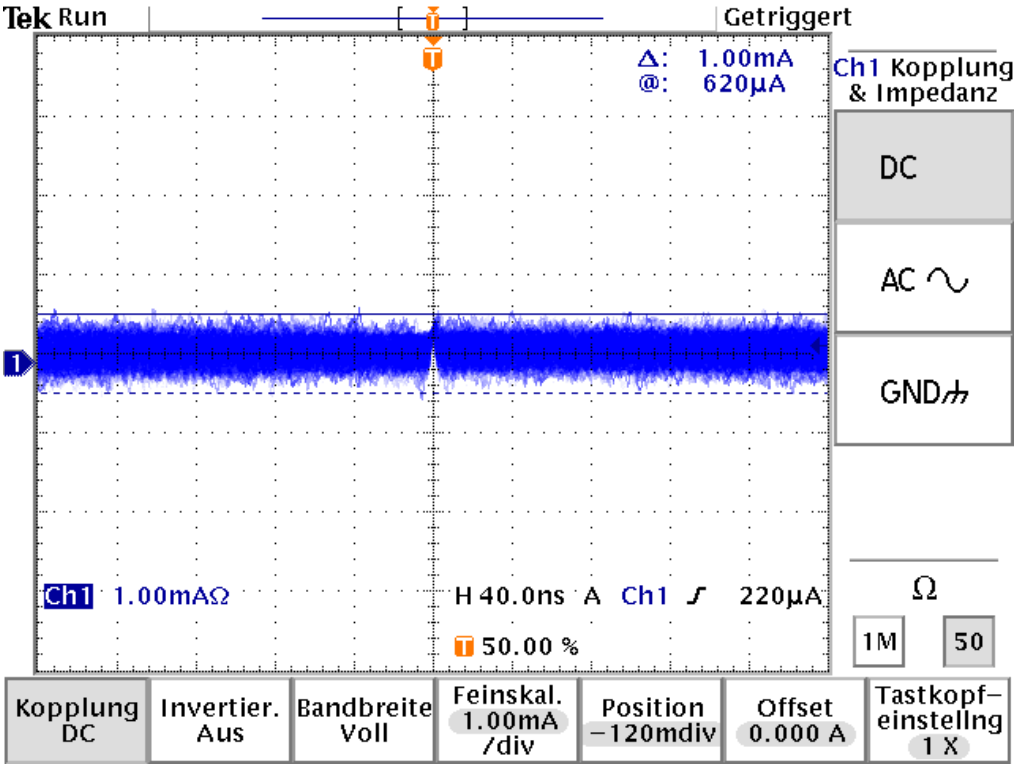

Fig. 15: Current ripple 40ns CM

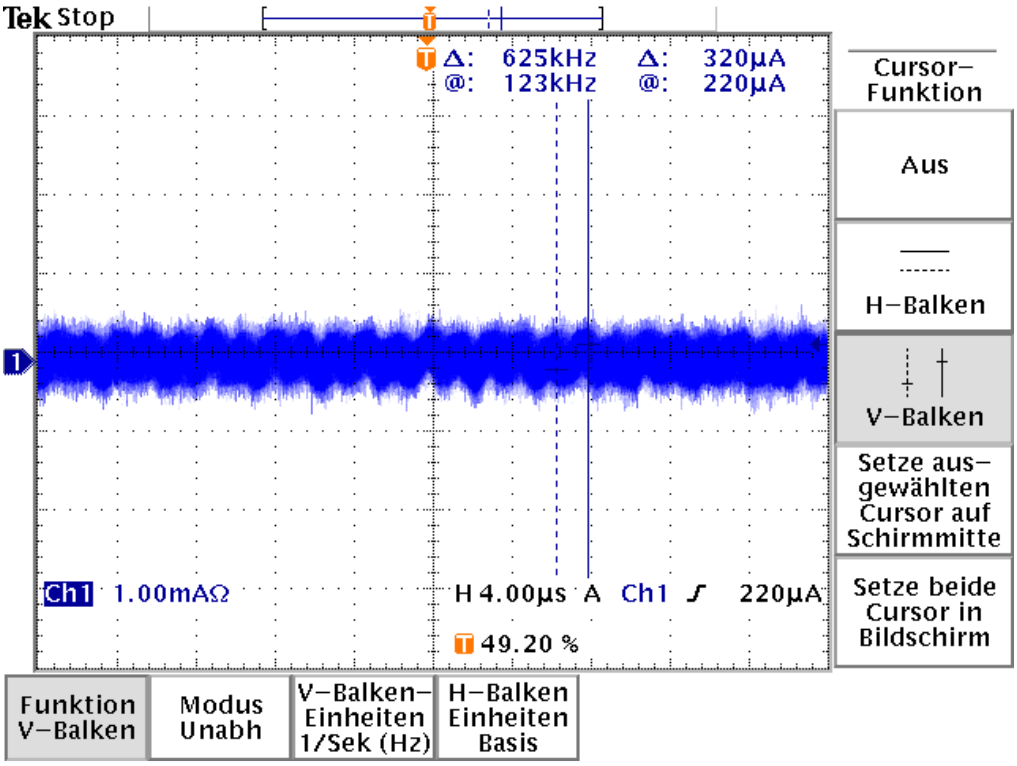

Fig. 16: Current ripple 4.0µs CM signal at 625kHz

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 STEP EM

Test Procedure : SO-EPD-KIE-TP-0009, Issue 1, Revision 1, date 20.03.2014

Comment : limit line for noise, 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

