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Information Documentaire / Document Information

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General Design, Control and Interface Specification (GDCIS) - electrical part applicable for Units of the repeater and the TTC-RF

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REQUIREMENT CHANGE RECORDS

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1. INTRODUCTION

This document establishes the general electrical design and interface requirements for equipments included in SPACEBUS 4000 repeaters to be met to ensure their correct performance during assembly, integration, testing, storage, transportation, launch and orbital operations.

This document is applicable for the units of the repeater and TTC.

2. APPLICABLE AND REFERENCE DOCUMENTS

2.1 Applicable documents

In case of conflict between any specification document and this applicable document, the specification document shall have precedence.

Any discrepancy shall be notified to the attention of Contractor for clarification and resolution.

Denom.	Title	Doc Ref.
AD 14	*Data Bus Network Electrical and Protocol Specification*	SBF 6AV2 AS SP 338
AD 15	*MIL STD 1553B Protocol and Interface Requirements for DBN*	SBF 6AV2 AS SP 504
AD 18	*MIL STD 1553B "Aircraft Internal Time Division Command/Response Multiplex Data Bus", with Notice 4*	
AD19	IDS RUBI	SBF 6AV22 DEV IS 00331
	The reduced sniff RE and snort RS EMC test procedure	SDR-ASPI-TP-0058
AD11	Instruction for preparing IDS and ICD	REF-ASPI-CN-88-E

2.2 Reference documents

The following documents listed hereinafter are for reference and information only. They have been used as basis for some requirements defined in the present specification.

AD01: Part 3 - EMC/ESD Requirements for Subsystems and Units SB4-6A-AS-SP-015

AD01: Part 4 - Subsystems and Units Requirements - Electrical Design and Interface Requirements SB4-6A-AS-SP-065

2.3 ACRONYMS, SYMBOLS AND ABBREVIATIONS

A/D	Analog/numeric conversion
ABM	Apogee Boost Motor
AC	Alternating current
ADPM	Antenna Deployment and Pointing Mechanism
AN	TM Analog
AOCS	Attitude and Orbit Control Subsystem
AOCSP	Attitude and Orbit Control System PCB
AOCSP_NG	Attitude and Orbit Control System PCB_ New Generation
APM	Antenna Pointing Mode
AWG	American Wire Gauge
BAPTA	Bearing and Power Transfer Assembly
BBC	Bus Brick Connection
BCRB	Battery Connection Relay Box
CM	Common Mode
CRM	Central Reconfiguration Module
DB	TM Digital bi-level
DC	Direct current
DC/DC	Direct current/Direct current
DM	Differential Mode
DOCON	DOwn CONverter
DR	TM Digital Relay
DS16	TM Digital Serial 16 bit
DSPG	Distributed Single Point Grounding
EED	Electro-Explosive Devices
EGRN	Electrical Ground Reference Network
EGRP	Electrical Ground Reference Point
EGSE	Electrical Ground Support Equipment
EMC	Electro-Magnetic Compatibility
EPC	Electrical Power Conditioning
EPS	Electrical Power Subsystem
ESD	Electro-Static Discharges
HLC	High Level Command
HPC	High Priority Command
ICD	Interface Control Drawing
IDS	Interface Data Sheet
ITO	Iridium Tantale Oxyd
IRES	Infra-Red Earth Sensor

LLC	Low Level Command
LMU	Li-Ion Battery Management Unit
LNA	Low Noise Amplifier
LPC	Low Priority Command
LSB	Least Significant Bit
MLC	Memory Load Command
MLI	Multi Layer Insulator
MSB	Most Significant Bit
NRZ	Non Return to Zero
NRZ-L	Non Return to Zero Level
OBDH	On Board Data Handling
OBP	On Board Processor
OSR	Optical Surface Radiator
PCB	Printed Circuit Board
PCM	Pulse Code Modulation
PCU	Power Conditioning Unit
PFDIU	PlatForm Distribution and Interface Unit
PLDIU	Payload Distribution and Interface Unit
PROP	PROPulssion electronic (Chemical/Plasmic) PCB
PPS	Plasmic Propulsion Subsystem
PPU	Power Processing Unit
PYPGP	Pyrotechnic Pcb with GP relays
RA	Rotary Actuator
RUBI	Remote User Brick Interface
RF	Radio Frequency
RX	Receiver
S/C	Spacecraft
S/W	Software
S4DSAP	SB4000 Deployment of Solar Array PCB
SA	Solar Array
SADM	Solar Array Drive Mechanism
SADP	Solar Array and Deployment PCB
SBDL	Standard Balanced Digital Signal
SDIU	Satellite Distribution and Interface Unit
SDMP	Stepper and Deployment Motor PCB
SLI	Single Layer Insulator
SMU	Satellite Management Unit
SPF	Single Point Failure
SSM	Second Surface Mirror
STR	Star Tracker

TC	Telecommand
TCR	Telemetry, Command and Ranging
TH	Thermistor
TLM	Telemetry
TM	Telemetry
TOM	Thruster Orientation Mechanism
TTC	Tracking, Telemetry and Command
TWT	Travelling Wave Tube
TWTA	Travelling Wave Tube Amplifier
TX	Transmitter
UPCON	UP CONverter
UPS	Unified Propulsion Subsystem
w.r.t.	with respect to

3. GENERAL SPECIFICATIONS

3.1 Engineering specifications

Reference **[CU-GDCEL-REQ-001]**

The metric standard (SI - International system) shall be used for design, manufacturing and testing of systems or subassemblies.

In Reference *

Reference **[CU-GDCEL-REQ-002]**

All requirements in this document shall be applicable in all environmental conditions (mechanical, thermal,radiation,)

In Reference *

3.2 Lifetime

Reference **[CU-GDCEL-REQ-003]**

Units and subsystems shall be designed for a 15 years lifetime after having been stored for 5 years in a protected environment and having been used for tests and integrations for 2 years.

In Reference *

3.3 Delivery

Reference **[CU-GDCEL-REQ-004]**

All unit/subsystem shall be delivered in POWER OFF status.

In Reference *

3.4 Redundancy rules

Reference **[CU-GDCEL-REQ-005]**

When redundancy is implemented in the design, any single failure leading to total or partial loss of the unit operational capability or mission shall be forbidden.

In Reference *

Reference **[CU-GDCEL-REQ-006]**

When nominal and redundant ways are designed on the same board or device, the two functions shall be separated physically in order to avoid any risk of failure propagation.

In Reference *

Reference **[CU-GDCEL-REQ-007]**

Nominal and redundant ways shall use separated connectors.

In Reference *

3.5 Single point failure

Reference **[CU-GDCEL-REQ-008]**

All units, with nominal power consumption higher than 20W, shall always be able to switch-off in any case of failure (except in case of OFF command interface failure).

In Reference *

3.6 Test points

Reference **[CU-GDCEL-REQ-009]**

The test points shall be clearly identified in the unit ICD/IDS.

In Reference *

Reference **[CU-GDCEL-REQ-010]**

Test points on multi-pin connectors shall be designed to withstand, without causing damage to the unit, the highest voltage on that connector unit as well as short circuits

In Reference *

Reference **[CU-GDCEL-REQ-011]**

Unit test connectors shall be provided with electrically conductive covers

In Reference *

Reference **[CU-GDCEL-REQ-012]**

Input test points shall be connected to a referenced voltage point

In Reference *

4. ELECTRICAL ARCHITECTURE REQUIREMENTS

4.1 Grounding and isolation requirements

4.1.1 Grounding concept

The spacecraft structure constitutes a low impedance reference named Electrical Ground Reference Network (EGRN).

Reference **[CU-GDCEL-REQ-013]**

All metallic sub-chassis, chassis and enclosures of each unit, including all connectors' shells and other fittings, shall be considered electrically as extensions of the EGRN.

 # In Reference *

The grounding and bonding concept is a "returns by wires" concept with a Distributed Single Point Grounding (DSPG) configuration.

Possible grounded solutions for unit secondary reference point are shown in the following figure.

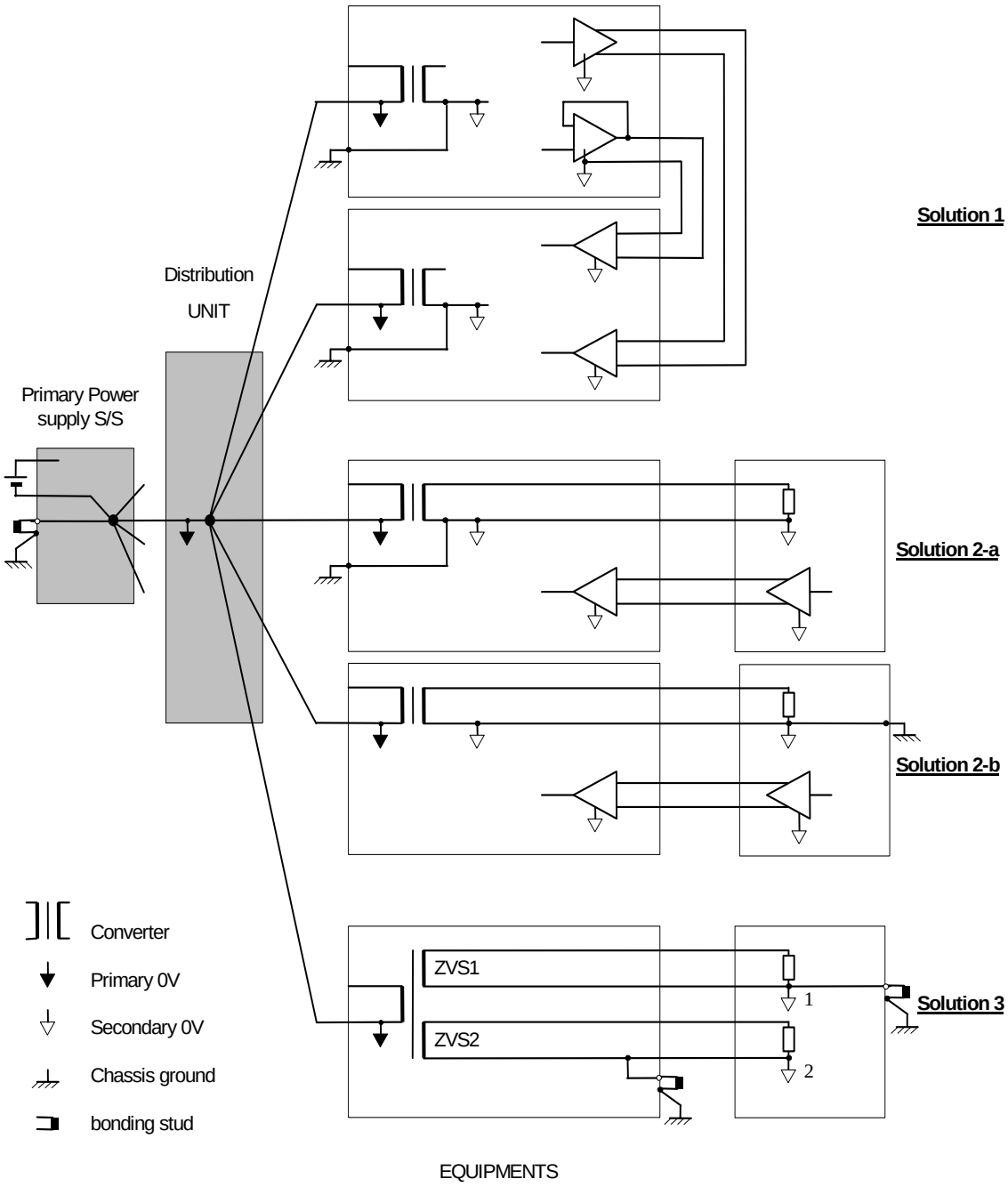


Figure 4.1-1: Basic philosophy for Distributed Single Grounding Concept

4.1.2 Grounding Solutions

Reference **[CU-GDCEL-REQ-014]**

One of the solutions listed below shall be used for units grounding

Solution 1: The unit secondary reference point is insulated from the secondary reference point of other units (implying the use of insulated or differential interfaces between the units). In this case, the equipment shall be grounded internally to its own housing in order to ensure a low impedance ground path.

Solution 2 : The unit secondary reference point is common to several units.

In this case :

- the unit assembly shall be grounded at only one point,

Solution 3: Unit shall provide dedicated bounding studs so that each unit secondary reference point can be grounded externally to the equipment housing. One of the grounding stud shall be insulated from the equipment structure and connected to the unit secondary reference point; the other one shall be connected directly to the chassis ground (See the following figure).
It shall be possible to ground the unit secondary reference point by placing a bar (removable strap) between the two bounding studs.
This requirement is not mandatory for RF equipment which have an internal link.
It must be noted that the above-mentioned bounding studs is different from the bounding strap used to connect the unit case to the mechanical structure

The bar shall be supplied by the equipment manufacturer.

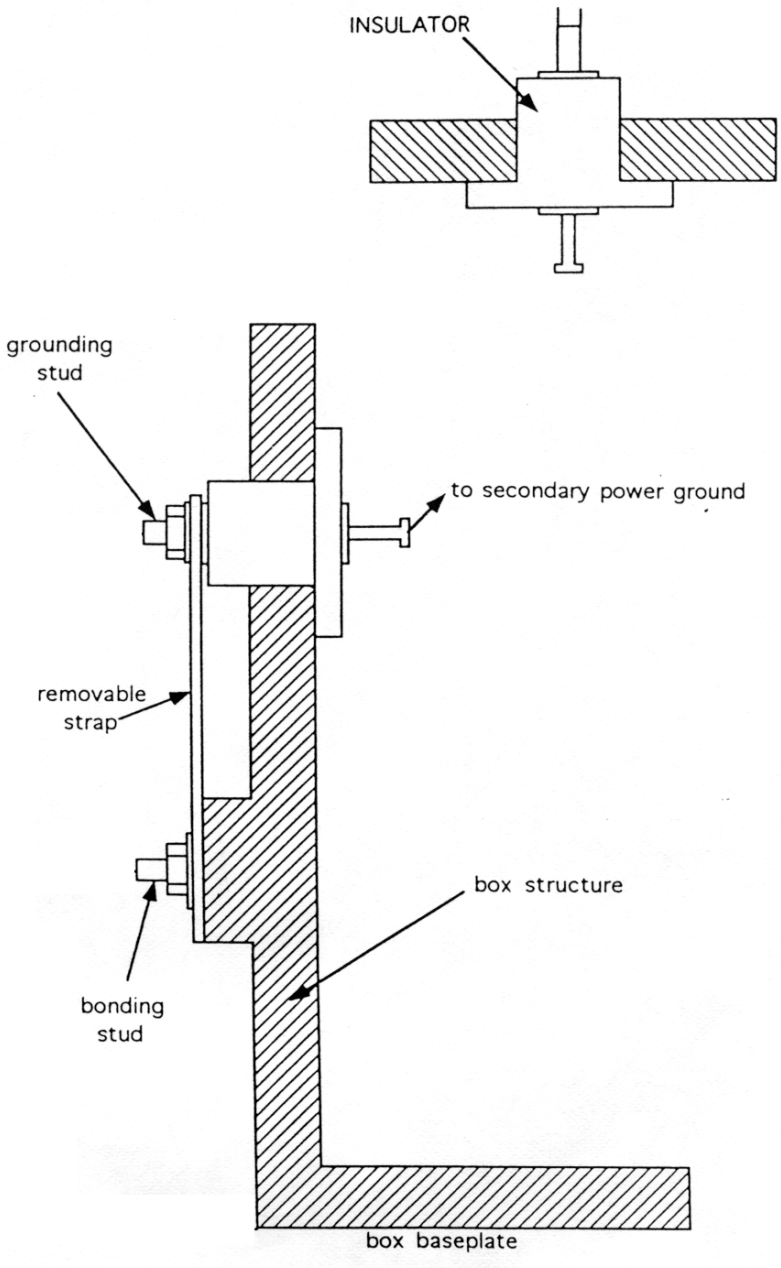


Figure 4.1-2: Grounding of a unit secondary reference point via a bonding stud

*# In Reference *

4.1.3 Grounding and isolation diagram

Reference **[CU-GDCEL-REQ-015]**

This diagram shall indicate any AC or DC loop, the type of isolation/insulation used, and any impedance coupling between zero volt and structure and shall be established for all Equipment and Subsystems containing electrical/electronic circuits.

In Reference *

Reference **[CU-GDCEL-REQ-016]**

An overall zero volt and grounding diagram shall be provided in the IDS for establishing functional and electromagnetic compatibility.

In Reference *

4.1.4 Power lines grounding

Reference **[CU-GDCEL-REQ-017]**

The grounding connection impedance between the unit electrical 0V ground and its housing shall be lower than 2.5 mΩ measured under 1 Adc current and inductance shall not exceed 100 nH.

In Reference *

4.1.4.1 **Grounding of secondary power bus 0V**

Reference **[CU-GDCEL-REQ-018]**

The high voltages necessary for the TWT's shall be considered as secondary power and shall be referenced at the EPC (via EPC structural part) and at the TWT side (via the TWT structural part).

In Reference *

Reference **[CU-GDCEL-REQ-019]**

The grounding path shall be designed and sized to withstand a current equal to 1.5 times the worst case fault current as limited by the unit primary power bus protection device. The following current shall be considered :

- either a primary current due a short-circuit between the primary power supply positf line and the unit secondary reference point/mechanical ground.
- or a secondary current due to a short-circuit between a secondary power line and the secondary reference point/mechanical ground.

In Reference *

Reference **[CU-GDCEL-REQ-020]**

All transformer screens shall be grounded to chassis.

In Reference *

4.1.5 Primary and secondary power lines insulation

Reference **[CU-GDCEL-REQ-021]** AD-AV4-AD01_Part4-5.8.2-001/a

The primary power lines shall be transformer insulated from all secondary power.

 # In Reference *

Nota: During measurement rating on components must be withstood. Derating may be exceeded.

	Insulation	**Isolation resistor with stray capacitance in parallel**
[CU-GDCEL-REQ-022]	Between unit primary power + (positive) input lines and structure with measurement 100 Vdc	**(>1 MΩ) // (< 50 nF)**
[CU-GDCEL-REQ-023]	Between unit primary power - (negative) input lines and structure with mesurement 50 Vdc	**(>1 MΩ) // (< 600nF)**
[CU-GDCEL-REQ-024]	Between primary power leads and secondary power leads with measurement 100 Vdc both polarities	**(>1 MΩ) // (< 50 nF)**

4.1.6 High voltage units

Reference **[CU-GDCEL-REQ-025]**

Isolation between the highest voltage inside the equipment and thermistor, relay coil, relay contact or heater leads shall be guaranted with 6 dB margin.

 # In Reference *

4.2 Bonding requirements

4.2.1 General purpose

Reference **[CU-GDCEL-REQ-026]**

To avoid surfaces discharge, each electrically conductive area larger than 5 cm^2 shall be connected to a referenced voltage.

 # In Reference *

4.2.2 Bonding characteristics at unit level

	Bonding connection	**Electrical continuity**
[CU-GDCEL-REQ-027]	between two adjacent parts of a metal case including the resistance between any point of the case and any point of the cover or bonding point (possibly after vibration tests)	**≤ 5 mΩ under 1Adc current**
[CU-GDCEL-REQ-028]	between connector shell and unit structure	**≤ 2.5 mΩ under 1Adc current**
[CU-GDCEL-REQ-029]	between connector back-shell and connector body	**≤ 5 mΩ under 1Adc current**

4.2.3 Thermal Part Assembly Bonding

4.3 Paints and coatings characteristics

Reference **[CU-GDCEL-REQ-030]**

Coatings (including paintings) on non conductive surface (not applicable on coating inside units)

Coatings applied on a dielectric or non-conductive surface shall be grounded to the ground reference network on the edges.

The coating surface resistivity applied on non conductive materials shall be less than 1 E9 Ω / square.

 # In Reference *

Reference **[CU-GDCEL-REQ-031]**

Coatings (including paints) on conductive surface (not applicable on coating inside units)

The coating resistivity applied on a conductive surface shall be less than 1 E9 Ω.m assuming a depth e ≤ 100 μm.

 # In Reference *

4.4 Electrical connector requirements

4.4.1 Connector types

Reference **[CU-GDCEL-REQ-032]**

All connectors shall be selected according to AD11.

