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GENERAL DESIGN AND INTERFACE REQUIREMENTS

Written by: Satellite Engineering team	
Accepted by: B. MILLET (CNES), Project Manager J. CHEGANCAS (AIRBUS D&S), Project Manager M. VACANCE (Thales Alenia Space), Project Manager	 Millet Bruno 2023.01.27 14:11:20 +01'00'  Signé numériquement par : Jean Chegancas Nom DN : CN = Jean Chegancas email = jean.chegancas@airbus.com C = FR O = Airbus Defence & Space SAS Date : 2023.01.25 15:24:26 +01'00'  Signé numériquement par : VACANCE Michel Nom DN : CN = VACANCE Michel O = Thales Date : 2023.01.26 17:14:19 +02'00'
Approved by: B. MILLET (CNES), Project Manager J. CHEGANCAS (AIRBUS D&S), Project Manager M. VACANCE (Thales Alenia Space), Project Manager	 Millet Bruno 2023.01.27 14:11:42 +01'00'  Signé numériquement par : Jean Chegancas Nom DN : CN = Jean Chegancas email = jean.chegancas@airbus.com C = FR O = Airbus Defence & Space SAS Date : 2023.01.25 15:25:00 +01'00'  Signé numériquement par : VACANCE Michel Nom DN : CN = VACANCE Michel O = Thales Date : 2023.01.26 17:14:52 +02'00'

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FOREWORD

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INDEX SHEET

TITLE:	General Design and Interface Requirements
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CHANGES

Version	Date	Modified by	Comments
1.0	07/07/2011		First version, based on ECSS-E flow-down and industrial REX
2.0	30/09/2011		Version of the document (completed and corrected) prepared for ISIS Phase 3 Final Review.
3.0draft	21/09/2012		- Issue exported from DOORS (Ed2 imported except Chap7 "Elec"). - Chap 7.3 "Pyro" and 8 "Operations design and Interface requirements" (Monitoring & Control) added
4.0	25/02/2013		DM ISIS-FT-180 - Version issued after configuration management with RCM. - Chap 7.2 "Electrical part" added - Paragraph 9.3 canceled (electrical ICD, now described in § 7) - 1553 electrical requirements have been removed from ISIS-SL-IF-315-CNES v4 and inserted in paragraph 7.4.17
5.0	28/06/2013		DM ISIS-FT-217 - Comments from TAS and ASTR taken into account, - REX from MYR-Evol missionisation taken into account, ISIS-GDIR-REQ-70002 v.1 ISIS-GDIR-REQ-70004 v.1 ISIS-GDIR-REQ-70015 v.1 ISIS-GDIR-REQ-70018 v.1 ISIS-GDIR-REQ-70039 v.1 ISIS-GDIR-REQ-70040 v.1 ISIS-GDIR-REQ-70044 v.1 ISIS-GDIR-REQ-70080 v.1 ISIS-GDIR-REQ-70086 v.1 ISIS-GDIR-REQ-70087 v.1 ISIS-GDIR-REQ-70096 v.1 ISIS-GDIR-REQ-70219 v.1 ISIS-GDIR-REQ-70220 v.1 ISIS-GDIR-REQ-70236 v.1 ISIS-GDIR-REQ-70237 v.1 ISIS-GDIR-REQ-70251 v.1 ISIS-GDIR-REQ-70252 v.1 ISIS-GDIR-REQ-70257 v.1 ISIS-GDIR-REQ-70258 v.1 ISIS-GDIR-REQ-70266 v.1 ISIS-GDIR-REQ-70267 v.1 ISIS-GDIR-REQ-70272 v.1 ISIS-GDIR-REQ-70273 v.1 ISIS-GDIR-REQ-70372 v.1 ISIS-GDIR-REQ-70412 v.1 ISIS-GDIR-REQ-70415 v.1 ISIS-GDIR-REQ-70417 v.1 ISIS-GDIR-REQ-70458 v.1 ISIS-GDIR-REQ-70465 v.1 ISIS-GDIR-REQ-70467 v.1 ISIS-GDIR-REQ-70540 v.1 ISIS-GDIR-REQ-70543 v.1 ISIS-GDIR-REQ-70545 v.1 ISIS-GDIR-REQ-70546 v.1 ISIS-GDIR-REQ-70554 v.1 - Correction of typo errors : ISIS-GDIR-REQ-30005 v.1 ISIS-GDIR-REQ-40090 v.1 ISIS-GDIR-REQ-40122 v.1 ISIS-GDIR-REQ-40134 v.1 ISIS-GDIR-REQ-40149 v.1 ISIS-GDIR-REQ-40158 v.1 ISIS-GDIR-REQ-50012 v.1 ISIS-GDIR-REQ-70001 v.1 ISIS-GDIR-REQ-70021 v.1 ISIS-GDIR-REQ-70031 v.1 ISIS-GDIR-REQ-70042 v.1 ISIS-GDIR-REQ-70197 v.1 ISIS-GDIR-REQ-70244 v.1 ISIS-GDIR-REQ-70350 v.1 ISIS-GDIR-REQ-70361 v.1 ISIS-GDIR-REQ-70364 v.1 ISIS-GDIR-REQ-70397 v.1 ISIS-GDIR-REQ-70433 v.1 ISIS-GDIR-REQ-70441 v.1 ISIS-GDIR-REQ-70449 v.1 ISIS-GDIR-REQ-70451 v.1 ISIS-GDIR-REQ-70453 v.1 ISIS-GDIR-REQ-70472 v.1 ISIS-GDIR-REQ-70476 v.1 ISIS-GDIR-REQ-70497 v.1 ISIS-GDIR-REQ-70523 v.1 ISIS-GDIR-REQ-70525 v.1 ISIS-GDIR-REQ-70542 v.1 ISIS-GDIR-REQ-90003 v.1 ISIS-GDIR-REQ-90012 v.1 ISIS-GDIR-REQ-90014 v.1
6.0	10/10/2013		DM ISIS-FT-247 - Comments from TAS and ASTR taken into account.
7.0	03/07/2014		DM ISIS-FT-348 - Modifications to take into account CNES RNC. ISIS-GDIR-REQ-70001 ISIS-GDIR-REQ-70034 ISIS-GDIR-REQ-70573 ISIS-GDIR-REQ-70575 - Bug correction of table in §7.5.1.0

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8.0	19/06/2018		DM ISIS-FT-2528 - Meca: - REQ-40010 (v.2) precisions added on the table 3 - REQ-40011 (v.2) removed - REQ-40012 (v.2) modified - REQ-40020 (v.2) modified - REQ-40173 (v.1) added - REQ-40116 (v.1) suppression of the requirement Rationale ("Pending review of fracture control ECSS"). - REQ-40124 (v.2) modified ("Contact surface roughness" value) - REQ-40127 (v.2) removed - REQ-40140 (v.2) refined - Thermal: - REQ-50024 (v.1) comment added - REQ-50037 (v.2) removed - Elect: - REQ-70181 (v.2) modified - REQ-70208 (v.2), REQ-70220 (v.3), REQ-70237 (v.3), REQ-70255 (v.1) refined - REQ-70374 (v.2) reworded for REACH regulations - REQ-70487 (v.2) reworded - REQ-70528 (v.2), REQ-70536 (v.2) refined - typo / wording corrections: - REQ-40018 (v.2), REQ-40019 (v.2), REQ-40074 (v.2), REQ-40097 (v.2), REQ-40151 (v.2), REQ-40156 (v.2), REQ-40170 (v.3), REQ-40172 (v.2) -REQ-50038 (v.2), -REQ-50044 (v.2)
8.1	04/01/2023		DM ISIS-FT-7746 The modifications established as part of this change request consist in: • Typo corrections, • Punctuation corrections, • TBC removals in section #7, • Overall review of section #7 (Electrical Design And Interface Requirements) to take into consideration especially the relevant evolutions of the ECSS specifications (ECSS-E-ST-20C - Space Engineering – Electrical and electronic, in Rev. 2).

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TBC TABLE

Requirement Identifier	Object Text	TBC Comment
§4.3	Note, as general rules: - For unit masses over s....	

TBD TABLE

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1. INTRODUCTION

1.1. SCOPE

This document, designated as General Design and Interface Requirements (specification), constitutes the general requirements for the various equipments of the spacecraft.

It is a generic document that will be tailored/missionized and be applicable in the frame of satellite programs.

The document specifies contractually relevant requirements as well as assumptions and constraints, which apply to the development, design, manufacturing, assembly, verification and delivery of the project deliverables to the extent specified in the governing specification for that deliverable.

In the case of conflicts between this specification and subsystem or unit specifications, this specification is superseded by the subsystem or unit specification within the scope of the conflict only. The conflict shall be reported to the spacecraft prime.

It has to be noticed that this document applies to new equipments to be developed in the frame of ISIS standard, but not to already existing and qualified equipment items belonging to industrial product lines.

1.2. HERITAGE FROM ECSS

ECSS requirements have been made applicable through the present document by tailoring them and flow down as standalone requirements with respect to the ECSS frame. Therefore, source ECSS standards are not made applicable, but simply listed as reference documents in §2.1.

Whenever specific ECSS standards have not followed that process, they are explicitly identified as applicable documents in §2.2 and called by dedicated text.

1.3. REQUIREMENT NUMBERING AND VERIFICATION

Requirements within this document are shown as per the template here below. Each requirement is associated with the following fields.

- Requirement Number
- Intended Verification Method

The Requirement Number has the form ISIS-GDIR-REQ-xxxxx where xxxxx is a unique number assigned consecutively in each chapter.

The Intended Verification Method codes are as follows:

- T – Test
- A – Analysis (includes S – Similarity as per [RD-1])
- R – Review
- I – Inspection

The requirement text follows the requirement number. If tables are considered as part of requirement, they are referenced clearly in the text and inserted after the requirement text.

All document elements not presented in the format explained above are not requirements and will not be verified or tracked.

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1.4. EXPORT REGULATION

This document does not contain export controlled information.

As a consequence, sensitive information has been removed from the original publication and some sections are intentionally not fulfilled.

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2. REFERENCE AND APPLICABLE DOCUMENTS

2.1. REFERENCE DOCUMENTS

Index	Reference	Title of document
RD-1	ECSS-E-ST-10-02C	Space Engineering – Verification
RD-2	ECSS-E-ST-20C	Space Engineering – Electrical and electronic
RD-3	ECSS-E-ST-20-06C	Space Engineering – Spacecraft charging
RD-4	ECSS-E-ST-20-07C	Space Engineering – Electromagnetic compatibility
RD-5	ECSS-E-ST-31C	Space Engineering – Thermal control general requirements
RD-6	ECSS-E-ST-32C	Space Engineering – Structural general requirements
RD-7	ECSS-E-ST-32-03C	Space Engineering – Structural finite element models
RD-8	ECSS-E-ST-32-10C	Space Engineering – Structural factors of safety for spaceflight hardware
RD-9	ECSS-E-ST-50-13C	Space Engineering – Interface and communication protocol for MIL-STD-1553B data bus on-board spacecraft
RD-10	ECSS-E-ST-50-14C	Space Engineering – Spacecraft discrete interfaces

2.2. APPLICABLE DOCUMENTS

Index	Reference	Title of document
AD1	ECSS-E-ST-33-01	Space Engineering – Mechanisms
AD2	ECSS-E-ST-33-11	Space Engineering – Explosive systems and devices
AD3	ISIS-SY-TN-115-CNES	ISIS Glossary and Acronyms
AD4	ISIS-SL-TS-781-CNES	ISIS structural finite element models general requirements

2.3. TERMINOLOGY AND ABBREVIATIONS

2.3.1. Terminology

This section defines general terms used throughout the document. Terms specific to an engineering domain are defined in the relevant sections.

Terms	Definitions

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2.3.2. Abbreviations

Abbreviations	Definitions

2.3.3. Product Categories

Product categories are defined according to Table 1.

CATEGORY	DESCRIPTION
A	Off-the-shelf product without modifications and • Subjected to a qualification test programme at least as severe as that imposed by the actual project specifications including environment and • Produced by the same manufacturer or supplier and using the same tools and manufacturing processes and procedures
B	Off-the shelf product without modifications. However: It has been subjected to a qualification test programme less severe or different to that imposed by the actual project specifications (including environment).
C	Off-the-shelf product with modifications. Modification includes changes to design, parts, materials, tools, processes, procedures, supplier or manufacturer.
D	Newly designed and developed product.

Table 1 – Product categories according to heritage

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3. GENERAL DESIGN REQUIREMENTS

3.1. ENGINEERING STANDARD UNITS

ISIS-GDIR-REQ-30001 v: 1

All drawings, specifications and engineering data shall use the International System of Units (SI units).
The use of derived units, based on the International System of Units, is authorised.

Name	Unit symbol	Quantity	Symbol
metre	m	length	<i>l</i> (a lowercase L)
kilogram	kg	mass	<i>m</i>
second	s	time	<i>t</i>
ampere	A	electric current	<i>I</i> (a capital i)
kelvin	K	Thermodynamic temperature	<i>T</i>

Table 2 – Standard units

Comment: Note 1: A prefix may be added to a unit to produce a multiple of the original unit (i.e. mega, kilo, milli, micro, ...)

Note 2: Exception are allowed for some derived units

- Accelerations may be expressed in multiple of g (gravity)
- Temperatures may be expressed in in terms of °C (degree Celcius)

Verification Method: R

3.2. VENTING

ISIS-GDIR-REQ-30002 v: 1

In case that provision for venting is not made, the unit shall withstand build-up pressure (including safety factors).

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-32C 4.5.15b

ECSS DOORS Req ID: [ECSS-E-ST-32_0050084]

ISIS-GDIR-REQ-30003 v: 1

The openings for venting shall be compatible with the purging system gas supply pressure and flow rate.

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-32C 4.5.15c

ECSS DOORS Req ID: [ECSS-E-ST-32_0050085]

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3.3. HANDLING, PACKING , TRANSPORTATION AND STORAGE

ISIS-GDIR-REQ-30004 v: 1

Each unit weighing more than 10 kg shall be equipped with handling points (e.g. threaded bushes) that enable the connection to special handling MGSE for integration or dismounting.

Rationale: Qualitatively heavy units are safer and easier to manipulate with handling tools.
Quantitatively the reason of the limit mass of 10 kg is unknown.

Verification Method: R

ISIS-GDIR-REQ-30005 v: 3

Lifting and transportation interfaces shall be arranged such that, except for the points themselves, ground handling loads will not drive the overall units design.

Comment: Applicable to equipment units.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.2.1a, ECSS-E-ST-32C 4.2.1c

ECSS DOORS Req ID: [ECSS-E-ST-32_0050001], [ECSS-E-ST-32_0050003]

ISIS-GDIR-REQ-30006 v: 1

Handling points shall be defined in the Interface Control Drawings (ICDR).

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.4a, ECSS E ST 32 C 4.4c

ECSS DOORS Req ID: [ECSS-E-ST-32_0050044], [ECSS-E-ST-32_0050046]

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4. MECHANICAL DESIGN AND INTERFACE REQUIREMENTS

4.1. UNIT PHYSICAL CHARACTERISTICS

4.1.1. General Requirement

ISIS-GDIR-REQ-40001 v: 1

The unit design (i.e. overall volume and interfaces) shall be in conformance with IRD definition.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.4a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050044]

ISIS-GDIR-REQ-40002 v: 1

All interface dimensional properties shall be indicated in Interface Control Drawings (ICDR).

Comment: Requirement for detailed content of the Interface Control Document (ICD) are given in chapter "Mechanical Interface Control Documents".

Verification Method: R

ISIS-GDIR-REQ-40003 v: 1

The overall dimensions and associated tolerances of unit, including interface assembly, shall not differ from the values stated in the ICDR.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.3.9a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050036]

ISIS-GDIR-REQ-40004 v: 1

Mass and inertia properties of the unit shall be determined during all phases of the design.

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-32C 4.5.5a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050058]

ISIS-GDIR-REQ-40005 v: 1

Mass and inertia properties shall be compliant with the mass budget allocation.

Comment: The mass and inertia properties of a unit comprise its mass, the location of its centre of gravity, its moments and products of inertia.

Verification Method: I

Standard Origin Source: ECSS-E-ST-32C 4.5.5b

ECSS DOORS Req ID: [ECSS-E-ST-32_0050059]

ISIS-GDIR-REQ-40006 v: 1

The mass and inertia data shall include the following:

1. mass,

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2. co-ordinates of the centre of mass with respect to unit reference frame,
3. moments of inertia with respect to unit reference frame,
4. the principal moments of inertia and their orientation with respect to unit reference frame.

Comment: "Unit reference frame" text added.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.6.2.18d

ECSS DOORS Req ID: [ECSS-E-ST-32_0050134]

ISIS-GDIR-REQ-40007 v: 1

Moment of inertia shall be provided at the center of mass of the unit.

Comment: There is no requirement in the Structural ECSS defining the Mol calculation requirement.

Verification Method: A, T

4.1.2. Mass

ISIS-GDIR-REQ-40008 v: 1

A breakdown of mass to component level shall be given together with mass contingency estimates based on the design maturity.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.6.2.18c

ECSS DOORS Req ID: [ECSS-E-ST-32_0050133]

ISIS-GDIR-REQ-40009 v: 1

The mass of each unit, with tolerances, shall be reported in the unit ICDR.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C A.2.1<6.3>a, ECSS-E-ST-32C I.2.1<8.4>a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050293], [ECSS-E-ST-32_0050484]

ISIS-GDIR-REQ-40010 v: 2

The margin to be added to each item estimated mass for budget consolidation shall follow the rules expressed in Table 3.

CATEGORY	DESIGN MATURITY	MARGINS
A	Existing off the shelf or recurring equipment fully qualified Existing/Re-use	0%
	Existing off the shelf or recurring equipment fully Build to print from existing hardware	2%
B	Existing off the shelf or recurring equipment which requires a delta qualification	5%
C	modified equipment for which a qualification shall be made	15%
D	new equipment to be developed and qualified	20%

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Table 3 – Mass Budget Maturity Margins, Excluding measurement uncertainties

Comment: For category B, C and D, the maturity margin could be reduced with the increased confidence in project maturity (i.e. the design and analysis become more detailed and / or availability of test data).

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.6.2.18c

ECSS DOORS Req ID: [ECSS-E-ST-32_0050133]

ISIS-GDIR-REQ-40012 v: 2

The actual mass of all units intended for Qualification, Flight and Flight Spare(s) shall not deviate from the nominal value by more than 2%.

Comment: All units still need to be compliant with maximum mass allocation.

Verification Method: I, R, T

Standard Origin Source: ECSS-E-ST-32C 4.5.5b

ECSS DOORS Req ID: [ECSS-E-ST-32_0050059]

4.1.3. Center of Mass and Moment of Inertia

ISIS-GDIR-REQ-40013 v: 1

The inertia properties shall be computed according to the specified accuracy using the inertia matrix of individual components.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.6.2.18a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050131]

ISIS-GDIR-REQ-40014 v: 1

The center of mass shall be computed according to the specified accuracy using the mass properties of individual components.

Comment: It seems that a req asking to evaluate the CoM including margin is missing in the ECSS.

Verification Method: A

Standard Origin Source:

ISIS-GDIR-REQ-40015 v: 1

The location of the centre of mass of each unit, with tolerances, shall be given in the unit ICDR.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C A.2.1<6.3>a, ECSS-E-ST-32C I.2.1<8.4>a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050293], [ECSS-E-ST-32_0050484]

ISIS-GDIR-REQ-40016 v: 1

The products of inertia of each unit, with tolerances, shall be recorded in the unit ICDR.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C A.2.1<6.3>a, ECSS-E-ST-32C I.2.1<8.4>a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050293], [ECSS-E-ST-32_0050484]

ISIS

ISIS-GDIR-REQ-40017 v: 2 w

The uncertainty of each item CoM and Mol calculation for budget consolidation shall follow the rules expressed in Table 4.

CATEGORY	DESIGN MATURITY	CoM UNCERTAINTY	Mol UNCERTAINTY
A	As per definition §2.3.3	1 mm radius sphere	± 5% for each axis
B	As per definition §2.3.3	2 mm radius sphere	± 10% for each axis
C	As per definition §2.3.3	3 mm radius sphere	± 20% for each axis
D	As per definition §2.3.3	5 mm radius sphere	± 30% for each axis

Table 4 – Unit CoM and Mol uncertainty

Comment: For category B, C and D, the uncertainty could be reduced with the increased confidence in project maturity (i.e. the design and analysis become more detailed and / or availability of test data).

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.6.2.18a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050131]

ISIS-GDIR-REQ-40018 v: 2

The unit centre of mass shall be determined with an accuracy of ± 1mm.

Comment: The center of mass or mass center is the mean location of all the mass in a system.

The term center of mass is often used interchangeably with center of gravity, but they are physically different concepts. They happen to coincide in a uniform gravitational field, but where gravity is not uniform, center of gravity refers to the mean location of the gravitational force acting on a body. This results in small but measurable gravitational torque that must be accounted for in the operation of artificial satellites.

Verification Method: T

ISIS-GDIR-REQ-40019 v: 1

The value of the moments of inertia of units intended for Qualification, Flight and Flight Spare(s) shall not deviate from the nominal value by more than 10% except for equipment having a moment of inertia lower than 0.1 kg.m².

Comment: ECSS Testing as probable source.

Verification Method: R

ISIS-GDIR-REQ-40020 v: 2

The moments of inertia shall be determined with an accuracy of ± 10%.

Comment: ECSS Testing as probable source.

Verification Method: T

ISIS-GDIR-REQ-40021 v: 1

The location of the center of mass of equipment intended for Qualification, Flight and Flight Spare(s) shall not deviate from the nominal location by more than 2.0 mm radius sphere.

Comment: ECSS Testing as probable source.

Verification Method: R

ISIS

4.2. STRUCTURAL DESIGN

4.2.1. General Requirement

The Service life is the interval beginning with the last item inspection or flaw screening proof test after manufacturing, and ending with completion of its specified life.

ISIS-GDIR-REQ-40022 v: 1

Structural assemblies and components shall be designed to withstand applied loads due to the mechanical environments to which they are exposed during the service-life.

Verification Method: A, I, R, T

Standard Origin Source: ECSS-E-ST-32C 4.2.1a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050001]

ISIS-GDIR-REQ-40023 v: 1

Structural assemblies and components shall fulfil, in operation, the mission objectives for the specified duration.