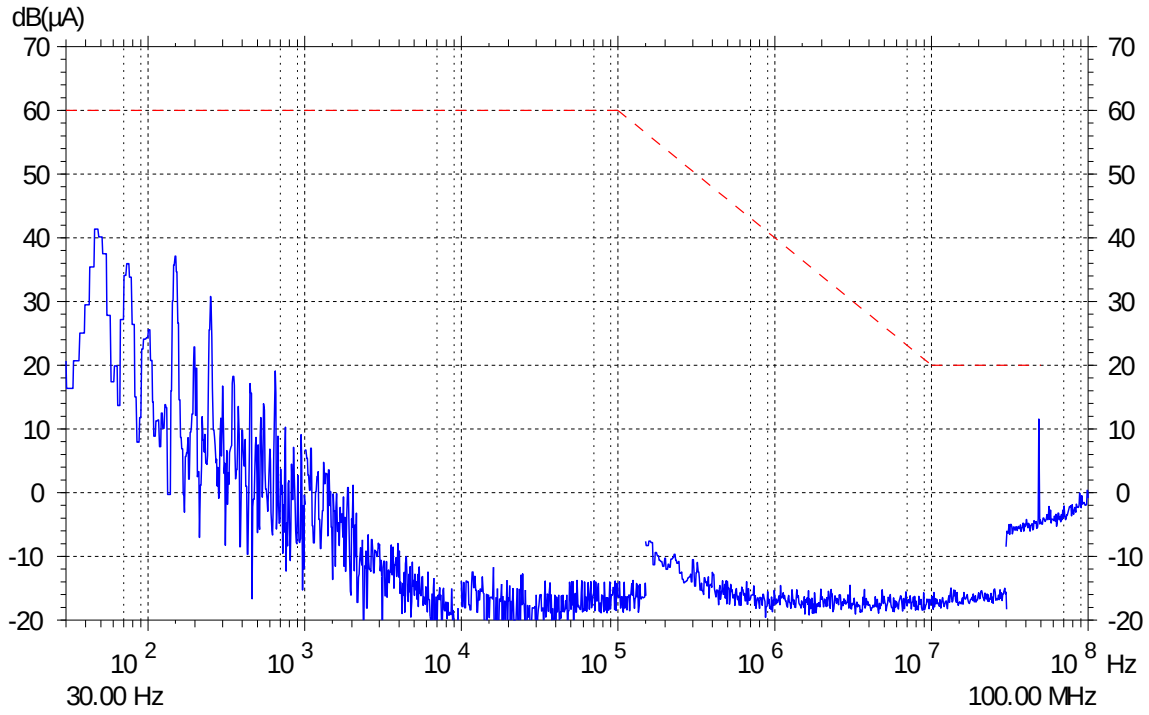

Fig. 17: Conducted emission 30Hz – 100MHz NOISE DM +28V DC

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

E.U.T. : SOLAR ORBITER ENERGETIC PARTICLE DETECTOR STEP EM

Test Procedure : SO-EPD-KIE-TP-0009, Issue 1, Revision 1, date 20.03.2014

Comment : limit line for noise, 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