 # In Reference *

Reference **[CU-GDCEL-REQ-033]**

MDM and very high density (ex.:AMP104) connectors shall not be used.

 # In Reference *

Reference **[CU-GDCEL-REQ-034]**

All connectors, not dedicated to power generation and distribution outputs, shall be pin type.

In Reference *

4.4.2 *Connector characteristics*

4.4.2.1 Connectors mating and demating requirements

Reference **[CU-GDCEL-REQ-035]**

Mating and demating of each connector shall be less than 20 before unit delivery

In Reference *

4.4.2.2 **Connector mounting requirements**

Reference **[CU-GDCEL-REQ-036]**

The connectors shall be placed in such a way that connection and disconnection on one connector shall be made without any specific tool and without disconnecting the other connectors.

In Reference *

Reference **[CU-GDCEL-REQ-037]**

At least, 6mm shall be kept between two adjacent connectors.

In Reference *

Reference **[CU-GDCEL-REQ-038]**

The connectors shall be mounted according to manufacturer connector requirements.

In Reference *

4.4.2.3 **Connector identification**

Reference **[CU-GDCEL-REQ-039]**

Each unit or bracket shall be permanently marked by visible connector identification closely adjacent to the corresponding connector.

In Reference *

4.4.3 *Connector savers*

Reference **[CU-GDCEL-REQ-040]**

Saver connectors shall be used during unit integration to lower number of mating and demating.

In Reference *

4.4.4 Pins characteristics

Reference **[CU-GDCEL-REQ-041]**

Lines which have a common return shall be placed on adjacent contacts to facilitate cable twisting and/or shielding (except for matrix concept).

 # In Reference *

Reference **[CU-GDCEL-REQ-042]**

The connected contacts on each connector shall never be inferior to two third of its maximum capacity.

 # In Reference *

5. POWER SUBSYSTEM INTERFACES REQUIREMENTS

5.1 Power Bus Definition

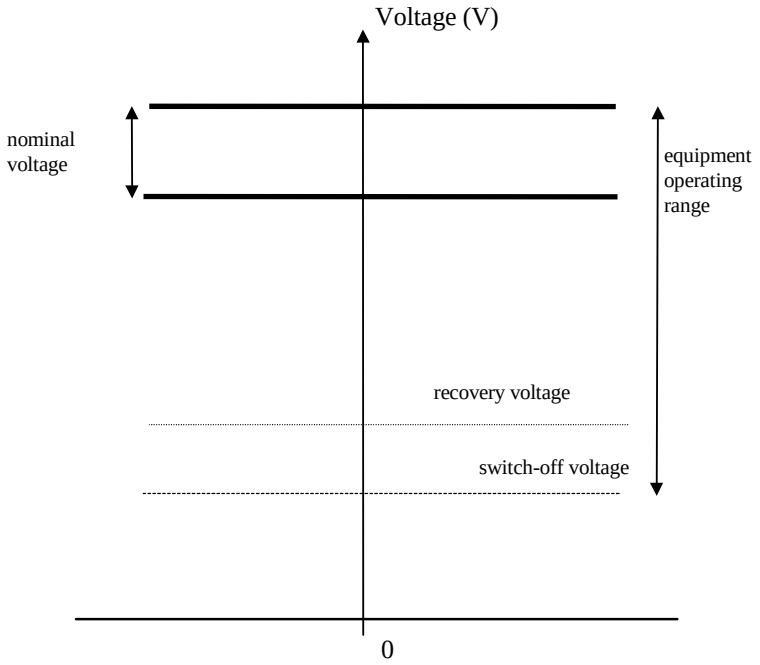


Figure 5.1-1: Equipment operating range.

5.2 Power bus nominal voltage

The power conditioning subsystem provides one regulated 100 V power bus, which is distributed to the spacecraft users.

Reference **[CU-GDCEL-REQ-043]** AD-AV4-AD01_Part4-5.1.1.2-001/a

At the loaded input connector of user, the nominal bus voltage is defined as follows :

Maximal DC bus voltage : 102V

Minimal DC bus voltage : 98V

*# In Reference **

5.3 Power bus operational voltage

Reference **[CU-GDCEL-REQ-044]**

The DC/DC of spacecraft equipment shall be able to operate according to the following voltage.

Function	DC MIN VOLTAGE (V)
High Power Payloads Units (> 20W)	**95**
Low Power Payloads Units (< 20W)	**95**
Beacons	**95**
TTC RF (TX , RX and transponders)	**70**

5.4 Equipment operating requirements

Reference **[CU-GDCEL-REQ-045]**

Status of the units shall not be modified (Switch off, mode, gain step...) if the power bus voltage is under their automatic switch-off voltage level during less than 10 μs.

 # In Reference *

Reference **[CU-GDCEL-REQ-046]**

Units shall be automatically switched off if the power bus voltage is under their automatic switch-off voltage level during more than 1 second

Function	AUTOMATIC Switch-Off Voltage (V)	AUTOMATIC RECOVERY	RECOVERY VOLTAGE(V)
High Power Payload Units (> 20 W)	94 ± 1	NO	≥ 95
Low Power Payload Units (< 20W)	< 95 **or**	NO/YES	≥ 95
	No automatic Switch-Off voltage	YES	≥ 95
Beacons	< 95 **or**	NO/YES	≥ 95
	No automatic Switch-Off voltage	YES	≥ 95
TTC RF (RX,TX and transponders)	< 70	YES	72 ± 1

 # In Reference *

5.5 Distribution requirements

The mean power demand is defined as the maximum average power drawn from its dedicated power lines in the worst conditions.

Specifically, the maximum average is defined as the average during a period of 5 minutes shifted to any point in time where this average will yield a maximum and does not include peak power defined hereafter.

The long peak power demand is defined as the maximum operational average power drawn from the unit dedicated power lines in the worst .
Specifically, the maximum operational average is defined as the average during a period of 50 msec shifted to any point in time where this average will yield a maximum. Operational mode change requires specification of the average power demands per mode and duration.

Reference **[CU-GDCEL-REQ-047]**

The unit input ON/OFF relay contact shall be sized to withstand twice the peak current corresponding to the long peak power demand.

In Reference *

5.5.1 Mean power demand

Reference **[CU-GDCEL-REQ-048]**

The mean power demand shall be measured in voltage nominal conditions (see chapter "Power bus nominal voltage") during a period of 5 minutes.

In Reference *

5.5.2 Peak power demand

Reference **[CU-GDCEL-REQ-049]**

The long peak power demand shall be measured in voltage nominal conditions (see chapter "Power bus nominal voltage") at worst functional case of equipment (wheel spin up, telecomand generation, etc)

In Reference *

5.6 Load current limitation

Reference **[CU-GDCEL-REQ-050]**

For High Power Payload Units (> 20 W), the maximum current drawn by the unit from the supply lines in case of failure, shall be limited to 1.5 times the peak current value corresponding to the long peak power demand (except during the unit ON/OFF sequence).

For Low Power Payload Units (< 20W), the maximum current drawn by the unit from the supply lines in case of failure, shall be limited to 2 times the peak current value corresponding to the long peak power demand (except during the unit ON/OFF sequence).

In Reference *

5.7 Fuses

Reference **[CU-GDCEL-REQ-051]**

Fuses shall not be implemented inside equipments

 # In Reference *

6. SIGNAL LINE INTERFACE REQUIREMENTS

Reference **[CU-GDCEL-REQ-052]**

Signal interface shall use a return by wire concept.

 # In Reference *

6.1 Conventions

- Time duration :The time duration is defined at 50% of the measured full amplitude.

- Signal rise and fall times : The rise and fall times of a signal are defined as the time between 10% and 90% of the measured voltage swing.

- Measurements : Measurements are made at the unit (or harness) connector level.

6.2 Command interface

6.2.1 Low Level and High Level Commands (LLC & HLC)

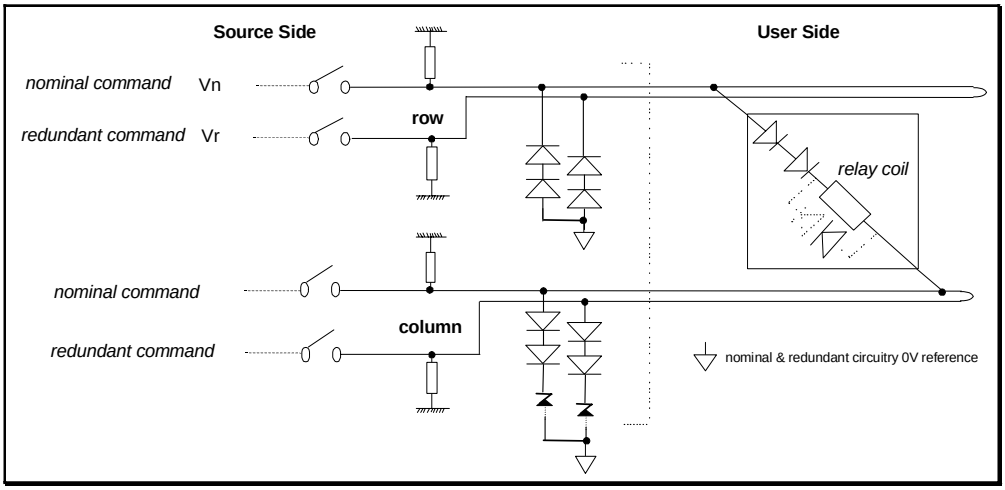
HLC and LLC commands are generated through matrix row and column drivers. One row pulled up to a positive voltage and one column pulled down to the secondary 0v in order to command only the device at the node of the activated row and column.

The command signal is a differential voltage pulse distributed to the user for :

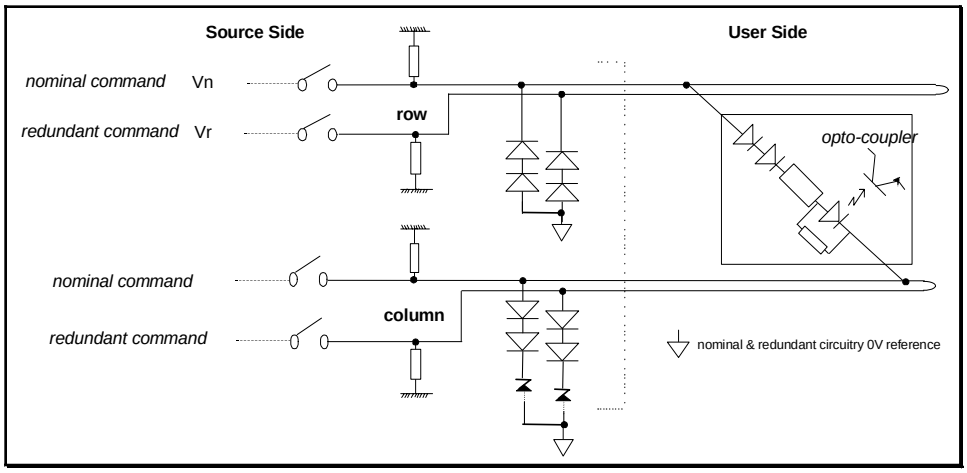
- relay driving or general logic control application with low level commands
- payload waveguide relay driving with high level commands

6.2.1.1 **Matrix command schematics**

Relay interface



Opto coupler interface



6.2.1.2 **User side requirements**

Reference **[CU-GDCEL-REQ-053]** AD-AV4-AD01_Part4-6.1.6.1.2-001/a

all telecommand users shall provide two diodes in series with the commanded device at any matrix node.

 # In Reference *

Reference **[CU-GDCEL-REQ-054]**

For user interface with relay coil, two serial free wheel diodes shall be implemented in parallel with the relay coil at user side.

When the time constant of relay (L/R) is inferior to 1ms for LLC or 5ms for HLC, the diodes could be non implemented in the receiver interface.

 # In Reference *

Reference **[CU-GDCEL-REQ-055]**

L/R time constant of the relay/RF switch shall be lower than 15 ms

In Reference *

Reference **[CU-GDCEL-REQ-056]**

The user shall not impose any potential or grounding reference on any row or column.

In Reference *

6.2.1.3 **Failures management**

Reference **[CU-GDCEL-REQ-057]**

The user interface design shall permit the unit power on/off without damage when all the electrical interface are not connected

In Reference *

Reference **[CU-GDCEL-REQ-058]**

Unpowered equipments shall not be damaged and degraded in their performances when command signals are applied.

In Reference *

Reference **[CU-GDCEL-REQ-059]**

Each command source failure shall not cause the loss of more than 1 command.

In Reference *

6.2.1.4 **Command signal characteristics**

6.2.1.4.1 ***Command signal waveform***

Signal duration (Td): time between crossing points of rise and fall time to 50% of the full amplitude

Signal rise/fall time (Tr ; Tf): maximum between 10% and 90% of the nominal voltage swing

Delay between 2 signals: time between the voltage crossing point at 50% of the full amplitude level

Closed time Tc: Command duration with switch closed

Free wheeling time (Ti): Duration between end of pulse and switch opening

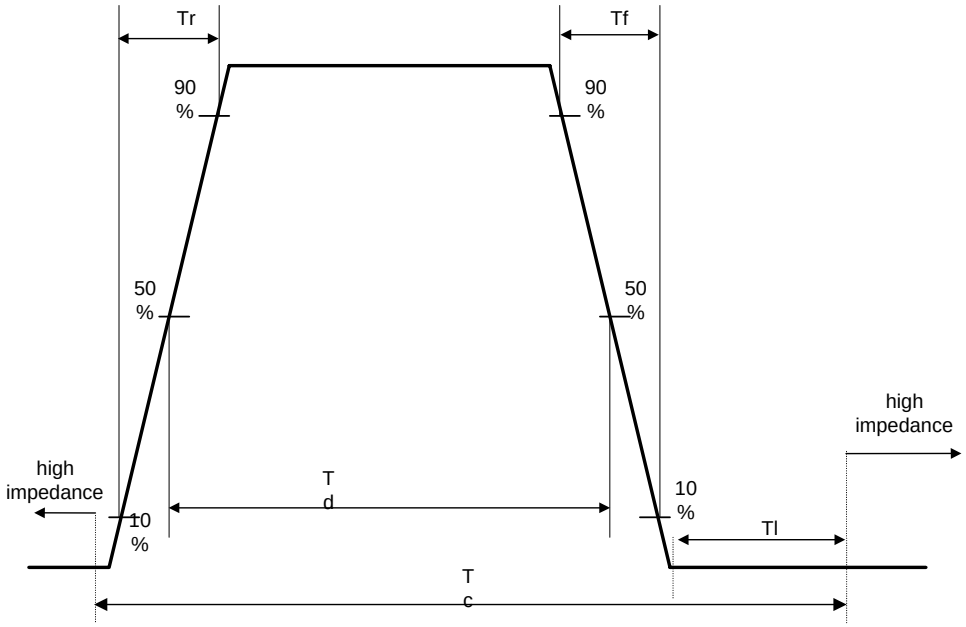


Figure 6.2-1: Matrix command signal waveform

6.2.1.4.2 ***LLC electrical parameters***

Reference **[CU-GDCEL-REQ-060]**

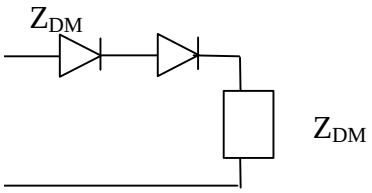
The unit shall be commanded by the command signal waveform defined below:

PARAMETERS	**SOURCE SIDE**
Rise Time (Tr)	**50 µs ≤ Tr ≤ 500 µs**
Fall Time (Tf)	**1 µs ≤ Tf ≤ 600 µs**
« On » duration (Td)	**40 ms ≤ Td ≤ 50 ms**
Closed duration (Tl)	**20 ms ≤ Td ≤ 30 ms**

These LLC electrical characteristics are defined below:

	PARAMETERS	**USER SIDE**
	TYPE	
[CU-GDCEL-REQ-061]	Input type	**Differential**
	VOLTAGE	
[CU-GDCEL-REQ-062]	DM low « 0 » voltage	**-29V / +4V**
[CU-GDCEL-REQ-063]	DM high « 1 » voltage	**26 V (+3V / -5V)**
[CU-GDCEL-REQ-064]	Threshold	**7 V ≤ V_T ≤19V**
[CU-GDCEL-REQ-065]	CM Permanent Fault Voltage Emission (DM = 0)	**-5 V ≤ fault ≤ 40 V**
[CU-GDCEL-REQ-066]	DM Transient Fault Voltage Emission	**± 2V / 25 ms**
[CU-GDCEL-REQ-067]	DM Transient Fault Voltage Tolerance	**-63 V/1 s +33V/80ms**
	CURRENT	
[CU-GDCEL-REQ-068]	Load current (Considering the whole DM high level voltage range)	**2,2 mA ≤ *load* ≤180 mA**
	IMPEDANCE (Differential impedance excluding the two serial diodes (see figure NOTE 1))	
[CU-GDCEL-REQ-069]	Impedance under DM low voltage	**R≤ 9kΩ**
	TIME	
[CU-GDCEL-REQ-070]	Spurious Command (Period = 20 ms)	**Td ≤ 0,1 ms**
	MATRIX COMMAND GROUNDING AND ISOLATION (2)	
[CU-GDCEL-REQ-071]	Between matrix ground and Chassis: R equivalent	**> 10 MΩ**
[CU-GDCEL-REQ-072]	between one row or one column and Chassis: Equivalent Capacitance (In // R equivalent)	**C_CM<500 pF (Around 10 KHz)**
[CU-GDCEL-REQ-073]	between row / column lines and relay or opto-coupler at user side	**galvanic isolation**
	SPECIFIC REQUIREMENT	
[CU-GDCEL-REQ-074]	Transient	**The input LLC shall not be activated with the following setup hereafter(4) (U=29V with tr 50 to 500 µs)**

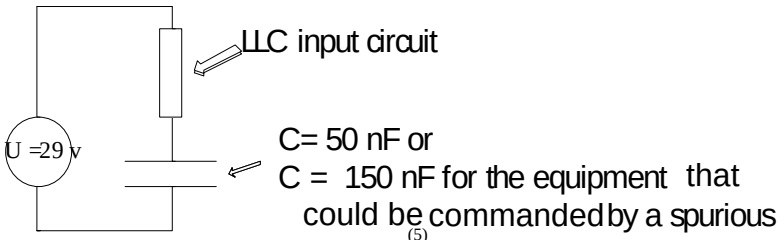
NOTE 1



- (2) Primary 0V and users secondary 0V grounds shall be considered connected to chassis for measurements

  Note: CM: Common mode / DM: Differential Mode

Test setup(4)



Test setup

(5) 150 nF is only applicable to Payload units.

Reference **[CU-GDCEL-REQ-075]**

For LLC a single return shall be allowed for a maximum of 4 LLC commands.

In Reference *

Reference **[CU-GDCEL-REQ-076]**

Each return shall be electrically insulated from any other return.