Verification Method: A, I, R, T

Standard Origin Source: ECSS-E-ST-32C 4.2.1b

ECSS DOORS Req ID: [ECSS-E-ST-32_0050002]

ISIS-GDIR-REQ-40024 v: 1

Components and assemblies for space applications shall be compatible with the natural and induced environments, including:

1. the on ground, launch and operational environment conditions,
2. the atmospheric conditions on earth in which they are manufactured, stored and tested, including corrosion effects,
3. the effects of gravitation,
4. the exposure of sensitive materials to manufacturing and atmospheric environments.

Comment: -Note 1: The natural environment covers climatic, thermal, chemical and vacuum conditions, cleanliness, level of radiation and the meteoroid and debris environment.

-Note 2: The induced environment covers static and dynamic loads encountered during its entire life, including manufacturing, assembly, handling, transportation, testing, launch and in-orbit operations.

Verification Method: A, I, R, T

Standard Origin Source: ECSS-E-ST-32C 4.2.2a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050006]

ISIS-GDIR-REQ-40025 v: 1

The layout of each unit shall take into account:

- Electrical requirements (i.e. access to electrical connectors, ...),
- Thermal interfaces requirements (i.e. coatings, temperature sensors, heaters, MLI, ...),
- Alignment and centre of mass requirements,
- Mechanical requirements (i.e. access to fasteners, flatness, ...),
- AIT requirements (i.e. mounting and removal, provision to avoid mismating, ...).

ISIS

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.4a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050044]

ISIS-GDIR-REQ-40026 v: 1

Structural dimensioning of the units shall consider critical combination of simultaneously acting loads (e.g. mechanical and thermo mechanical; first of all at the beginning of the launch phase).

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-32C B.2.1<6.3>a, ECSS-E-ST-32C 4.2.6a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050323], [ECSS-E-ST-32_0050016]

ISIS-GDIR-REQ-40027 v: 1

The following failure modes, for units, for entire lifetime (including all environments), shall be prevented:

- Permanent deformation
- Rupture
- Instability and buckling
- Gapping and sliding of bolted joints
- Degradation of bonded joints
- Vibration induced mounting interface slip
- Loss of alignment of equipment and payloads subject to alignment stability requirements
- Excessive strains or stresses impairing mechanisms operation, release, or deployment
- Distortion violating any specified envelope
- Distortion causing functional failure or short circuit.

Comment: ECSS normative reference as probable source.

Verification Method: A, T

ISIS-GDIR-REQ-40028 v: 1

The stability (i.e. no buckling) of the unit structure shall be verified for the design loads.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-32C 4.3.4a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050027]

ISIS-GDIR-REQ-40029 v: 1

Local buckling shall be prevented.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-32C 4.3.4b

ECSS DOORS Req ID: [ECSS-E-ST-32_0050028]

ISIS-GDIR-REQ-40030 v: 1

Constraints imposed by the thermal design and impacting the structure shall be identified.

Comment: The unit supplier needs to identify any additional internal thermal load in combination with external loading (mec + therm) that can impact the units design.

ISIS

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-32C 4.3.7a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050032]

ISIS-GDIR-REQ-40031 v: 1

The temperatures and temperature variations and gradients during all phases of a mission, including manufacturing and storage, shall be used, both in the material selection and in the design in order to achieve the specified functional and structural performance.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-32C 4.3.7b

ECSS DOORS Req ID: [ECSS-E-ST-32_0050033]

ISIS-GDIR-REQ-40032 v: 1

Structural requirements derived from electrical conductivity requirements shall be identified.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-32C 4.3.10a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050039]

ISIS-GDIR-REQ-40033 v: 1

The unit structure shall be designed to dissipate static electrical charges.

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-32C 4.3.11a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050040]

ISIS-GDIR-REQ-40034 v: 1

Structural requirements derived from electromagnetic compatibility requirements shall be identified.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-32C 4.3.12a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050041]

ISIS-GDIR-REQ-40035 v: 1

Modal analysis shall be performed to

1. verify that the structure conforms to the natural frequency requirements, and
2. determine associated modal characteristics (e.g. natural frequencies, mode shapes, generalized and effective masses).

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.6.2.4a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050106]

ISIS-GDIR-REQ-40036 v: 1

It shall be demonstrated by analysis that alignment requirements can be met with the chosen design tolerances.

Comment: It is understood that for any equipment requiring positioning accuracy on the structure, the contractor of the equipment will have to report the alignment tolerances (i.e. between the mating and the sensitive axis, as well as between the dowel line and the sensitive axis).

ISIS

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.6.2.19a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050135]

ISIS-GDIR-REQ-40037 v: 1

The following causes of misalignment shall be analysed and quantified as contributors to the stability budget:

- Setting due to mounting procedure,
- Setting due to launch distortion,
- Misalignment due to gravity release,
- Thermal deformation under in-orbit temperatures,
- Material ageing,
- micro-vibrations,
- Composite structure deformation due to moisture release in-orbit.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.6.2.20b, ECSS-E-ST-32C 4.3.9a, ECSS-E-ST-32C 4.3.13b

ECSS DOORS Req ID: [ECSS-E-ST-32_0050137], [ECSS-E-ST-32_0050156], [ECSS-E-ST-32_0050043]

ISIS-GDIR-REQ-40038 v: 1

The alignment errors shall be included in the pointing and localisation errors as established in the unit alignment and pointing error budget.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.6.2.19a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050135]

ISIS-GDIR-REQ-40039 v: 1

Alignment/stability requirements shall be maintained during AIT phase, after launch and during all mission duration.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.3.9c

ECSS DOORS Req ID: [ECSS-E-ST-32_0050038]

4.2.2. Fracture control

N/A

4.2.3. Design requirement

ISIS-GDIR-REQ-40061 v: 1

To ensure structural integrity, the requirement to inspect a component, assembly or structure shall be met during the following:

1. at various stages throughout manufacture,

ISIS

2. at various stages during assembly,
3. after testing.

Verification Method: A, I

Standard Origin Source: ECSS-E-ST-32C 4.5.1a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050048]

ISIS-GDIR-REQ-40062 v: 1

All parts or subassemblies identified by an item number shall be functionally and dimensionally interchangeable with items which are identically numbered.

Verification Method: A, I

Standard Origin Source: ECSS-E-ST-32C 4.5.2a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050051]

ISIS-GDIR-REQ-40063 v: 1

The mechanical design shall be performed in such a way that assembly, integration and repair and maintenance activities can be carried out with tools and test equipment agreed with the customer.

Verification Method: A, I

Standard Origin Source: ECSS-E-ST-32C 4.5.3a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050052]

ISIS-GDIR-REQ-40064 v: 1

The results of the maintenance programme evaluation shall

1. avoid alterations and replacement of parts,
2. form the criteria with which various concept designs are evaluated.

Verification Method: A, I

Standard Origin Source: ECSS-E-ST-32C 4.5.3d

ECSS DOORS Req ID: [ECSS-E-ST-32_0050055]

ISIS-GDIR-REQ-40065 v: 1

Structures that are not accessible shall be maintenance free during service-life.

Verification Method: A, I

Standard Origin Source: ECSS-E-ST-32C 4.5.3e

ECSS DOORS Req ID: [ECSS-E-ST-32_0050056]

4.2.4. Material selection

ISIS-GDIR-REQ-40066 v: 1

The material selected for corrosion resistance shall be compatible with:

1. the specific environment,
2. interaction with contained fluid,
3. design, fabrication, storage of individual and assembled components,
4. interactions with dissimilar materials,

ISIS

5. susceptibility to fretting and crack initiation.

Verification Method: A, I, R, T

Standard Origin Source: ECSS-E-ST-32C 4.5.6.2a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050060]

ISIS-GDIR-REQ-40067 v: 1

In cases where the behaviour of a material in a specific environment is not known, corrosion tests of representative materials (composition and condition) shall be performed, either under the service conditions, or in more severe conditions (accelerated testing).

Verification Method: A, I, R, T

Standard Origin Source: ECSS-E-ST-32C 4.5.6.2b

ECSS DOORS Req ID: [ECSS-E-ST-32_0050061]

It is still debated if ECSS-E-ST-32 Req 4.5.8.a to 4.5.8d (Material design allowable) is to be added to the GDIR or to the PA Plan.

ISIS-GDIR-REQ-40068 v: 1

All design allowances for metals shall be defined by their A--values.

Comment: The requirement does not prohibit the use of B-Basis values, but use of B-values must be justified (e.g.: redundant concept, large margin, ...) and accompanied by a risk mitigation plan. Deviation will be addressed on a case by case basis.

Verification Method: A, I, R, T

Standard Origin Source: ECSS-E-ST-32C 4.5.9a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050068]

ISIS-GDIR-REQ-40069 v: 1

All design allowances for composite materials (stress or strain) shall be defined by their A--values.

Comment: The requirement does not prohibit the use of B-Basis values, but use of B-values must be justified (e.g.: redundant concept, large margin, ...) and accompanied by a risk mitigation plan. Deviation will be addressed on a case by case basis.

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-32C 4.5.11a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050075]

ISIS-GDIR-REQ-40070 v: 1

All design allowances for adhesive materials in bonded joints (stress or strain) shall be defined according to standards agreed with the customer.

Verification Method: A, I

Standard Origin Source: ECSS-E-ST-32C 4.5.12a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050078]

ISIS-GDIR-REQ-40071 v: 1

Design allowable of structural elements (i.e. inserts, ...) used in the MoS calculation, shall be A-Basis values.

Use of B-Basis value is authorized and is pending the acceptance of an acceptable technical justification.

ISIS

Rationale: This complete the definition of allowable from ECSS for metal and composite with a req for insert, screws, ...

Comment: The requirement does not prohibit the use of B-Basis values, but use of B-values must be justified (e.g.: redundant concept, large margin, ...) and accompanied by a risk mitigation plan. Deviation will be addressed on a case by case basis.

Verification Method: A, R

4.2.5. Stiffness requirement

ISIS-GDIR-REQ-40072 v: 1

Unless otherwise specified, units fixed on a rigid interface shall have their first main resonant frequency above 140Hz.

Comment: Uncoupling unit first frequency from S/L modes up to 100 Hz. If unit frequency not compliant, quasistatic loads may have to be increased.

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-32C 4.3.5.b, ECSS-E-ST-32C 4.3.6a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050031], [ECSS-E-ST-32_0050030]

ISIS-GDIR-REQ-40073 v: 1

The stiffness requirements shall be demonstrated taking into account definition and analysis uncertainties as given in Table 5.

CATEGORY	DESIGN MATURITY	FEM calculation margin	Hand calculation margin
A	As per definition §2.3.3 (or after vibration test)	N/A	N/A
B	As per definition §2.3.3 (or at detail design / CDR)	± 5%	± 30%
C	As per definition §2.3.3 (or at preliminary design / PDR)	± 10%	± 30%
D	As per definition §2.3.3 (or at start of development)	± 15%	± 30%

Table 5 – Unit stiffness requirement uncertainty

Comment: - To cope with analysis uncertainties and mitigate risk of under-design.

- Stiffness are to be calculated using the maximum mass of the unit (i.e. including all design and project margins).

- For category B, C and D, the FEM calculation margin could be reduced with the increased confidence in project maturity (i.e. the design and analysis become more detailed and / or availability of test data).

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-32C 4.3.5a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050029]

ISIS

ISIS-GDIR-REQ-40074 v: 2

Assumptions shall be presented taking into account the worst cases for material data base characteristics (e.g. Young Modulus or thickness) or proven measurements from the manufacturer for hazardous components (pressurized and hoisting point...).".

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-32C 4.6.2.1f

ECSS DOORS Req ID: [ECSS-E-ST-32_0050098]

ISIS-GDIR-REQ-40075 v: 1

Mass figures shall include the actual predicted margins as per Section "4.1.2 Mass".

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.6.2.18c

ECSS DOORS Req ID: [ECSS-E-ST-32_0050133]

4.2.6. Strength Requirements

4.2.6.1. Definitions and General Requirements

ISIS-GDIR-REQ-40076 v: 1

Analysis methods shall be agreed between customer and supplier.

Comment: Different state of the art analysis methods are available, such as handbooks, standards or validated numerical solutions.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.6.2.1a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050093]

ISIS-GDIR-REQ-40077 v: 1

A mathematical model (e.g. finite element model) shall be developed for units.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.6.2.1b

ECSS DOORS Req ID: [ECSS-E-ST-32_0050094]

ISIS-GDIR-REQ-40173 v: 1

If the first mode is lower than 140 Hz (including 15% margins) the mathematical model shall be delivered.

ISIS-GDIR-REQ-40078 v: 1

It shall be demonstrated that the analysis tools used are adequate for the intended purpose.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-32C 4.6.2.1d

ECSS DOORS Req ID: [ECSS-E-ST-32_0050096]

ISIS-GDIR-REQ-40079 v: 1

A justification of assumptions made in tools, methods, models and input data shall be provided.

ISIS

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-32C 4.6.2.1e

ECSS DOORS Req ID: [ECSS-E-ST-32_0050097]

ISIS-GDIR-REQ-40080 v: 1

The influence of tolerances (including overall dimensions and thickness) shall be assessed whenever potentially critical.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-32C 4.6.2.1f

ECSS DOORS Req ID: [ECSS-E-ST-32_0050098]

ISIS-GDIR-REQ-40081 v: 1

All analysis data shall be traceable, and the organization responsible for the analysis shall provide procedures to ensure data traceability during the life of the product.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-32C 4.6.2.1g

ECSS DOORS Req ID: [ECSS-E-ST-32_0050099]

ISIS-GDIR-REQ-40082 v: 1

Static analysis shall be performed to verify that the structural responses (e.g. displacements, forces, stresses and internal loads) to (quasi) static loads conform to the structural requirements.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.6.2.3a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050102]

ISIS-GDIR-REQ-40083 v: 1

The static analysis shall use representative load introduction, load distribution and boundary conditions.

Comment: Requirement in GDIR will cover exhaustively all failure mode to be analysed.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.6.2.3b

ECSS DOORS Req ID: [ECSS-E-ST-32_0050103]

ISIS-GDIR-REQ-40084 v: 1

Provisions shall be made to include the effects of residual stresses due to the manufacturing process (e.g. welding).

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.6.2.3c

ECSS DOORS Req ID: [ECSS-E-ST-32_0050105]

ISIS-GDIR-REQ-40085 v: 1

Static analysis shall take into account stress concentrations.

ISIS

Comment: Stress concentrations essentially take place in areas with steeply varying shape or section and with notches (macro and micro stress raisers). For metals stress concentrations are known to have a detrimental effect on fatigue lifetime. For fibre reinforced plastics stress concentrations have a detrimental effect on static strength.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.6.2.3d

ECSS DOORS Req ID: [ECSS-E-ST-32_0050104]

ISIS-GDIR-REQ-40086 v: 1

Buckling analysis shall be used to predict the loads at which the onset of structural instability occurs.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.6.2.10a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050119]

ISIS-GDIR-REQ-40087 v: 1

Effects on stability of boundary conditions, defects and geometrical imperfections in the structure shall be included in the buckling analysis.

Comment: Geometrical imperfections refer to any deviation from the nominal shape including effect due to assembly tolerances.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.6.2.10c

ECSS DOORS Req ID: [ECSS-E-ST-32_0050121]

ISIS-GDIR-REQ-40088 v: 1

Minimum gauge shall be used for buckling analysis.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.6.2.10d

ECSS DOORS Req ID: [ECSS-E-ST-32_0050122]

ISIS-GDIR-REQ-40089 v: 1

Thermo-elastic analysis shall be performed to compute stresses and deformations due to occurring temperatures.

Comment: To perform thermo-elastic analysis temperature distributions defined by thermal analysis are usually mapped on the structural model.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.6.2.11a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050123]

ISIS-GDIR-REQ-40090 v: 2

Hygro-thermal analysis shall be performed to compute deformations due to occurring moisture release or absorption.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.6.2.11b

ECSS DOORS Req ID: [ECSS-E-ST-32_0050124]

ISIS

ISIS-GDIR-REQ-40091 v: 1

The analysis of bonded joints shall be performed in accordance with standards or procedures agreed with the customer.

Comment: Note 1: For the mechanical characteristics of the bonded joints the following is usually taken into account:

- the influence of the characteristics of the adhesive,
- the material of the adherents any surface treatments,
- the dimensions of the bonded areas,
- and the relative stiffness of the parts.

Note 2: For bonded joints, see ECSS-E-HB-32-21.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.6.2.12a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050125]

ISIS-GDIR-REQ-40092 v: 1

Bolted joints shall be analysed according to standards or procedures agreed with the customer.

Comment: For bolted joints, see ECSS-E-HB-32-23.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.6.2.13a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050126]

ISIS-GDIR-REQ-40093 v: 1

Welded joints shall be analysed according to standards or procedures agreed with the customer.

Comment: The analytical verification of welded joints usually takes into account the following:

- stress concentrations,
- type and quality of the weld,
- local maximum allowable geometrical defects (e.g. mismatch and peaking),
- residual stresses and material characteristics changes due to local heating and cooling.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.6.2.14a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050127]

ISIS-GDIR-REQ-40094 v: 1

Riveted joints shall be analysed according to standards or procedures agreed with the customer.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.6.2.15a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050128]

ISIS-GDIR-REQ-40095 v: 1

Inserts shall be analysed according to standards or procedures agreed with the customer.

Comment: Note 1: Inserts are generally used in sandwich constructions with cores of low strength.

Note 2: For inserts, see ECSS-E-HB-32-22.

ISIS

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.6.2.16a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050129]

ISIS-GDIR-REQ-40096 v: 1

The units shall withstand the Design Limit Loads (DLL) without failing or exhibiting permanent deformations that can endanger the mission objectives.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.3.2.a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050025]

ISIS-GDIR-REQ-40097 v: 2

The specified design factors for loads (Km, Kp, Kq), additional factor for design (Kld), the definition of those factors values and definition of Factors of Safety (FoS) values, shall be applied for both the design and test phases of units as defined in ISIS-GDIR-REQ-40098.

Comment: Km and Kp are factors targeted at design phase only.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32-10C-4.1.2a, ECSS-E-ST-32-10C-4.1.2b

ECSS DOORS Req ID: [ECSS-E-ST-32-10_0110001], [ECSS-E-ST-32-10_0110002]

ISIS-GDIR-REQ-40098 v: 1

QL, AL, DLL, DYL and DUL, for the test and the design of units, shall be calculated from the LL as specified in Table 6 and Table Table 7.

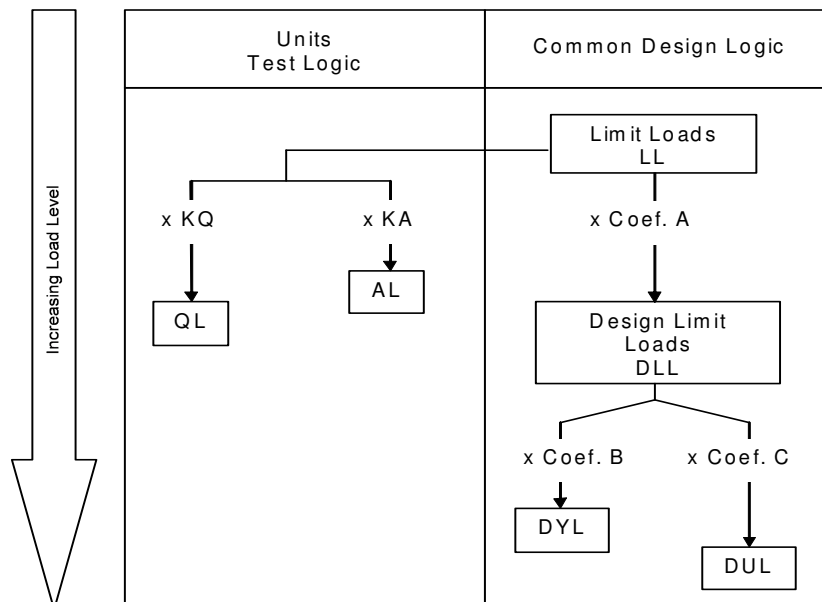


Table 6 – Logic for Factor of Safety application

ISIS

Coefficient	Satellite
Coef A or Design factor	$K_Q \times K_P \times K_M$
Coef B	$FOSY \times K_{LD}$
Coef C	$FOSU \times K_{LD}$

Table 7 – Relationship among (structural) factors of safety, design factors and additional factors

Comment: All the mechanical environment loads defined in Unit Environment Specification [RD-...] are Qualification Test Load (QL) and Acceptance Test Load (AL), derived from AIT specifications or from satellite system analyses. The QL and AL levels already include K_Q and K_A factors as required. Therefore, DLL can be obtained from QL by applying the K_m and K_p factors only.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32-10C-4.2.1a, ECSS-E-ST-32C 4.2.8a

ECSS DOORS Req ID: [ECSS-E-ST-32-10_0110014], [ECSS-E-ST-32_0050022]

The **Limit Load (LL)**, are the maximum load(s), which a unit is expected to experience with a given probability, during the performance of specified missions in specified environments.

Note: LL are the maximum loads that result from the flight, ground or test environments. LL also includes combinations of thermally induced loads, preloads, inertia loads (e.g. for mechanisms).

The **Qualification Test Load (QL)** is reflecting the maximum level expected to be encountered during the unit lifetime increased by qualification margins.

The **Acceptance Test Load (AL)** is reflecting the maximum level expected to be encountered during the unit lifetime increased by acceptance margins.

The **Test Factors (KA and KQ)** are used to define respectively the acceptance and the qualification test loads.

The **Design Limit Load (DLL)** is the Limit Load multiplied by the Design Factor (Coef A).

The **Design Yield Load (DYL)** is the Design Limit Load multiplied by the Yield Safety Factor (FOSY).

The **Design Ultimate Load (DUL)** is the Design Limit Load multiplied by the Ultimate Safety Factor (FOSU).

The **Yield Strength**, is the maximum load or stress that a structure or material can withstand without incurring specified permanent deformation or yield (conventionally taken at a unit strain of 0.002 or 0.2% proof/stress).

The **Ultimate Strength**, is the maximum load or stress that a structure or material can withstand without incurring rupture or collapse.