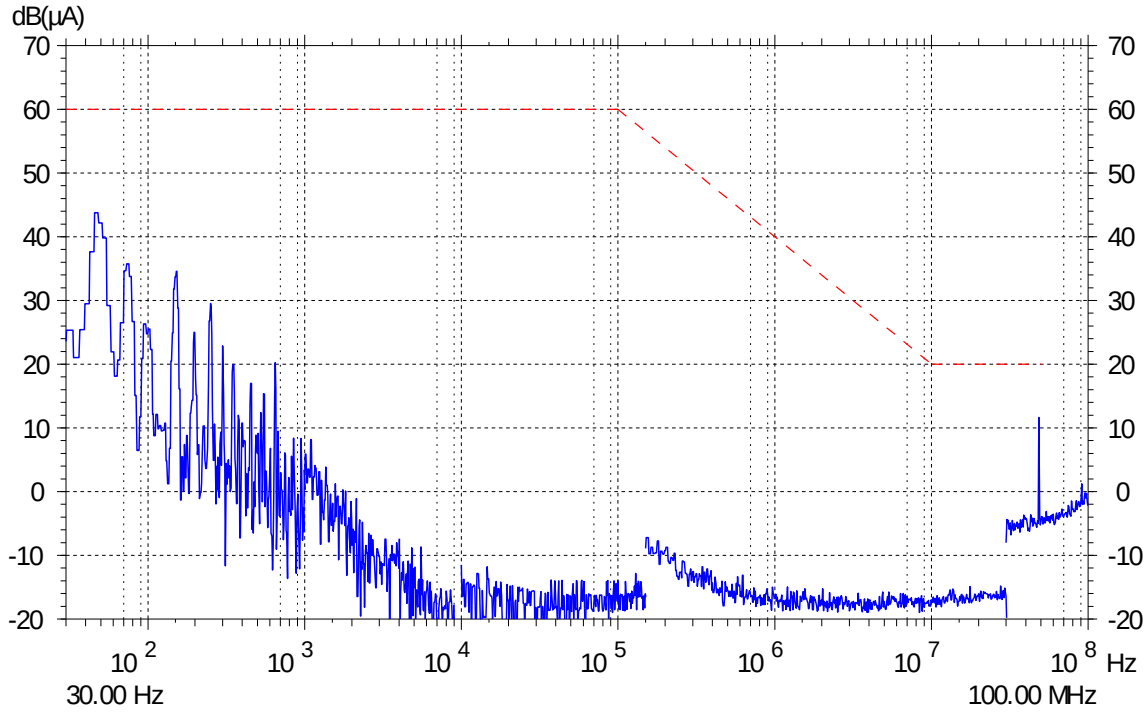

Fig. 18: Conducted emission 30Hz – 100MHz NOISE DM 0V DC

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

E.U.T. : SOLAR ORBITER ENERGETIC PARTICLE DETECTOR STEP EM

Test Procedure : SO-EPD-KIE-TP-0009, Issue 1, Revision 1, date 20.03.2014

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

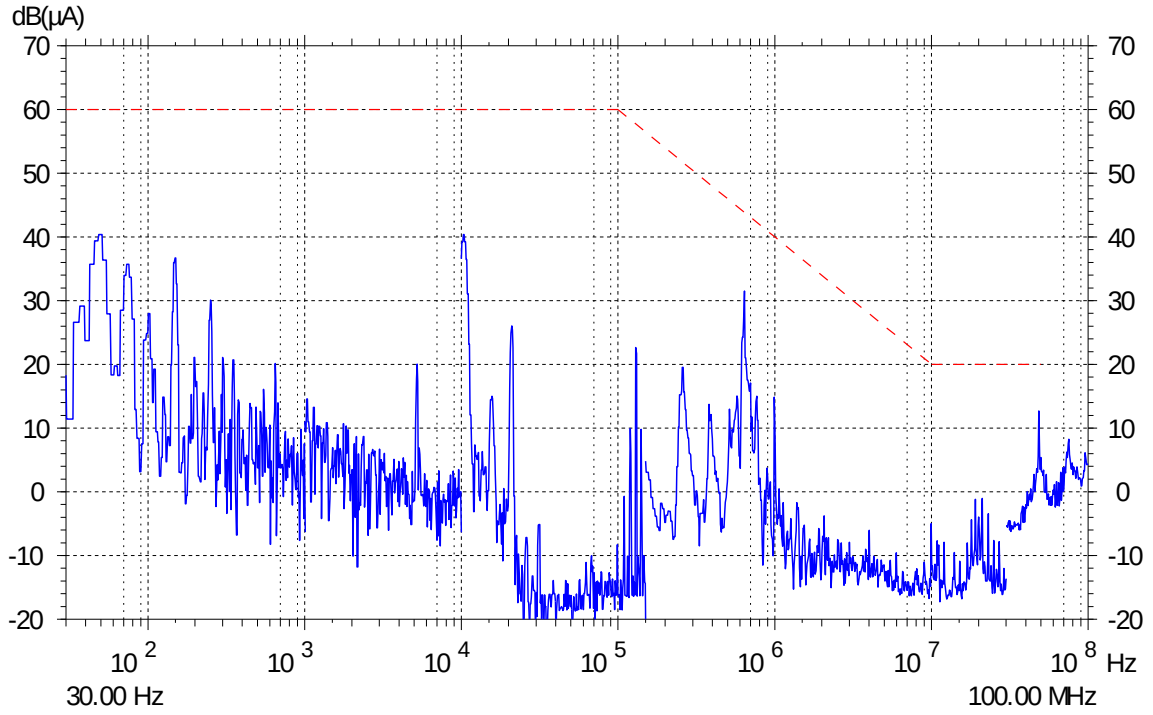

Fig. 19: Conducted emission 30Hz – 100MHz DM +28V DC

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

E.U.T. : SOLAR ORBITER ENERGETIC PARTICLE DETECTOR STEP EM