In Reference *

6.2.1.4.3 ***HLC electrical parameters***

Reference **[CU-GDCEL-REQ-077]**

The unit shall be commanded by the command signal waveform defined below:

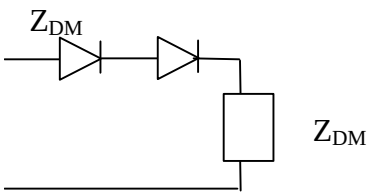
PARAMETERS	**SOURCE SIDE**
Rise Time (Tr)	**50 µs ≤ Tr ≤ 500 µs**
Fall Time (Tf)	**1 µs ≤ Tf ≤ 600 µs**
« On » duration (Td)	**500 ms ≤ Td ≤ 530 ms**
Closed duration (Tl)	**110 ms ≤ Td ≤ 140 ms**

*# In Reference **

These HLC electrical characteristics are defined below:

	PARAMETERS	**USER SIDE**
	TYPE	
[CU-GDCEL-REQ-078]	Input type	**Differential**
	VOLTAGE	
[CU-GDCEL-REQ-079]	DM low « 0 » voltage	**-29V / +4V**
[CU-GDCEL-REQ-080]	DM high « 1 » voltage	**26 V (+3V / -5.5V)**
[CU-GDCEL-REQ-081]	Threshold	**$7V \leq V_T \leq 20.5V$**
[CU-GDCEL-REQ-082]	CM Permanent Fault Voltage Emission (DM = 0)	**Not allowed**
[CU-GDCEL-REQ-083]	DM Transient Fault Voltage Emission	**± 2 V/ 125 ms**
[CU-GDCEL-REQ-084]	DM Transient Fault Voltage Tolerance	**-63 V/1 s +33V/1s**
	CURRENT	
[CU-GDCEL-REQ-085]	Load current (Considering the whole DM high level voltage range)	**$22\ mA \leq load \leq 500\ mA$**
	IMPEDANCE (Differential impedance excluding the two serial diodes (see figure NOTE 1))	
[CU-GDCEL-REQ-086]	Impedance under DM low voltage	**$R \leq 9k\Omega$**
	TIME	
[CU-GDCEL-REQ-087]	Spurious Command	**Td ≤ 0,1 ms**
	MATRIX COMMAND GROUNDING AND ISOLATION (2)	
[CU-GDCEL-REQ-088]	Between matrix ground and Chassis: R equivalent	**> 10 MΩ**
[CU-GDCEL-REQ-089]	between one row or one column and Chassis: Equivalent Capacitance (In // R equivalent)	**C_CM<500 pF (Around 10 KHz)**
[CU-GDCEL-REQ-090]	between row / column lines and relay or opto-coupler at user side	**galvanic isolation**
	SPECIFIC REQUIREMENT	
[CU-GDCEL-REQ-091]	Transient	**The input HLC shall not be activated with the following setup hereafter(4) (U=29V with tr 50 to 500 µs)**

NOTE 1

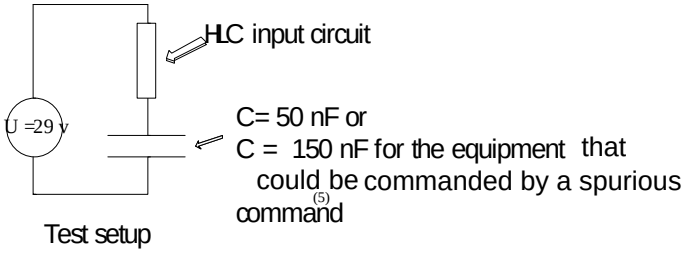


- (2) Primary 0V and users secondary 0V grounds shall be considered connected to chassis for measurements

Note: CM: Common mode / DM: Differential Mode

Note: CM: Common mode / DM: Differential Mode

Test setup(4)



Test setup

(5) 150 nF is only applicable to Payload units.

Reference **[CU-GDCEL-REQ-092]**

Each return shall be electrically insulated from others returns.

In Reference *

Reference **[CU-GDCEL-REQ-093]**

For HLC a single return shall be allowed for a maximum of 4 HLC commands.

In Reference *

6.3 Telemetry interface

Reference **[CU-GDCEL-REQ-094]**

The Analog Channel and Digital Bi Level Channel telemetries shall be only used by the Channel Amplifier and the EPC

In Reference *

6.3.1 *Telemetry channel types*

The telemetry channel types are :

a. Analog Channel (AN) for Camp/EPC interface

b. Digital Bi Level Channels (DB) for Camp/EPC interface

c. Digital relay channels (DR)

d. Digital Serial Channel 16-bit (DS16)

e. Thermistors Power Supply and Conditioning (TH)

6.3.2 Analog channels

6.3.2.1 **Analog channels definition**

The information is presented in the form of a voltage varying between two defined boundaries. This voltage is sampled regularly, analog to digital converted in the encoders .

For unit including RUBI device, the analog TM is coded in 10 bits.

6.3.2.2 **User side (or receiver side) requirements**

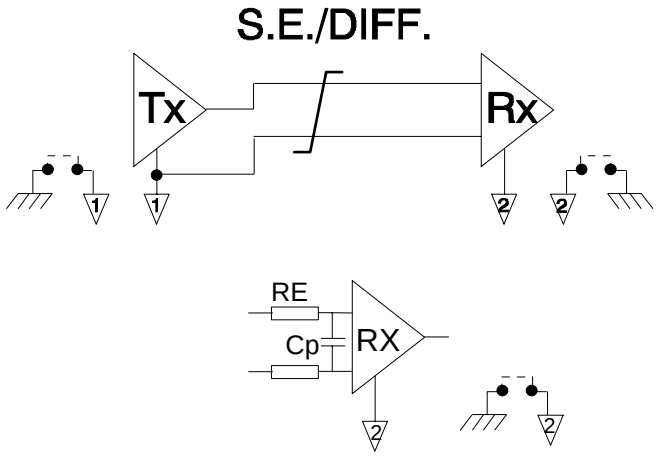
Reference **[CU-GDCEL-REQ-095]** AD-AV4-AD01_Part4-6.2.3.6-001/b

Analog channels shall be completely isolated from any other return (primary ground or mechanical ground) inside the user equipment. Differential receiver is required.

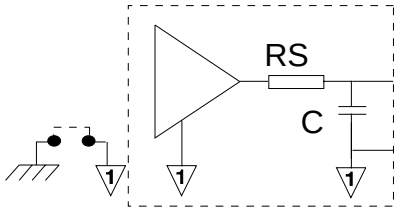
 # In Reference *

6.3.2.3 **Analog channels schematics**

" standard " analog channel

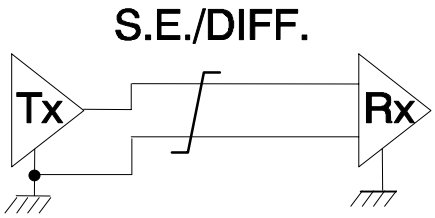


Parameter definition

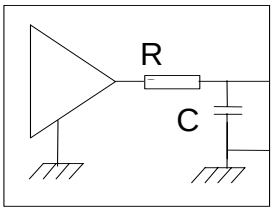


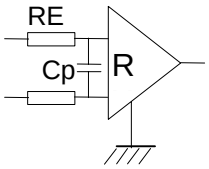
6.3.2.4 **Analog channels characteristics**

- Standard analog channel:



- Parameter definition:





Reference **[CU-GDCEL-REQ-096]** AD-AV4-AD01_Part4-6.2.3.8-001/b

The analog telemetry shall comply these analog electrical characteristics :

PARAMETERS	SOURCE SIDE EPC	USER SIDE Camp	COMMENT
TYPE			
Output type	Single ended		
Input type		Differential	
Transfer	DC COUPLED	DC COUPLED	
VOLTAGE			
Range	0 V / 5 V		
Common mode		**(1)**	
Fault Voltage Emission	± 15 V	± 15 V	
Fault Voltage Tolerance	± 17 V	± 17 V	

(1) * The common mode voltage is related to chassis ground.

PARAMETERS	SOURCE SIDE EPC	USER SIDE Camp	COMMENT
CURRENT			
Over-current	≤ 15 mA		permanent
IMPEDANCE			
impedance ON	Rs ≤ 5 KΩ in parallel with 100 nF ≤ C ≤ 1 µF (RS x C ≥ 0,1 ms)	≥ 50KOhms	
impedance OFF	RP ≤ 100 kΩ	≥ 50KOhms	
Receiver input Capacitance		100 pF Max	
DC in line series resistor		Re ≥ 3 KΩ	
GROUNDING AND ISOLATION			
From secondary ground (0Vs)	connected	≥ 50KOhms	
From Chassis	≥ 1 MΩ // ≤ 50 nF	≥ 50KOhms	the isolation at source side is valid when the stud is removed

Table 6.2.3 : ANALOGIC TELEMETRY CHARACTERISTICS

 # In Reference *

6.3.3 *Digital Bi-level channel*

6.3.3.1 **Source side requirements**

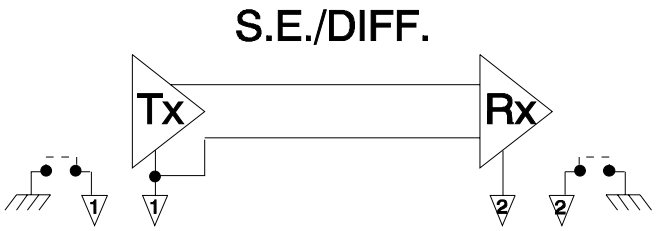
Reference **[CU-GDCEL-REQ-097]** AD-AV4-AD01_Part4-6.2.4.3-001/a

Digital Bilevel shall be referenced to secondary ground inside the source equipment

Other design (Primary ground reference, ...) shall be submitted to Prime approval.

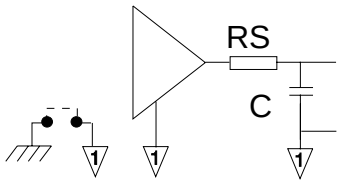
 # In Reference *

6.3.3.2 **User side (or receiver side) requirements**

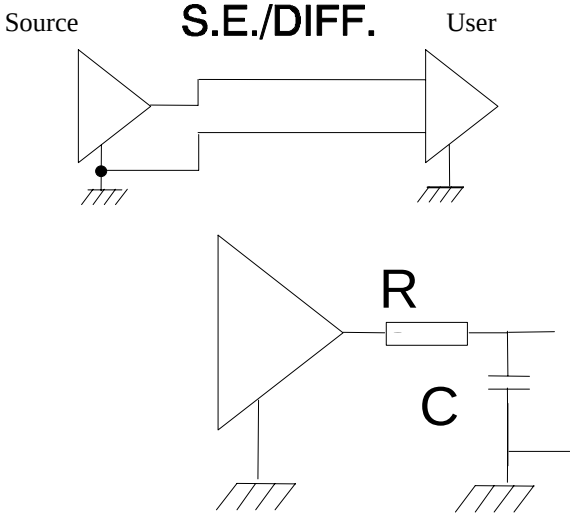


6.3.3.3 **Digital Bi-Level channel telemetry schematics**

Parameter definition



6.3.3.4 **Digital Bi-Level channel characteristics**



Reference **[CU-GDCEL-REQ-098]** AD-AV4-AD01_Part4-6.2.4.6-001/b

The digital bi-level telemetry shall comply these digital bi-level electrical characteristics :

PARAMETERS	SOURCE SIDE EPC	USER SIDE Camp	COMMENT
TYPE			
Output type	Single ended		
Input type		Single ended	
Transfer	DC COUPLED	DC COUPLED	
VOLTAGE			
Low level output voltage (discrete ''0'')	0V to 0.5V		
High level output voltage (discrete ''1'')	+3.5V to +5 V		
Fault Voltage Emission	± 15 V	± 15 V	
Fault Voltage Tolerance	± 17 V	± 17 V	
CURRENT			
Over-current	≤ 10 mA		permanent

PARAMETERS	SOURCE SIDE EPC	USER SIDE Camp	COMMENT
IMPEDANCE			
impedance ON	Rs ≤ 5 KΩ in parallel with 100 nF ≤ C ≤ 1 µF (RS x C ≥ 0,1 ms)	≥ 220 kΩ	
impedance OFF	RP ≤ 100 kΩ	≥ 220 kΩ	
Capacitance		100 pF max	
GROUNDING AND ISOLATION			
From secondary ground (0Vs)	connected	connected	
From Chassis	connected	connected	

Table 6.2.4 : DIGITAL BILEVEL TELEMETRY CHARACTERISTICS

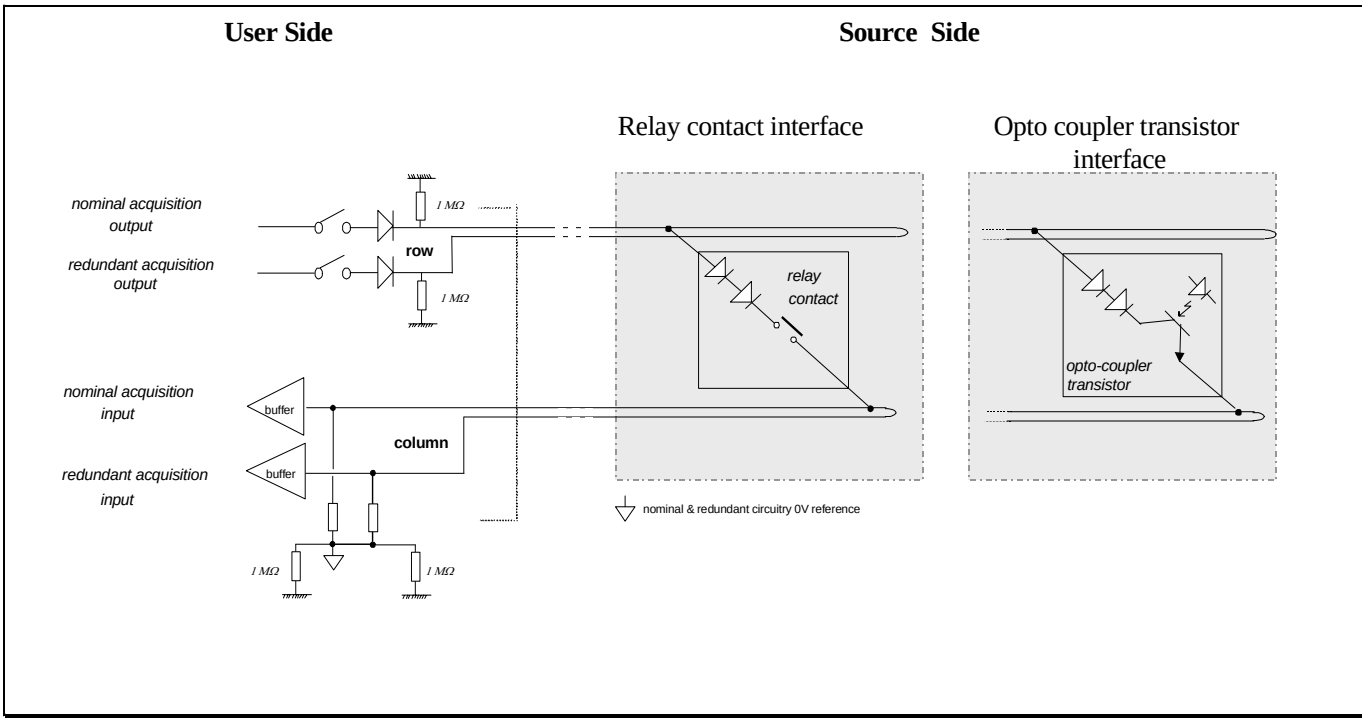
*# In Reference *

6.3.4 *Digital switch closure channel telemetry*

The Digital relay acquisition also called DR shall be used to transmit a relay or a switch status signal.

6.3.4.1 **Matrix switch closure acquisition definition**

The matrix switch closure acquisitions are performed through a matrix organisation. One row is pulled up to a positive voltage and the switch closure status is acquired on the column.



6.3.4.1.1 ***Source side requirements***

Source side is related to the switch closure location

Reference **[CU-GDCEL-REQ-099]**

All sources shall provide two diodes in series with the switch closure device.

In Reference *

Reference **[CU-GDCEL-REQ-100]** AD-AV4-AD01_Part4-6.2.5.3.1-003/a

The source equipment shall provide a galvanic isolation between the switch closure (contact or opto-coupler transistor) lines and the source electrical circuitry

In Reference *

Reference **[CU-GDCEL-REQ-101]**

The source equipment shall not impose any potential or grounding reference on any row or column.

In Reference *

Reference **[CU-GDCEL-REQ-102]**

Closed contact shall correspond to the TM "Zero" level with the unit powered or active

In Reference *

Reference **[CU-GDCEL-REQ-103]**

Open contact shall correspond to the TM "One" level with the unit unpowered or inactive

In Reference *

6.3.4.1.2 ***Receiver (or user) side requirements***

Receiver side correspond at one hand to the switch closure polarisation outputs and at the other hand to the switch closure acquisition input.

6.3.4.2 **Digital relay channel telemetry characteristics**

These Digital relay channel telemetry(DR) characteristics are defined below:

	PARAMETERS	**SOURCE SIDE DR**
	TYPE	
[CU-GDCEL-REQ-104]	Output type	**Differential**
	VOLTAGE	
[CU-GDCEL-REQ-105]	DM Fault Voltage Emission	**Not allowed**
[CU-GDCEL-REQ-106]	DM Fault Voltage Tolerance (permanent, ON or OFF)	**- 17 V**
[CU-GDCEL-REQ-107]	DM Fault Voltage Tolerance (permanent OFF only)	**± 17 V**
[CU-GDCEL-REQ-108]	CM Fault Voltage Emission	**Not allowed**
[CU-GDCEL-REQ-109]	Drop voltage ("ON state") - relay: 2 diodes + 1 relay contact - opto: 2 diodes + 1 transistor junction	**≤ 3.7 V at 1 mA**
[CU-GDCEL-REQ-110]	CM Fault Voltage Tolerance (DM=0)	**± 17 V**
	CURRENT	
[CU-GDCEL-REQ-111]	Contact capability "ON" (Permanent, closed contact)	**I ≥ 1 mA**
[CU-GDCEL-REQ-112]	Contact capability "OFF"(leakage) (Permanent, open contact)	**< 200 µA @ 17 V**
	MATRIX COMMAND GROUNDING AND ISOLATION (1)	
[CU-GDCEL-REQ-113]	Between row / column lines and Chassis	**≥ 1 MΩ// <50 pF for switch** <500 pF for all the other equipment****
[CU-GDCEL-REQ-114]	between switch closure lines and the electrical circuitry	**galvanic isolation**

- (1) Primary 0V and users secondary 0V shall be considered connected to chassis for measurements

In Reference *

Reference **[CU-GDCEL-REQ-115]**

A single return isolated from ground is allowed for a maximum of 4 DR telemetry

In Reference *

6.4 TCR RF interfaces

6.4.1.1 SMU / Receiver interfaces

6.4.1.1.1 Tranceiver TC

Reference **[CU-GDCEL-REQ-116]**

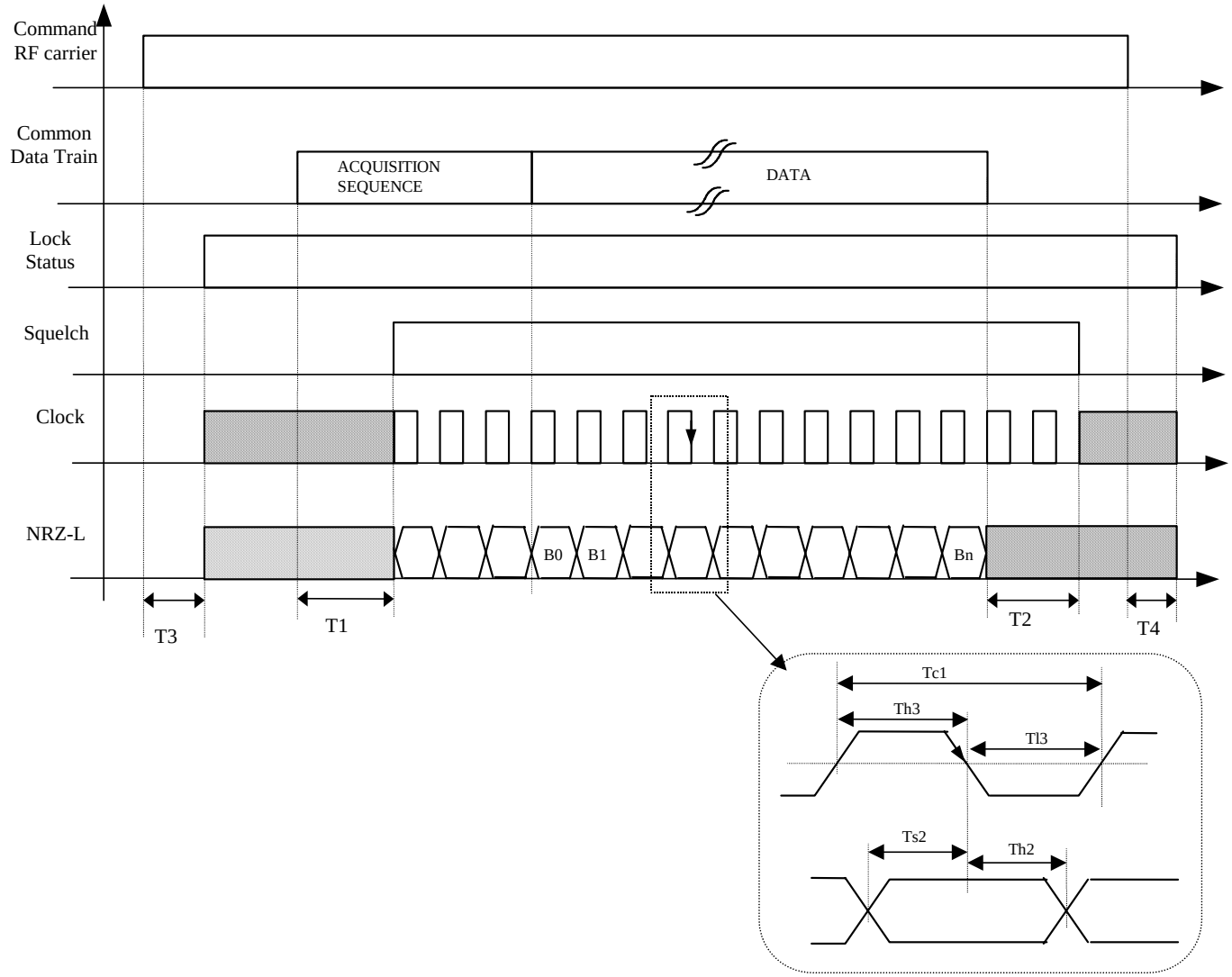


Figure 6.4-1: NRZ-L TC timing

T1 : *≤168 bits duration*

1 bit duration ≤T2 ≤128 bits duration

T3 & T4 *≤100ms*

Tc1 (Bit clock period) = 1 Bit rate +/-5%

Th3 (TC bit clock high level duration at 50% edge) : ≥60µs

Tl3 (TC bit clock low level duration at 50% edge) : ≥60µs

Ts2 (Set-up time from NRZ DATA bit stable to clock falling edge (sampling edge)) : ≥10µs

Th2 (Hold time from clock falling edge to NRZ DATA bit change) : ≥20µs

The above described interface is used to transmit from the receiver to the SMU the following signal : SQUELCH , CLOCK , DATA

In Reference *

Notes :

The bit clock is running as soon as Lock Status is 'high' and it will run until Lock Status falls to 'low'.