ISIS-GDIR-REQ-40099 v: 1

A "model factor" K_M shall be applied to account for uncertainties (e.g. hyperstaticity, junction stiffness uncertainty, non correlated dynamic behaviour, ...) in mathematical models when predicting dynamic response, loads, and evaluating load paths.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32-10C 4.1.4.2a

ECSS DOORS Req ID: [ECSS-E-ST-32-10_0110005]

ISIS-GDIR-REQ-40100 v: 1

K_M value shall be justified.

Verification Method: A, R

ISIS

Standard Origin Source: ECSS-E-ST-32-10C 4.1.4.2b

ECSS DOORS Req ID: [ECSS-E-ST-32-10_0110006]

ISIS-GDIR-REQ-40101 v: 1

A specific "project factor" KP shall be applied to account for the maturity of the program (e.g. stability of the mass budget, well identified design, ...) and the confidence in the specification given to the project.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32-10C 4.1.4.3a

ECSS DOORS Req ID: [ECSS-E-ST-32-10_0110007]

ISIS-GDIR-REQ-40102 v: 1

KP value shall be justified.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-32-10C 4.1.4.3b

ECSS DOORS Req ID: [ECSS-E-ST-32-10_0110008]

ISIS-GDIR-REQ-40103 v: 1

Local Design Factor (Kld) shall be applied when the sizing approach or local modelling are complex.

Comment: This factor accounts for specific uncertainties linked to the analysis difficulties or to the lack of reliable dimensioning methodology or criteria where significant stress gradients occur (e.g. geometric singularities, fitting, welding, riveting, bonding, holes, inserts and, for composite, lay-up drop out, sandwich core thickness change, variation of ply consolidation as a result of drape over corners).

Verification Method: R

Standard Origin Source: ECSS-E-ST-32-10C 4.1.5.2a

ECSS DOORS Req ID: [ECSS-E-ST-32-10_0110010]

ISIS-GDIR-REQ-40104 v: 1

Kld value shall be justified.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-32-10C 4.1.5.2b

ECSS DOORS Req ID: [ECSS-E-ST-32-10_0110011]

4.2.6.2. Structural Safety Factors

ISIS-GDIR-REQ-40105 v: 1

The Local Design factor Kld value shall be greater than or equal to 1.0.

Rationale: It is proposed by this requirement to responsabilise the sub co by not specifying in hard a Kld value. The unit provider has to chose (if necessary) a value and justify it.

Comment: A typical value of 1.2 is advised for complex local design. Using advised value of Kld does not preclude the necessity of justifying the Kld value.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32-10C 4.1.5.2b

ECSS DOORS Req ID: [ECSS-E-ST-32-10_0110011]

ISIS

ISIS-GDIR-REQ-40106 v: 2

Where design loads are generated using FE analyses one shall apply the value of K_m defined in Table 8.

FEM status	K_m Value
Before, or no correlation of FEM with dynamic testing	1.2
FEM correlated with dynamic testing	1.0

Table 8 – K_m values

Verification Method: A

Standard Origin Source: ECSS-E-ST-32-10C 4.1.4.2a

ECSS DOORS Req ID: [ECSS-E-ST-32-10_0110005]

ISIS-GDIR-REQ-40107 v: 1

As a minimum, the Project Factor (K_p) shall be as defined in Table 9.

Project status	K_p Value
From feasibility study to (and including) Phase A	1.25
From Phase B to (including PDR)	1.1
After PDR	1.0

Table 9 – K_p values

Verification Method: A

Standard Origin Source: ECSS-E-ST-32-10C 4.1.4.3a

ECSS DOORS Req ID: [ECSS-E-ST-32-10_0110007]

ISIS-GDIR-REQ-40108 v: 1

The factor of safety for global and local buckling shall be selected from Table GDI-140.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32-10C 4.3.2.3a

ECSS DOORS Req ID: [ECSS-E-ST-32-10_0110025]

ISIS-GDIR-REQ-40109 v: 1

The factor of safety for metallic, FRP, sandwich, bonded joints, glass and ceramic structural parts shall be selected from Table GDI-140.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32-10C 4.3.2.1a

ECSS DOORS Req ID: [ECSS-E-ST-32-10_0110020]

ISIS

ISIS-GDIR-REQ-40110 v: 1

The factors provided in Table.. shall apply for all additive loads including thermal induced loads

Verification Method: A

Standard Origin Source: ECSS-E-ST-32-10C 4.3.2.1b

ECSS DOORS Req ID: [ECSS-E-ST-32-10_0110021]

ISIS-GDIR-REQ-40111 v: 1

When loads including thermal induced loads are relieving, both FOSU and FOSY shall be 1,0 or less.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32-10C 4.3.2.1c

ECSS DOORS Req ID: [ECSS-E-ST-32-10_0110022]

STRUCTURE TYPE / SIZING CASES (NON PRESSURE LOAD CASES)	Tested Unit FOSY	Tested Unit FOSU	YIELD FOSY Verification by analysis only	ULTIMATE FOSU Verification by analysis only
Conventional material / metallic structures (see note 1)	1.10	1.25	1.25	2.0
Non conventional material (see note 5)	1.25	1.5	1.5	2.5
FRP structure (see note 2)		1.25		2.0
Bonded joints, insert and sandwich failures (see note 2)	-	1.25		2.0
Fasteners gapping and sliding	-	1.25		2.0
Global buckling (see note 4)	-	1.25		2.0
Brittle material, e.g. glass/ceramic	-	2.5 (Note 3)		5.0 (note 3)

Table 10 – Design Safety Factors

Following assumptions shall be taken into account:

- 1) Applicable failure criteria have to be agreed with the customer; sufficient statistical data shall be available to derive A values.
- 2) Those value are to take into account considering that material and design allowances are statistically fully verified by means of an adequate unit level test program considering also the manufacturing reliability e.g. proof tests.
When not fully verified, the Factor of Safety (FoS) may be increased to $FoS = 1.5$, in agreement with the customer.
- 3) These materials have strength properties which are highly dependent on the manufacturing process, the size of the part and of the surface quality. Therefore, the stress/strength allowances must be derived from representative samples, to be agreed by the customer.
- 4) The factor of safety does not convert the knock down factors commonly used in buckling analyses - see Buckling HB (ECSS-E-HB-32-24).
- 5) Non conventional material are defined as material not justifying sufficient statistical data to derive A values or B values.

4.2.6.3. Margin of Safety

ISIS-GDIR-REQ-40112 v: 1

A summary of the stress analysis, including the load assumptions, safety factors, allowances and margins of safety for all elements of the unit to all design loads shall be reported in a single document.

Verification Method: R

ISIS

Standard Origin Source: ECSS-E-ST-32C K.2.1<8.2>j

ECSS DOORS Req ID: [ECSS-E-ST-32_0050570]

ISIS-GDIR-REQ-40113 v: 1

Margins of safety (MOS) shall be calculated by the following formula:

$$MOS = \frac{\text{design allowable load}}{\text{design limit load} \times FOS} - 1$$

Where:

Factor of Safety (FOS) is either Coef. B or Coef. C as defined in Table 7.

Coef. B is defined as FOSY x Kld

Coef. C is defined as FOSU x Kld x

Comment: Table 7 is defined in requirement ISIS-GDIR-REQ-40098.

Load can be replaced by stress if the load-stress relationship is linear.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.5.16a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050086]

ISIS-GDIR-REQ-40114 v: 1

All margins of safety shall be positive.

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.5.16b

ECSS DOORS Req ID: [ECSS-E-ST-32_0050087]

ISIS-GDIR-REQ-40115 v: 1

In case of a proto-flight approach, the yield and ultimate MOS shall be greater than 0.2.

Rationale: This additional margin is today justified by TAS / ASTR perception that the unit supplier is not systematic enough when taking into account fatigue effects on standard equipment.

We could alternatively impose a minimum margin, by defining a minimum value of Kp.

Verification Method: A

ISIS-GDIR-REQ-40116 v: 1

Fatigue analysis shall be carried out where relevant, and demonstrate a positive reserve after application of 4 times the most constraining life cycles.

Verification Method: A

ISIS-GDIR-REQ-40117 v: 1

MOS shall be computed by accounting for interactions of different types of failures (e.g. failure of a bolt due to shear and tension).

Verification Method: A

Standard Origin Source: ECSS-E-ST-32C 4.5.16d

ECSS DOORS Req ID: [ECSS-E-ST-32_0050089]

ISIS

4.3. ATTACHMENT

ISIS-GDIR-REQ-40118 v: 1

In case of new development, the definition of the boxes attachment points (number, pattern and size) shall be agreed with the prime contractor, in order to prevent sliding and gapping at unit support structure interfaces, under application of the worst case of mechanical and thermal environments.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.4a, ECSS-E-ST-32C 4.2.3c

ECSS DOORS Req ID: [ECSS-E-ST-32_0050044], [ECSS-E-ST-32_0050010]

Note, as general rules:

- For unit masses over 3kg (TBC), interface bolts will preferably be M5 or larger,
For smaller units, M4 bolts can be accepted on a case by case,
- Boxes with a mass < 1.5 kg should not have more than 4 attachment points.

Maturity: TBC

ISIS-GDIR-REQ-40119 v: 1

The attachment points shall provide a controlled surface contact between the units and the structure to allow control of thermal conditions on the unit as well as electrical bonding.

Verification Method: A, T

ISIS-GDIR-REQ-40120 v: 1

The contact shall be maintained under all operating conditions, taking into account loading resulting from the different thermal coefficient expansion between dissimilar materials.

Verification Method: A, T

ISIS-GDIR-REQ-40121 v: 1

The lugs co-planarity and/or the interface plane flatness of a unit, shall be better than 0.1mm over 100mm.

Verification Method: T

Standard Origin Source: ECSS-E-ST-32C 4.4a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050044]

ISIS-GDIR-REQ-40122 v: 3

When required by thermal subsystem, the overall interface plane flatness (unit bottom face) shall be better than:

- 0.1mm/100mm or
 - 0.2 mm over the complete contact area
- whichever is the most constraining.

Comment: This requirement, when the thermal architect specify this need, ask for compatibility of the unit interface (what ever the size of the unit interface) with a tolerance allowing the use of thin thermal paste (i.e. sigraflex 0.25 mm).

Verification Method: T

Standard Origin Source: ECSS-E-ST-32C 4.4a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050044]

ISIS

ISIS-GDIR-REQ-40123 v: 1

Unless otherwise specified, the unit shall be through-bolted into threaded inserts.

Verification Method: I, R

ISIS-GDIR-REQ-40124 v: 3 w

Unit attachment hole dimensions and tolerances shall be as defined in Table 11.

	Mounting feet attachment bolt			
	M4	M5	M6	Other
Attachment hole size	4.5 to 4.6 mm	5.5 to 5.6 mm	6.5 to 6.6 mm	
Spot face of upper lug surface (washer contact area)	11 mm -0.5/-0.1 mm	13 mm -0.5/-0.1 mm	13 mm -0.5/-0.1 mm	
Spot face parallelism wrt mouting plane	0.05 mm			
Spot face counterbore depth	0.2 mm +0.1/-0.0 mm			
For information, flat washers will be	8 mm	10 mm	12 mm	
Hole positioning tolerance (diameter)	0.1 mm	0.1 mm	0.1 mm	
Lengh of mounting feet (relatively to unit wall)	≥ 16 mm ≤ 18 mm	≥ 18 mm	≥ 18 mm	
Free width between webs	≥ 16 mm	≥ 18 mm	≥ 18 mm	
Mounting feet thickness	4 mm (note, lower thickness is)			
Attachment hole axis wrt mounting plane	90° +/- 0.5°			
Contact surface roughness	<3.2 μ RA			
Chamfer (remove sharp edge)	0.2mm			
Edge radius	0.5mm			

Table 11 – Unit attachment hole dimensions and tolerances

Verification Method: I, R

ISIS-GDIR-REQ-40125 v: 1

For equipment requiring positioning accuracy, the interface design, dimensions, tolerance and adjustment process shall be agreed with the customer.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-32C 4.4a, ECSS-E-ST-32C 4.3.9c

ECSS DOORS Req ID: [ECSS-E-ST-32_0050044], [ECSS-E-ST-32_0050038]

ISIS-GDIR-REQ-40126 v: 1

Sufficient clearance shall be allowed between mechanical parts of the unit to cover design, manufacturing, assembly tolerances, alignment translation/rotation ranges and environmental displacements.

ISIS

Verification Method: I, R

ISIS-GDIR-REQ-40128 v: 1

Fasteners shall comply with the requirements of ECSS-Q-70-46C "Requirements for manufacturing and procurement of threaded fasteners".

Comment: ECSS-Q-70-46C as probable source.

Verification Method: I, T

Standard Origin Source:

ISIS-GDIR-REQ-40129 v: 1

Any structural / thermal or qualification model shall be able to survive 4 times all mechanical qualification tests.

Comment: ECSS Testing as probable source.

Verification Method: A

ISIS-GDIR-REQ-40130 v: 1

Where the model philosophy requires a protoflight model, the protoflight model shall be able to survive 4 times all mechanical qualification tests (at acceptance duration) plus one launch.

Comment: ECSS Testing as probable source.

Verification Method: A

ISIS-GDIR-REQ-40131 v: 1

Any Flight Model shall be able to survive 4 times all mechanical acceptance tests plus one launch.

Comment: Survivability to test and associated requirements of refurbished QM (already subjected to requirement 40129) models intended to flight, will be defined on a case by case basis.

Verification Method: A

ISIS-GDIR-REQ-40132 v: 1

The unit design shall prevent single inserts loading in bending and torsion at unit attachment points.

Verification Method: A, R

ISIS-GDIR-REQ-40134 v: 2

In case of symmetrical packaging, a specific marking shall be implemented to prevent any mismounting.

Comment: ECSS normative reference as probable source.

Verification Method: I, R

ISIS-GDIR-REQ-40135 v: 1

If not already defined in IRD, the distance between two adjacent lugs shall be smaller than 300 mm, but not closer than 30 mm.

Verification Method: I, R

Standard Origin Source: ECSS-E-ST-32C 4.4a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050044]

ISIS-GDIR-REQ-40136 v: 1

No part of the box shall be in the volume above the lugs indicated as "free access required".

ISIS

Verification Method: I, R

Standard Origin Source: ECSS-E-ST-32C 4.4a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050044]

ISIS-GDIR-REQ-40137 v: 1

The unit contact area with the mounting surface shall be reported on the ICDR.

Verification Method: A, I, R

ISIS-GDIR-REQ-40139 v: 1

When M4 standard bolts are used, the ratio "unit maximal mass / number of attachment points" shall be below 1.5 kg.

Verification Method: A, T

ISIS-GDIR-REQ-40140 v: 2

Screws untightening when subjected to mechanical and thermal environment shall be prevented by effective locking provisions (such as: locking helicoils, strapping compound, nylok...) or sufficient tension to avoid gaping and sliding.

Comment: Locking helicoils are known to cause difficulty in characterisation of the tension-torque relationship and are therefore to be avoided.

Verification Method: R

ISIS-GDIR-REQ-40141 v: 1

The locking provisions shall be capable of being subjected to a minimum of 5 tightening and slackening operations without any significant effect on its braking power.

Verification Method: R

ISIS-GDIR-REQ-40142 v: 1

The contact area between unit and structure shall be at the area of the lugs.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.4a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050044]

ISIS-GDIR-REQ-40143 v: 1

The contact area of the units shall be flat with no protrusion below the mounting plane.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.4a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050044]

ISIS-GDIR-REQ-40144 v: 1

The contact area or spot faces area shall be unpainted.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.4a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050044]

ISIS-GDIR-REQ-40145 v: 1

All mating surfaces between unit and spacecraft structure, on unit side, shall be left bare.

ISIS

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.4a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050044]

4.4. ALIGNMENT PROVISIONS

Optical reference: refers to the coordinate system defined and characterised by use of the alignment mirror. By extension, the optical reference is also understood as being all the alignment mirrors defining the optical reference.

Alignment mirror: physical mirror used to perform an alignment characterisation. Several mirrors can form a cube (alignment cube)

Reflecting surface: geometrical surface of an alignment mirror.

ISIS-GDIR-REQ-40146 v: 1

When the unit alignment is achieved by the use of angled brackets, screw adjusters, and/or shims, they shall be designed and supplied as parts of the unit, unless provided as an integral part of the unit.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.3.9c

ECSS DOORS Req ID: [ECSS-E-ST-32_0050038]

ISIS-GDIR-REQ-40147 v: 1

When shims have to be machined at end of alignment, 5 sets of spare shims with maximum possible thickness shall be provided

Verification Method: I, R

ISIS-GDIR-REQ-40148 v: 1

Any unit that requires an alignment accuracy of $\pm 0.20^\circ$ or better shall have alignment mirrors.

Comment: Compromise between TAS / AST (0.15-0.25)

The wording alignment mirror is chosen to describe physically the alignment item.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.3.9c

ECSS DOORS Req ID: [ECSS-E-ST-32_0050038]

ISIS-GDIR-REQ-40149 v: 2

The unit shall be delivered with mountable/dismountable protective covers on alignment mirrors.

Verification Method: I, R

ISIS-GDIR-REQ-40150 v: 1

Fixed alignment mirrors shall be used.

Comment: Note: If dismountable alignment mirrors are used, repeatability in orientation accuracy will need to be demonstrated.

Note: Each unit requiring alignment about 2 axes will carry a reflecting mirror parallel to the plane containing those 2 axes or two reflecting mirrors, each one being perpendicular to the relevant axis. When two or more reflecting surfaces are provided, it is preferable to use an optical cube.

ISIS

Note: Each unit requiring alignment about 3 axes will carry two perpendicular reflecting mirrors. When two or more reflecting surfaces are provided, it is preferable to use an optical cube.

Verification Method: R, T

Standard Origin Source: ECSS-E-ST-32C 4.3.9b, ECSS-E-ST-32C 4.3.9c

ECSS DOORS Req ID: [ECSS-E-ST-32_0050037], [ECSS-E-ST-32_0050038]

ISIS-GDIR-REQ-40151 v: 2

The fixation of the alignment mirrors shall be compatible with mechanical and thermal vacuum testing environment, and without gassing requirements.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.3.13b

ECSS DOORS Req ID: [ECSS-E-ST-32_0050043]

ISIS-GDIR-REQ-40152 v: 1

Optical references are required to withstand all the environments supported by the unit with stability better than ± 15 microrad with respect to each of the 3 unit axes.

Comment: Optical reference is the term chosen to define the "function" of the alignment mirrors.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.3.9c, ECSS-E-ST-32C 4.3.13b

ECSS DOORS Req ID: [ECSS-E-ST-32_0050038], [ECSS-E-ST-32_0050043]

ISIS-GDIR-REQ-40153 v: 1

Location and orientation with associated tolerances of optical references on units shall be agreed between customer and subcontractor through the ICD.

Comment: The final agreement of the location and orientation of the optical reference is pending agreement with the customer and depend of clear visibility of the reflecting surface at higher-level assembly integration (during all AIT phase of integration) as identified in top assembly drawings.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.3.9c, ECSS-E-ST-32C 4.4a

ECSS DOORS Req ID: [ECSS-E-ST-32_0050038], [ECSS-E-ST-32_0050044]

ISIS-GDIR-REQ-40154 v: 1

The reflecting surfaces shall be optically polished, with a flatness within $\lambda / 4$ (sodium yellow $\lambda = 589$ nm).

Rationale: System to provide rational

Verification Method: R

ISIS-GDIR-REQ-40155 v: 1

If not defined in the unit specification, the optical reference axes orientation w.r.t. unit axes shall be known with an accuracy better than 50micro-rad.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.3.9c

ECSS DOORS Req ID: [ECSS-E-ST-32_0050038]

ISIS-GDIR-REQ-40156 v: 2

ISIS

The optical reference design shall provide a minimum reflecting surface of 15 mm diameter.

Verification Method: R

ISIS-GDIR-REQ-40157 v: 1

The alignment mirrors must have a minimum thickness of 4mm.

Verification Method: R

ISIS-GDIR-REQ-40158 v: 2

Reflecting surfaces of provided alignment cube shall be perpendicular with an accuracy of ± 5 arc sec.

Comment: This is understood as being the manufacturing specification of the procured optical cube.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.3.9c

ECSS DOORS Req ID: [ECSS-E-ST-32_0050038]

4.5. ELECTRICAL CONNECTORS ACCOMMODATION

Electrical connectors accommodation requirements are specified in the relevant sections below.

4.6. MECHANICAL INTERFACE CONTROL DOCUMENTS

ISIS-GDIR-REQ-40159 v: 1

External interfaces shall include:

1. spacecraft-launcher interface,
2. interfaces with equipment, optics and avionics,
3. ground support equipment for pre-flight and post-flight operations, and
4. support equipment for in-orbit operations.

Verification Method: I, R

Standard Origin Source: ECSS-E-ST-32C 4.4c

ECSS DOORS Req ID: [ECSS-E-ST-32_0050046]

ISIS-GDIR-REQ-40160 v: 1

Interfaces shall be explicitly defined with respect to the design requirements.

Comment: These include areas, volumes, alignments, surface finishing and properties, tolerances, geometry, flatness, fixations, conductivity, constraints imposed by the launcher (e.g. geometric, static and dynamic envelopes) and by design concepts (e.g. thermal and optical design), mass and inertia properties.

Verification Method: I, R

Standard Origin Source: ECSS-E-ST-32C 4.4d

ECSS DOORS Req ID: [ECSS-E-ST-32_0050047]

External loads applied to the interfaces, including temperature effects and overfluxes caused by adjacent structures.

Global and local stiffness.

Electrical, magnetic and radio frequency aspects, where applicable.

ISIS

ISIS-GDIR-REQ-40161 v: 1

The mechanical configuration and its interface requirements and dimensions, shall be fully detailed in one (or more) Interface Control Document(s) that shall be fully referenced by the unit subcontractor.

Comment: Interface Control Document (ICD) is understood as being a collection of drawings (ICDR's) and Interface Data Sheets (IDS) of the unit, that are available as a single referenced document.

Verification Method: A

ISIS-GDIR-REQ-40162 v: 1

The ICDR's shall detail all co-ordinate systems utilised and their relationship to each other, together with the principal unit interfaces.

Comment: ECSS normative reference as probable source.

Verification Method: A

ISIS-GDIR-REQ-40163 v: 3 w

The Interface Data Sheet (IDS) shall be completed according to the template given in annex (section Mechanical ICD)

Comment: ECSS normative reference as probable source.