Test Procedure : SO-EPD-KIE-TP-0009, Issue 1, Revision 1, date 20.03.2014

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

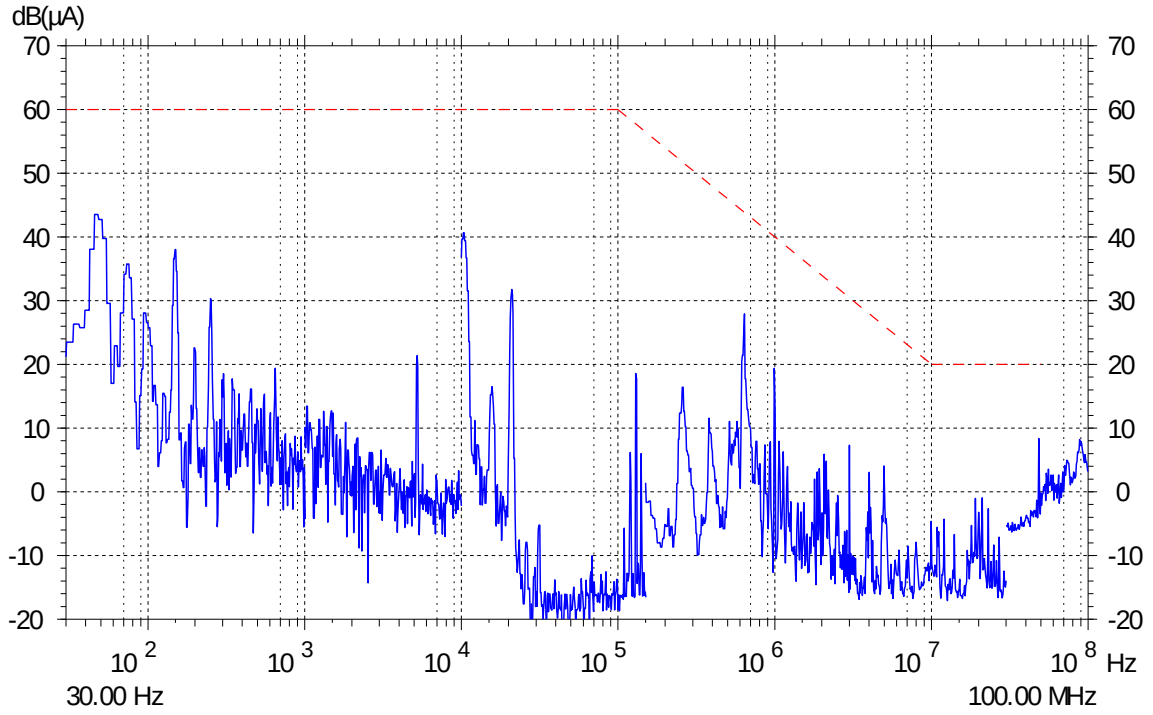

Fig. 20: Conducted emission 30Hz – 100MHz DM 0V DC

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

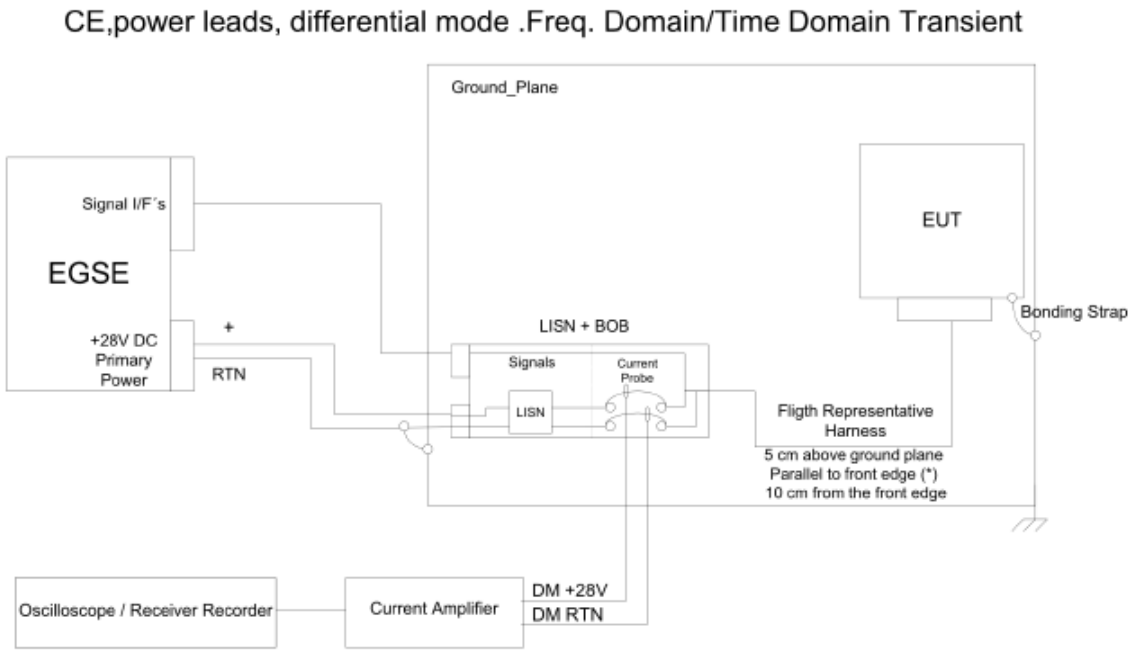

Fig. 21: Schematic of the Test Set-Up for CE-DM-TD

According to SO-EPD-KIE-TP-0009, Issue 1, Revision 1, date 20.03.2014:

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.