Reference **[CU-GDCEL-REQ-117]**

The receiver bit clock shall be running as soon as Lock Status is 'high'.

In Reference *

Reference **[CU-GDCEL-REQ-118]**

Data Validation shall be performed on the falling edge of the clock signal.

In Reference *

Reference **[CU-GDCEL-REQ-119]** AD-AV4-AD01_Part4-6.4.1-004/a

The bit clock stability shall be better than +/- 5% as soon as SQUELCH is high and until SQUELCH falls to low.

In Reference *

6.4.1.1.2 SBDL Electrical Characteristics

Reference **[CU-GDCEL-REQ-120]**

The following electrical characteristics shall be applied to a "point to point" connection. The cross strap of two redundant transmitters (MASTER) inside the unit (the same Pcb) is allowed.

In Reference *

Reference **[CU-GDCEL-REQ-121]**

SBDL serial link differential signals shall be identified as "non-inverted" and "inverted line".

In Reference *

Reference **[CU-GDCEL-REQ-122]**

The status of the signal shall be defined as true (logical " 1 ") when the non-inverted line has a positive voltage level w.r.t. the inverted line, i.e. when the non inverted line is at a high voltage level and the inverted line is at a low voltage level.

In Reference *

These SBDL interfaces are defined below:

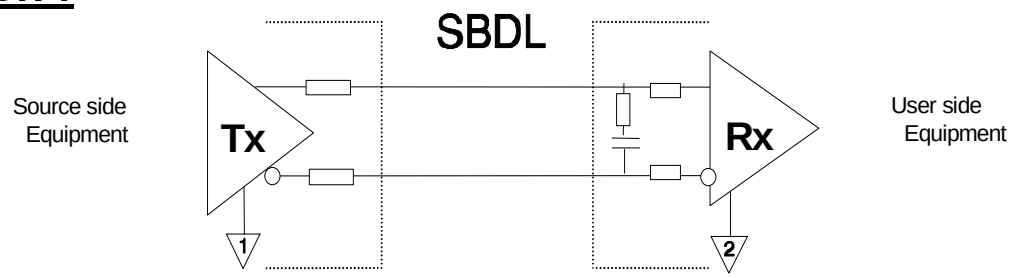
	PARAMETERS	**SOURCE SIDE RX**
	TYPE	
[CU-GDCEL-REQ-123]	Output type	**Differential driver (required for ML 16 drivers)or balanced driver**
	VOLTAGE	
[CU-GDCEL-REQ-124]	Low level output voltage (VOL)	**0 V to 0.5 V**
[CU-GDCEL-REQ-125]	High level output voltage (VOH)	**4 V to 5.5 V**
[CU-GDCEL-REQ-126]	Low level differential output voltage (logical 0)	**- 5.5 V to -3.5 V**
[CU-GDCEL-REQ-127]	High level differential output voltage (logical 1)	**3.5 V to 5.5 V**
[CU-GDCEL-REQ-128]	CM Permanent Fault Voltage Emission	**-0.5V to +7V**
[CU-GDCEL-REQ-129]	Overvoltage Tolerance (CM)	**-7 Vto + 12 V**
	CURRENT	
[CU-GDCEL-REQ-130]	Current capability (Differential short circuit)	**20 mA min. to 100 mA max.**
	IMPEDANCE	
[CU-GDCEL-REQ-131]	Power on differential Impedance (Serial resistor required)	**120 Ω ± 10 %**
[CU-GDCEL-REQ-132]	Power off differential Impedance	**4 kΩ min.**
	TIME	
[CU-GDCEL-REQ-133]	Rise Time (Tr) (Measured on 120 Ω with 50pF in parallel. Only applicable to ML16/DS16)	**10 ns ≤ Tr ≤ 100 ns**
[CU-GDCEL-REQ-134]	Fall Time (Tf) (Measured on 120 Ω with 50pF in parallel. Only applicable to ML16/DS16)	**10 ns ≤ Tf ≤ 100 ns**
	GROUNDING AND ISOLATION	
[CU-GDCEL-REQ-135]	from Secondary Ground (0 Vs)	**Circuit is referenced to 0 Vs**
[CU-GDCEL-REQ-136]	From Primary Ground	**Isolated (> 1MΩ // 50nF)**
[CU-GDCEL-REQ-137]	from chassis	**Connected**

For information:

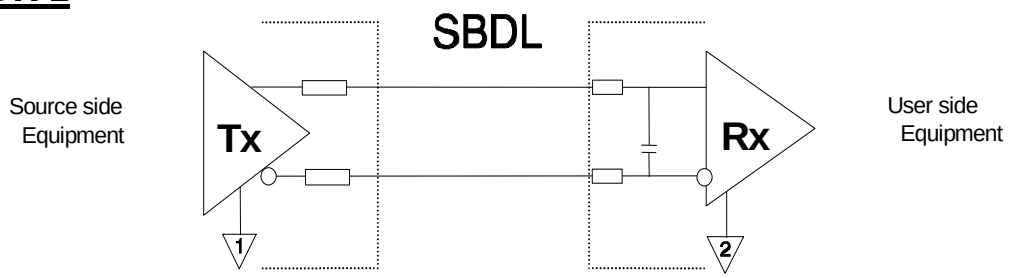
PARAMETERS	**USER SIDE**
IMPEDANCE	
AC differential Impedance (Option 1)	**120 Ω in series with 100 pF to 1nF max.**
AC differential Impedance (Option 2)	**2 x 2.2 KΩ min with 10 pF min. in parallel**
DC in line series resistor (the value is related to each receiver input)	**2.2 KΩ min.**
DC differential Impedance	**10 KΩ min.**

SBDL electrical interface is according to one of these schematics (Option1 and Option2):

OPTION 1



OPTION 2



6.4.2 TRANSCEIVER TM video signals

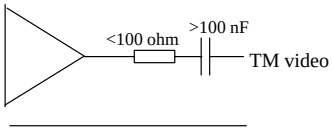
The TM video signals are defined below:

	PARAMETERS	TELEMETRY TRANSMITTER
	TYPE	
[CU-GDCEL-REQ-138]	Input type	**Differential**
[CU-GDCEL-REQ-139]	Type of Modulation	**NRZ-L / BPSK**
[CU-GDCEL-REQ-140]	Waveform	**Filtered quasi sine wave**
	VOLTAGE	
[CU-GDCEL-REQ-141]	DC Fault Voltage Emission	**±17V in series with >2kΩ**
[CU-GDCEL-REQ-142]	DC Fault Voltage Tolerance	**-1V<U<10V**
	IMPEDANCE	
[CU-GDCEL-REQ-143]	input impedance	**>10kΩ// <500pF**
	SPECIFIC REQUIREMENT	
[CU-GDCEL-REQ-144]	TM sub-carrier frequency (upgrade: 32768 Hz)	**65536 Hz**
[CU-GDCEL-REQ-145]	TM bit rate	**4096 bit/s or 8192 bit/s**
	GROUNDING AND ISOLATION	
[CU-GDCEL-REQ-146]	from Secondary Ground (0 Vs)	**Grounded**
[CU-GDCEL-REQ-147]	From Primary Ground	**Isolation ≥ 1 MΩ**
[CU-GDCEL-REQ-148]	from chassis	**Isolation ≥ 80 KΩ**

For information:

PARAMETERS	**SMU SIDE**
IMPEDANCE	
output impedance **(1)**	**< 100Ω in series with > 100nF**

(1)



6.5 Data Bus interfaces

The nominal bus is OBDH - 485.

Reference **[CU-GDCEL-REQ-149]**

The unit shall be able to receive telecommands and transmit telemetries through nominal and redondant OBDH buses in less than 2 seconds after ON command receipt.

 # In Reference *

6.5.1 *OBDH - 485*

The "Data Bus Network Electrical and Protocol Specification" (SBF 6AV2 AS SP 338) document comprises the requirements to be satisfied by the OBDH-485.
(See chapter "Applicable documents")

7. EMC/ESD PERFORMANCE REQUIREMENTS

7.1 Purpose

The purpose of this chapter is to establish the EMC / ESD management, design, performance and test method requirements for equipments .

Compliance with this specification will be demonstrated by the Co-contractor by tests, analysis or similarity.

7.2 E-field and H-field RE and RS requirements

7.2.1 Radiated emission (RE) requirements

7.2.1.1 E-field Radiated Emissions

Reference **[CU-GDCEL-REQ-150]**

E field radiated limit emissions shall be defined at 1 meter distance from unit under test fitted with its test harness. Intentional and unintentional radiated emissions through the test harness shall be included in the limit specifications

 # In Reference *

Reference **[CU-GDCEL-REQ-151]** SB-AD01.3-6.03-020

The requirements shall be met in the range from 1 MHz to 40 GHz.

 # In Reference *

Reference **[CU-GDCEL-REQ-152]** SB-AD01.3-6.03-021

Both horizontal and vertical polarisations of the test antenna shall be used for frequencies above 25 Mhz, except if this antenna is circularly polarized.

 # In Reference *

Reference **[CU-GDCEL-REQ-153]** SB-AD01.3-6.03-039

Upper frequency limit of RE requirements to be demonstrated is function of the equipment or subsystem operating frequency :

- for non RF/IF equipments RE tests shall be performed up to 1GHz .
- for RF/IF equipments RE tests shall be limited to the second harmonic of the payloads highest transmit frequency ranges.

 # In Reference *

Reference **[CU-GDCEL-REQ-154]**

E-field RE limit requirements in transfer , orbit and emergency phases

Frequency assignment and range allocations are specific to each satellite program and are defined in the unit specification .

General	1 MHz to 40 GHz (out-of transmission, reception and specific frequency bands)	70 dbµV / m (r.m.s.)
Reception frequency ranges - Telecommand, - Communication	- L and S band (RX)	25 dbµV / m (r.m.s.)
	- C, X, KU and KA band (RX)	30 dbµV / m(r.m.s.)
Transmission frequency ranges - Telemetry - Communication	- L and S band (TX)	90 dbµV / m (r.m.s.)
	- C, X, KU and KA band (TX)	90 dbµV / m (r.m.s.)
	- Harmonic limit levels * second harmonic * other harmonics	 * ≤ 77 dbµV / m (r.m.s.) * ≤ 70 dbµV / m (r.m.s.)
Specific frequency ranges	- Local oscillator (LO) band	55 dbµV / m (r.m.s.)
	- Intermediary frequency (IF) band	55 dbµV / m (r.m.s.)

In Reference *

Reference **[CU-GDCEL-REQ-155]**

E-field RE limit requirements for launch phases

In addition to the basic requirements, no equipment operating before or during launch (until separation from the launcher) shall perturb the TC receiver of the launcher.

The narrowband limits (including ARIANE 5, ATLAS launchers, LONG MARCH and PROTON requirements) are presented in the following table.

Launchers frequency range		
- ARIANE 5	- 420 MHz to 480 MHz - 5450 MHz to 5825 MHz	35 dBµV/ m(r.m.s.) 70 dBµV /m(r.m.s.)
- PROTON /block DM	- 771 MHz to 776 MHz	36 dBµV/m (r.m.s.)
- PROTON /Breeze M	- 1570 MHz to 1620 MHz - 2720 MHz to 2730 MHz - 5700 MHz to 5800 MHz	45 dBµV/m (r.m.s.) 60 dBµV/m (r.m.s.) 30dBµV/m (r.m.s.)
- LONG-MARCH 3B	- 560 MHz to 760 MHz - 5580 MHz to 5910 MHz	15 dBµV/m (r.m.s.) 35 dBµV/m (r.m.s.)
- SEA LAUNCH	- 762 MHz to 776 MHz	20 dBµV/m (r.m.s.)
- ATLAS	No specific range allocation	General Req : 70dBµV/m (r.m.s.)

In Reference *

7.2.1.2 DC H-Field Radiated Emission

To reduce unit magnetic moment impact on the satellite attitude control, it is recommended to limit the use of magnetic material, to minimise current loops which generate magnetic fields and to arrange magnetic parts (relays, TWT etc...) in order to compensate their effects.

Reference **[CU-GDCEL-REQ-156]** SB-AD01.3-6.03-025

The DC H Field radiated emission shall be lower than :

IMUX, SSPA, Isolators, OMUX, TWTA : 101 dBpT

Other units : 92 dBpT

DC H field radiated limit emissions shall be defined at 1 meter distance from unit under test.

In Reference *

Reference **[CU-GDCEL-REQ-157]**

The compliance shall be demonstrated by analysis or by tests and included in the test report.

In Reference *

Reference **[CU-GDCEL-REQ-158]** SB-AD01.3-6.03-048

Unit magnetic moment level shall be given by the co-contractor in the 3 axis (X,Y,Z).

In Reference *

Reference **[CU-GDCEL-REQ-159]**

Magnetic filed measurement shall be performed in worst operational conditions.

In Reference *

Reference **[CU-GDCEL-REQ-160]** SB-AD01.3-6.03-050

Magnetic moment payload allocation shall be lower than: 20 Am^2

In Reference *

7.2.2 *Radiated Susceptibility (RS) requirements*

7.2.2.1 **E-field Radiated Susceptibility**

Reference **[CU-GDCEL-REQ-161]** SB-AD01.3-6.03-027

Over the frequency range from 1 MHz to 40 GHz, the unit under test fitted with its test harness shall meet specifications during E-field radiated susceptibility tests.

In Reference *

Reference **[CU-GDCEL-REQ-162]**

The sine wave signal shall be 30 % amplitude modulated by a 1 kHz square wave.

In Reference *

Reference **[CU-GDCEL-REQ-163]** SB-AD01.3-6.03-031

In the range from 25 MHz to 40 GHz, the tests shall be performed in both horizontal and vertical polarisations if a linearly-polarised antenna is used.

In Reference *

Reference **[CU-GDCEL-REQ-164]** SB-AD01.3-6.03-039

Upper frequency limit of RS requirements to be demonstrated is function of the equipment or subsystem operating frequency :

- for non RF/IF equipments RS tests shall be limited to the payloads highest transmit frequency ranges.
- for RF/IF equipments RS tests shall be limited to the second harmonic of the payloads highest transmit frequency ranges.

In Reference *

Reference **[CU-GDCEL-REQ-165]**

Frequency assignment and range allocations are specific to each satellite program and are defined in the units specifications requirements.

Requirements related to RX equipment don't take into account reception through antenna path.

RS levels to be applied:

General requirements	1 MHz to 40 GHz (out-of transmission, reception and specific frequency bands)	1V/m (RMS)	-inside and outside the spacecraft
Transmission frequency ranges - Telemetry - Communication	- L and S band (TX) - C, X, KU and KA band (TX)	10V/m (RMS) 200V/m (RMS)	- inside spacecraft - outside spacecraft
Reception frequency ranges **(1)** - Telecommand - Communication	- L and S band (RX) - C, X, KU and KA band (RX)	1.8 mV/m (RMS) 5.6 mV/m (RMS)	- inside and outside the spacecraft
Specific frequency range **(1)**	-Local oscillator (LO) band -Image and Intermediary frequency (IF) band	56 mV/m (RMS) 56 mV/m (RMS)	- inside and outside the spacecraft
Launcher radar and launcher telemetry frequency ranges **(2)**	- L, S, C and X band	10V/m (RMS) 100V/m (RMS)	- inside spacecraft - outside spacecraft

(1) This requirement is only applicable to RF RX equipments

(2) These requirements are applicable :

- to all equipments ON and OFF outside the spacecraft
- only to equipments ON inside the spacecraft

The frequency plans are specific to each satellite program and shall be defined in unit specification .

*# In Reference *

7.2.2.2 DC H-field Radiated susceptibility

Reference **[CU-GDCEL-REQ-166]** SB-AD01.3-6.03-034

The unit under test fitted with its test harness shall not exhibit performances loss during and after DC H-field radiated susceptibility tests with the following level:

- 180 dBpT (1 milli-Tesla) in the 3 axis (X, Y, Z)

*# In Reference *

7.3 Repeater and TTC/RF passive units sheilding efficiency

Reference **[CU-GDCEL-REQ-167]**

The shielding efficiency (SE), defined as the ratio of the total interfering power at unit output with respect isotropic radiated power shall not exceed -75 dBi for the units of the repeater input section (before the TWTA) and -65 dBi for the units of the repeater output section (after the TWTA) and TTCRF subsystem, at working frequency range.

In Reference *

Reference **[CU-GDCEL-REQ-168]**

The shielding effectiveness of the unit shall be measured from the RE sniff test or RS snort test methods as describe in the document "the reduced sniff RE and snort RS EMC test procedure" or similar procedure shall be approved by the prime.

In Reference *

7.4 Susceptibility to Electrostatic Discharges

Reference **[CU-GDCEL-REQ-169]**

The unit (or group of units) under test fitted with its test harness shall not exhibit any malfunction, degradation of performance, or deviation from specified indication beyond tolerances indicated in the corresponding unit specification when subjected to conducted discharges into unit structure and wire inside the bundle, with the discharge signal shall have the following characteristics:

- amplitude: 50 A peak min
- duration: 50 nsec
- rise time: 10 ns

In Reference *

7.4.1 Conducted discharges into unit structure:

Reference **[CU-GDCEL-REQ-170]**

The ESD test shall be accomplished by using diametrically opposed locations through the unit structure.

The two injection points shall be the most distant points of the unit structure where electrical connection is feasible (mounting hole, bonding point, connector, cover screw...).