Verification Method: R

ISIS-GDIR-REQ-40164 v: 1

One of the attachment holes of the shall be specified as the reference hole and marked with the capital letter R on the Interface Control Drawing (ICDR).

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.4d

ECSS DOORS Req ID: [ECSS-E-ST-32_0050047]

ISIS-GDIR-REQ-40165 v: 1

The unit reference frame shall have its origin at the centre of the unit reference hole (R) at the mounting plane interface

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.4d

ECSS DOORS Req ID: [ECSS-E-ST-32_0050047]

ISIS-GDIR-REQ-40166 v: 1

The positive Z-axis shall be normal to the mounting plane interface

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.4d

ECSS DOORS Req ID: [ECSS-E-ST-32_0050047]

ISIS-GDIR-REQ-40167 v: 1

The unit alignment reference frame shall have its origin at the centre of the optical cube or at the center of the reflecting surface of the alignment mirror.

Comment: ECSS normative reference as probable source.

Verification Method: R

ISIS

ISIS-GDIR-REQ-40168 v: 1

The box coordinates shall be related to the Unit Reference Frame.

Comment: ECSS normative reference as probable source.

Verification Method: A

4.7. MECHANICAL MATHEMATICAL MODEL REQUIREMENTS

This section defines the requirements for the preparation, and the delivery of the Finite Element mathematical models of the assemblies and units in order to incorporate them into the higher-level assembly mathematical model.

ISIS-GDIR-REQ-40169 v: 1

A structural Finite Element Model shall be delivered for units with a principal mode below 140 Hz which is associated to an effective modal mass > 10%.

Rationale: Models that have a main frequency below 140 Hz are not guaranteed to be dynamically decoupled from other subsystem. Delivery of FEM in that case is required for dynamic system analysis.

Verification Method: A, R

ISIS-GDIR-REQ-40170 v: 3

The deliverable unit Finite Element Model shall be compliant with the Generic Mechanical FEM Specification (AD-11).

Comment: ECSS normative reference as probable source.

Verification Method: R

Standard Origin Source:

ISIS-GDIR-REQ-40171 v: 1

The delivered FEM shall be detailed enough to ensure an appropriate derivation/verification of the design loads and the modal response for all important modes associated with an effective mass > 10 % of the total mass, up to 140 Hz.

Comment: Note: This is understood as FEM model which is dynamically representative of the unit real dynamic behaviour

Note: On case by case basis and in agreement with the unit supplier, a more detailed FEM (i.e. better dynamic representativity of local modes with low effective masses) could be requested.

Verification Method: R

Standard Origin Source: ECSS-E-ST-32C 4.6.2.1b

ECSS DOORS Req ID: [ECSS-E-ST-32_0050094]

ISIS-GDIR-REQ-40172 v: 3

The delivered FEM's shall be correlated against the results of the qualification and acceptance tests carried out at unit level as specified in the Generic Mechanical FEM Specification (AD-11).

Rationale: Insure correct representativity of the delivered FEM with reality.

Verification Method: R

ISIS

4.8. MECHANISMS

AD1 is applicable, once tailored for the specific purpose of a mission.

4.9. PYROTECHNICS AND ONE-SHOT RELEASE MECHANISMS

AD2 is applicable, once tailored for the specific purpose of a mission.

ISIS

5. THERMAL DESIGN AND INTERFACE REQUIREMENTS

5.1. DEFINITION OF TERMS RELATIVE TO TEMPERATURES

Note: the eleven following terms definitions are adapted from ECSS-E-ST-31C.

Temperature Reference Point (TRP):

Physical point located on a unit and defined in the unit ICD to provide a simplified representation of the unit temperature (see figure 5.1).

Conductive interface temperature (or conductive interface temperature point, CITP):

Physical point appropriately located on the structure of the system, used to evaluate the heat exchanged by conduction between a unit and the spacecraft (see figure 5.1).

Note: each CITP is linked to only one TRP by a conductive coupling.

Radiative sink temperature:

Virtual black body radiation temperature used to define the equivalent radiative thermal load on an item (see figure 5.1)

Note: each radiative sink is linked to only one TRP by a radiative coupling.

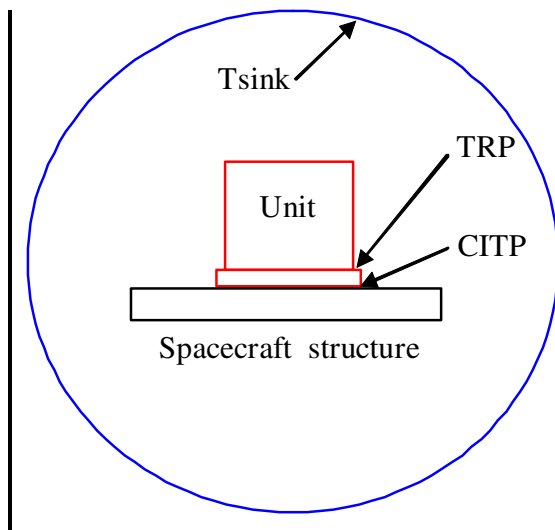


Figure 5.1: Unit TRP & boundary temperatures (a very usual and simple case)

Qualification temperature range:

Temperature range at a TRP specified for the operating and non-operating mode, for which this unit is guaranteed to fulfil all specified requirements (see figure 5.2).

Note: the qualification temperature range is the temperature range used during qualification or proto qualification tests to verify all specified requirements and workmanship.

Acceptance temperature range:

Temperature range at a TRP obtained from the qualification temperature range after subtraction of qualification margins specified for the operating and non-operating mode (see figure 5.2).

Note 1: the acceptance temperature range is the extreme temperature range that the unit can reach, but never exceed, during all envisaged mission phases (based on worst case assumption).

Note 2: the acceptance temperature range is the temperature range used during acceptance tests to verify all specified requirements and workmanship.

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Unit acceptance test temperature range:

Extreme temperature range at a TRP which is used for acceptance at unit level (see figure 5.2).

Note: the unit acceptance test temperature range is obtained from the specified acceptance temperature range after the addition of a suitable value to account for test inaccuracies.

Unit qualification test temperature range:

Extreme range at a TRP which is used for unit qualification at unit level (see figure 5.2).

Note: the unit qualification test temperature range is obtained from the specified qualification temperature range after addition of a suitable value to account for test inaccuracies.

Unit internal design temperature range:

Extreme range defined on each unit TRP, for which unit internal materials, processes and parts are selected and for which unit internal Thermal Control is designed (see figure 5.2).

Note: unit internal design temperatures are derived from unit thermal calculations including uncertainties and margins.

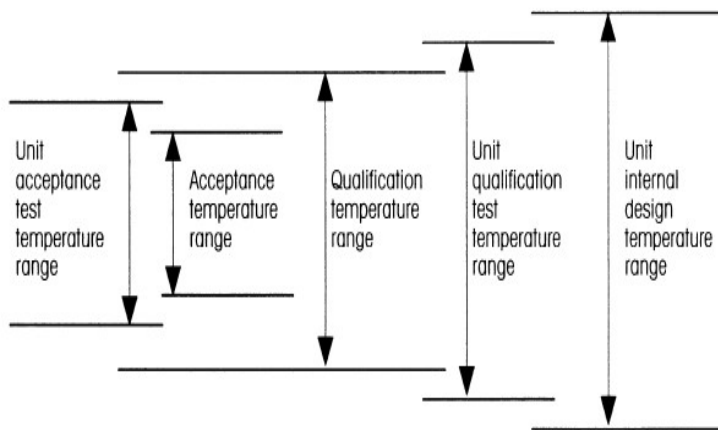


Figure 5.2: Temperature definition for unit thermal design (extract from ECSS-E-ST-31C)

Minimum switch-on (or minimum start-up) temperature:

Minimum temperature at which a unit can be switched from the non-operating mode to the operating mode and functions nominally when the unit temperature is brought back to the relevant operating mode temperatures.

Temperature difference:

Difference in temperature of two points at a given time.

Temperature gradient:

Spatial derivation of temperature in a point at a given time.

Note: it is expressed by a temperature divided by unit length.

5.2. REQUIREMENTS FOR TRP IDENTIFICATION AND UTILISATION

ISIS-GDIR-REQ-50001 v: 1

The location(s) of the temperature reference points (TRP) shall be defined by the unit supplier.

Verification Method: R

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ISIS-GDIR-REQ-50002 v: 1

The TRP location(s) shall be approved by the customer.

Verification Method: R

ISIS-GDIR-REQ-50003 v: 1

Each TRP shall be located to provide a simplified representation of a significant conductive or radiative heat transfer applied on the unit by its interfaces or by its natural environment.

Comment: Depending on the unit dimensions and depending on its environment/interface complexity, more than one temperature reference point can be located and defined in the unit ICD.

Verification Method: R

ISIS-GDIR-REQ-50004 v: 1

Hot spots on the external casing due to point heat sources shall not be used as TRP.

Verification Method: R

ISIS-GDIR-REQ-50005 v: 1

Temperatures at the TRP(s) shall be used at unit level to verify requirements by analysis and to drive the temperatures during acceptance and qualification thermal vacuum tests.

Comment: Those temperatures will be also used at system level (ground & flight).

Verification Method: R

ISIS-GDIR-REQ-50006 v: 1

Concerning the unit baseplate, the TRP location shall be:

- accessible for instrumentation by flight and ground temperature sensors,
- for a unit that is non homogeneous in temperature, representative of the coldest point of the baseplate with a 3°C tolerance.

Rationale: AIV constraint and design need.

Comment: In practice, the unit baseplate TRP is located near a cold fixation foot.

Verification Method: R

ISIS-GDIR-REQ-50007 v: 1

The unit internal thermal control shall take into account qualification margins of +5/-5 °C respectively on the upper and lower operating/non-operating acceptance temperatures.

Verification Method: R

ISIS-GDIR-REQ-50008 v: 1

The different start-up temperatures shall be as followed:

- the qualification start-up temperature is equal to or within the range [Tqualif N-OP; Tqualif OP],
- the acceptance start-up temperature is equal to or within the range [Taccep N-OP; Taccep OP],
- the qualification start-up temperature is equal to or lower than the acceptance start-up temperature.

Rationale: Margin philosophy requirement not present in ECSS.

Comment: The philosophy of acceptance & qualification does apply for the start up of a unit.

Verification Method: R

ISIS

5.3. THERMAL DESIGN REQUIREMENTS

ISIS-GDIR-REQ-50009 v: 1

The internal thermal control of the unit shall be the responsibility of the unit supplier.

Verification Method: R

ISIS-GDIR-REQ-50010 v: 1

The internal thermal control of an external unit shall take into account the EVTR.

Verification Method: R

ISIS-GDIR-REQ-50011 v: 1

The unit internal thermal control shall insure that EEE components predicted temperatures will not exceed the rated & derated temperature limits in operation considering TRP temperatures at respectively qualification & acceptance levels.

Rationale: Design constraint for unit integrity

Verification Method: R

ISIS-GDIR-REQ-50012 v: 2

The unit internal thermal control shall insure that materials, mechanical parts & processes will not exceed their temperature limits in operation & non-operation considering TRP temperature at qualification level.

Rationale: Design constraint for unit integrity

Verification Method: R

ISIS-GDIR-REQ-50013 v: 1

The unit internal thermal control shall insure all other temperature requirements if any as defined in the technical specification of a complex unit such as antenna, stellar sensor, mechanism.

Comment: For example, requirements concerning temperature difference, stability or homogeneity.

Verification Method: R

ISIS-GDIR-REQ-50014 v: 1

The unit internal thermal control shall be achieved primarily by passive means (i.e., coatings, MLI, conductive paths, insulating washers, ...).

Verification Method: R

ISIS-GDIR-REQ-50015 v: 1

The unit supplier shall have customer agreement prior using, for unit internal thermal design, moving masses or fluids such as cryo-coolers, heat pipes or fluid loops.

Verification Method: R

ISIS-GDIR-REQ-50016 v: 1

The unit supplier shall have customer agreement prior using, for unit internal thermal design, EEE parts such as heaters or thermo electric coolers.

ISIS-GDIR-REQ-50017 v: 1

The unit internal thermal control shall be testable on ground.

Verification Method: T

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ISIS-GDIR-REQ-50018 v: 1

Temperature internal sensors shall be implemented if no other telemetries can guaranty the health check & the integrity of the unit in flight.

Verification Method: A

ISIS-GDIR-REQ-50019 v: 1

All units with an average heat flow rate density, through the housing radiative effective area, higher than 70 W/m² shall be conductively controlled.

Rationale: System thermal design limitation

Comment: For low heat dissipation unit (below 70 W/m²) radiative and/or conductive thermal control is allowed.

ISIS-GDIR-REQ-50020 v: 1

If a unit presents a maximal operational TRP temperature inferior or equal to +45°C with an average heat flow rate density, through the housing radiative effective area, higher than 50 W/m², then it shall be conductively controlled.

Rationale: System thermal design limitation

ISIS-GDIR-REQ-50021 v: 1

A conductively controlled unit shall interface with the spacecraft with a flat and full contact surface (baseplate).

Verification Method: R

ISIS-GDIR-REQ-50022 v: 1

A conductively controlled unit shall be designed to transfer the heat through the baseplate only, unless a radiative interface temperature is given in the unit specification.

Verification Method: R

ISIS-GDIR-REQ-50023 v: 1

A radiatively controlled unit shall be designed to transfer the heat through its housing only by radiative exchanges.

Verification Method: R

ISIS-GDIR-REQ-50024 v: 1

A conductively controlled unit shall be designed to be homogeneous in temperature i. e. the maximum temperature difference into its baseplate is less than 3°C.

Comment: For unit not fulfilling this requirement complementary analysis and/or interface mathematical model delivery will be mandatory to confirm design feasibility.

Verification Method: R

ISIS-GDIR-REQ-50025 v: 1

A radiatively controlled unit shall be designed to be homogeneous in temperature i. e. the maximum temperature difference into its housing & baseplate is less than 5°C.

Verification Method: R

ISIS-GDIR-REQ-50026 v: 1

For a dissipative unit the uncertainties on calculated temperature differences between internal parts and TRP shall be justified.

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Verification Method: R

ISIS-GDIR-REQ-50027 v: 1

For an external unit the uncertainties on calculated temperatures shall be justified.

ISIS-GDIR-REQ-50028 v: 1

For a complex unit such as an antenna, a stellar sensor or a mechanism, the uncertainties on other thermal control calculated performances if any shall be justified.

Comment: For example, performances concerning temperature stability or homogeneity.

ISIS-GDIR-REQ-50029 v: 1

For an unit that needs electrical power for its internal thermal control, the uncertainties on electrical power calculated consumptions shall be justified.

ISIS-GDIR-REQ-50030 v: 1

Radiative and conductive heat transfer shall be justified by measurement when unit internal thermal control is using low thermal conductivity elements with high internal temperature difference ($> 100\text{ }^{\circ}\text{C}$).

Rationale: Design verification need

Verification Method: T

5.4. THERMAL INTERFACE REQUIREMENTS

ISIS-GDIR-REQ-50031 v: 1

The integrity and full performance of internal temperature sensor(s) shall be verified during vacuum testing.

Verification Method: T

ISIS-GDIR-REQ-50032 v: 1

Unit mounting areas shall not be painted or anodised, in order to obtain a good conductive thermal contact with the spacecraft structure.

Verification Method: R

ISIS-GDIR-REQ-50033 v: 1

At each conductive interface, the contact surface & surface coefficient of heat transfer values shall be agreed by the customer.

Verification Method: R

ISIS-GDIR-REQ-50034 v: 1

At each radiative interface, the effective radiative area & effective infrared emissivity values shall be agreed by the customer.

Comment: For example, the radiative heat transfer can be reduced through faces with numerous connectors or through closing cover...

Verification Method: R

ISIS-GDIR-REQ-50035 v: 1

MLI blankets if any, shall have its efficiency values justified by the unit supplier and agreed by the customer.

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Verification Method: S

ISIS-GDIR-REQ-50036 v: 1

In case of insulating fixation delivery, the values of the decoupling shall be justified by the unit supplier and agreed by the customer.

Comment: For example, thermal washers or blades.

Verification Method: S

ISIS-GDIR-REQ-50038 v: 2

Maximal and average heat fluxes through the baseplate contact area shall be limited to the values presented in the following table, for application of unit on panel with or without doubler.

Allowable Base Contact Heat Flux		
Baseplate area	Average Heat flux	Max local I/F heat flux
0.01 m ²	2100 W/m ²	3150 W/m ²
0.03 m ²	1100 W/m ²	1650 W/m ²
0.1 m ²	540 W/m ²	810 W/m ²
0.2 m ²	400 W/m ²	600 W/m ²

For application of unit on heat-pipe, maximal heat flux shall be limited to 4 W/cm² and average heat flux shall be limited to 1 W/cm².

Rationale: Approach allowing maximum accommodation flexibility of units at system level (with respect to different missions and environments) with a simple and robust system thermal design.

Comment: Nota 1: For intermediate surfaces, linear interpolation must be performed.

Note 2: Surface accounted for heat flux calculation shall be the effective contact area.

Note 3: For unit not fulfilling this requirement complementary analysis and/or interface mathematical model delivery will be mandatory to confirm design feasibility.

Verification Method: A

ISIS-GDIR-REQ-50039 v: 1

External unit coating shall present an hemispherical IR emissivity higher than 0.8 unless otherwise required by each unit technical specification.

Verification Method: R

ISIS-GDIR-REQ-50040 v: 1

The hemispherical solar absorptivity value shall be defined for both BOL and EOL conditions, guaranteed at ± 0.03 for BOL and including effects of ageing (radiations, UV...) for EOL.

ISIS-GDIR-REQ-50041 v: 1

The hemispherical IR emissivity value shall be guaranteed at ± 0.02 for values <0.1 and at ± 0.03 for values >0.1 .

ISIS-GDIR-REQ-50042 v: 1

The specific heat dissipation of the unit shall be guaranteed at:

- $\pm 10\%$ before electrical measurements
- $\pm 5\%$ after electrical measurements

Verification Method: A

ISIS

ISIS-GDIR-REQ-50043 v: 1

The unit supplier shall provide a flat and coating free area of 1cm in diameter, for temperature sensors implementation on unit TRPs.

Verification Method: R

5.5. THERMAL INTERFACE DOCUMENTATION

ISIS-GDIR-REQ-50044 v: 2

All unit thermal interfaces shall be described within the unit ICD as per Annex 2.

Verification Method: R

ISIS-GDIR-REQ-50045 v: 1

The location of the Temperature Reference Points (TRPs) shall be indicated in the TICD and on the Interface Control Drawings.

Verification Method: R

ISIS-GDIR-REQ-50046 v: 1

The location & type of all devices used for unit temperature measurement shall be defined in the TICD.

Verification Method: R

5.6. THERMAL ANALYSES AND MODELS

ISIS-GDIR-REQ-50047 v: 1

For dissipative units the thermal analyses shall predict (including uncertainties) internal temperatures reached by all components, materials and processes for the unit worst hot operating mode.

Comment: Note 1: in accordance with thermal interfaces in section "Thermal Interface Requirements" and environment specifications in EVTR.

Note 2: it should be taken into account in the thermal analyses deviations and temporal degradations from the nominal values of:

- external & internal heat flow rates,
- thermo-optical properties,
- heat capacities,
- conductive & radiative couplings.

Verification Method: A

ISIS-GDIR-REQ-50048 v: 1

In nominal operation, the thermal analyses shall verify the following points:

- The temperatures of EEE parts are lower or equal to the limits allowed by the derating rules applicable to the project when submitted to TRP acceptance ranges,
- The temperatures of EEE parts are lower or equal to the limits allowed by the rating rules applicable to the project when submitted to TRP qualification ranges.

Verification Method: A

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ISIS-GDIR-REQ-50049 v: 1

In nominal operation, the thermal analyses shall verify that the temperatures of material and processes are inside the qualified range.

Verification Method: A

ISIS-GDIR-REQ-50050 v: 1

In nominal operation, the thermal analyses shall verify that the heat flux at the conductive interface and the unit temperature homogeneity are inside the specified values.

Verification Method: A

ISIS-GDIR-REQ-50051 v: 1

In case of failure, thermal analyses shall be performed in order to demonstrate that there is no failure propagation.

Verification Method: A

ISIS-GDIR-REQ-50052 v: 2 w

Considering the thermal analyses, the unit supplier shall insure that the calculated TRP temperatures are coherent with TRP definition as required in section "Requirements for TRP identification and utilisation" and as agreed with the customer.

Verification Method: R

ISIS-GDIR-REQ-50053 v: 1

Analysis of units internal thermal control shall be conducted using design mathematical models (DTMM & DGMM).

Comment: Each PCB should be detailed in the design mathematical models.

Verification Method: R

ISIS-GDIR-REQ-50054 v: 1

For external units, each calculation case shall take into account the corresponding external environmental conditions, including orbit and satellite attitudes.

Verification Method: R

ISIS-GDIR-REQ-50055 v: 1

The thermal analysis reports shall include:

- The list of the analysis cases with the rationale for the selection of them,
- A description of the design models showing the main modelling assumptions (boundary conditions, heat dissipations...) and schematic views of the models if any,
- A summary of the main results, including comparison with rating & derating temperature limits and demonstration of compliance to each design and interface requirement,
- Detailed results of all analysis cases, provided in report annexes.

Verification Method: R

ISIS-GDIR-REQ-50056 v: 1

In accordance with annex B, interface mathematical models (ITMM&IGMM) shall be provided for units that are non homogeneous in temperature.

Comment: For an external unit or for a complex unit such a mechanism, the unit technical specification completes or supersedes annex B with ITMM&IGMM delivery particular requirements.

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export controlled data**

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Verification Method: R

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6. OPTICAL DESIGN AND INTERFACE REQUIREMENTS

(Not Applicable)

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7. ELECTRICAL DESIGN AND INTERFACE REQUIREMENTS

7.1. GENERAL REQUIREMENTS

7.1.1. Failure containment and redundancy

ISIS-GDIR-REQ-70576 v: 1 w

Failure propagation shall meet the following conditions:

1. A single hardware failure does not propagate to neighbouring components circuits or interfaces in an undetermined way.
2. Failure propagation is verified by analysis.
3. Mechanical, thermal or electrical propagation of single hardware failures does not impair the corresponding protection or redundancy implemented at equipment or system level.
4. Single hardware failure does not propagate to equipment or functions under different contractual responsibility than the item where the failure takes place.