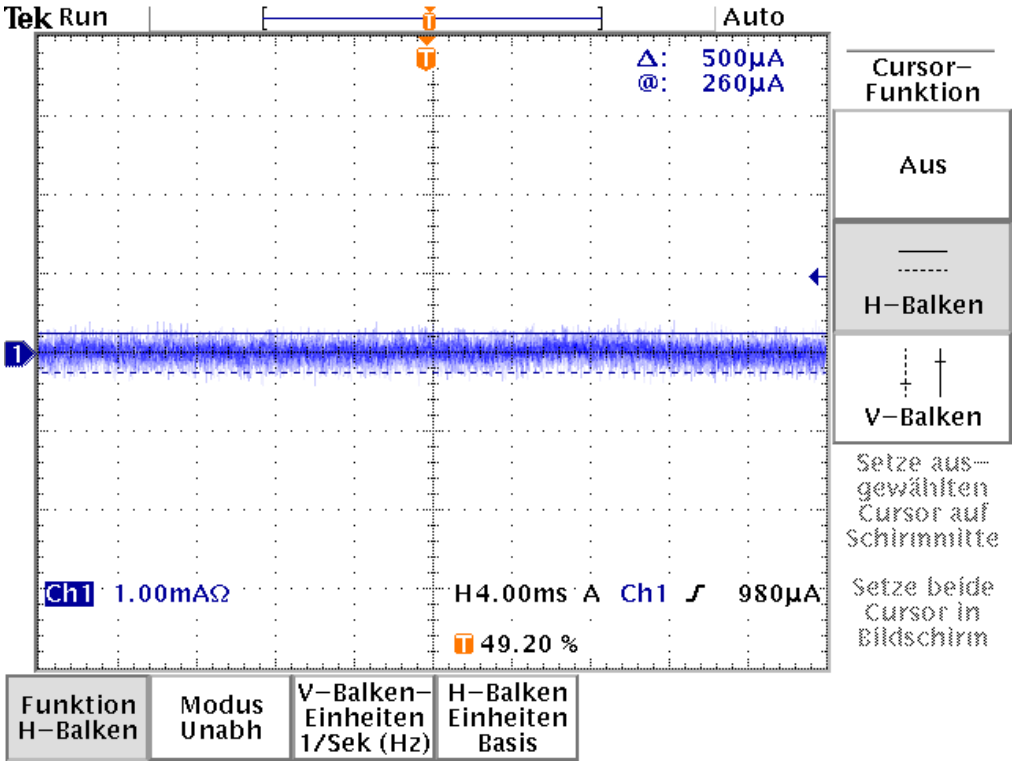

Fig. 22: Current ripple 4 ms DM +28V DC EUT off

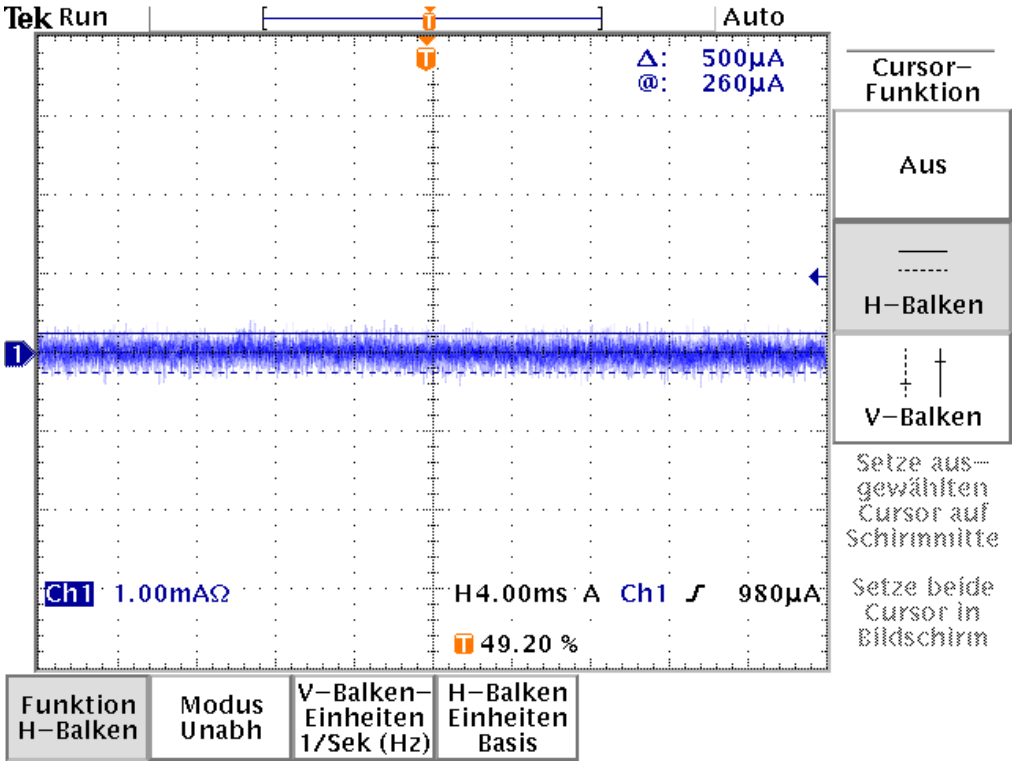

Fig. 23: Current ripple 4 ms DM 0V DC EUT off

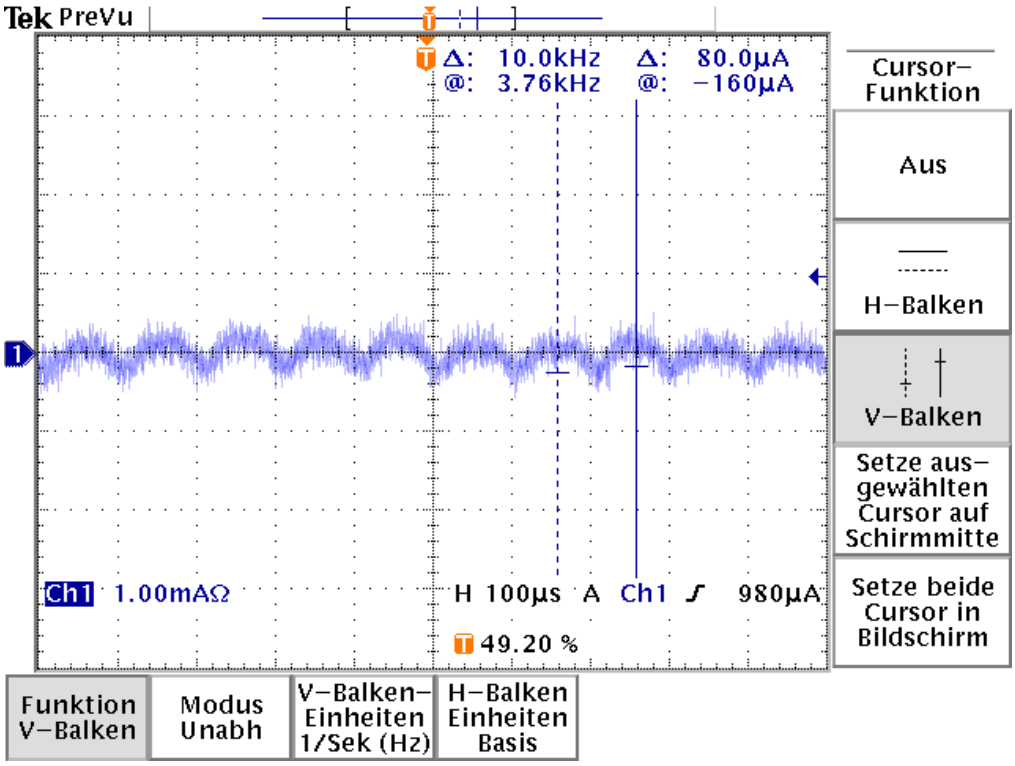

Fig. 24: Current Current ripple 100 µs DM +28V DC EUT on, 10kHz ripple