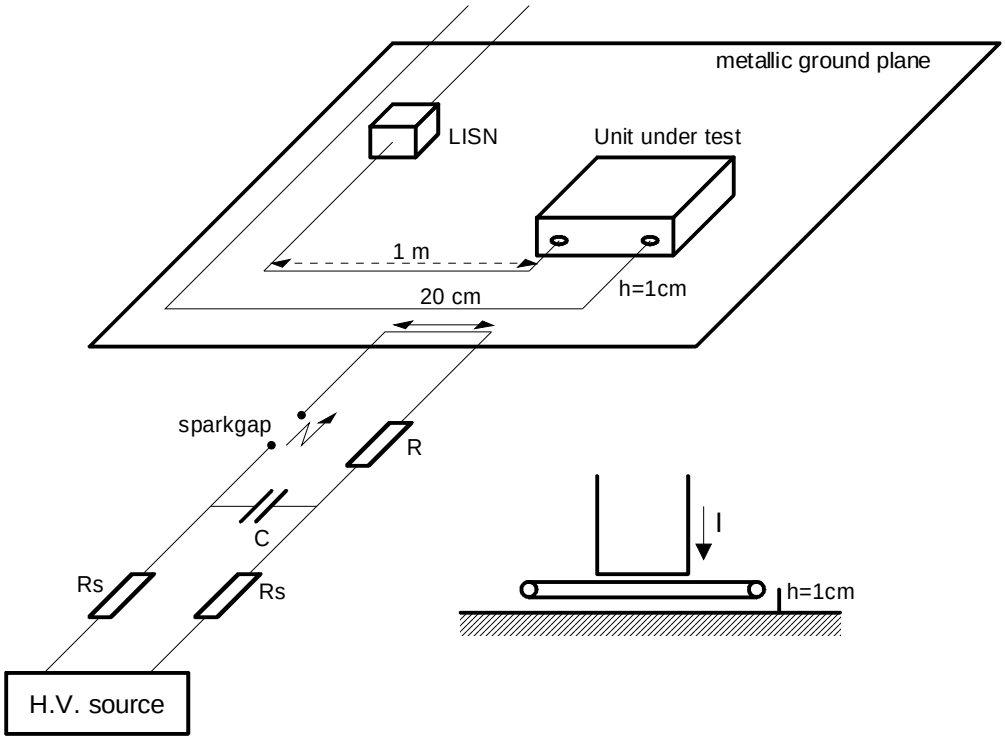
In Reference *

7.4.2 Conducted discharges into wire inside bundle:

Reference **[CU-GDCEL-REQ-171]**

The ESD test set-up for conducted discharge into wire coupled to the harness shall be as follow:

The distance of the parallel wire inside the bundle shall be 0.2 m.



The component values shall be adjusted in order to get the proper current.

Test set-up component are defined in the following table:.

Test set-up components	
Rs = Decoupling resistor	4.7kΩ
C = Discharge capacitor	50pF
R = Discharge resistor	100Ω
Spark gap voltage	6kV

In Reference *

7.5 Primary power lines CE and CS requirements

7.5.1 *Users of Primary Power Supplies*

Reference **[CU-GDCEL-REQ-172]**

A LISN defined in the paragraph "LISN specified" shall be used to simulate the power supplies impedance.

In Reference *

Reference **[CU-GDCEL-REQ-173]**

CE/CS tests shall be performed under following DC supply voltage:

- CE tests: 100 V DC voltage tolerance: - 2 V / + 0 V
- CS tests: lower operational voltage 98 V

In Reference *

7.5.1.1 Conducted Emission (CE)

Continuous conducted emission is specified in narrow band

Reference **[CU-GDCEL-REQ-174]**

In case of CE out of specification results outside TDMA operation, time domain conducted emission shall be recorded and included in the test report.

In Reference *

Reference **[CU-GDCEL-REQ-175]**

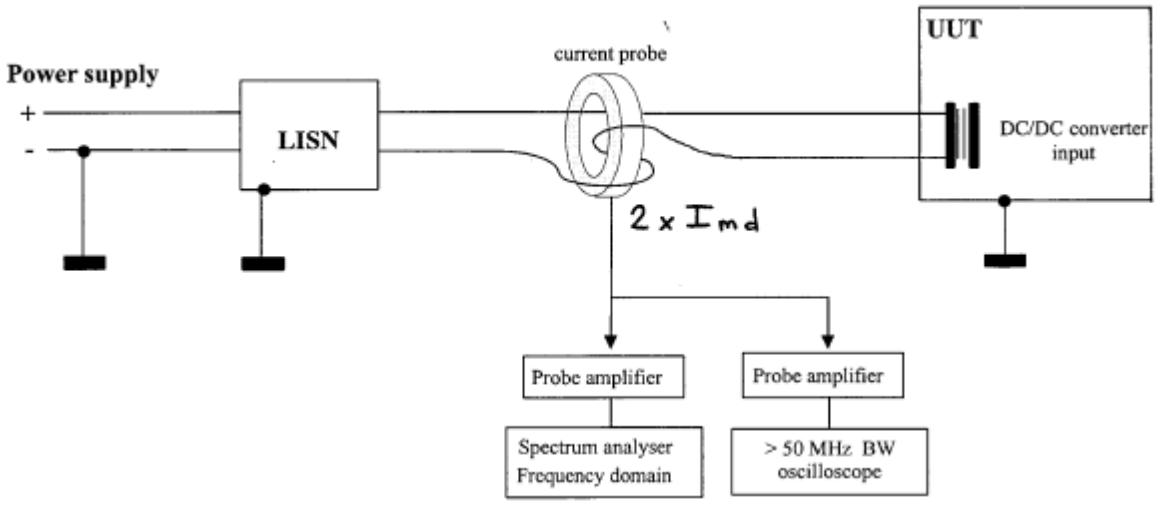
Inside TDMA operation narrowband (frequency domain) and time domain measurements shall be performed.

In Reference *

7.5.1.1.1 Differential continuous mode

- **Test method**

Reference **[CU-GDCEL-REQ-176]**



In Reference *

- **Required limits**

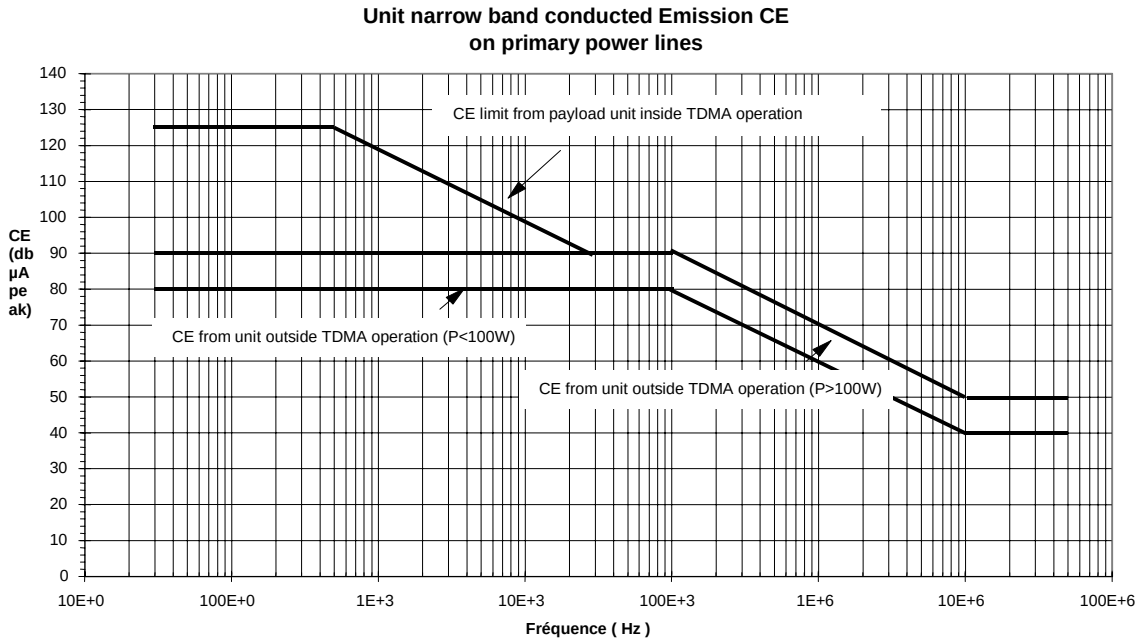
Reference **[CU-GDCEL-REQ-177]**

* applicable to [2x Imd] measurement minus 6dB (-6db factor shall be included in plots provided in the test report).

*# In Reference **

Reference **[CU-GDCEL-REQ-178]**

In the frequency range from 30 Hz to 50 Mhz, the conducted emission CE injected in differential mode on the main bus by the unit under test shall be within the limit levels defined in the following figure.



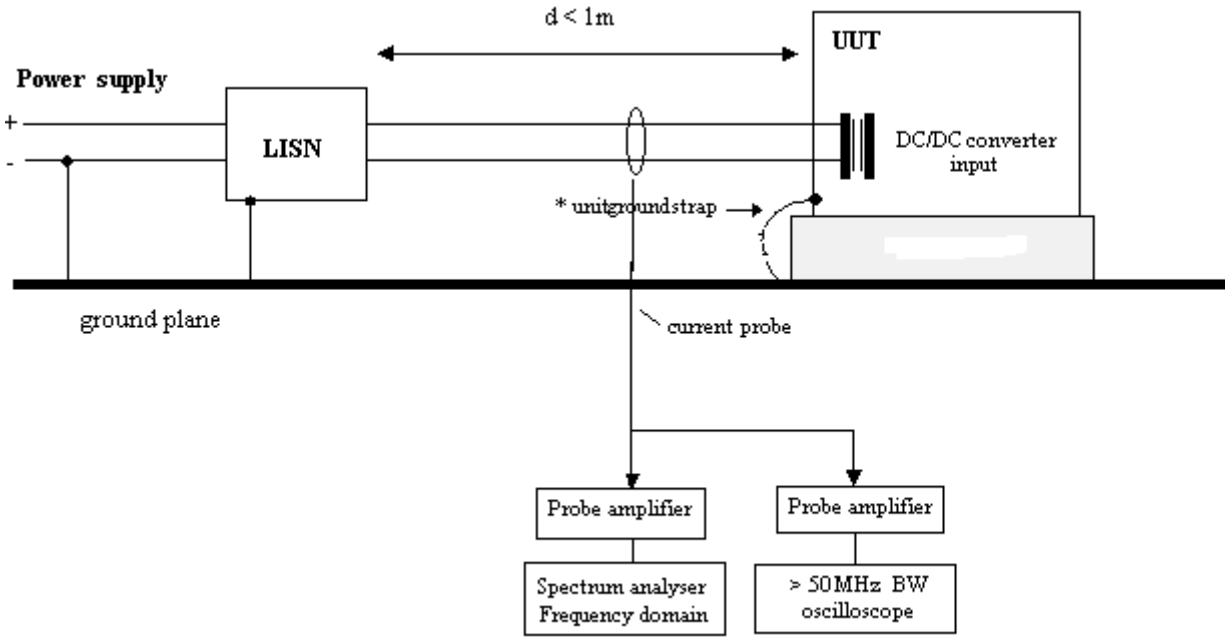
*# In Reference **

7.5.1.1.2 Common continuous mode

- Test method

Reference **[CU-GDCEL-REQ-179]**

***** The unit ground strap shall be as low inductive and resistive (< 2.5 mΩ) as possible.

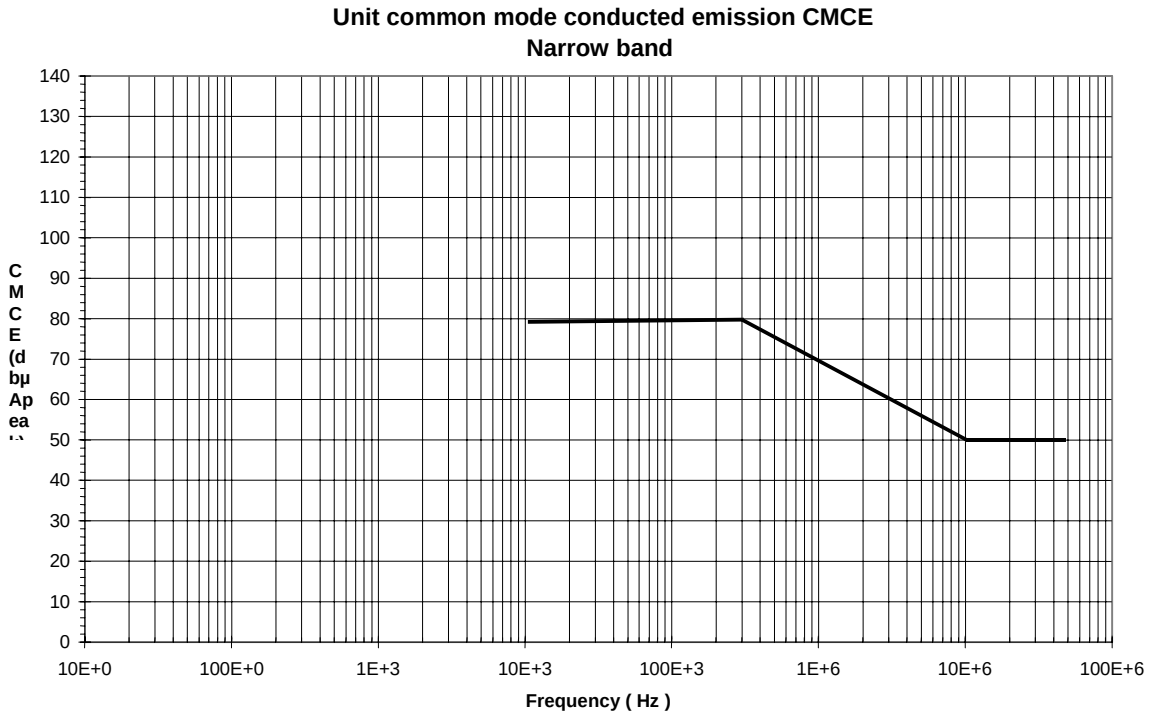


*# In Reference **

- Required limit

Reference **[CU-GDCEL-REQ-180]**

Conducted emission which may appear in common mode shall be within the limit levels defined in the following figure and in 10 KHz to 50 MHz frequency range.



In Reference *

- **No requirement for TDMA operation (EPC/TWTA)**

7.5.1.1.3 Transient mode (Power supply voltage stabilized)

Reference **[CU-GDCEL-REQ-181]**

The following requirement shall be applied :

* during switch ON and switch OFF of the unit,
* during any change of unit configuration.

Idc = maximum DC current of the unit for power voltage supply = 100V

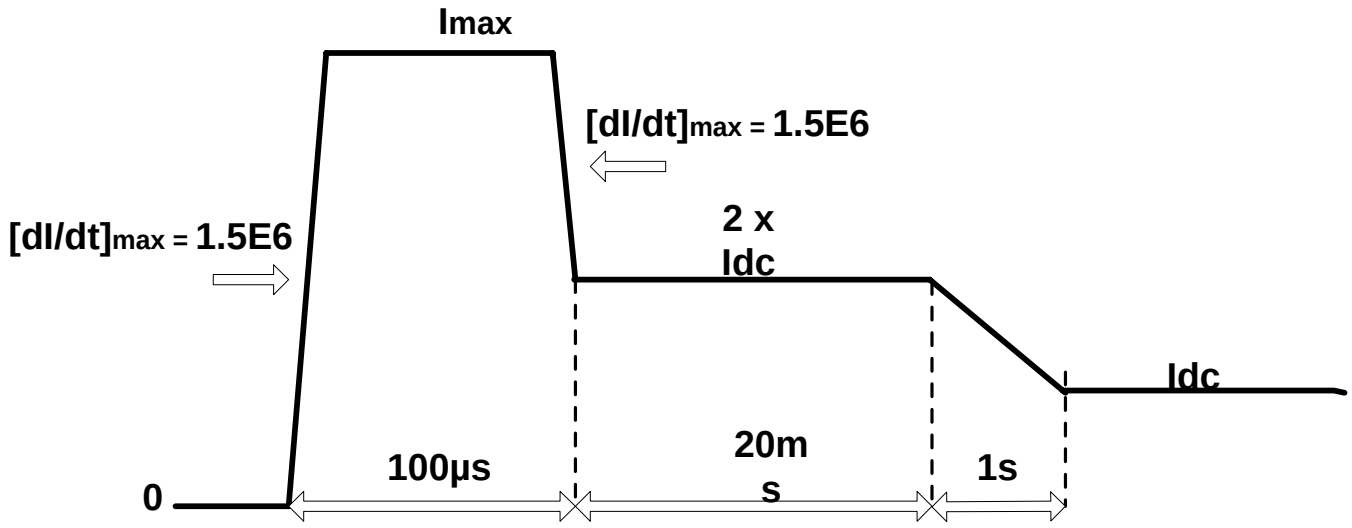


Figure 7.5-1: UNIT INRUSH CURRENT LIMIT AND LOAD CURRENT SLEW RATE

Imax = 1A for Idc < 0.5A

Imax = 4 x Idc for 0.5A ≤ Idc ≤ 2.5A

Imax = 10A for Idc > 2.5A

In Reference *

- Test method

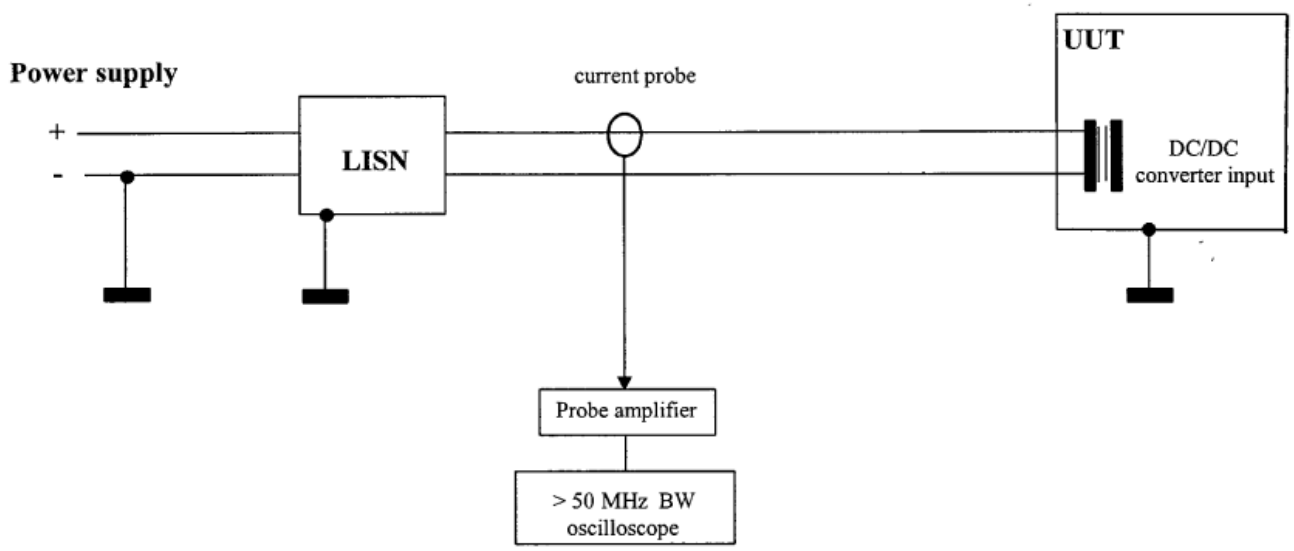
Reference **[CU-GDCEL-REQ-182]**

Transient current shall be measured on the positive power line under the following conditions :

∗ Power supply voltage stabilized,

∗ OFF command sent several seconds after ON command.

Transient current measurements shall be recorded and included in the EMC test report.



In Reference *

7.5.1.2 **Users conducted susceptibility (CS)**

Reference **[CU-GDCEL-REQ-183]** SB-AD01.3-6.03-093

During the test, the level of the injected current and the injected voltage at unit input shall be measured and included in the test report.

In Reference *

7.5.1.2.1 ***Differential mode***

Reference **[CU-GDCEL-REQ-184]** SB-AD01.3-6.03-091

The unit under test fitted with its test harness shall meet specifications when subjected to the following perturbations into the positive primary power line (current injection) or between the primary positive power line and the return line (voltage injection).