Comment: Component assembly (e.g. single cavity hybrid) and integrated circuits, especially if they contain redundancy or protection, require special attention.

Verification Method: R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020021]

ISIS-GDIR-REQ-70577 v: 1 w

Redundant signal or power lines should be segregated via physically separated connectors and harnesses.

Verification Method: R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020022]

ISIS-GDIR-REQ-70578 v: 1 w

Redundant functions shall be physically separated with no risk of failure propagation by thermal or other coupling and as a minimum, contained within different integrated circuits to avoid failure propagation.

Comment: Example of physical separation are by a minimum distance, insulation, or cut-out.

Verification Method: R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020024]

ISIS-GDIR-REQ-70002 v: 2

For redundant functions implemented on the same PCB, any deviation of the physical separation shall be tracked in the Critical item List.

Verification Method: R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020026]

ISIS-GDIR-REQ-70003 v: 2 w

In case a cold redundant function is simultaneously activated together with the nominal one, by a deliberate or wrong command or due to a fault, this shall not induce permanent degradation of either of the two functions or loss of the mission before reconfiguration action.

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Comment: E.g. thermal and EMC functions.

Verification Method: A, R, T

ECSS DOORS Req ID: [ECSS-E-ST-20_0020028]

ISIS-GDIR-REQ-70005 v: 1

In case of signal cross-strapping, no single failure of either interface circuit shall propagate to the other one.

Verification Method: A, R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020031]

ISIS-GDIR-REQ-70006 v: 2 w

Equipment connected to independent, redundant power buses not protected at the source shall ensure that:

1. for unmanned missions, no single failure causes the loss of more than one power bus;
2. for manned missions, two failures do not cause the loss of more than one power bus.

Verification Method: A, R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020225]

ISIS-GDIR-REQ-70554 v: 1

After a failure of the nominal function with permanent power below the limit of current limitation, the redundant function shall operate with full performance.

Verification Method: A, R

ISIS-GDIR-REQ-70579 v: 1 w

Occurrence of a non-destructive SEE after a failure shall not lead to the loss of the mission.

Comment: Accordingly, a non-destructive SEE cannot derail a reconfiguration process after first hardware failure.

Verification Method: A, R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020407]

7.1.2. Testing

ISIS-GDIR-REQ-70007 v: 1

The functionality shall be provided to test the redundant function of a closed unit.

Verification Method: R, T

ECSS DOORS Req ID: [ECSS-E-ST-20_0020067]

ISIS-GDIR-REQ-70008 v: 2 w

All protection functions shall be tested, up to the highest possible level of integration of the unit.

Verification Method: R, T

ECSS DOORS Req ID: [ECSS-E-ST-20_0020076]

ISIS

7.2. ELECTRICAL POWER SUPPLY

7.2.1. General description of power distribution switches & protections / User interface

The satellite main primary Power BUS is an unregulated DC voltage bus with battery connected directly on the bus.

The satellite power distribution electronics which is part of the PCDU will provide a centralised protection of the main primary power bus against short circuit or overload on any load path. Such a protection is achieved by the implementation of an active current limiter on each distributed power lines.

Each unit (or each function for units embedding Nominal and Redundant part within a single unit) draws its power from a dedicated power line.

The power is distributed via:

- Auto-retriggerable Latching current limiters (R-LCL) or Foldback current limiters (FCL) for permanent and non-commutable loads, generally OBC and S-band Rx.
- Latching current limiters (LCL) for commutable loads that are generally AOCS units, S-band Tx, platform and instruments (or payload) units.
- ON Protected Latching Current Limiter (OP-LCL) for commutable loads which are generally payload units.

1] Power line supplying commutable loads

Two different types of power lines delivered by the PCDU can be needed depending on the load characteristics and its nominal status for all operational satellite modes:

- A standard power line with Latching Current Limiter (LCL)
- An ON protected power line (OP-LCL) which is achieved by a specific Latching Current Limiter equipped with a double switch and making the following function: ON/OFF switching of loads needing at system level, two OFF command stages and not having their own ON/OFF capability.

Note: A double OFF command can be achieved by two ways, either by the use of OP-LCL in the PCDU or by the use of a switch present at the input of the load equipment. A double OFF command is used for maintaining the possibility to switch off the line in case of LCL failed in permanent ON state.

Each LCL type is an ON/OFF commandable solid state switch, which provides at its output an over-current limitation (ILIM) for a definite time before automatic switch-off (trip-off time). If the over-current condition exceeds the trip-off time, the LCL is automatically switched off. The LCL remains latched in this switch-off mode, until an ON-command release the LCL from its latched condition (rearming command).

The standard Latching Current Limiter (LCL) has the following functions:

- ON/OFF Switching via PCDU TC
- Protection of the power line in case of overcurrent and undervoltage
- ON/OFF status and current monitoring
- current rate control at switch-ON (TAS only)

2] Power line supplying non-commutable loads via either a Fold-Back current limiter (FCL) or an auto-retriggerable Permanent On Latching Current Limiters (R-LCL).

a) A Fold-Back Current Limiter (FCL) has the following functions:

- Automatic switch-ON at main bus power-up
- No OFF TC

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- Overcurrent limitation and reduction according to fold-back characteristic
- ON/OFF status and current monitoring

b) An auto-retriggerable Permanent On Current Limiter (R-LCL) has the following functions:

- Automatic switch-ON at main bus power-up with limitation of transient current rate
- No OFF TC
- Protection of the power line in case of overcurrent and undervoltage
- Automatic retriggering cycle after trip-off (with disabling capability via TC)
- ON/OFF status and current monitoring

Note: Each R-LCL has the same characteristics than a standard LCL except:

- automatically ON at main bus start-up
- no OFF command
- after switch OFF due to user failure, a dedicated automatism resets the LCL ON after few seconds, this automatism can be inhibited by a TC received from OBC.

[*] For each User equipment, the type will be defined by the Prime Contractor on dedicated unit specification.

All LCL/FCL/R-LCL include also an under voltage protection with an Under Voltage Detection threshold (UVD) which will be higher than the minimum limit of the operational voltage range specified at User equipment level.

For each current limiter, the UVD threshold will be adjustable on-ground during PCDU board integration down to a minimum value defined by the Prime Contractor.

Each User equipment primary power line delivered by the PCDU and equipped with a LCL is monitored via the 1553 serial data bus, including ON/OFF status, protection status and output current value with an accuracy better than $\pm 5\%$.

7.2.2. Primary Power Bus voltage range

ISIS-GDIR-REQ-70009 v: 1

Each commutable load supplied via a LCL (or OP-LCL) shall operate nominally and meet full performances at voltage range of <VBNRMIN> to <VBNRMAX> (at unit input connector level).

Parameter: VBNRMAX = 39 V

VBNRMIN = 21 V

Verification Method: A, T

ISIS-GDIR-REQ-70010 v: 1

Each permanent and non-commutable load supplied via a FCL or R-LCL shall operate nominally and meet full performances at input voltage range of <VBNRMINP> to <VBNRMAX> (at unit input connector level).

Parameter: VBNRMAX = 39 V

VBNRMINP = 19 V

Verification Method: A, T

ISIS-GDIR-REQ-70011 v: 1

If an under-voltage protection is implemented at load level, for commutable load, the under-voltage threshold (switch-off) shall be less than <UVDOFFMAX>.

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Parameter: UVDOFFMAX = 20,5 V

Verification Method: A, T

ISIS-GDIR-REQ-70012 v: 1

If an under-voltage protection is implemented at load level, for permanent and non-commutable load, the under-voltage threshold (switch-off) shall be less than <UVDOFFMAX> (V).

Parameter: UVDOFFMAXP = 18,5 V

Verification Method: A, T

ISIS-GDIR-REQ-70013 v: 1

If under-voltage protection is implemented at load level, for commutable load, the undervoltage threshold hysteresis shall be implemented for switch on, with a switch-on voltage threshold of less than <UVDONMAX>.

Parameter: UVDONMAX = 21,5 V

Verification Method: A, T

ISIS-GDIR-REQ-70014 v: 1

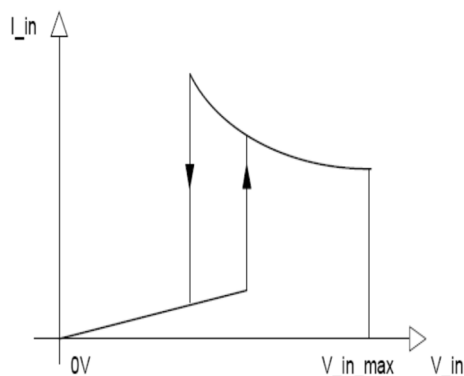
If under-voltage protection is implemented at load level, for permanent and non-commutable load, the undervoltage threshold hysteresis shall be implemented for switch on, with a switch-on voltage threshold of less than <UVDONMAXP>.

Parameter: UVDONMAXP = 21 V

Verification Method: A, T

ISIS-GDIR-REQ-70015 v: 2

Static input I(V) curve shall be provided and measured on an electrical representative model (breadboard or Engineering Model) of the unit from 0V to <VBNRMAX> and from <VBNRMAX> to 0V.



Parameter: VBNRMAX = 39 V

Verification Method: T

ISIS-GDIR-REQ-70016 v: 1

The power bus users shall be designed to withstand voltage range of 0V to <VMAX> DC without stress or damage.

Parameter: VMAX = 40 V

Comment: For voltages outside the nominal operational DC voltage range, the equipment does not have to be operational, but only to not be stressed or damaged."

Verification Method: A, R, T

ISIS

ISIS-GDIR-REQ-70017 v: 1

When the unit is subjected to power down and up inside the specified voltage range and with $60\text{V/ms} < dV/dt < 600\text{V/ms}$ regardless of the intended configuration of the unit, all components within the unit shall remain within their derating.

Verification Method: A, T

ISIS-GDIR-REQ-70018 v: 2

When the unit is subjected to power down and up in the range of 0V to $\langle \text{VBNRMAX} \rangle$ and with $60\text{V/ms} < dV/dt < 600\text{V/ms}$, the unit components shall remain within their derating and the unit shall not generate any spurious signals.

Parameter: VBNRMAX = 39 V

Verification Method: A

ISIS-GDIR-REQ-70019 v: 1

Unit shall be designed taking into account the source impedance as it is specified by the LISN in ISIS-EMC-REQ-0520.

Verification Method: A, T

7.2.3. Main BUS User voltage transient

ISIS-GDIR-REQ-70020 v: 1

All electronic logic units/circuits shall assume a defined and safe configuration upon application of power in all conditions.

Verification Method: A

During the switch ON of an unit powered by a latching protection device, the dI/dT measured on the input current shall be limited by the latching protection device to less than $2\text{A}/\mu\text{s}$.

ISIS-GDIR-REQ-70021 v: 2

Supplied unit shall not suffer damage and shall operate nominally after going through the following sequences:

- Switch ON, $\langle \text{DELAYONOFF} \rangle$, Switch OFF, $\langle \text{DELAYONOFF} \rangle$, Switch ON

Parameter: DELAYONOFF = 100 ms

Verification Method: A, T

7.2.4. Power distribution protections characteristics applicable to User input interface

ISIS-GDIR-REQ-70022 v: 1

The compatibility of unit (Power ON, operating mode, switch OFF) connected to any power lines (LCL, FCL, OP-LCL, R-LCL) shall be verified with suitable margins by analysis in all case conditions and shall be tested with representative models of power protection and load.

The electrical characteristics of the protection shall be provided by the prime to the unit manufacturer.

Verification Method: A, T

ISIS-GDIR-REQ-70023 v: 1

Margins are:

ISIS

- The limitation duration during the switch ON of the unit shall be lower than <TRIPMARGIN> (%) of the minimum trip-off time of the protection device,
- The maximum steady state current of the unit in all nominal operations shall be lower than <ILIMMARGIN> (%) of the minimum limitation current of the protection device.

Parameter: ILIMMARGIN = 80 Percent

TRIPMARGIN = 80 Percent

Verification Method: A, T

ISIS-GDIR-REQ-70024 v: 1

Permanent and non-commutable loads shall not rely on power cycling (OFF/ON) to recover from any "lock-up" phenomenon.

Verification Method: A, T

ECSS DOORS Req ID: [ECSS-E-ST-20_0020037]

ISIS-GDIR-REQ-70580 v: 1 w

The stability of current limiters shall be verified by analysis under worst-case conditions, and tested under a set of cases agreed with the customer.

Verification Method: A, T

ECSS DOORS Req ID: [ECSS-E-ST-20_0020421]

7.2.4.1. LCL/RLCL Load Circuit Interface Specification

The choice of the LCL and RLCL characteristics (current limitation and trip-off time) is made by the satellite contractor.

Different classes of LCL/RLCL are available typically from 1A to 15A limitation current and from 1ms to 12ms trip-off time.

A preliminary selection of the LCL class will be done through the analysis of the unit definition and the unit DCI. Then during the test of compatibility required by ISIS-GDIR-REQ-70022 and ISIS-GDIR-REQ-70023 the final choice of LCL class will be done.

ISIS-GDIR-REQ-70025 v: 1

Each load shall be compatible (no part stress) with an LCL reaction time of 5μs during which current is not limited.

Verification Method: A, R

ISIS-GDIR-REQ-70026 v: 1

The effective differential inductance of the load power input shall be less than 500μH.

Verification Method: R

7.2.4.2. FCL Load Circuit Interface Specification

The choice of the FCL class is made by the satellite contractor.

Different classes of FCL are available up to 2A limitation current.

A preliminary selection of the FCL class will be done through the analysis of the unit definition and the unit DCI. Then during the test of compatibility required by ISIS-GDIR-REQ-70022 and ISIS-GDIR-REQ-70023 the final choice of FCL class will be done.

ISIS

ISIS-GDIR-REQ-70027 v: 1

The units shall be compatible with an FCL reaction time of $5\mu\text{s}$ during which current is not limited.

Verification Method: A, R

ISIS-GDIR-REQ-70028 v: 1

The effective differential inductance of the unit power input shall be less than $100\mu\text{H}$.

Verification Method: R

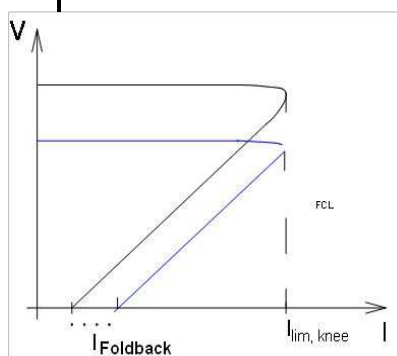
ISIS-GDIR-REQ-70029 v: 1

For permanent and non-commutable load (i.e. supplied by FCL), the effective differential capacitance of the power input shall be less than $100\mu\text{F}$.

Verification Method: R

ISIS-GDIR-REQ-70030 v: 1

Following switch-ON, and during input filter charging, the user shall ensure that the instantaneous load characteristic never crosses the foldback region (see figure here after):



Verification Method: R, T

The following table shows typical classes of LCL.

ISIS

TAS LCL and OP_LCL	ILIMmin (A)	ILIMMAX (A)	Tmin(ms)	TMAX (ms)	IMAXnom design (A)	IMAXnom/ILIMm in design
A	1	1.2	6	12	0.8	0.80
B	2.5	3	6	12	2	0.80
C	5	6	6	12	4.1	0.82
D	7.35	8.82	6	12	6.1	0.83
E	10	12	3	6	8.3	0.83
AST LCL	ILIMmin (A)	ILIMMAX (A)	Tmin(ms)	TMAX (ms)	IMAXnom design (A)	IMAXnom/ILIMm in design
0	0.54	0.66	9	20	0.5	0.93
1	1.08	1.32	9	20	1	0.93
2	2.16	2.64	9	20	2	0.93
3	3.24	3.96	55	20	3	0.93
4	4.32	5.28	5	20	4	0.93
5	5.4	6.6	4	8	5	0.93
6	6.48	7.92	3	8	6	0.93
8	8.64	10.56	2	8	8	0.93
10	10.8	13.2	2	8	10	0.93
12	13.2	15	1	2	12	0.91
16	17.6	20	1	2	16	0.91
28	31.7	36	1	2	28.8	0.91
TAS R_LCL	ILIMmin (A)	ILIMMAX (A)	Tmin(ms)	TMAX (ms)	IMAXnom design (A)	IMAXnom/ILIMm in design
A	1	1.2	5	10	0.8	0.80
B	2.5	3	5	10	2	0.80
C	5	6	5	10	4.1	0.82
D	7.35	8.82	5	10	6.1	0.83
E	10	12	3	6	8.3	0.83
AST FCL	ILIMmin (A)	ILIMMAX (A)	Ifoldback/Ik nee min	Ifoldback/Ik ee max	IMAXnom design (A)	IMAXnom/ILIMm in design
0	0.57	0.69	0.15	0.60	0.5	0.88
1	1.13	1.39	0.15	0.60	1	0.88
2	2.25	2.75	0.15	0.60	2	0.89

7.2.5. Protections of the power electronics and main BUS interfaces

ISIS-GDIR-REQ-70031 v: 2

Fuses shall not be used for primary power bus protection against short-circuit or user load overcurrent.

Verification Method: R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020402]

ISIS-GDIR-REQ-70032 v: 2 w

When protection elements are in cascade, the closest one upstream from the anomaly should be the first to act.

Verification Method: A, R, T

ECSS DOORS Req ID: [ECSS-E-ST-20_0020230]

ISIS-GDIR-REQ-70033 v: 2 w

When protections are used in cascade from a power source to a function to be supplied, the compatibility of these protections shall be ensured.

Verification Method: A, R, T

ECSS DOORS Req ID: [ECSS-E-ST-20_0020231]

ISIS-GDIR-REQ-70035 v: 1

All current limiting devices and automatic switch-off circuits shall be monitored by telemetry.

Verification Method: R, T

ISIS

ECSS DOORS Req ID: [ECSS-E-ST-20_0020214]

ISIS-GDIR-REQ-70036 v: 1

The failure of the monitoring function of current limiting devices and automatic switch-off circuits shall not cause the protection elements to fail.

Verification Method: A, R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020215]

ISIS-GDIR-REQ-70037 v: 1

Permanent and non commutable loads shall not be permanently disconnected from its power source as a consequence of an SEE.

Verification Method: A, R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020220]

ISIS-GDIR-REQ-70038 v: 1

Applicable to units not always ON during nominal operations: Unit shall provide operating mode where the consumption is lower than <PSTBY> (standby mode). This specific low power consumption mode shall be commanded through the OBC TM/TC interface.

Parameter: PSTBY = 40 W

Verification Method: A, R

7.2.6. Heater power supply lines

ISIS-GDIR-REQ-70039 v: 2

When a unit implements its own thermal control with heaters mounted by the unit before delivery and powered by the primary power bus:

Heaters shall be sized (installed power) for a minimum primary bus voltage of <VTHSIZE>.

Parameter: VTHSIZE = 27 V

Verification Method: A, R

ISIS-GDIR-REQ-70040 v: 2

When a unit implements its own thermal control with heaters mounted by the unit before delivery and powered by the primary power bus:

Thermal control shall comply with all power requirements at maximum voltage of <VBNRMAX>.

Parameter: VBNRMAX = 39 V

Verification Method: A, R

7.2.7. Power consumption/dissipation definitions and margins

Power allocations for each unit is given in the unit specification for each operating mode. Power allocation are split on three types: mean (or average) , long peak, and short peak power figures.

Mean power represents the average consumption of the equipment during 5 minutes in steady-state (after thermal stabilisation of the equipment).

ISIS

Long peak represents any peak consumption of the equipment lasting more than 1 ms (peak duration > 1 ms)

Note: Test setup will be an oscilloscope with a cut-off frequency around 1 KHz.

Short peak represents the average consumption in any time slot of 1 ms.

Note: Short peak represents the peak consumption of the equipment lasting less than 1 ms (peak duration < 1ms) measured with oscilloscope with large bandwidth eg 50 MHz

ISIS-GDIR-REQ-70041 v: 1

The compliance versus the power allocations shall be established by taking into account the worst-case conditions within the extreme operational temperature range and the in-orbit lifetime including radiation effects.

Verification Method: A, R

ISIS-GDIR-REQ-70042 v: 2

Power consumption and dissipation shall be provided for all operational modes and each Unit primary power interface (BOL and EOL):

- at minimum, maximum and average voltage: <VBNRMIN>, <VBNRMAX>, and between <VBNRNOMN> <VBNRNOMX>
- at ambient and the extremes of temperature

Parameter: VBNRMAX = 39 V

VBNRMIN = 21 V

VBNRNOMN = 31 V

VBNRNOMX = 34 V

Verification Method: A, R, T

ISIS-GDIR-REQ-70043 v: 1

Under nominal and failure cases, the unit shall not inject reverse current into the power bus except otherwise specified in the unit specifications.

Verification Method: A, R

The supplier will deliver a model of the unit presenting the worst-case and nominal case power consumption covering the following variable aspects (aging, radiation, operating mode, temperature, any key parameters: speed for Wheel ... for example).

Detail and type of model will be defined on unit specification.

ISIS-GDIR-REQ-70044 v: 2

At equipment level (excluding active thermal control consumption), the following design maturity power margins shall be applied:

- 5% for Off-The-Shelf (OTS) equipment (ECSS category A/B),
- 10% for OTS items requiring minor modifications (ECSS category C),
- 20% for new designed/developed items, or items requiring major modifications or re-design (ECSS category D).

Verification Method: A, T

ISIS

7.2.8. Secondary power lines

ISIS-GDIR-REQ-70045 v: 1

It shall be possible to switch on the source unit without having to connect an external load to its power outputs. When unloaded, the output voltages shall correspond to their specified values under these conditions (during Unit acceptance test each output voltage shall be measured in both loaded and unloaded conditions).

Comment: Output voltage values (in both loaded and unloaded conditions) will be defined on source unit specification.

Verification Method: A, T

ISIS-GDIR-REQ-70046 v: 1

The source unit shall be protected against external short-circuits on the secondary power lines (either differential or to the mechanical ground).