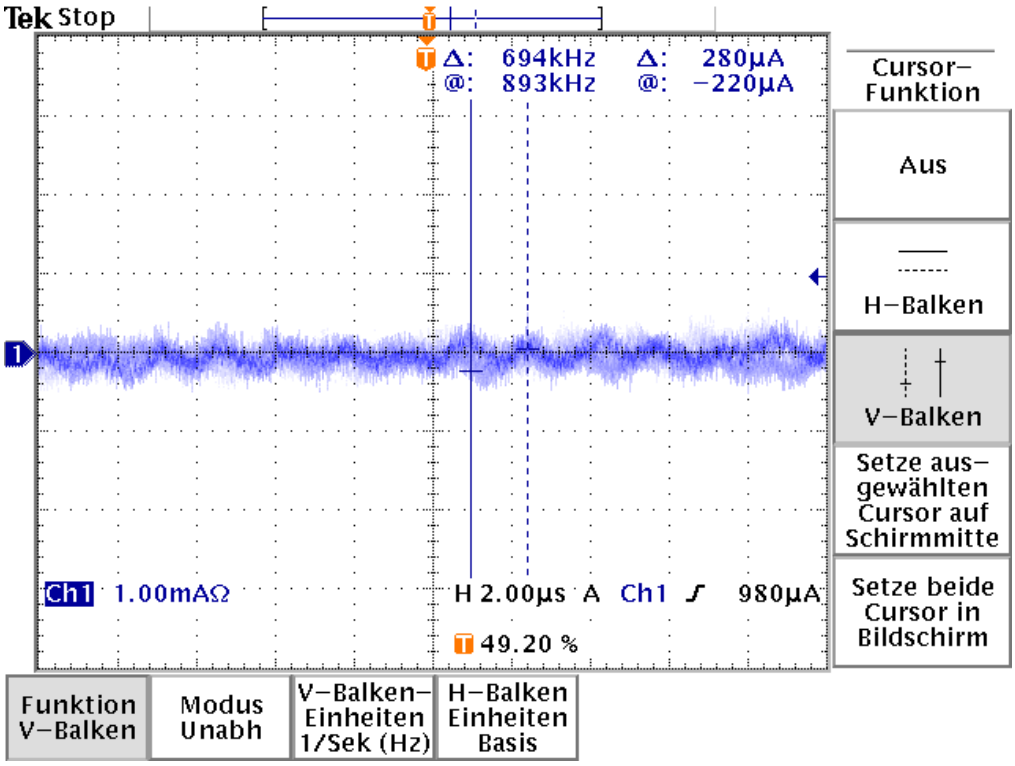

Fig. 25: Current ripple 2 µs DM +28V DC EUT on, 694kHz ripple

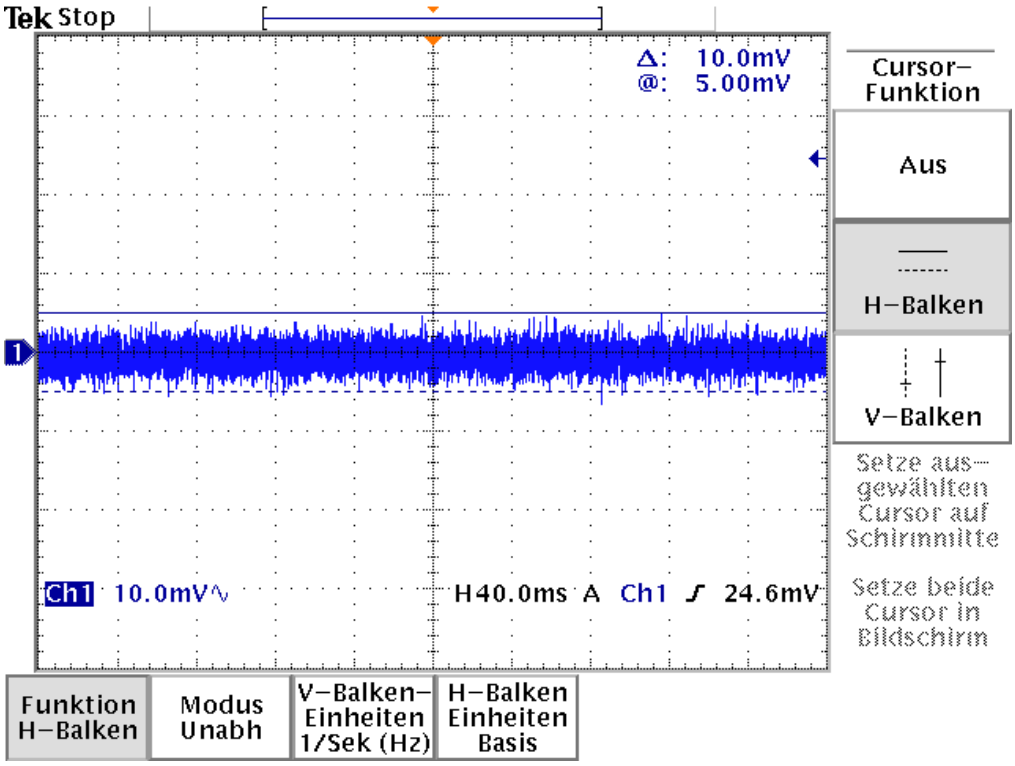

Fig. 26: Voltage ripple 10 µs DM DC EUT off

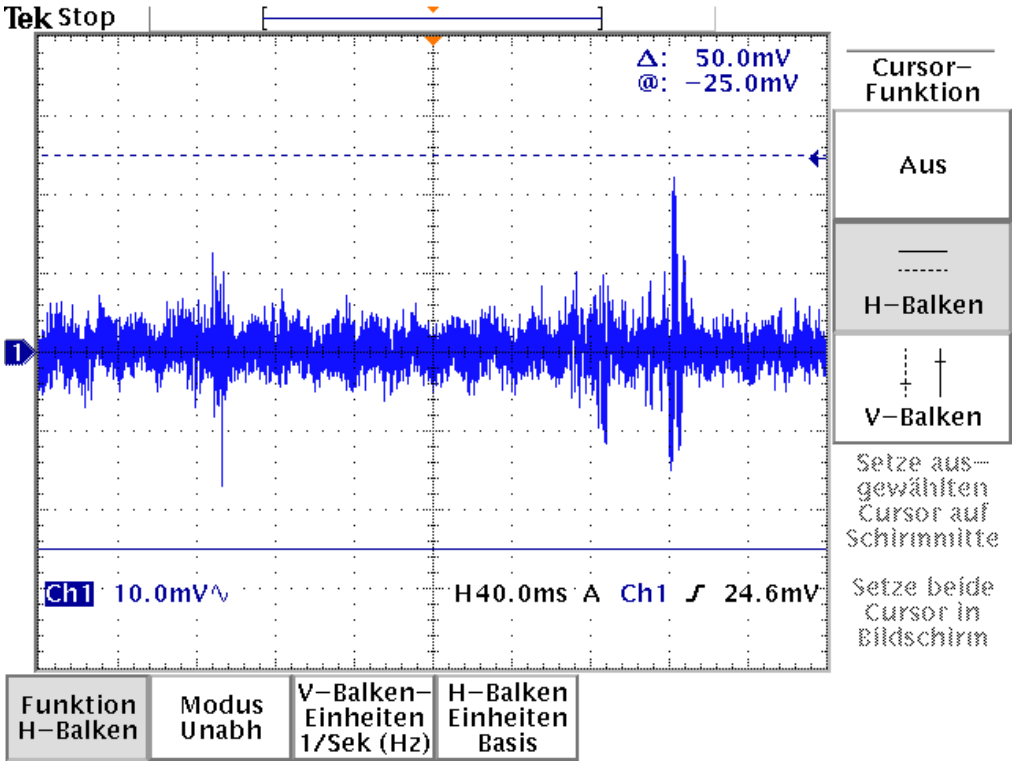