In Reference *

7.5.1.2.1.1 ***Continuous injection***

• Required injection

Reference **[CU-GDCEL-REQ-185]** SB-AD01.3-6.03-094

The unit shall be subjected to a sine wave signal with the following characteristics :

- 2 Vr.m.s.: from 30 Hz to 1 KHz
- decreasing by 20 dB / dec between 1 KHz to 2 Khz

- 1Vr.m.s.: from 2 KHz to 50 MHz

In Reference *

Reference **[CU-GDCEL-REQ-186]**

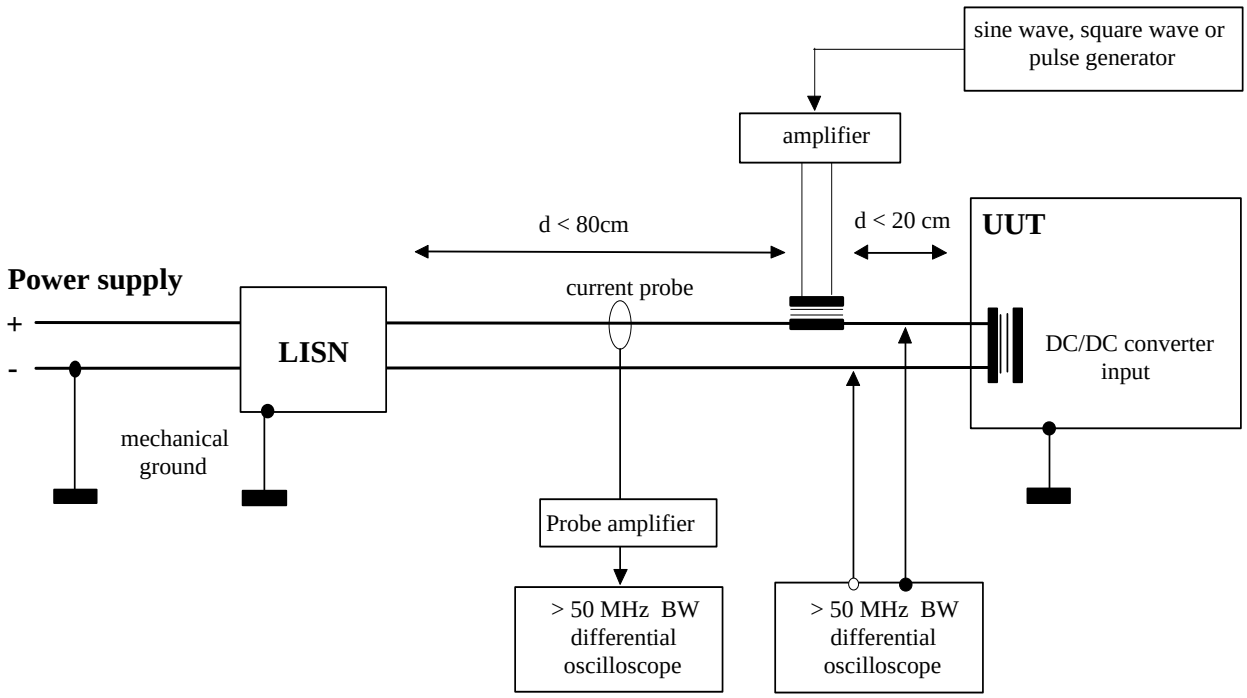
The injected current shall be limited to 1 A r.m.s and the voltage may be reduced if necessary.

In Reference *

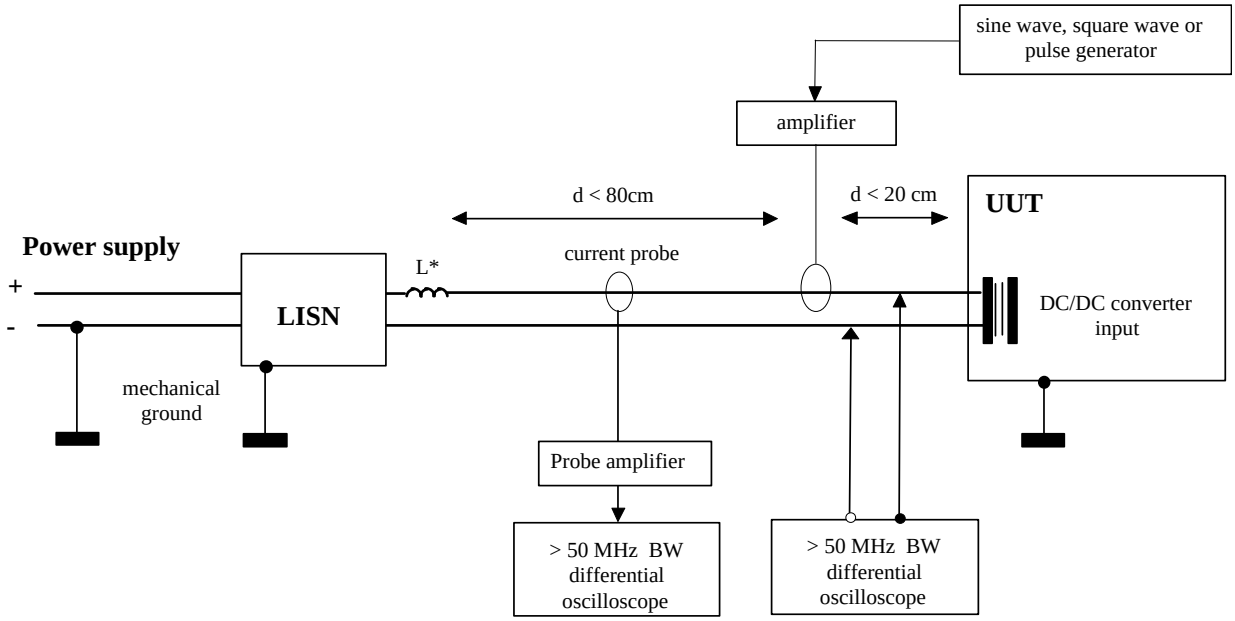
• Test methods

Reference **[CU-GDCEL-REQ-187]** SB-AD01.3-6.03-122

a. continuous wave from 30 Hz to 50 KHz and long term transient single event



b. continuous wave from 50 KHz to 50 MHz and short term transient single event



* an additional decoupling series inductance can be added to the LISN in order to limit the current flowing through the power supply positive output and to avoid the use of high power amplifier.

Note : capacitive injection is allowed for conducted susceptibility tests

*# In Reference *

7.5.1.2.1.2 ***Transient injection***

Reference **[CU-GDCEL-REQ-188]**

Short terms single events

The following transient shape shall be applied

E = 10 Vp Tau = 10 μs tr = 1 μs

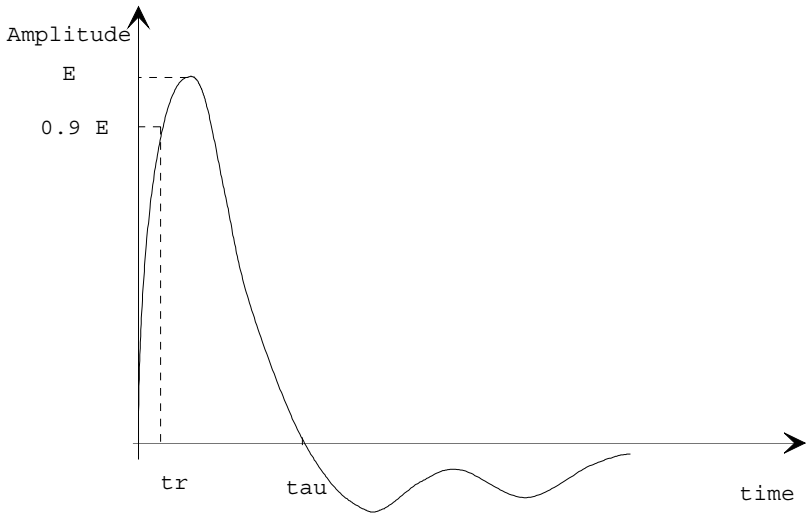


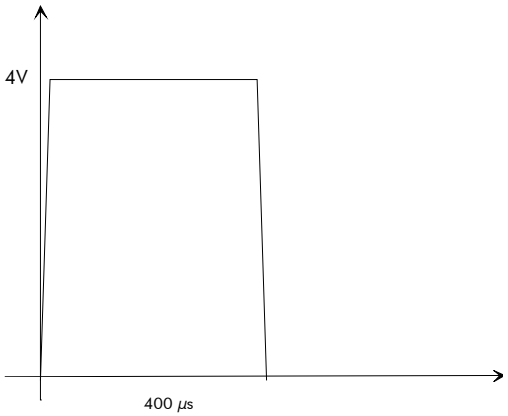
Figure 7.5-1: CONDUCTED SUSCEPTIBILITY TRANSIENT WAVE SHAPE (short terms)

In Reference *

Reference **[CU-GDCEL-REQ-189]**

Long terms single events

The following transient shape shall be applied



E = 4 Vp Tau = 400 µs tr < 20 µs

Repetition frequency 1 Hz and 10 Hz

In Reference *

Reference **[CU-GDCEL-REQ-190]** SB-AD01.3-6.03-096

For all transient injections the transient current injected shall be limited to 1Ap.

In Reference *

Reference **[CU-GDCEL-REQ-191]** SB-AD01.3-6.03-098

Two tests shall be performed for transient injection :

- one with positive pulses at the highest supply voltage allowed by the unit performance specifications.
- the other with negative pulses and at the lowest voltage allowed by the unit performance specifications.

In Reference *

7.5.1.2.1.3 ***Fluctuating power bus voltage***

Reference **[CU-GDCEL-REQ-192]**

All users of these power lines shall safely survive any steady state or fluctuated voltage in the full range 0V to 102 V and recover nominal operating performances whatever the bus voltage rise time to reach its nominal range (dV/dt < 1V/μsec).

In Reference *

Reference **[CU-GDCEL-REQ-193]**

The unit shall be initially in a configuration which maximise the risk of degradation (ex: unit in ON state).

In Reference *

Reference **[CU-GDCEL-REQ-194]**

Users are not required to meet performance parameters under these conditions but must safely survive to this event without any overstressing or damage and must recover all their nominal operating performance.

In Reference *

Reference **[CU-GDCEL-REQ-195]** SB-AD01.3-6.03-104

Equipment connected on DATA HANDLING bus or acting as command generator shall not send spurious commands during such power variations.

Applicability : Command Receiver, S band transponder,

In Reference *

Reference **[CU-GDCEL-REQ-196]**

Low speed power fluctuation (integration and hardware verification).

The test shall be performed when the bus voltage starts from 0V to nominal voltage (100V) with 20V/ms < dV/dt < 10 V/s (see figure below). During such event, the bus voltage shall be within hatched areas.

The unit input current shall be recorded and included in test report.

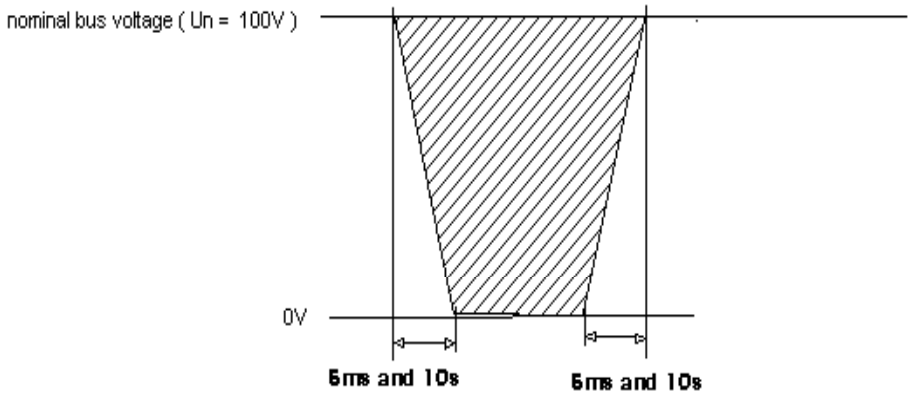


Figure 7.5-2: Low speed power bus fluctuation (low dV/dt)

In Reference *

Reference **[CU-GDCEL-REQ-197]**

High speed power fluctuation

These power fluctuation requirements are related to fuse blowing or to an instantaneous short circuit occurring on the power line. The tests conditions are given Figure: "TRANSIENTS DUE TO FUSE BLOWING" and correspond to the worst case.

The tests shall be performed for the two transients waves defined below.

The current drain when the power bus returns to its nominal voltage shall be in the limits given for switch-on current wave shape (Figure: "UNIT INRUSH CURRENT LIMIT AND LOAD CURRENT SLEW RATE") and compatible with the ratings of the protection devices.

If current amplitude is higher than the limit given Figure: "UNIT INRUSH CURRENT LIMIT AND LOAD CURRENT SLEW RATE" second criteria shall be applied :

$$\int I_1^2 dt + \int I_2^2 dt < A$$

I1 : transient current induced during falling voltage drop
I2 : transient current during rising voltage drop

DC power demand of the unit	A
P< 25W	1^{E}-3
25W<P<50W	4 * 1^{E}-3
50W<P<120W	2.5 * 1^{E}-2
P>120W	1

The unit input current shall be recorded and included in the test report.

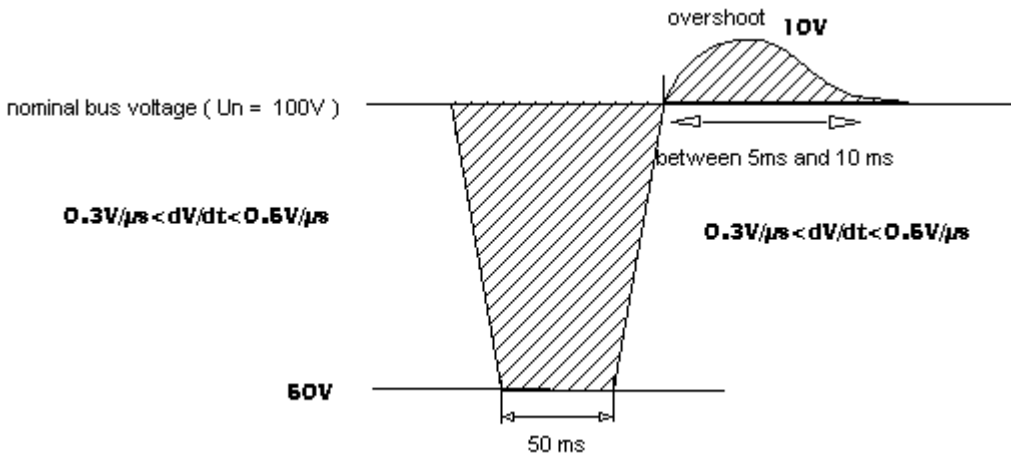


Figure 7.5-3: TRANSIENTS DUE TO FUSE BLOWING

In Reference *

7.5.1.2.2 ***Common mode***

Reference **[CU-GDCEL-REQ-198]**

The unit under test fitted with the test harness shall meet specifications when subjected to the following perturbations injected into the primary power leads in common mode.

In Reference *

7.5.1.2.2.1 ***Continuous injection***

- **Required injection**

Reference **[CU-GDCEL-REQ-199]**

The unit under test shall be subjected to a 0.7 Vr.m.s. sine wave signal from 10 kHz up to 50 MHz injected between the ground plane and the primary power lines .

In Reference *

Reference **[CU-GDCEL-REQ-200]**

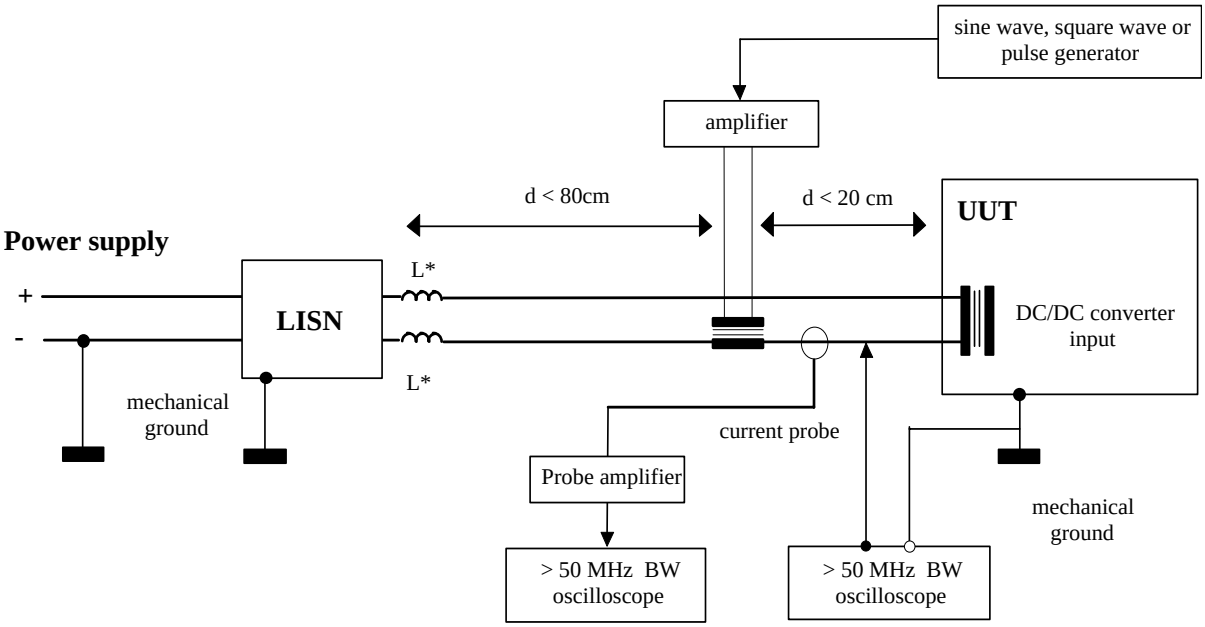
The injected current shall be limited to 0.1 A r.m.s from 10kHz and 50 MHz and the voltage may be reduced if necessary.

In Reference *

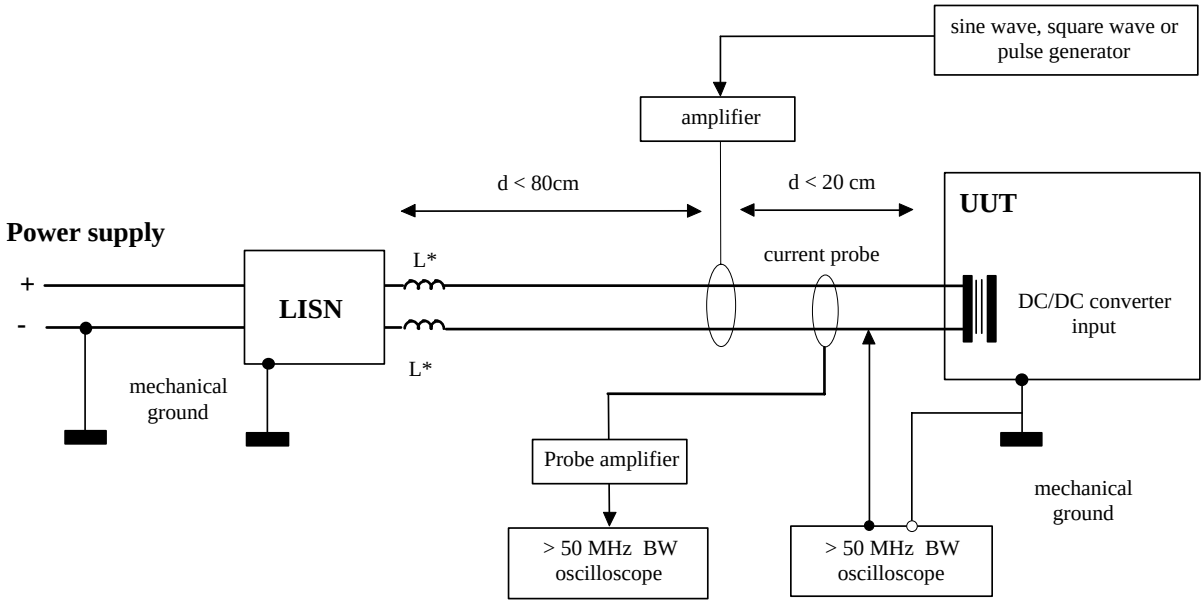
• Test methods

Reference **[CU-GDCEL-REQ-201]**

a. continuous wave from 30 Hz to 50 KHz and long term transient single event injections

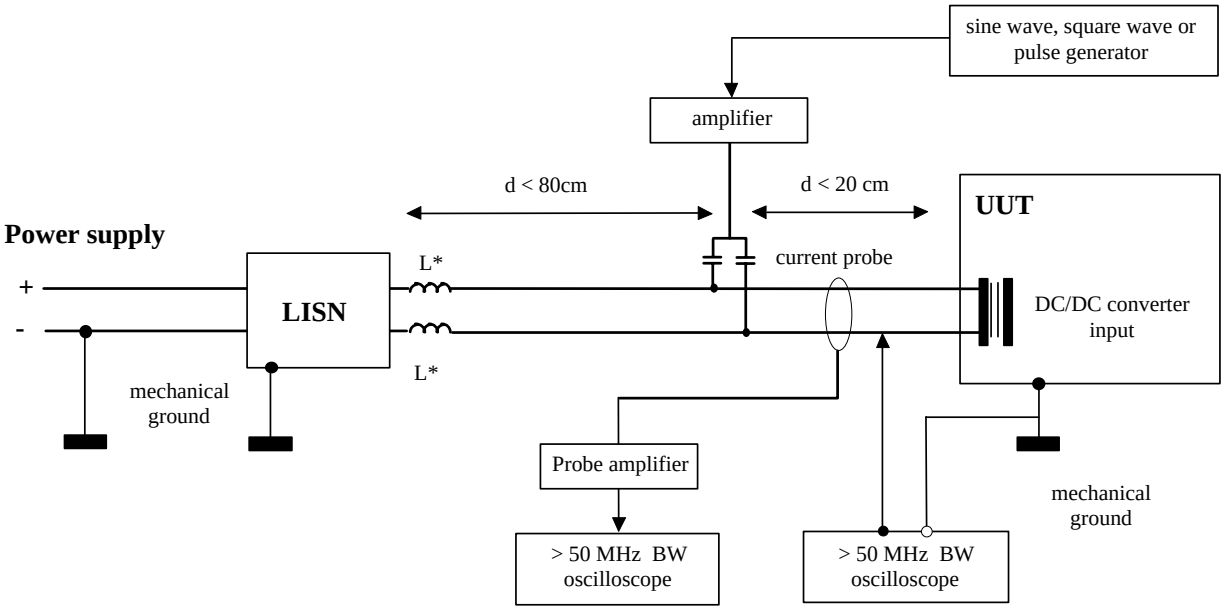


b. continuous wave from 50 KHz to 50 MHz and short term transient single event injections (Toroid current core injection)



* additional series de-coupling inductances can be added to the LISN in order to limit the current flowing through the power supply outputs and to avoid the use of high power amplifier.

c. continuous wave from 50 KHz to 50 MHz and short term transient single event injections (capacitive injection)



* additional series de-coupling inductances can be added to the LISN in order to limit the current flowing through the power supply outputs and to avoid the use of high power amplifier.