Verification Method: A, T

ISIS-GDIR-REQ-70047 v: 1

The output lines of unit converters (external) shall have protections against over voltages and over current to prevent failure propagation except otherwise specified in the unit specifications.

Verification Method: A, T

ISIS-GDIR-REQ-70048 v: 1

In any case, the supplied unit shall withstand without stress or damage the faulty supply voltages generated by the source unit failure.

The faulty voltages values will be defined on Source and Load units specification.

Comment: Verification method at unit level

- fault voltages figures at Source verification result from FMECA analysis,
- Verification that the load can withstand source fault voltages results from stress analysis.

Verification Method: A, T

ISIS-GDIR-REQ-70049 v: 2

In case of a reversed voltage applied to the power input of the supplied unit, all components shall remain within their rating except specified by the prime contractor.

Verification Method: A

In case of powering different functions by the same converter, the failure of one electronic unit should not have consequence on the other units or at least should not lead to any more failure propagation.

The potential failure mode of the different Loads will be defined on Source unit specification.

7.2.9. DC/DC converter design requirements

ISIS-GDIR-REQ-70050 v: 2 w

If a switching converter is externally synchronized, it shall deliver output voltages within specification for any increase or decrease of synchronizing frequency, intermediate amplitude of synchronizing signal, phase jumps, or loss and recovery of the signal.

Verification Method: R, T

ECSS DOORS Req ID: [ECSS-E-ST-20_0020208]

ISIS

ISIS-GDIR-REQ-70051 v: 1

The free-running frequency shall be limited to $\pm 10\%$ of the nominal frequency.

Verification Method: A, T

ISIS-GDIR-REQ-70052 v: 1

The as designed free-running frequency and frequency variations shall be reported in the unit Frequency plan.

(eventually included in the Unit Interface Control Document)

Verification Method: R

ISIS-GDIR-REQ-70053 v: 1

A minimum margin of 10% shall be taken between maximum transient unit consumption and converter power capability.

Verification Method: A, R, T

ISIS-GDIR-REQ-70054 v: 2 w

The phase margin of converters and regulators in close loop control shall be at least 50° and the gain margin 6dB for worst case end-of-life conditions with representative loading. For converters and regulators of the power subsystem, this requirement shall apply after any single failure. A chart (e.g. Bode, Nichols, Nyquist) shall be provided to justify the closest loop stability margin.

Verification Method: A, T

ECSS DOORS Req ID: [ECSS-E-ST-20_0020204], [ECSS-E-ST-20_0020205]

ISIS-GDIR-REQ-70581 v: 1 w

Whenever two or more blocks are connected in cascade, the stability of the cascade between each source block and load block shall be analysed, in compliance with Figure below.

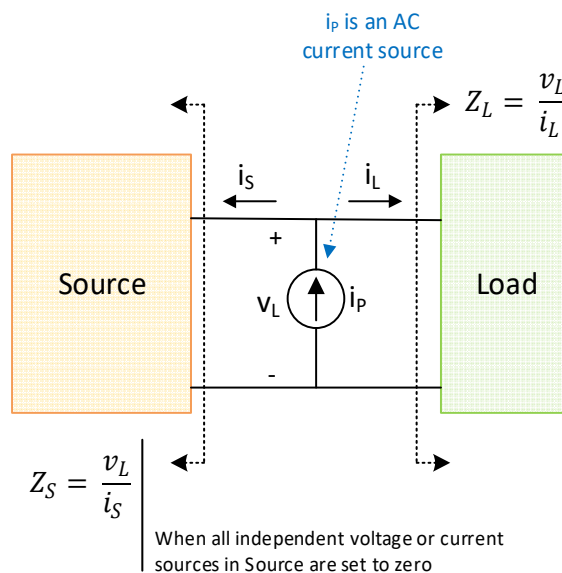


Figure 7.1: Source and load impedance characterisation

Verification Method: A

ECSS DOORS Req ID: [ECSS-E-ST-20_0020412]

ISIS

7.3. PYRO AND ONE-SHOT RELEASE MECHANISM LINES

7.3.1. General

ISIS-GDIR-REQ-70055 v: 1

Check-out circuits dedicated to AIT tests shall not allow current flow or electrostatic discharge causing unintentional effects in the explosive system.

Verification Method: A, R

ECSS DOORS Req ID: [ECSS-E-ST-33-11_0280145]

7.3.2. Properties

ISIS-GDIR-REQ-70056 v: 1

The electrical properties of the explosive or OSRM system before firing and after firing shall be identified and listed.

Verification Method: A, R

ECSS DOORS Req ID: [ECSS-E-ST-33-11_0280001]

ISIS-GDIR-REQ-70057 v: 1

For every explosive component or OSRM component, electrical characteristics of actuation, non-actuation and non degradation limits shall be identified and quantified.

Verification Method: A, R

ECSS DOORS Req ID: [ECSS-E-ST-33-11_0280002]

ISIS-GDIR-REQ-70058 v: 1

The properties of the explosive system shall remain stable over time before firing and after firing when subject to external loads or environmental conditions, within the qualification values.

Verification Method: A, R

ECSS DOORS Req ID: [ECSS-E-ST-33-11_0280004]

7.4. STANDARD SIGNALS AND INTERFACES

7.4.1. Signal interface general requirements

ISIS-GDIR-REQ-70059 v: 1

Interface engineering shall ensure that the characteristics on both sides of each interface are compatible, including source and load impedances, the effects of the interconnecting harness and the grounding network between both sides comprising: common mode impedance conducted and radiated susceptibility and emission.

Verification Method: A, R, T

ECSS DOORS Req ID: [ECSS-E-ST-20_0020001]

ISIS-GDIR-REQ-70060 v: 1

ISIS

In order to minimize the number of interface types, standard interface circuitry shall be defined to be applied throughout a project.

Verification Method: R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020002]

ISIS-GDIR-REQ-70061 v: 2

The application of the nominal signals or a faulty signal to an un-powered interface shall not cause damage to that interface.

Comment: In case verification by analysis is not conclusive a complementary verification by test is necessary.

Verification Method: A, R, T

ECSS DOORS Req ID: [ECSS-E-ST-20_0020004]

ISIS-GDIR-REQ-70062 v: 1

An undetermined status at the interfaces of a powered unit shall not cause damage to an un-powered interface.

Comment: Note 1: Undetermined status includes: non-nominal operating modes, permanent and non-permanent failure modes, powered and un-powered interfaces.

Note 2: In case verification by analysis is not conclusive a complementary verification by test is necessary.

Verification Method: A, R, T

ECSS DOORS Req ID: [ECSS-E-ST-20_0020005]

ISIS-GDIR-REQ-70064 v: 1

Among other failure cases, receivers shall not be stressed and not show degraded performance when input is open circuit except on the input I/F that is open circuit.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.2.1.a.1

ECSS DOORS Req ID: [ECSS-E-ST-50-14_0940001]

ISIS-GDIR-REQ-70065 v: 1

Among other failure cases, receivers shall not be stressed and not show degraded performance when input is short circuit to ground except on the input I/F that is short circuit.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.2.1.a.2

ECSS DOORS Req ID: [ECSS-E-ST-50-14_0940001]

ISIS-GDIR-REQ-70066 v: 1

Among other failure cases, transmitters shall not be stressed and not show degraded performance when output is open circuit except on the output I/F that is open circuit.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.2.2.a.1

ECSS DOORS Req ID: [ECSS-E-ST-50-14_0940002]

ISIS-GDIR-REQ-70067 v: 1

Among other failure cases, transmitters shall not be stressed when output is short circuit to ground.

ISIS

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.2.2.a.2

ECSS DOORS Req ID: [ECSS-E-ST-50-14_0940002]

ISIS-GDIR-REQ-70068 v: 1

Input interfaces shall not be damaged or harmed during power cycling conditions taking the transmitting side state into account in any normal state.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.3.1.a

ECSS DOORS Req ID: [ECSS-E-ST-50-14_0940003]

ISIS-GDIR-REQ-70069 v: 1

Receivers shall not supply the other circuits or be stressed when the unit is OFF while connected to an active driver.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.3.1.b

ECSS DOORS Req ID: [ECSS-E-ST-50-14_0940004]

ISIS-GDIR-REQ-70070 v: 1

Output interfaces shall not be damaged or harmed during power cycling conditions when the receiving side state is in any normal state.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.3.2.a

ECSS DOORS Req ID: [ECSS-E-ST-50-14_0940005]

ISIS-GDIR-REQ-70071 v: 1

For pulse commands it shall be ensured that spurious commands are not emitted during power cycling that exceed the no-activation limits for the receivers.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.3.2.b

ECSS DOORS Req ID: [ECSS-E-ST-50-14_0940006]

This requirement does not specify the prevention of spurious pulses, but ensures either that:

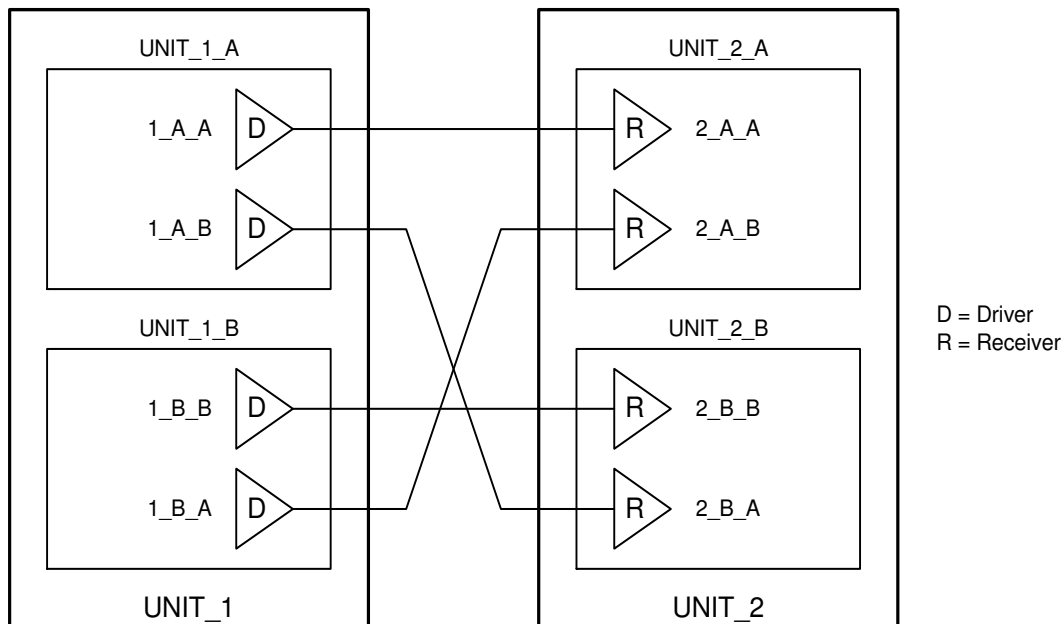
- spurious pulses are below the threshold for the receiver, or
- the spurious pulse duration is short enough to not drive the load into activation (for example a relay coil or opto-coupler diode).

7.4.2. Cross-Strapping

ISIS-GDIR-REQ-70072 v: 1

For 2 units (UNIT_1 & UNIT_2), that can be used in redundancy, the cross-strapping of drivers and receivers shall be as specified in Figure.

ISIS



Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.4.1.a

ECSS DOORS Req ID: [ECSS-E-ST-50-14_0940007]

ISIS-GDIR-REQ-70073 v: 1

The UNIT_2_A I/F shall be capable to receive:

- A signal from the UNIT_1_A I/F through a dedicated link
- A signal from the UNIT_1_B I/F through a dedicated link

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.4.1.a.1

ISIS-GDIR-REQ-70074 v: 1

The UNIT_2_B I/F shall be capable to receive:

- A signal from the UNIT_1_A I/F through a dedicated link
- A signal from the UNIT_1_B I/F through a dedicated link

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.4.1.a.2

ISIS-GDIR-REQ-70075 v: 1

The UNIT_1_A I/F shall be capable to deliver:

- A signal to the UNIT_2_A I/F through a dedicated link
- A signal to the UNIT_2_B I/F through a dedicated link

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.4.1.a.3

ISIS-GDIR-REQ-70076 v: 1

ISIS

The UNIT_1_B I/F shall be capable to deliver:

- A signal to the UNIT_2_A I/F through a dedicated link
- A signal to the UNIT_2_B I/F through a dedicated link

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.4.1.a.4

ISIS-GDIR-REQ-70077 v: 1

To achieve full cross-strapping benefits, in terms of reliability, any potential common failure of UNIT_1_A and UNIT_1_B drivers and UNIT_2_A and UNIT_2_B receivers shall be avoided.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.4.1.b

ISIS-GDIR-REQ-70078 v: 1

Under the condition (Receiver = ON linked to Transmitter = OFF of UNIT_1), in the configuration where UNIT_1 driver is OFF and UNIT_2 receiver is ON, the information received by this receiver shall not disturb the valid information received by the other receiver (linked to a Transmitter ON).

Comment: In this configuration the electrical status at receiver output is stable (due to hysteresis) but possibly unknown (logical "1" or "0").

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.4.2.a

ISIS-GDIR-REQ-70079 v: 1

It shall be ensured that any input signal is in a known (inactive) stable state when driver is OFF.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.4.2.b

ISIS-GDIR-REQ-70080 v: 3

If any input signal is not in a known (inactive) stable state when driver is OFF, a validation / inhibition stage at the receiver output of UNIT_2 shall be implemented.

Comment: For example, the validation of the path can be made by a dedicated direct command arriving from UNIT_1, which inhibits the UNIT_2 receiver output unused (if such a configuration has been thoroughly designed with respect to failure cases).

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.4.2.c

ISIS-GDIR-REQ-70081 v: 1

Under the condition (Transmitter = OFF linked to Receiver = ON of UNIT_2), whether powered or not, UNIT_1 drivers shall withstand any receiver characteristics.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.4.3

ISIS-GDIR-REQ-70082 v: 1

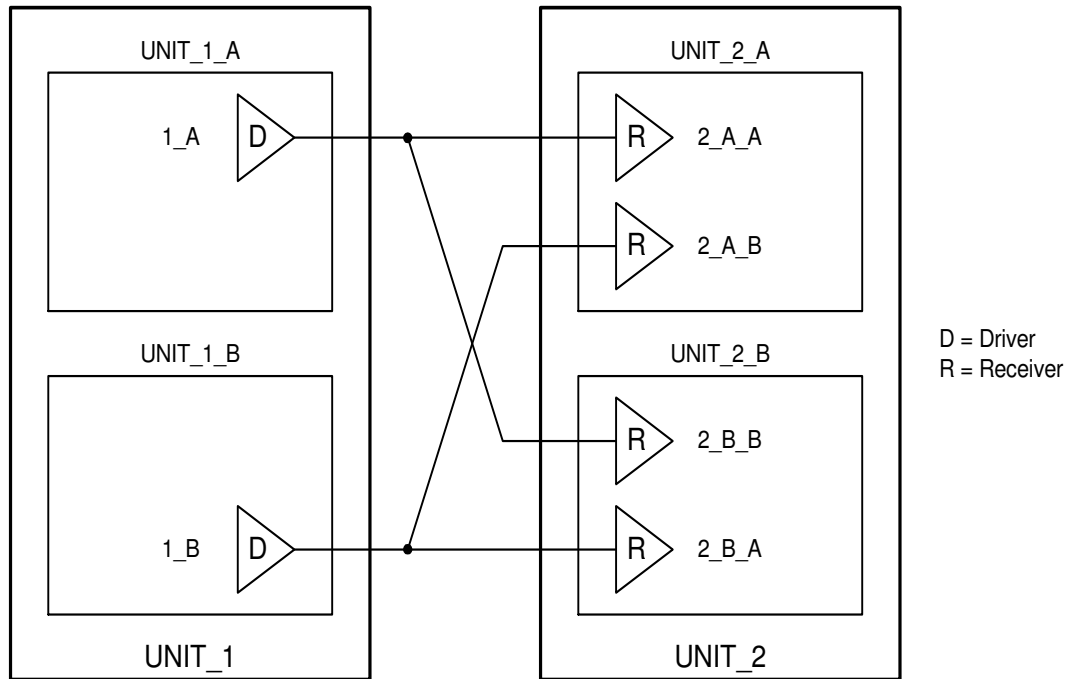
Under the condition (Receiver = OFF linked to Transmitter = ON of UNIT_1), whether powered or not, UNIT_2 receivers shall withstand any driver characteristics.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.4.4

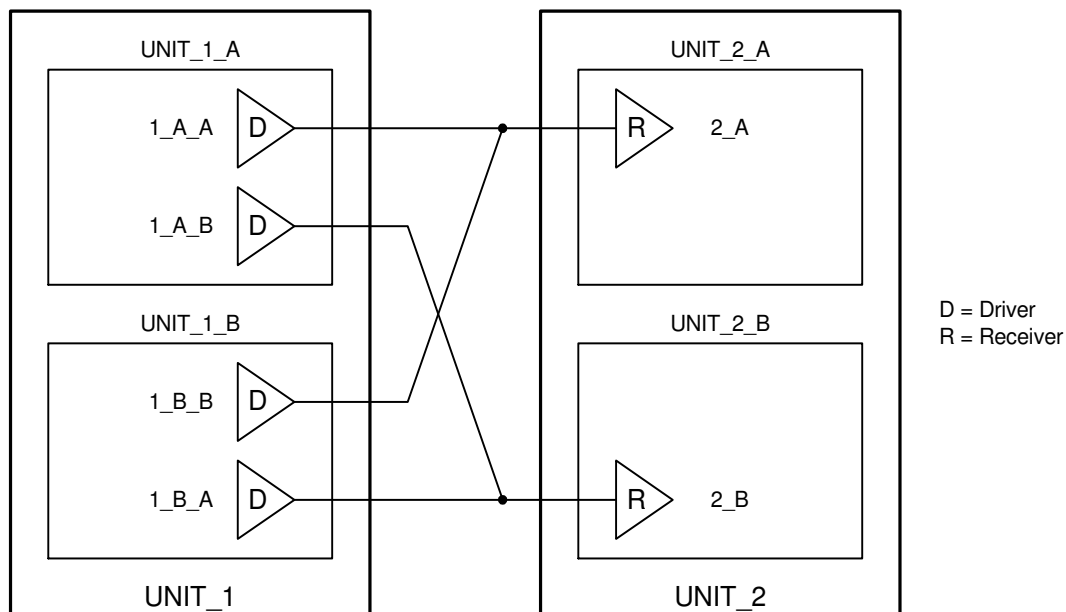
ISIS

Note: Single source - Dual receiver harness cross-trapping



Standard Origin Source: ECSS-E-ST-50-14C 4.2.5.1

Note: Dual source - Single receiver harness cross-trapping



Standard Origin Source: ECSS-E-ST-50-14C 4.2.5.1

ISIS-GDIR-REQ-70083 v: 1

If harness cross-trapping is used, there shall be no mechanism whereby the failure of either the receiver or unit interface can propagate to the I/F of another, unrelated unit.

ISIS

Comment: This requirement refers to a common mode failure where a failure of one interface then propagates inside the receiver thereby affecting units unrelated to the original failure.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.5.2.a

ISIS-GDIR-REQ-70084 v: 1

If harness cross-strapping is used, the calculation of the overall system reliability shall include the potential degradation or damage of the I/F of a redundant unit due to the failure of other interface.

Comment: This requirement refers to the failure on a nominal unit causing the inoperability of the cross-strap. This means that there is a reduction in the possible reliability of the cross-strap.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.5.2.b

ISIS-GDIR-REQ-70085 v: 1

If harness cross-strapping is used, the capability shall be provided to shut down the inoperable unit regardless of the failure mode

Comment: This implies that the power can be removed from the unit by independent means such as disabling the power interface at the power distribution unit.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.5.2.c

ISIS-GDIR-REQ-70086 v: 2

Under the condition (Transmitter = OFF linked to Receiver = ON of UNIT_2), whether powered or not, UNIT_1 drivers shall withstand any receiver characteristics.

Comment: The receiver characteristics are those described in the chapter "Standard signals and interfaces".

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.5.2.d

ISIS-GDIR-REQ-70087 v: 2

Under the condition (Receiver = OFF linked to Transmitter = ON of UNIT_1), whether powered or not, UNIT_2 receivers shall withstand any driver characteristics.

Comment: The driver characteristics are those described in the chapter "Standard signals and interfaces".

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 4.2.5.2.e

7.4.3. HPC interfaces

ISIS-GDIR-REQ-70088 v: 1

The passive state of the HPC_OUT signal shall be low.

Verification Method: A, R, T

Standard Origin Source: ECSS-E-ST-50-14C 7.1.2.2

ISIS-GDIR-REQ-70089 v: 1

ISIS

The active state of the HPC_OUT signal shall be high.

Verification Method: A, R, T

Standard Origin Source: ECSS-E-ST-50-14C 7.1.2.3

ISIS-GDIR-REQ-70090 v: 1

The HPC_OUT output signal shall be in passive state when the driver is unpowered.

Verification Method: A, R, T

Standard Origin Source: ECSS-E-ST-50-14C 7.1.2.4

ISIS-GDIR-REQ-70091 v: 1

The design of the high power pulse command interface shall ensure that no failure mode results in the output being permanently active (high state).

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.2.5

ISIS-GDIR-REQ-70092 v: 1

The high power discrete pulse command source shall be referenced to source signal ground.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.2.6.a

ISIS-GDIR-REQ-70093 v: 1

The load shall be isolated from any user electrical reference.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.2.6.b

ISIS-GDIR-REQ-70094 v: 1

Both the high power pulse command source and receiver shall be equipped with circuits to suppress any switching transients.

Comment: This is particularly important to suppress transients due to inductive loads such as relays, which can cause the current drive capability, or the overvoltage capability of the source to be exceeded.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.2.7

ISIS-GDIR-REQ-70095 v: 1

The high power pulse command source shall be short circuit proof for short circuits to source or receiver signal ground and structure.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.2.8

7.4.4. High Voltage High Power Command HV-HPC

7.4.4.1. Driver

ISIS-GDIR-REQ-70096 v: 2

ISIS

HV-HPC Driver: Circuit type shall be: Single ended driver with appropriate circuits to suppress negative switching transients.