Fig. 27: Voltage ripple 40 ms, f = 4 Hz voltage spike, +28V DC EUT on

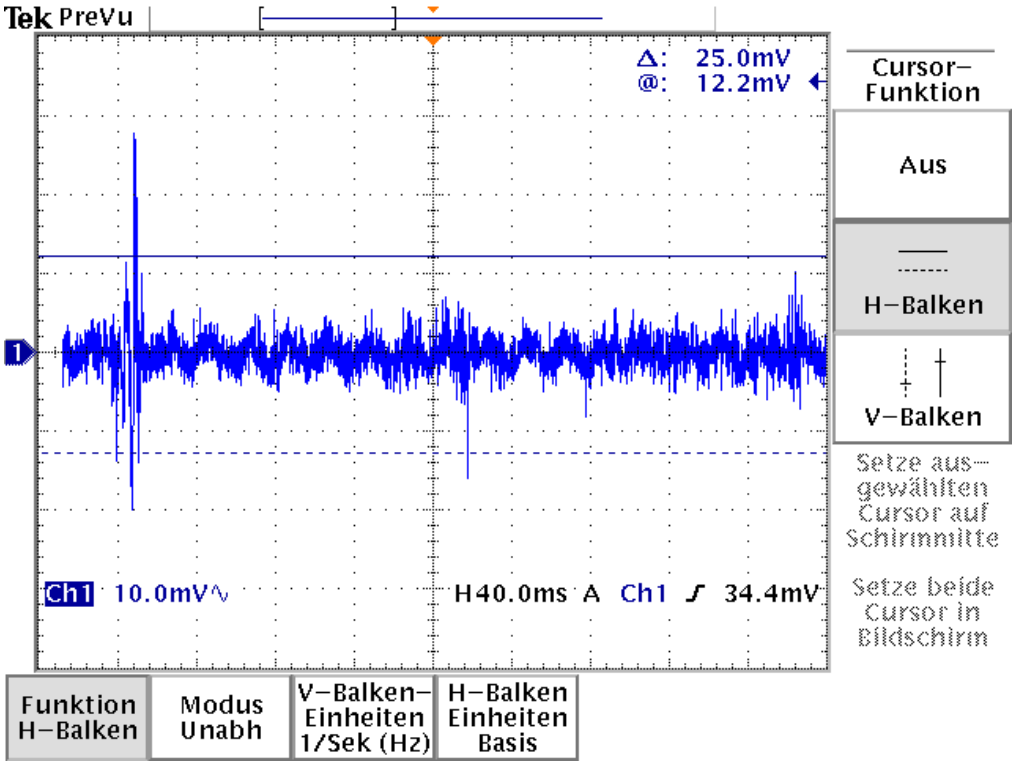

Fig. 28: Voltage ripple 40 ms, +28V DC EUT on

9 Photos of Test Set-Up

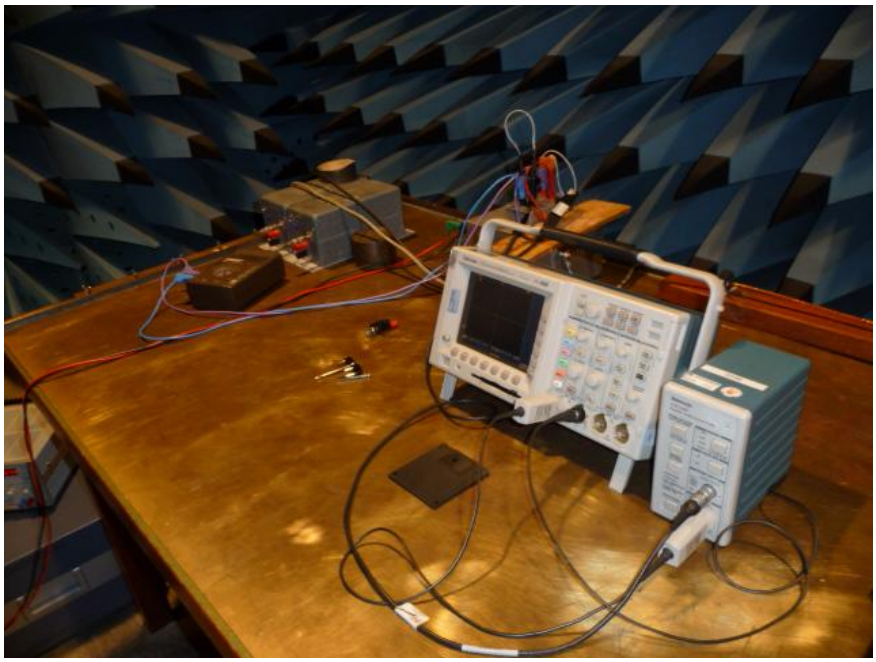

Fig. 29: Conducted emission, inrush current on power leads(6.2)