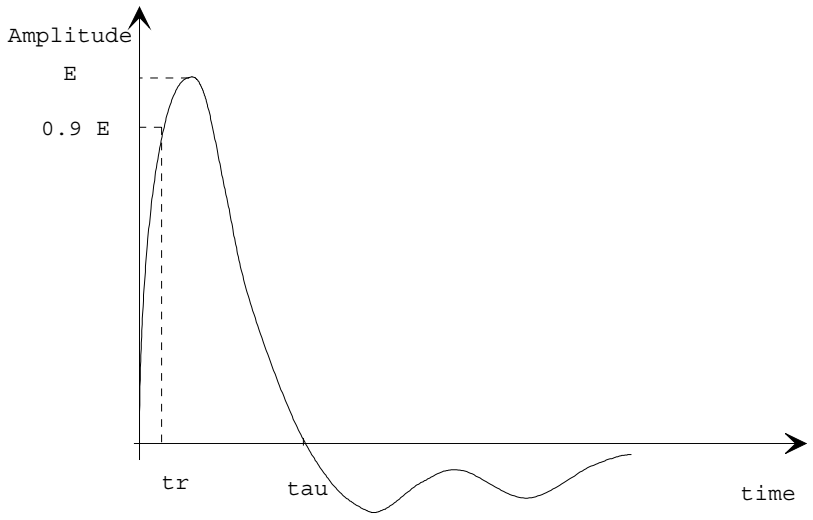
7.5.1.2.2.2 ***Transient injection***

Reference **[CU-GDCEL-REQ-202]** SB-AD01.3-6.03-112

Short term single events

The unit shall be subjected to transient voltages specified below and injected between the ground plane and the primary power lines.

- The following transient shall be applied
  - E = 5 Volts (both polarities) Tau = 10 μs tr = 100 nsec
  - Repetition frequency 1 Hz and 10 Hz



 # In Reference *

Reference **[CU-GDCEL-REQ-203]** SB-AD01.3-6.03-113

Fuse clearing transient

The unit under tests shall not exhibit any failure when transient voltages defined below are injected between the ground plane and the primary power lines.

- Amplitude 50V (both polarities)
- rise time tr = 100ns
- duration tau = 10μs

Users are not required to meet performance under these conditions but must safely survive to this event.

 # In Reference *

7.6 Secondary power lines CE and CS requirements

7.6.1 Conducted Emissions on Secondary Power Bus

Reference **[CU-GDCEL-REQ-204]**

Conducted Emissions on Secondary Power Bus-Source Side

The conducted differential and common modes voltage emissions on secondary power bus shall not exceed the levels defined in the following figure :

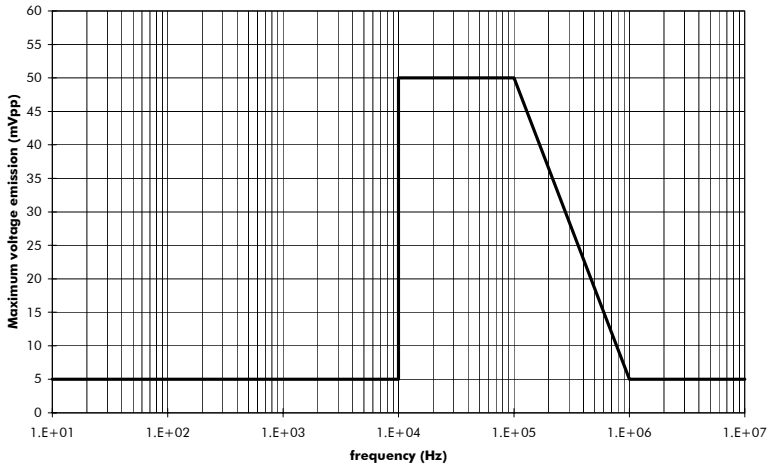


Figure 7.6-1: CE on secondary lines (source side)

This requirement is applicable only to unit which supplies other units (example : centralized DC/DC converter or EPC for CAMP)

This requirement is applicable with and without CS injection on primary power input .

 # In Reference *

7.6.2 Conducted susceptibility on Secondary lines

Reference **[CU-GDCEL-REQ-205]**

Conducted Susceptibility on Secondary Power Bus-User side

The unit, connected to a secondary power bus, shall meet all performance requirements when subjected to the following signal interference .

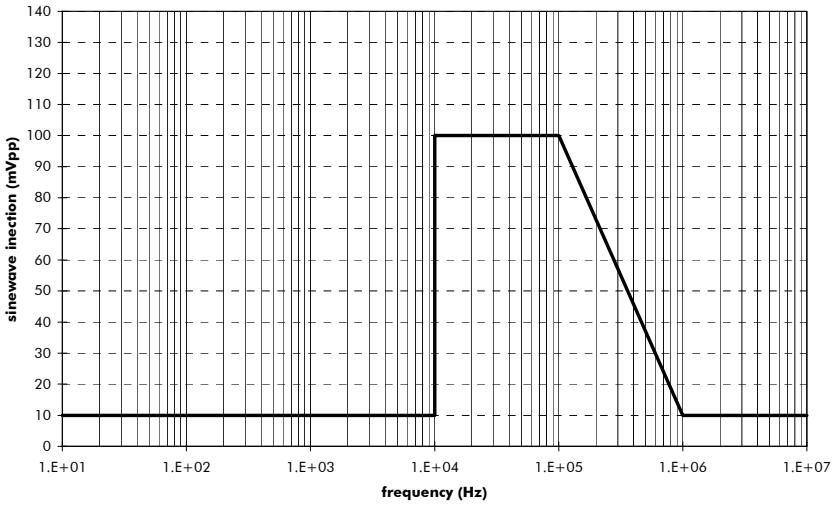


Figure 7.6-2: Sinewave injection on secondary power lines (user side)

*# In Reference *

7.7 Signal lines CE and CS requirements

7.7.1 TMTC lines

7.7.1.1 **General requirement**

The interface families tested are the following ones.

- Ana : Analog channel
- DB : Digital Bi-level channel
- DR : Digital Relay channel
- LLC : Low Level Command
- HLC : High Level Command
- Video lines
- Broadcast pulse signals (use SBDL memory load channel interface requirements)

7.7.1.1.1 ***Test limitation***

Reference **[CU-GDCEL-REQ-206]** SB-AD01.3-6.03-124

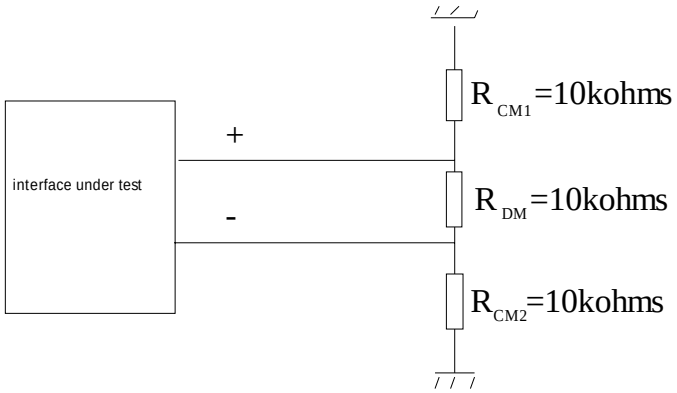
All the here under tests shall be applicable at each TM/TC lines . In case of identical circuits, 2 circuits or 10 % (whichever is more) of each TM/TC type circuits shall be tested.

 # In Reference *

7.7.1.1.2 *Test Configuration*

Reference **[CU-GDCEL-REQ-207]**

The TM/TC lines under test shall be loaded by dummy load as shown in figure hereafter:



If the use of dummy load is not possible, the EGSE may be used for these tests. In that case, the interface schematics of EGSE shall be delivered.

 # In Reference *

7.7.1.2 Conducted emission requirements

Reference **[CU-GDCEL-REQ-208]**

CE tests to perform (DM: differentiel mode, CM: common mode):

Input interface under test	Output (emiter)	Input (receiver)
ANA TM	DM + CM	DM
DB TM	DM + CM	DM
DR TM	DM + CM (*)	DM
LLC	CM	CM
HLC	-	-
TC video	DM	DM
TC video lock	DM	DM
TM video	DM	-

(*) except for RF switches

*# In Reference **

Reference **[CU-GDCEL-REQ-209]**

Conducted emission levels shall be less than the limit specified in time domain:

Input interface under test	DM	CM
ANA TM	20 mVpp + spike 300 mVpp (*)	1 Vpp
DB TM	100 mVpp + spike 300 mVpp (*)	1 Vpp
DR TM	100 mVpp + spike 300 mVpp (*)	1 Vpp
LLC	-	1 Vpp
HLC	-	-
TC video	100 mVpp	-
TC video lock	100 mVpp	-
TM video	100 mVpp	-

(*) Nota : spike waveform : transient high frequency oscillator, transient duration < 5µs, oscillation > 1 MHz

*# In Reference **

Reference **[CU-GDCEL-REQ-210]**

Both common mode (between interface links and ground plane) and differential mode (between twisted pair leads) measurements shall be performed:

in time domain with a 50 MHz min bandwidth oscilloscope measurement
If the interface is running during the test, the conducted emission levels specified shall be considered outside the signal specific operating frequency range (fundamental and harmonics).

In Reference *

7.7.1.3 Conducted Susceptibility Requirements

Reference **[CU-GDCEL-REQ-211]**

CS tests to perform (DM : differential mode, CM : common mode)

Input interface under test	Output (emitter)	Input (receiver)
ANA TM	-	CM
DB TM	-	CM
DR TM	-	CM
LLC	-	DM pulse (cf nota 1)
HLC	-	DM pulse (cf nota 1)
TC video	-	DM
TC video lock	-	DM
TM video	-	-

(*) nota 1 : no change of performance or status shall occur when a positive pulse train is injected between any TC input and its return with the following characteristics : amplitude : 26V, duration : 100 μs (at half amplitude), repetition rate : 2 ms

In Reference *

Reference **[CU-GDCEL-REQ-212]** SB-AD01.3-6.03-133

The input interface selected shall not exhibit any failure, malfunction or unintended responses when subjected to differential and common modes perturbations above mentioned:

a. Differential mode

Differential conducted susceptibility tests shall be performed in narrow band sinus wave-form and in the frequency range from 1k Hz to 50 MHz.

b. Common mode

Common mode conducted susceptibility is specified in narrow band sinus wave-form and in a frequency range of 1MHz to 50 MHz or in square modulated sine injection with a On duration > 5μs and a repetition frequency > 10 kHz

Input interface under test	DM	CM
ANA TM	-	2 Vpp
DB TM	-	2 Vpp
DR TM	-	2 Vpp
LLC	Cf nota 1	-
HLC	Cf nota 1	-
TC video	200 mVpp	-
TC video lock	200 mVpp	-
TM video	200 mVpp	-

In Reference *

Reference **[CU-GDCEL-REQ-213]**

The injected current shall be limited to 0.1 Ar.m.s. The voltage may be reduced if necessary.

In Reference *

7.7.2 *DATA HANDLING bus*

7.7.2.1 **Driver conducted emission**

Reference **[CU-GDCEL-REQ-214]**

The following test setup shall be used verify the OBDH485 driver common mode emission

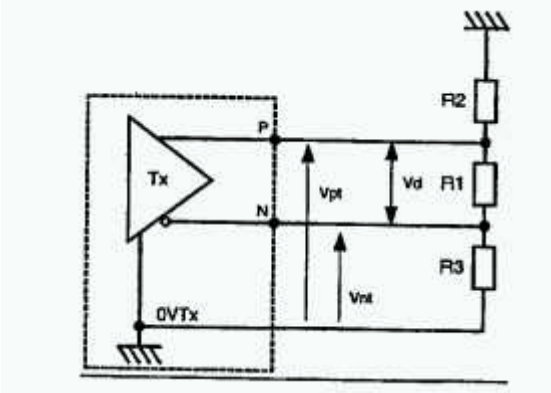


Figure 7.7-1: Driver CE test setup

R1 = 60Ω ± 10%

R2 = R3 = 22kΩ ± 10%

In Reference *

Reference **[CU-GDCEL-REQ-215]**

Measure shall be performed during CS representative test on the equipment primary or secondary power supply.

 # In Reference *

Reference **[CU-GDCEL-REQ-216]**

Driver differential mode emission

Temporal differential mode emitted noise measurement on inactive bus driver while at least one other interface is under activity shall not exceed 30mVpp.

Oscilloscope bandwidth shall be over 50 MHz.

 # In Reference *

Reference **[CU-GDCEL-REQ-217]**

Driver common mode emission

Temporal common mode emitted noise measurement on inactive bus driver while at least one other interface is under activity shall not exceed 150mVpp.

Oscilloscope bandwidth shall be over 50 MHz.

 # In Reference *

Reference **[CU-GDCEL-REQ-218]**

Oscilloscope measurement time base shall be tuned in order to :

- Identify noise envelope (large time base)
- Identify pulse characteristics (reduced time base)

These traces shall be set in the test report.

If common mode CE measurement (Vpt & Vnt) is greater than the limit required (150mVpp), complementary measurement is requested : Vpt & Vnt with R1 = 60 Ω & R2 = R3 = 10 Ω

 # In Reference *

7.7.2.2 **Receiver conducted emission**

Reference **[CU-GDCEL-REQ-219]**

The following test setup shall be used verify the OBDH485 receiver common mode emission

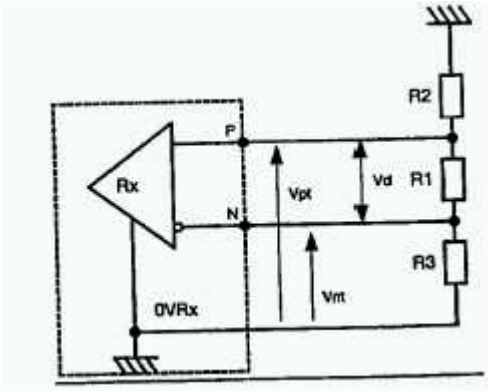


Figure 7.7-2: Receiver CE test setup

R1 = 60Ω ± 10%

R2 = R3 = 22kΩ ± 10%

In Reference *

Reference **[CU-GDCEL-REQ-220]**

Measure shall be performed during CS representative test on the equipment primary or secondary power supply.

In Reference *

Reference **[CU-GDCEL-REQ-221]**

Receiver differential mode emission

Temporal differential mode emitted noise measurement on inactive bus receiver while at least one other interface is under activity shall not exceed 150mVpp.

Oscilloscope bandwidth shall be over 50 MHz.

In Reference *

Reference **[CU-GDCEL-REQ-222]**

Receiver common mode emission

Temporal common mode emitted noise measurement on inactive bus receiver while at least one other interface is under activity shall not exceed 150mVpp.

Oscilloscope bandwidth shall be over 50 MHz.

In Reference *

Reference **[CU-GDCEL-REQ-223]**

Oscilloscope measurement time base shall be tuned in order to :

- Identify noise envelope (large time base)
- Identify pulse characteristics (reduced time base)

These traces shall be set in the test report.

If common mode CE measurement (Vpt & Vnt) is greater than the limit required (150mVpp), complementary measurement is requested : Vpt & Vnt with R1 = 60Ω & R2 = R3 = 10Ω

In Reference *

7.7.2.3 Receiver Conducted Susceptibility in common mode

Reference **[CU-GDCEL-REQ-224]** SB-AD01.3-6.03-159

During normal operation, the interface shall not exhibit any failure, malfunction or unintended responses when a common mode sine wave of 2.8 Vpp from 500 kHz to 50 MHz is injected between the input lines and the bus reference coupler (mechanical ground).

In Reference *

Reference **[CU-GDCEL-REQ-225]**

The injected current shall be limited to 0.1 Ar.m.s. and the voltage may be reduced if necessary.

In Reference *

7.8 General test conditions**:**

Tests conditions are based on MIL-STD-461E general requirements.

These general requirements are modified /completed to take into account SB4000 satellite design and dedicated EMC requirements.

7.8.1 *- Measurement tolerances*

Reference **[CU-GDCEL-REQ-226]**

Unless otherwise stated for a particular measurement, the tolerance shall be as follows:

- Distance: ±5%
- Frequency: ±2%
- Amplitude, measurement receiver: ±2 dB
- Amplitude, measurement system (includes measurement receivers, transducers, cables, and so forth): ±3 dB
- Time (waveforms): ±5%
- Resistors: ±5%
- Capacitors: ±20%

In Reference *

7.8.2 *Ambient electromagnetic level*

Reference **[CU-GDCEL-REQ-227]**

During CE & RE testing, the ambient electromagnetic level measured with the DUT de-energized and all auxiliary equipment turned on shall be at least 6 dB below the allowable specified limits. The ambient electromagnetic level shall be recorded in the EMC test report and shall not compromise the test results.

In Reference *

7.8.3 *- Shielded enclosures*

To prevent interaction between the DUT and the outside environment, shielded enclosures will usually be required for testing. These enclosures prevent external environment signals from contaminating emission measurements and susceptibility test signals from interfering with electrical and electronic items in the vicinity of the test facility.