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.4.1 a.1

ISIS-GDIR-REQ-70097 v: 1

HV-HPC Driver: Transfer shall be: DC coupled

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.4.1 a.2

ISIS-GDIR-REQ-70098 v: 1

HV-HPC Driver: Active state output voltage, VAout shall be: 22V to 29V

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 7.1.4.1 a.3

ISIS-GDIR-REQ-70099 v: 1

HV-HPC Driver: Active current drive capability, IAout shall be: 180mA

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.4.1 a.7

ISIS-GDIR-REQ-70100 v: 2 w

HV-HPC Driver: Passive state output leakage current, IPout shall be: < 300μA

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.4.1 a.4

ISIS-GDIR-REQ-70101 v: 1

HV-HPC Driver: Pulse width, tP shall be: 4ms to 1024ms

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 7.1.4.1 a.5

ISIS-GDIR-REQ-70102 v: 1

HV-HPC Driver: Output voltage rise and fall times, tr, tf shall be: 50μs to 500μs when connected to a resistive load of 200Ω

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 7.1.4.1 a.6

ISIS-GDIR-REQ-70103 v: 1

HV-HPC Driver: Short circuit output current, ISC shall be: ≤400 mA

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.4.1 a.9

ISIS-GDIR-REQ-70104 v: 1

HV-HPC Driver: Fault voltage tolerance, Vsft shall be: 0V to +33V

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.4.1 a.10

ISIS

ISIS-GDIR-REQ-70105 v: 1

HV-HPC Driver: Fault voltage emission, Vsfe shall be: 0V to +32V

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.4.1 a.11

ISIS-GDIR-REQ-70582 v: 1 w

HV-HPC Driver shall operate nominally considering parasitic capacitance between any HPC line and all other HPC lines lower than 10 nanoF.

Verification Method: A, T

7.4.4.2. Receiver

ISIS-GDIR-REQ-70106 v: 1

HV-HPC receiver: Circuit Type shall be: relay coil or an optocoupler

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.4.2 a.1

ISIS-GDIR-REQ-70107 v: 1

HV-HPC receiver: Active level at unit input terminal, V_{Ain} shall be: 20V to 29V

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 7.1.4.2 a.3

ISIS-GDIR-REQ-70108 v: 2 w

HV-HPC receiver: Passive level at unit input terminal (no activation), I_{Pin} shall be: 400μA

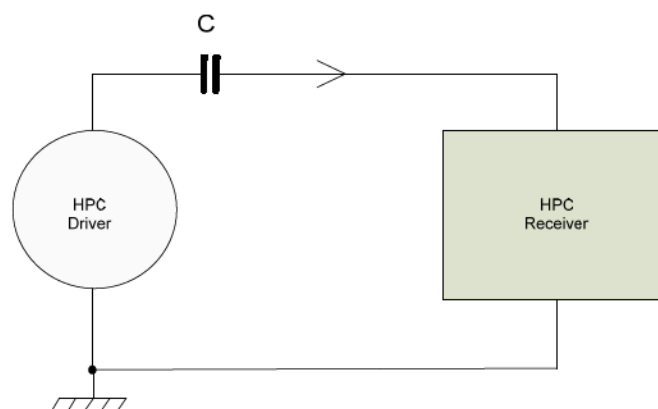
Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 7.1.4.2 a.4

ISIS-GDIR-REQ-70583 v: 1 w

HV-HPC receiver: Passive level transient immunity: Receiver shall not be activated when subjected to any transient that could be generated by here below schematic with:

- HPC Driver pulse up to 29V;
- HPC Driver rising and falling edges in the range of 50μs to 2ms;
- Serial Capacitance: C = 15nanoF.



ISIS

Verification Method: A, T

ISIS-GDIR-REQ-70110 v: 1

HV-HPC receiver: Load current, I_{load} shall be: $\leq 180\text{mA}$ (at 29V)

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 7.1.4.2 a.6

ISIS-GDIR-REQ-70111 v: 1

HV-HPC receiver: Fault voltage emission, V_{rfe} shall be: 0V to +32V

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.4.2 a.8

ISIS-GDIR-REQ-70112 v: 1

HV-HPC receiver: Fault voltage tolerance, V_{rft} shall be: 0V to +33V

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.4.2 a.9

7.4.4.3. Harness

ISIS-GDIR-REQ-70113 v: 1

HV-HPC Harness: Wire type shall be: Twisted Pair (TP), except otherwise specified by the prime contractor.

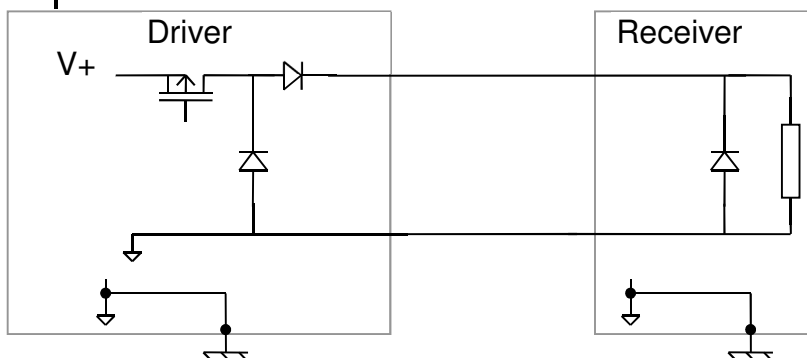
Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.6 a

7.4.4.4. Electrical schematic

ISIS-GDIR-REQ-70114 v: 1

HV-HPC: The electrical schematic shall be in case of Single source to single receiver:



Comment: If receiver is an opto-coupler device, the freewheeling diode is not mandatory.

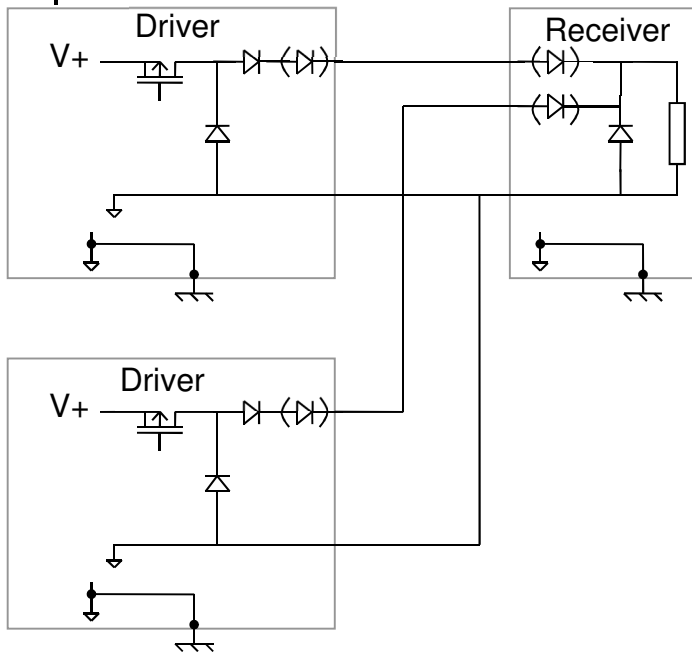
Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.7

ISIS

ISIS-GDIR-REQ-70115 v: 1

HV-HPC: The electrical schematic shall be in case of Double sources to single receiver:



Comment: If receiver is an opto-coupler device, the freewheeling diode is not mandatory.

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.7

7.4.5. Low Voltage High Power Command LV-HPC

7.4.5.1. Driver

ISIS-GDIR-REQ-70116 v: 1

LV-HPC Driver: Circuit type shall be: Single ended driver with appropriate circuits to suppress negative switching transients

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.3.1 a.1

ISIS-GDIR-REQ-70117 v: 1

LV-HPC Driver: Transfer shall be: DC coupled

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.3.1 a.2

ISIS-GDIR-REQ-70118 v: 1

LV-HPC Driver: Active state output voltage, VAout shall be: 12V to 16V

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 7.1.3.1 a.3

ISIS

ISIS-GDIR-REQ-70119 v: 1

LV-HPC Driver: Active current drive capability, I_{Aout} shall be: 180mA

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.3.1 a.7

ISIS-GDIR-REQ-70120 v: 2 w

LV-HPC Driver: Passive state output leakage current, I_{Pout} shall be: $< 300\mu A$

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.3.1 a.4

ISIS-GDIR-REQ-70121 v: 1

LV-HPC Driver: Pulse width, t_P shall be: 4ms to 1024ms

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 7.1.3.1 a.5

ISIS-GDIR-REQ-70122 v: 1

LV-HPC Driver: Output voltage rise and fall times, t_r , t_f shall be: 50 μs to 500 μs when connected to a resistive load of 100 Ω

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 7.1.3.1 a.6

ISIS-GDIR-REQ-70123 v: 1

LV-HPC Driver: Short circuit output current, I_{SC} shall be: $\leq 400mA$

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.3.1 a.9

ISIS-GDIR-REQ-70124 v: 1

LV-HPC Driver: Fault voltage tolerance, V_{sft} shall be: 0V to +20V

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.3.1 a.10

ISIS-GDIR-REQ-70125 v: 1

LV-HPC Driver: Fault voltage emission, V_{sfe} shall be: 0V to +19V

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.3.1 a.11, ECSS-E-ST-50-14C 7.1.4.1 a.11

ISIS-GDIR-REQ-70584 v: 1 w

LV-HPC Driver shall operate nominally considering parasitic capacitance between any HPC line and all other HPC lines lower than 10 nanoF.

Verification Method: A, T

7.4.5.2. Receiver

ISIS-GDIR-REQ-70126 v: 1

ISIS

LV-HPC Receiver: Circuit Type shall be: relay coil or an optocoupler

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.3.2.a.1

ISIS-GDIR-REQ-70127 v: 1

LV-HPC Receiver: Active level at unit input terminal, VAin shall be: 12V to 16V

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 7.1.3.2 a.3

ISIS-GDIR-REQ-70128 v: 1

LV-HPC Receiver: Passive level at unit input terminal (no activation), IPin shall be: 100μA

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 7.1.3.2 a.4

ISIS-GDIR-REQ-70129 v: 1

LV-HPC Receiver: Passive level transient immunity, tPtran shall be: No activation for pulses up to the active level 1ms wide

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 7.1.3.2 a.5

ISIS-GDIR-REQ-70130 v: 1

LV-HPC Receiver: Load current, Iload shall be: 180mA (at 16V)

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 7.1.3.2 a.6

ISIS-GDIR-REQ-70131 v: 1

LV-HPC Receiver: Fault voltage emission, Vrfe shall be: 0V to +19V

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.3.2 a.8

ISIS-GDIR-REQ-70132 v: 1

LV-HPC Receiver: Fault voltage tolerance, Vrft shall be: 0V to +20V

Verification Method: A

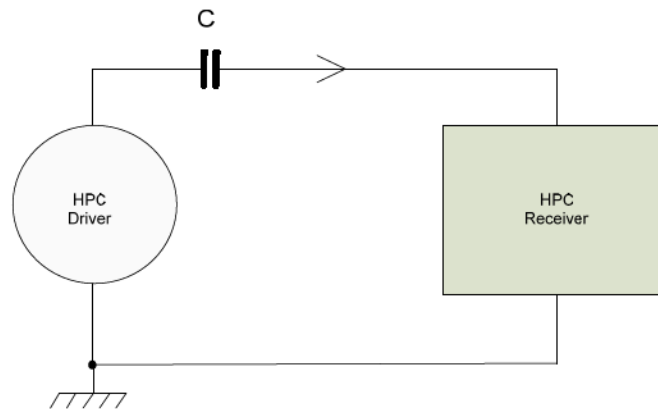
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ISIS-GDIR-REQ-70585 v: 1 w

LV-HPC receiver: Passive level transient immunity: Receiver shall not be activated when subjected to any transient that could be generated by here below schematic with:

- HPC Driver pulse up to 20V;
- HPC Driver rising and falling edges in the range of 50μs to 2ms;
- Serial Capacitance: C = 15 nanoF.

ISIS



Verification Method: A, T

7.4.5.3. Harness

ISIS-GDIR-REQ-70133 v: 1

LV-HPC Harness: Wire type shall be: Twisted Pair (TP), except otherwise specified by the prime contractor.

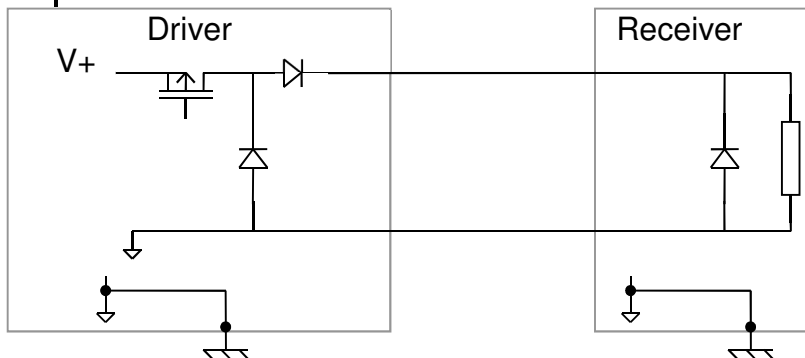
Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.6 a

7.4.5.4. Electrical schematic

ISIS-GDIR-REQ-70134 v: 1

LV-HPC: The electrical schematic shall be in case of Single source to single receiver:



Comment: If receiver is an opto-coupler device, the freewheeling diode is not mandatory.

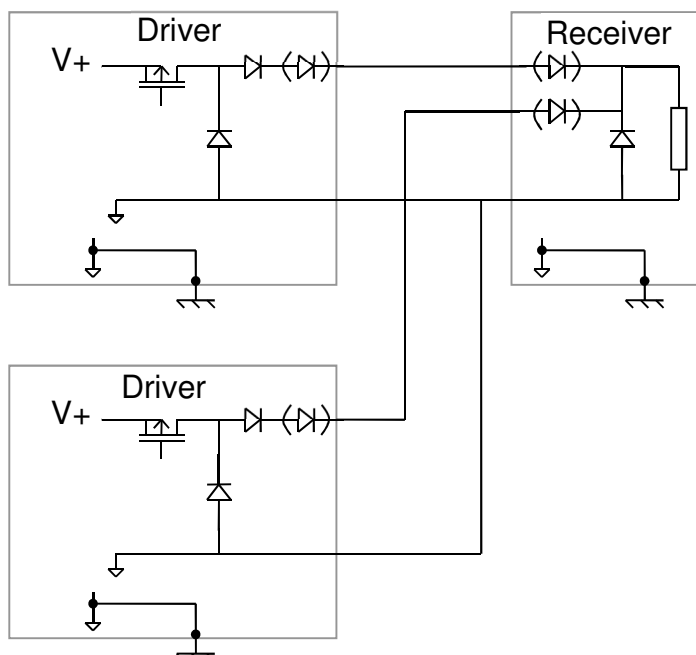
Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.7

ISIS-GDIR-REQ-70135 v: 1

LV-HPC: The electrical schematic shall be in case of Double sources to single receiver:

ISIS



Comment: If receiver is an opto-coupler device, the freewheeling diode is not mandatory.

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.7

7.4.6. High Current High Power Command HC-HPC

7.4.6.1. Driver

ISIS-GDIR-REQ-70136 v: 1

HC-HPC Driver: Circuit type shall be: Single ended driver return over wire

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.5.1 a.1

ISIS-GDIR-REQ-70137 v: 1

HC-HPC Driver: Transfer shall be: DC coupled

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.5.1 a.2

ISIS-GDIR-REQ-70138 v: 1

HC-HPC Driver: Active state output voltage, VAout shall be: 22V to 29V

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 7.1.5.1 a.3

ISIS-GDIR-REQ-70139 v: 2 w

HC-HPC Driver: Passive state output leakage current, IPout shall be: < 300μA

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.5.1 a.4

ISIS

ISIS-GDIR-REQ-70140 v: 1

HC-HPC Driver: Pulse width, tP shall be: 4ms to 1024ms (system design selectable depending on receiver characteristics)

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.5.1 a.5

ISIS-GDIR-REQ-70141 v: 1

HC-HPC Driver: Output voltage rise and fall times, tr, tf shall be: 50μs to 2ms when connected to a resistive load of 50Ω

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 7.1.5.1 a.6

ISIS-GDIR-REQ-70142 v: 1

HC-HPC Driver: Active current drive capability, IAout shall be: 600mA

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 7.1.5.1 a.7

ISIS-GDIR-REQ-70143 v: 1

HC-HPC Driver: Free-wheeling current capability (in passive state) shall be: IAout during tP

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.5.1 a.8

ISIS-GDIR-REQ-70144 v: 1

HC-HPC Driver: Short circuit output current, ISC shall be: ≤ 1A

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.5.1 a.9

ISIS-GDIR-REQ-70145 v: 1

HC-HPC Driver: Fault voltage tolerance, Vsft shall be: 0V to +33V

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.5.1 a.10

ISIS-GDIR-REQ-70146 v: 1

HC-HPC Driver: Fault voltage emission, Vsfe shall be: 0V to +32V

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.5.1 a.11

ISIS-GDIR-REQ-70586 v: 1 w

LV-HPC Driver shall operate nominally considering parasitic capacitance between any HPC line and all other HPC lines lower than 10 nanoF.

Verification Method: A, T

7.4.6.2. Receiver

ISIS-GDIR-REQ-70147 v: 2 w

ISIS

HC-HPC Receiver: Circuit type shall be: Relay or opto-coupler

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.5.2 a.1

ISIS-GDIR-REQ-70148 v: 1

HC-HPC Receiver: Transfer shall be: DC coupled

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.5.2 a.2

ISIS-GDIR-REQ-70149 v: 1

HC-HPC Receiver: Active level at unit input terminal, V_{Ain} shall be: 20V to 29V

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 7.1.5.2 a.3

ISIS-GDIR-REQ-70150 v: 1

HC-HPC Receiver: Passive level at unit input terminal (no activation), I_{Pin} shall be: 2mA

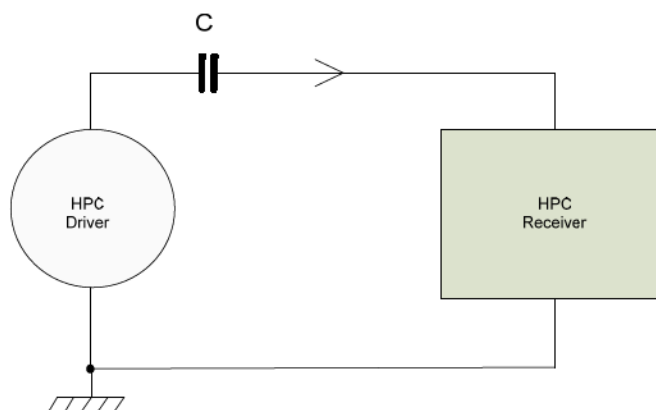
Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 7.1.5.2 a.4

ISIS-GDIR-REQ-70587 v: 1 w

HC-HPC receiver: Passive level transient immunity: Receiver shall not be activated when subjected to any transient that could be generated by here below schematic with:

- HPC Driver pulse up to 29V;
- HPC Driver rising and falling edges in the range of 50µs to 2ms;
- Serial Capacitance: C = 15 nanoF.



Verification Method: A, T

ISIS-GDIR-REQ-70152 v: 1

HC-HPC Receiver: Load current, I_{load} shall be: ≤ 600mA (at 29V)

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.5.2 a.6

ISIS

ISIS-GDIR-REQ-70153 v: 1

HC-HPC Receiver: Inputs to chassis isolation, Ziso shall be: $> 1M\Omega$

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.5.2 a.7

ISIS-GDIR-REQ-70154 v: 1

HC-HPC Receiver: Fault voltage emission, Vrfe shall be: 0V to +32V

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.5.2 a.8

ISIS-GDIR-REQ-70155 v: 1

HC-HPC Receiver: Fault voltage tolerance, Vrft shall be: 0V to +33V

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.1.5.2 a.8

7.4.6.3. Harness

ISIS-GDIR-REQ-70156 v: 1

HC-HPC Harness: Wire type shall be: Twisted Pair (TP), except otherwise specified by the prime contractor.

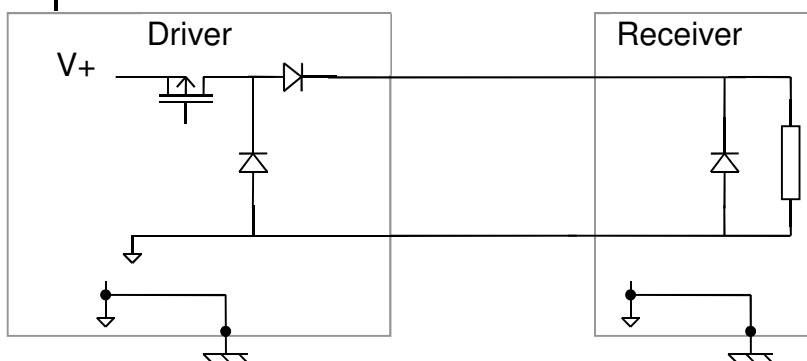
Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.6 a

7.4.6.4. Electrical schematic

ISIS-GDIR-REQ-70157 v: 1

HC-HPC: The electrical schematic shall be in case of Single source to single receiver:



Comment: If receiver is an opto-coupler device, the freewheeling diode is not mandatory.

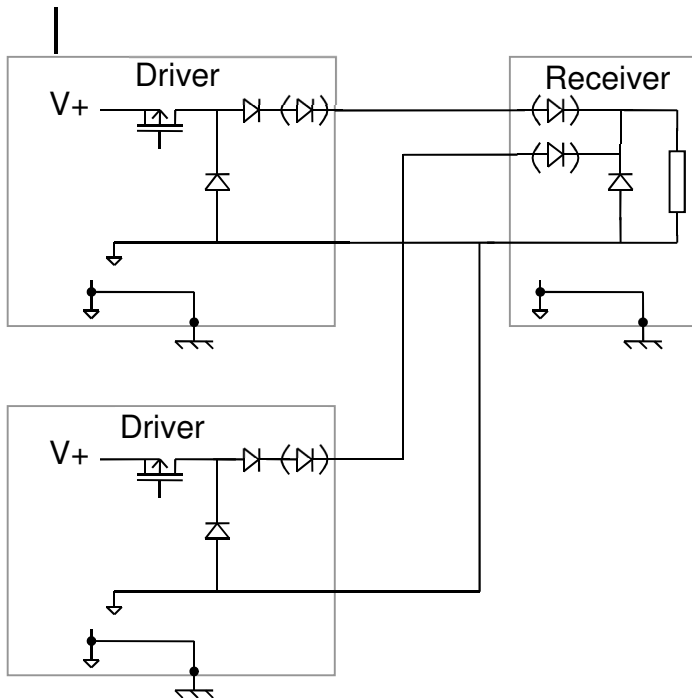
Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.7

ISIS-GDIR-REQ-70158 v: 1

HC-HPC: The electrical schematic shall be in case of Double sources to single receiver:

ISIS



Comment: If receiver is an opto-coupler device, the freewheeling diode is not mandatory.