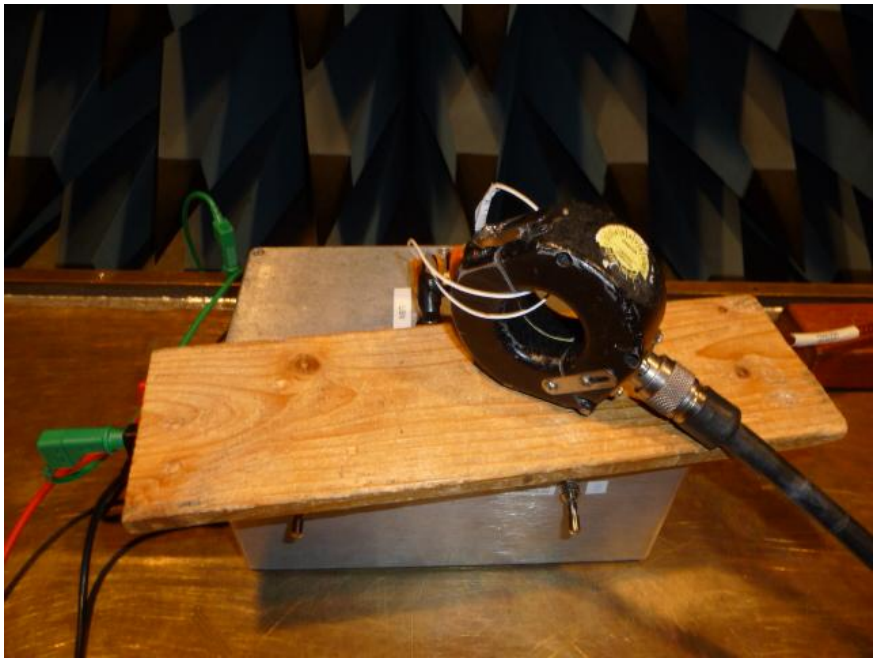

Fig. 30: Conducted emission on power leads, common mode, 30 Hz to 100 MHz, frequency domain(6.3)

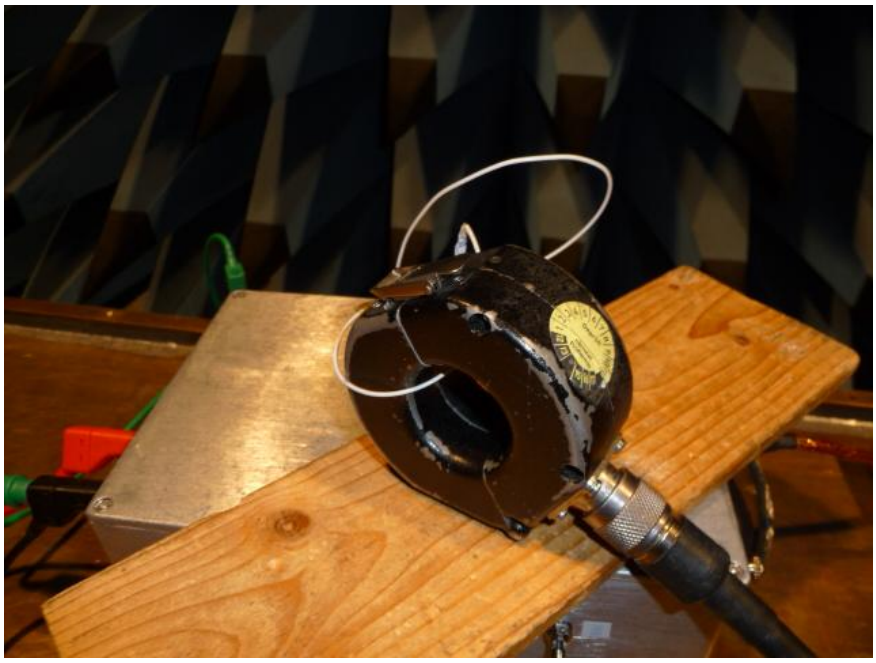

Fig. 31: Conducted emission on power leads differential mode, 30 Hz to 100 MHz, frequency domain(6.5)

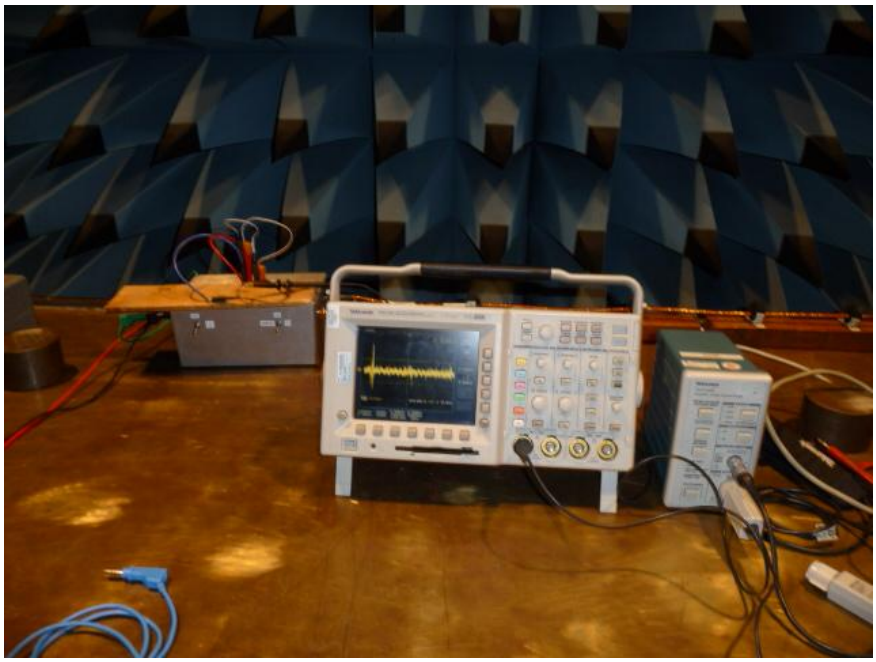

Fig. 32: Conducted Conducted emission on power leads differential mode, 30 Hz to 100 MHz, time domain(6.6)

END OF REPORT