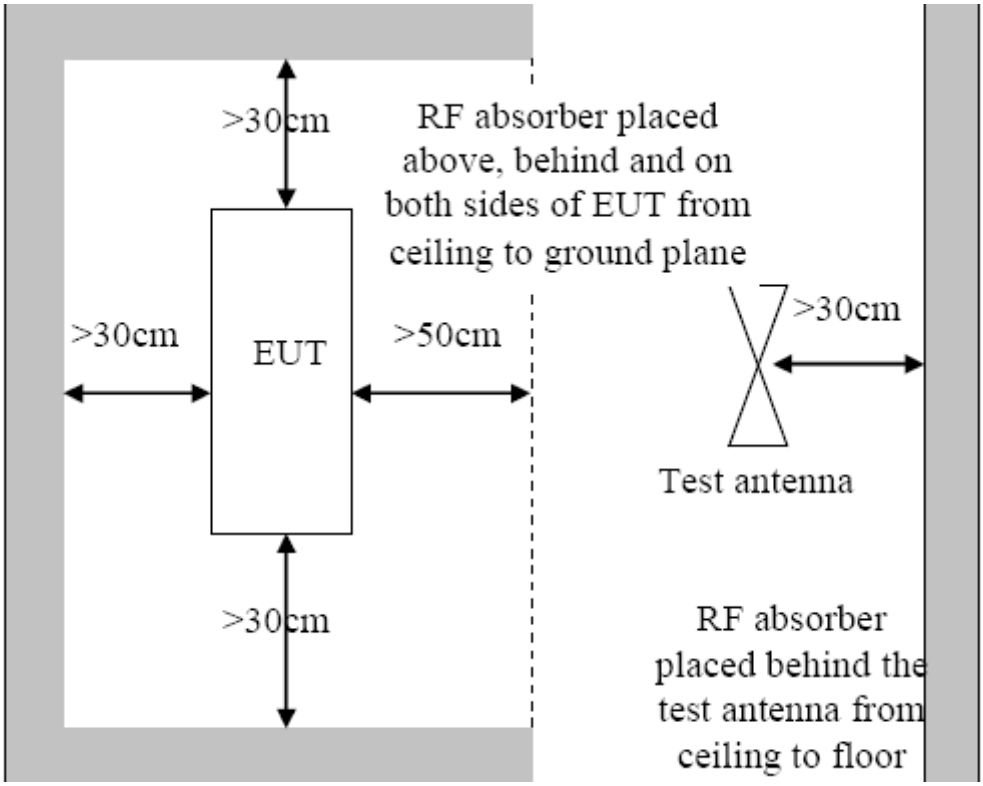
Reference **[CU-GDCEL-REQ-228]**

Shielded enclosures must have adequate attenuation such that the ambient requirements of paragraph “Ambient electromagnetic level” are satisfied.

RF absorber material (carbon impregnated foam pyramids, ferrite tiles, and so forth) shall be used when performing electric field radiated emissions or radiated susceptibility testing inside a shielded enclosure to reduce reflections of electromagnetic energy and to improve accuracy and repeatability. Minimum performance of the material shall be as specified in table “RF material absorption at normal incidence”.

In Reference *

The RF absorber can be placed above, behind, and on both sides of the DUT, and behind the radiating or receiving antenna as shown in the following figure .



Frequency	Minimum absorption
80 MHz - 250 MHz	6 dB
above 250 MHz	10 dB

Figure 7.8-1: RF material absorption at normal incidence

7.8.4 *Other test sites*

Reference **[CU-GDCEL-REQ-229]**

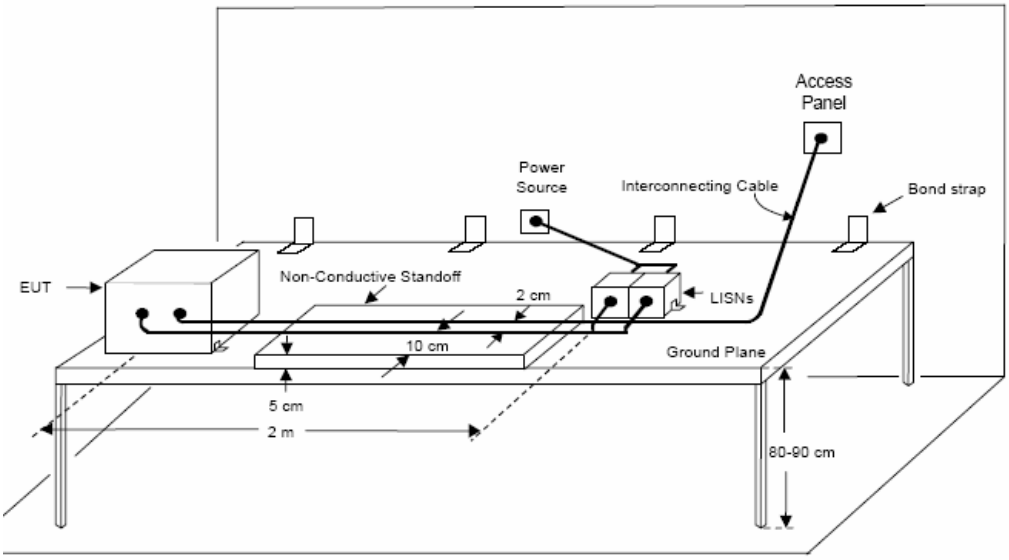
If other test sites are used, the ambient requirements of paragraph "**Ambient electromagnetic level**" shall be met.

 # In Reference *

7.8.5 Ground plane

Reference **[CU-GDCEL-REQ-230]**

The DUT shall be installed on a metallic ground plane as shown in the figure hereafter.



 # In Reference *

Reference **[CU-GDCEL-REQ-231]**

The ground plane shall have a surface resistance no greater than 0.1 milliohms per square. The DC resistance between metallic ground plane and the shielded enclosure shall be 2.5 milliohms or less.

 # In Reference *

Reference **[CU-GDCEL-REQ-232]**

The metallic ground plane shall be electrically bonded to the floor or wall of the basic shielded room structure at least once every 1 meter. The metallic bond straps shall be solid and maintain a five-to-one ratio or less in length to width.

 # In Reference *

7.8.6 DUT test configurations

7.8.6.1 **Bonding of DUT**

Reference **[CU-GDCEL-REQ-233]**

Only the provisions included in the design of the DUT shall be used to bond units such as equipment case and mounting bases together, or to the ground plane. When bonding straps are required, they shall be identical to those specified in the installation drawings.

- SB4000 satellite bonding requirements: DC resistance ≤ 2.5mohms, inductance ≤ 100nH.

 # In Reference *

7.8.6.2 **Orientation of DUT**

Reference **[CU-GDCEL-REQ-234]**

DUT shall be oriented such that surfaces which produce maximum radiated emissions and respond most readily to radiate signals face the measurement antennas.

 # In Reference *

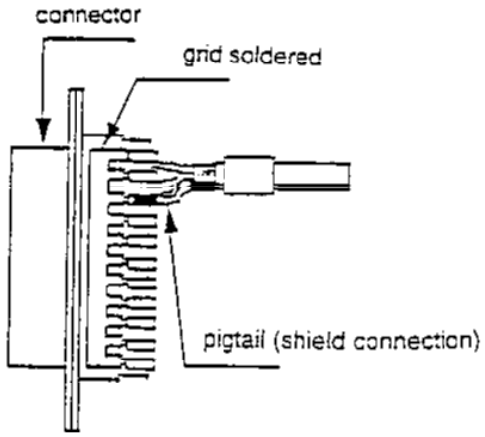
7.8.6.3 **Construction and arrangement of DUT cables**

Reference **[CU-GDCEL-REQ-235]**

The EUT shall be set up with harness that simulates flight harness in shielding presence and terminations, twisting, ground and wiring properties as define (if no other specific definition is given) in the table here below:

Bundle Ref	Signal type	Cable definition
1A	Primary Power lines	Twisted pair
1B	Secondary Power lines	Twisted pair
2A	Low level command LLC High level command HLC Analog channel telemetry Digital bi-level channel telemetry Digital switch closure channel telemetry	Twisted pair Twisted pair Twisted pair Twisted pair Twisted pair
4B	SMU / Transmitters TM video signals Receiver / transmitters interfaces	Shielded twisted pair Shielded twisted pair
4C	OBDH-485	Shielded twisted pair (gore 120 Ω)

- The separation routing distance of the bundles shall be 5cm.
- Bundle average height from the ground plane shall be 5cm.
- The shield of twisted pair shall be connected to connector housing.
- The housing of connectors shall be electrically connected to the EUT unit structure.
- The shielding pigtail length shall be 3cm.



In Reference *

Reference **[CU-GDCEL-REQ-236]**

Details on the test harness construction used for testing shall be included in the EMC test procedure.

In Reference *

7.8.6.4 **Interfaces of DUT**

Reference **[CU-GDCEL-REQ-237]**

Loading and excitation of the test sample shall be representative of actual flight units and stimulating circuits as representative as practicable. When flight loads or sources are impractical or unavailable the impedance characteristics of such loads and sources shall be representatively simulated.

In Reference *

Reference **[CU-GDCEL-REQ-238]**

The simulation shall consist of reactive and resistive elements as necessary to:

- Maximise the measured ripples for the Emission tests,
- Maximise the sensitivity of the DUT for Susceptibility tests.

In Reference *

Reference **[CU-GDCEL-REQ-239]**

Antenna ports on the DUT shall be terminated with shielded, matched loads.

In Reference *

7.8.7 Operation of DUT

Reference **[CU-GDCEL-REQ-240]**

During emission measurements, the DUT shall be placed in an operating mode which produces maximum emissions. During susceptibility testing, the DUT shall be placed in its most susceptible operating mode. For DUT with several available modes (including software controlled operational modes), a sufficient number of modes shall be tested for emissions and susceptibility such that all circuitry is evaluated. The rationale for modes selected shall be included in the EMC test procedure.

 # In Reference *

7.8.8 Detector

Reference **[CU-GDCEL-REQ-241]**

A peak detector shall be used for all frequency domain emission and susceptibility measurements. This device detects the peak value of the modulation envelope in the receiver band pass. Measurement receivers are calibrated in terms of an equivalent Root Mean Square (RMS) value of a sine wave that produces the same peak value. When other measurement devices such as oscilloscopes, non-selective voltmeters, or broadband field strength sensors are used for susceptibility testing, correction factors shall be applied for test signals to adjust the reading to equivalent RMS values under the peak of the modulation envelope.

 # In Reference *

7.8.9 Emission testing

7.8.9.1 **Bandwidths**

\# Reference **[CU-GDCEL-REQ-242]**

The measurement receiver bandwidths listed in table " Bandwidth and measurement time emissions" shall be used for emission testing. These bandwidths are specified at the 6 dB down points for the overall selectivity curve of the receivers. Video filtering shall not be used to bandwidth limit the receiver response. If a controlled video bandwidth is available on the measurement receiver, it shall be set to its greatest value. Larger receiver bandwidths may be used; however, they may result in higher measured emission levels. No bandwidth correction factors shall be applied to test data due to use of larger bandwidths.

Frequency Range	6 dB Bandwidth	Dwell Time	Minimum Measurement Time Analog Measurement Receiver
30 Hz - 1 kHz	10 Hz	0.15 sec	0.015 sec/Hz
1 kHz - 10 kHz	100 Hz	0.015 sec	0.15 sec/kHz
10 kHz - 150 kHz	1 kHz	0.015 sec	0.015 sec/kHz
150 kHz - 30 MHz	10 kHz	0.015 sec	1.5 sec/MHz
30 MHz - 1 GHz	100 kHz	0.015 sec	0.15 sec/MHz
Above 1 GHz	1 MHz	0.015 sec	15 sec/GHz

Table 7.8-1: Bandwidth and measurement time emissions

\# *In Reference* *

7.8.9.2 **Emission identification**

\# Reference **[CU-GDCEL-REQ-243]**

Regardless of characteristics shall be measured with the measurement receiver bandwidths specified in table "Bandwidth and measurement time emissions" and compared against the applicable limits. Identification of emissions with regard to narrowband or broadband categorization is not applicable.

\# *In Reference* *

7.8.9.3 **Frequency scanning**

\# Reference **[CU-GDCEL-REQ-244]**

For emission measurements, the entire frequency range for each applicable test shall be scanned. Minimum measurement time for analog measurement receivers during emission testing shall be as specified in table "Bandwidth and measurement time emissions". Synthesized measurement receivers shall step in one-half bandwidth increments or less, and the measurement dwell time shall be as specified in table "Bandwidth and measurement time emissions". For equipment that operates such that potential

emissions are produced at only infrequent intervals, times for frequency scanning shall be increased as necessary to capture any emissions.

In Reference *

7.8.9.4 **Emission data presentation**

Reference **[CU-GDCEL-REQ-245]**

Amplitude versus frequency profiles of emission data shall be automatically generated and displayed at the time of test and shall be continuous. The displayed information shall account for all applicable correction factors (transducers, attenuators, cable loss, and the like) and shall include the applicable limit.

In Reference *

7.8.9.5 **Time domain measurements using oscilloscope**

Reference **[CU-GDCEL-REQ-246]**

The minimum bandwidth required for oscilloscope and its associated probe is 50MHz. Real differential voltage probe is required for all CE voltage measurements.

If necessary, several measurements using different time base shall be performed to characterise completely the CE signal. For example, if the CE is a repetitive spike, the time base of the first plot shall be tuned to characterize the time re petition of the spike and time base of the second plot shall be tuned to characterize the spike (amplitude, duration, damped oscillation).

In Reference *

7.8.10 Susceptibility testing

7.8.10.1 **Frequency scanning**

Reference **[CU-GDCEL-REQ-247]**

For susceptibility measurements, the entire frequency range for each applicable test shall be scanned. For swept frequency susceptibility testing, frequency scan rates and frequency step sizes of signal sources shall not exceed the values listed in table "Susceptibility scanning". The rates and step sizes are specified in terms of a multiplier of the tuned frequency (fo) of the signal source. Analog scans refer to signal sources which are continuously tuned. Stepped scans refer to signal sources which are sequentially tuned to discrete frequencies. Stepped scans shall dwell at each tuned frequency for the greater of 3 seconds or the DUT response time. Scan rates and step sizes shall be decreased when necessary to permit observation of a response. The response shall be given in the test report for the entire frequency range or for at least 4 frequencies per decade (ex: 1, 3, 5 and 7).

Frequency Range	Analog Scans Maximum Scan Rates	Stepped Scans Maximum Step Size
30 Hz - 1 MHz	0.0333 f_o/s	0.05 f_o
1 MHz – 30 MHz	0.00667 f_o/s	0.01 f_o
30 MHz - 1 GHz	0.00333 f_o/s	0.005 f_o
1 GHz - 8 GHz	0.000667 f_o/s	0.001 f_o
8 GHz - 40 GHz	0.000333 f_o/s	0.0005 f_o

Table 7.8-2**:** Susceptibility scanning

 # In Reference *

7.8.10.2 **Thresholds of susceptibility**

Reference **[CU-GDCEL-REQ-248]**

When susceptibility indications are noted in DUT operation, a threshold level shall be determined where the susceptible condition is no longer present. Thresholds of susceptibility shall be determined as follows and described in the EMC test report:

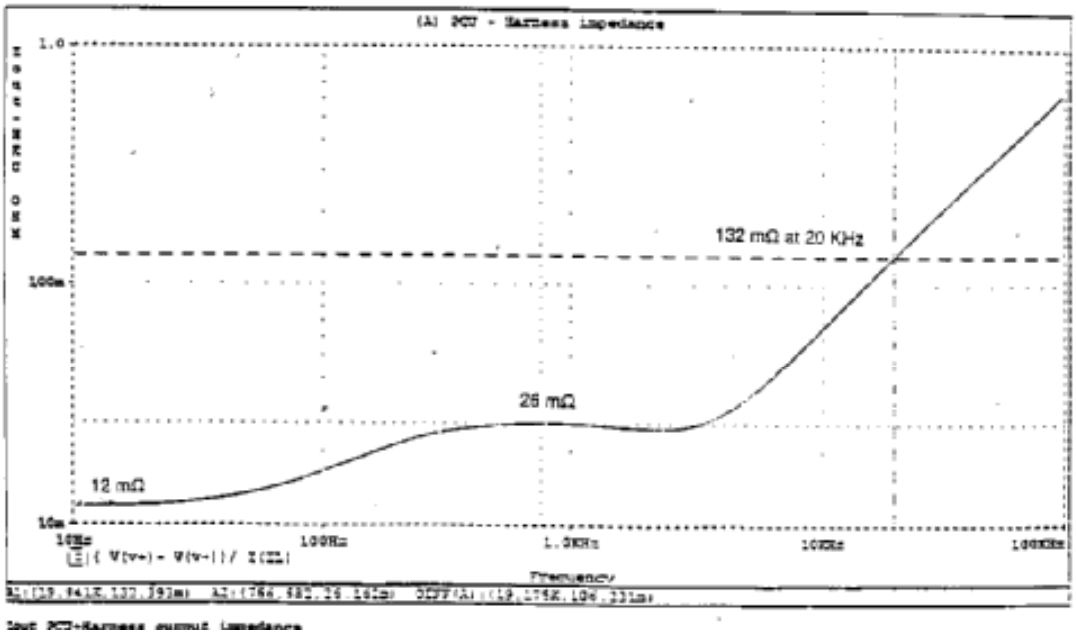
- When a susceptibility condition is detected, reduce the interference signal until the DUT recovers.
- Reduce the interference signal by an additional 6 dB.
- Gradually increase the interference signal until the susceptibility condition reoccurs. The resulting level is the threshold of susceptibility.
- Record this level, frequency range of occurrence, frequency and level of greatest susceptibility, and other test parameters, as applicable.

 # In Reference *

7.8.11 LISN specification

Reference **[CU-GDCEL-REQ-249]**

In order to normalise the measurement conditions between the various test sites, the measurement of the interference conducted emission on the power supply leads shall be performed by standardising the source impedance, in accordance with the following figure:



*# In Reference **

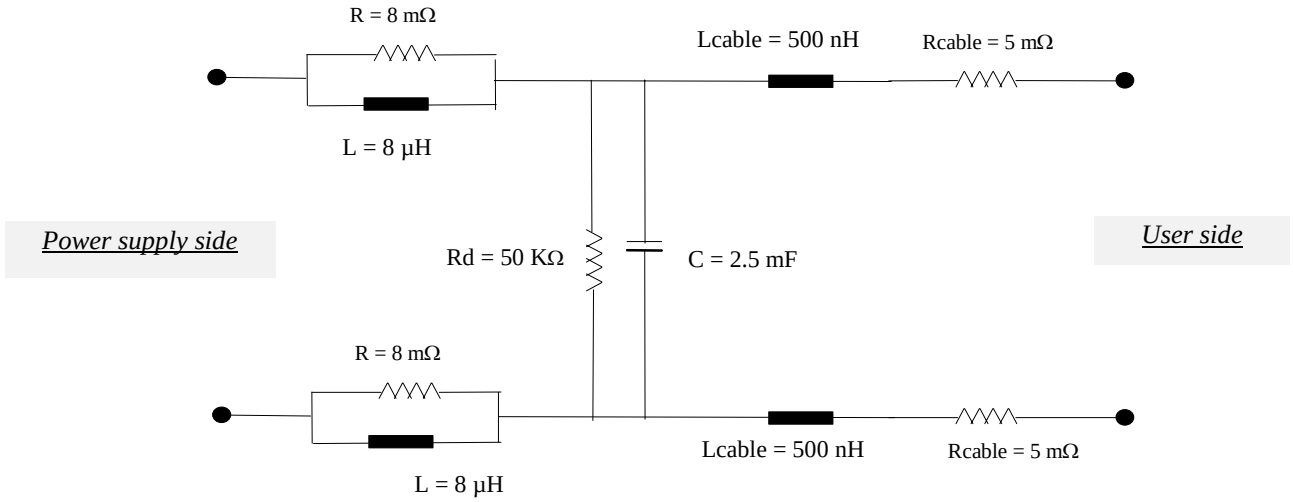
Reference **[CU-GDCEL-REQ-250]**

LISN shall be constitued of:

The LISN- DUT power leads defined in paragraph “Construction and arrangement of DUT cables”: 2 meters of unshielded twisted pair (Cu Gauge 22 or 24).

LISN electrical diagram:

- R = 8 mΩ ± 10 % ⇒ parasitic inductance ≤ 70 nH
- L = 8 μH ± 10 %⇒ parasitic resistance ≤ 1 mΩ
- Lcable = 500 nH ± 10 % ⇒ 4 mΩ ≤ Rparasitic ≤ 6 mΩ
- C = 2.5 mF ± 10 % ⇒ parasitic resistance ≤ 10 mΩ and parasitic inductance ≤ 100 nH
- Rd = 50 KΩ ± 20 % ⇒ 2.5 mF capacitance discharge resistor



 # In Reference *

Reference **[CU-GDCEL-REQ-251]**

The power lead return line shall be connected to metallic ground plane on a single point close as possible to the capacitance C_{LISN}. Connection to mechanical ground shall be as shorter as possible.

 # In Reference *

Reference **[CU-GDCEL-REQ-252]**

The length separation of positive & return power leads (for current probe insertion) shall be as shorter as possible.

 # In Reference *

Reference **[CU-GDCEL-REQ-253]**

LISN installation shall be detailed in EMC test report. The actual LISN impedance shall be measured before to start the EMC tests and the diagram shall be included in the test report.

 # In Reference *

END OF DOCUMENT