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.1.7

7.4.7. Low Power Command LPC

7.4.7.1. Driver

ISIS-GDIR-REQ-70159 v: 1

LPC Driver: Circuit type shall be: Single ended driver return over wire

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.2.3.1 a.1

ISIS-GDIR-REQ-70160 v: 1

LPC Driver: Transfer shall be: DC coupled

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.2.3.1 a.2

ISIS-GDIR-REQ-70161 v: 1

LPC Driver: Output resistance, R_{out} shall be: 370 Ω to 430 Ω

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.2.3.1 a.3

ISIS-GDIR-REQ-70162 v: 1

LPC Driver: Active signal open circuit output voltage, V_{Aout} shall be: 4,4V to 5,5V

Verification Method: A, T

ISIS

Standard Origin Source: ECSS-E-ST-50-14C 7.2.3.1 a.4

ISIS-GDIR-REQ-70163 v: 1

LPC Driver: Passive signal open circuit output voltage, VPout shall be: 0V to 0,5V

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 7.2.3.1 a.5

ISIS-GDIR-REQ-70164 v: 1

LPC Driver: Fault voltage emission, Vsfe shall be: 7V with a source impedance $\geq 350\Omega$

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.2.3.1 a.6

ISIS-GDIR-REQ-70165 v: 1

LPC Driver: Fault tolerance shall be: Continuous short circuit

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.2.3.1 a.7

ISIS-GDIR-REQ-70166 v: 1

LPC Driver: Passive state output leakage current, IPout shall be: $< 100\mu A$

Verification Method: A

ISIS-GDIR-REQ-70167 v: 1

LPC Driver: Pulse width for LPC-P shall be: $4ms \leq t_d \leq 120ms$

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 7.2.3.1 a.8

7.4.7.2. Receiver

ISIS-GDIR-REQ-70168 v: 1

LPC Receiver: Circuit type shall be: Opto-coupler, passive load

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.2.3.2 a

ISIS-GDIR-REQ-70169 v: 1

LPC Receiver: Transfer shall be: DC coupled

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.2.3.2 b

ISIS-GDIR-REQ-70170 v: 1

LPC Receiver: Active input signal, VAin shall be: 4,4V to 5,5V through a 370Ω to 450Ω source resistance

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 7.2.3.2 c

ISIS-GDIR-REQ-70171 v: 1

ISIS

LPC Receiver: Passive input signal, VPin shall be: 0V to 0,5V

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 7.2.3.2 d

ISIS-GDIR-REQ-70172 v: 2 w

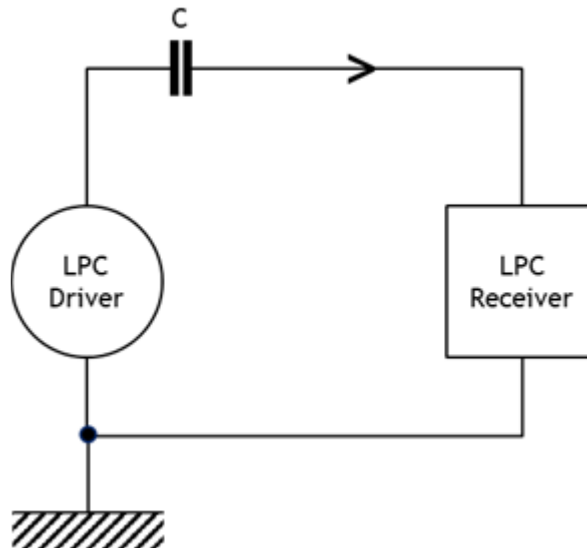
LPC Receiver: Passive level at unit input terminal (no activation), IPin shall be: 500μA

Verification Method: A, T

ISIS-GDIR-REQ-70588 v: 1 w

LPC receiver: Passive level transient immunity: Receiver shall not be activated when subjected to any transient that could be generated by here below schematic with:

- LPC Driver pulse up to 7V;
- LPC Driver rising and falling edges in the range of 50μs to 2ms;
- Serial Capacitance: C = 15 nanoF.



Verification Method: A, T

ISIS-GDIR-REQ-70174 v: 1

LPC Receiver: Fault voltage tolerance, V_{rft} shall be: 7V with a source impedance of 350Ω

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.2.3.2 e

ISIS-GDIR-REQ-70175 v: 1

LPC Receiver: Input to chassis isolation, Z_{iso} shall be: > 1MΩ

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 7.2.3.2 f

ISIS

7.4.7.3. Harness

ISIS-GDIR-REQ-70176 v: 1

LPC Harness: Wire type shall be: Twisted Pair (TP), except otherwise specified by the prime contractor.

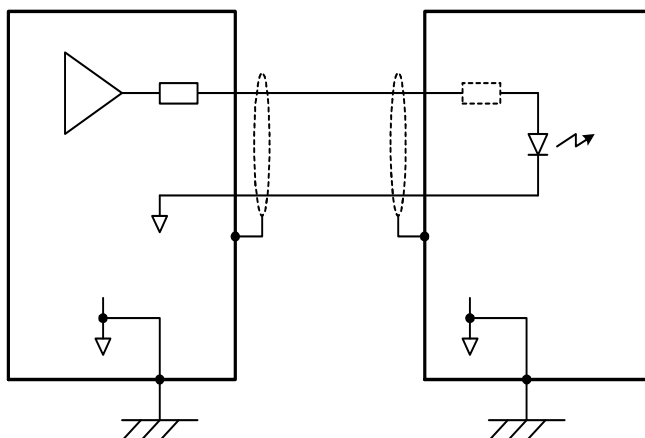
Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.2.4 a

7.4.7.4. Electrical schematic

ISIS-GDIR-REQ-70177 v: 1

LPC Electrical schematic: The electrical schematic shall be:



Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 7.2.5

7.4.8. Signal Balanced Differential Line SBDL

7.4.8.1. Driver

ISIS-GDIR-REQ-70178 v: 1

SBDL Driver: Electrical characteristics shall be: Differential

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 8.8 a.1

ISIS-GDIR-REQ-70179 v: 1

SBDL Driver: Differential output voltage open circuit, VOC shall be: $2\text{ V} \leq |VOC| \leq 5,5\text{ V}$

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 8.8 a.2

ISIS-GDIR-REQ-70180 v: 1

ISIS

SBDL Driver: Output voltage TRUE and COMP lines, V_e shall be: $V_e \leq 5,5 \text{ V}$

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 8.8 a.3

ISIS-GDIR-REQ-70181 v: 2

SBDL Driver: Differential output impedance, Z_{out} shall be: $120 \Omega \pm 10\%$

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 8.8 a.4

ISIS-GDIR-REQ-70182 v: 1

SBDL Driver: Short circuit output current, I_A shall be: $|I_A| \leq 150 \text{ mA}$ for each terminal to ground

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 8.8 a.5

ISIS-GDIR-REQ-70183 v: 1

SBDL Driver: Series protection, R_{os} shall be: $50 \Omega \pm 20\%$

Verification Method: A, T

ISIS-GDIR-REQ-70184 v: 1

SBDL Driver: Output voltage rise and fall times, t_r , t_f shall be: $t_r \leq 50 \text{ ns}$ if $t_b \geq 200 \text{ ns}$

$t_r \leq 20 \text{ ns}$ if $t_b \leq 200 \text{ ns}$

t_b : time duration of the unit interval at the applicable data rate (normally $0,5 \cdot \text{period duration}$).

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 8.8 a.6

ISIS-GDIR-REQ-70185 v: 1

SBDL Driver: Output leakage current in power off, I_O shall be: $|I_O| \leq 100 \mu\text{A}$

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 8.8 a.7

ISIS-GDIR-REQ-70186 v: 1

SBDL Driver: Fault voltage emission, V_{sfe} shall be: 0 V to 7 V (through 50Ω minimum series resistance)

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 8.8 a.8

ISIS-GDIR-REQ-70187 v: 1

SBDL Driver: Fault voltage tolerance, V_{sft} shall be: $-1,5 \text{ V}$ to 7 V (applied through $1 \text{ k}\Omega$ series resistance R_{is})

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 8.8 a.9

ISIS

7.4.8.2. Receiver

ISIS-GDIR-REQ-70188 v: 1

SBDL Receiver: Circuit Type shall be: Differential receiver

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 8.8 a.10

ISIS-GDIR-REQ-70189 v: 1

SBDL Receiver: Series protection, R_{is} shall be: 1 k Ω

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 8.8 a.11

ISIS-GDIR-REQ-70190 v: 1

SBDL Receiver: Differential input impedance shall be: DC: Greater than or equal to 5 k Ω including input series resistors

Verification Method: A

ISIS-GDIR-REQ-70191 v: 1

SBDL Receiver: Impedance adaptation Z_t

Mission and configuration dependant shall be: AC Typically:

120 Ohm in series with 50 pF

or 120 Ohm

Verification Method: A

ISIS-GDIR-REQ-70192 v: 1

SBDL Receiver: Polarisation Resistors R_{pp} , R_p , R_{pd} shall be: > 5k Ω Value of each resistor to be defined depending of the needed self biasing.

Verification Method: A

ISIS-GDIR-REQ-70193 v: 1

SBDL Receiver: Differential input voltage, VDI shall be: $\pm$ |600 mV to 5,5 V| each voltage in this range must be interpreted as valid signal

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 8.8 a.14

ISIS-GDIR-REQ-70194 v: 1

SBDL Receiver: Max input voltage (each input w.r.t. ground), V_I shall be: -10 V to +10 V

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 8.8 a.12

ISIS-GDIR-REQ-70195 v: 1

SBDL Receiver: Fault voltage emission, V_{rfe} shall be: 0 V to 5,5 V (through 1 k Ω series resistance R_{is})

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 8.8 a.15

ISIS

ISIS-GDIR-REQ-70196 v: 1

SBDL Receiver: Fault voltage tolerance, V_{rft} shall be: -1,5 V to 8,5 V

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 8.8 a.16

7.4.8.3. Harness

ISIS-GDIR-REQ-70197 v: 2

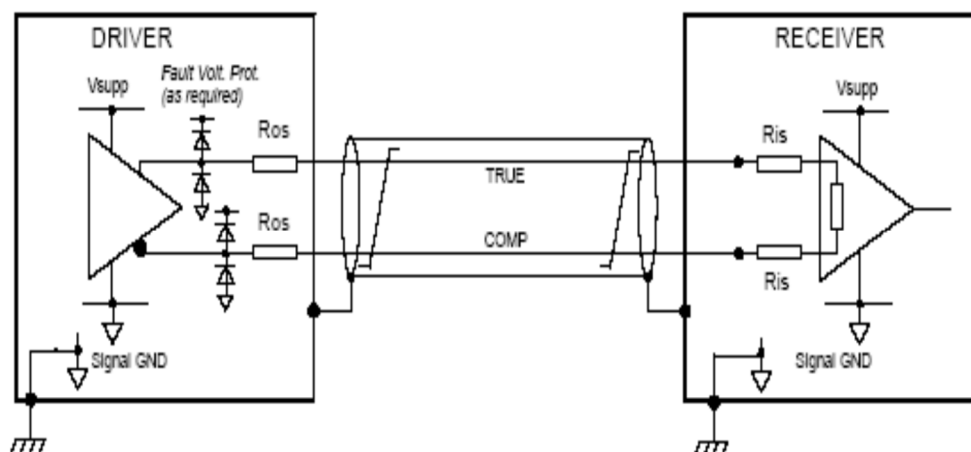
SBDL Harness: Wire type shall be: twisted Shielded Pair (TSP) or TwinAx (TCX) (120 Ω or 125 Ω balanced shielded lines according to ESA/SCC 3902/002)

Verification Method: R

7.4.8.4. Electrical schematic

ISIS-GDIR-REQ-70198 v: 1

SBDL Electrical schematic: The electrical schematic shall be:

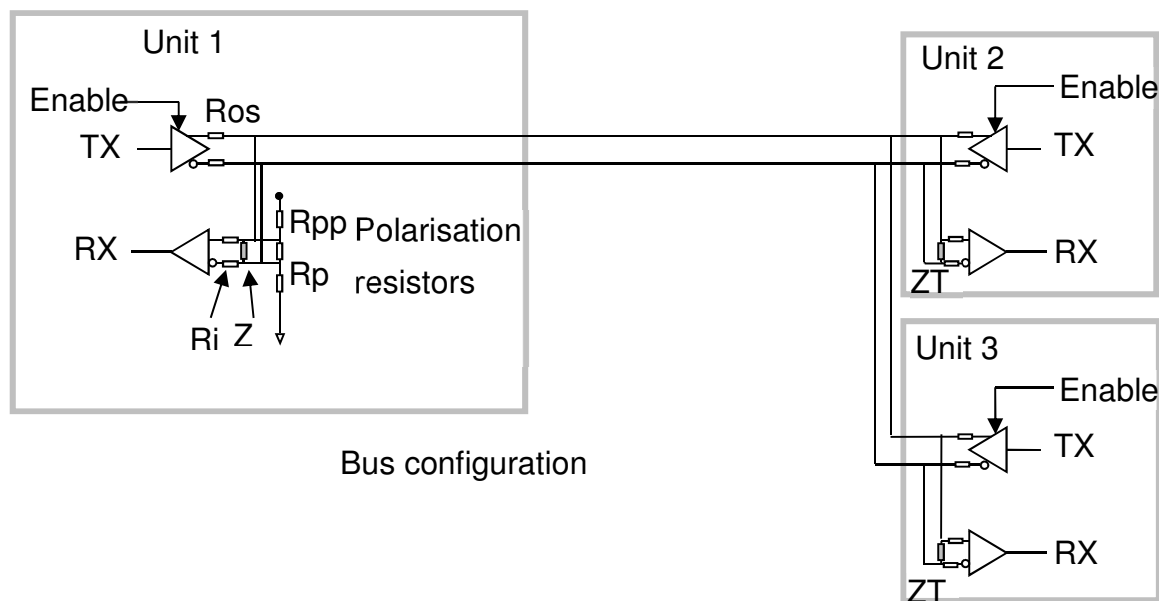


Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 8.8.2 c

For information, the electrical schematic in case of multiple transceivers connected to the bus will be:

ISIS



7.4.9. Analogue Signal Monitor ASM1

7.4.9.1. Driver

ISIS-GDIR-REQ-70199 v: 1

ASM1 Driver: Circuit type shall be: Single ended or differential

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 5.2.2.1 a.1

ISIS-GDIR-REQ-70200 v: 1

ASM1 Driver: Transfer shall be: DC coupled

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 5.2.2.1 a.2

ISIS-GDIR-REQ-70201 v: 1

ASM1 Driver: Differential nominal output voltage range, Vout shall be: 0 V to +5 V

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 5.2.2.1 a.4(a)

ISIS-GDIR-REQ-70202 v: 1

ASM1 Driver: Output impedance, Zout shall be: $\leq 5 \text{ k}\Omega$

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 5.2.2.1 a.5

ISIS-GDIR-REQ-70203 v: 1

ASM1 Driver: Fault voltage tolerance, Vsft shall be: -17,5 V to +17,5 V with an overvoltage source
impedance $> 1,0 \text{ k}\Omega$

Verification Method: A

ISIS

Standard Origin Source: ECSS-E-ST-50-14C 5.2.2.1 a.6

ISIS-GDIR-REQ-70204 v: 1

ASM1 Driver: Fault voltage emission, Vsfe shall be: -16,5 V to +16,5 V

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 5.2.2.1 a.7

7.4.9.2. Receiver

ISIS-GDIR-REQ-70205 v: 1

ASM1 Receiver: Circuit Type shall be: Differential receiver

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 5.2.2.2 a.1

ISIS-GDIR-REQ-70206 v: 1

ASM1 Receiver: Differential nominal input voltage range, Vin shall be: 0 V to +5 V

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 5.2.2.2 a.3(a)

ISIS-GDIR-REQ-70207 v: 1

ASM1 Receiver: ADC Resolution shall be: 12 bits

Verification Method: R

ISIS-GDIR-REQ-70208 v: 2

ASM1 Receiver: Measurement Chain Accuracy shall be: $\leq 1\%$ of the full scale, with details on offset and bias budget included in WCA.

Verification Method: A, T

ISIS-GDIR-REQ-70209 v: 1

ASM1 Receiver: Differential input impedance, Zis shall be: During and outside acquisition: $\geq 1 \text{ M}\Omega$

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 5.2.2.2 a.5, ECSS-E-ST-50-14C 5.2.2.2 a.6

ISIS-GDIR-REQ-70210 v: 1

ASM1 Receiver: Differential input impedance, Zis at power OFF shall be: $\geq 10 \text{ k}\Omega$

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 5.2.2.2 a.7

ISIS-GDIR-REQ-70211 v: 1

ASM1 Receiver: Low pass filtering shall be: $\leq 1 \text{ kHz}$ at 3dB

Verification Method: A

ISIS-GDIR-REQ-70212 v: 1

ASM1 Receiver: Fault voltage emission, Vrfe shall be: -16,5 V to +16,5 V with a series impedance 1,0 k Ω

ISIS

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 5.2.2.2 a.11

ISIS-GDIR-REQ-70213 v: 1

ASM1 Receiver: Fault voltage tolerance, V_{rft} shall be: -17,5V to +17,5 V

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 5.2.2.2 a.12

7.4.9.3. Harness

ISIS-GDIR-REQ-70214 v: 1

ASM1 Harness: Wire type shall be: Twisted Shielded Pair (TSP) or Twisted Pair (TP), AWG 26

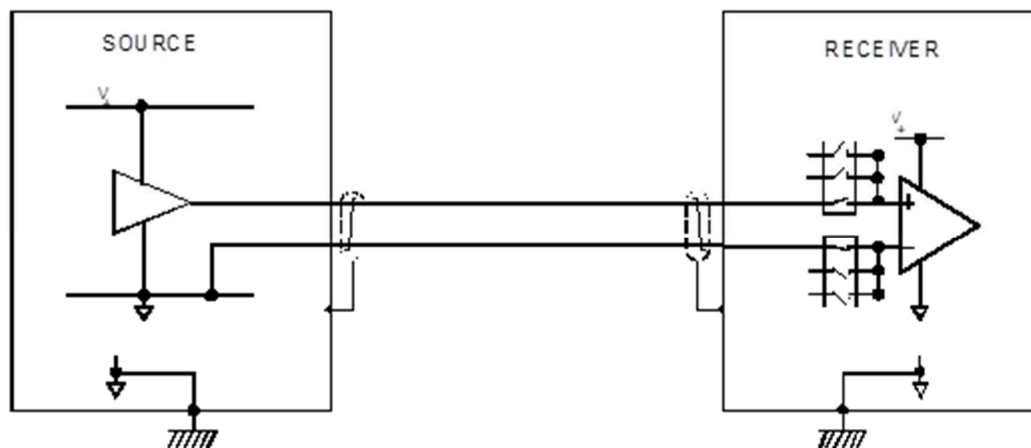
Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 5.2.2.3.1 a

7.4.9.4. Electrical schematic

ISIS-GDIR-REQ-70215 v: 1

ASM1 Electrical schematic: The electrical schematic shall be:



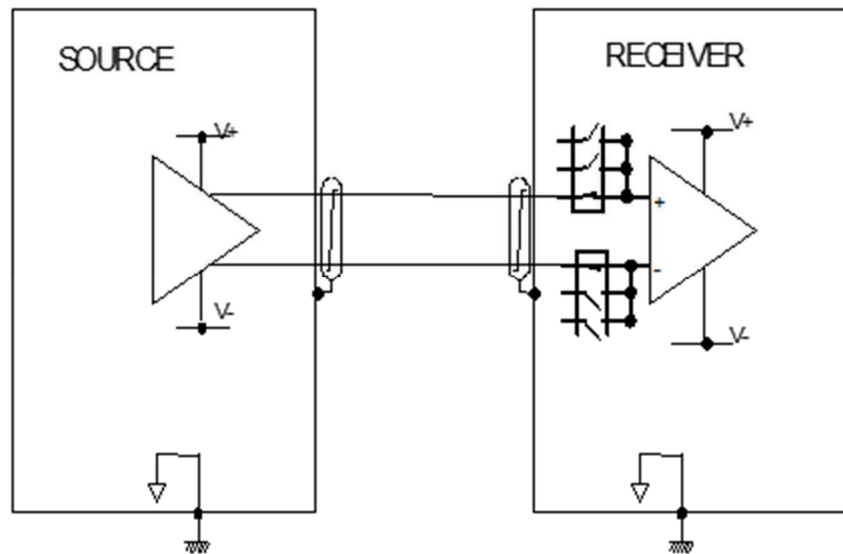
Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 5.2.2.4

ISIS-GDIR-REQ-70551 v: 1

ASM1 Electrical schematic in case of differential source shall be:

ISIS



Verification Method: R

7.4.10. Analogue Signal Monitor ASM2

7.4.10.1. Driver

ISIS-GDIR-REQ-70216 v: 1

ASM2 Driver: Circuit type shall be: Single ended or differential

Verification Method: R

ISIS-GDIR-REQ-70217 v: 1

ASM2 Driver: Transfer shall be: DC coupled

Verification Method: R

ISIS-GDIR-REQ-70218 v: 1

ASM2 Driver: Differential nominal output voltage range, V_{out} shall be: -5 V to +5 V

Verification Method: A, T

ISIS-GDIR-REQ-70221 v: 1

ASM2 Driver: Output impedance, Z_{out} shall be: $\leq 5 \text{ k}\Omega$

Verification Method: A

ISIS-GDIR-REQ-70222 v: 1

ASM2 Driver: Fault voltage tolerance, V_{sft} shall be: -17,5 V to +17,5 V with an overvoltage source impedance $> 1,0 \text{ k}\Omega$

Verification Method: A

ISIS-GDIR-REQ-70223 v: 1

ASM2 Driver: Fault voltage emission, V_{sfe} shall be: -16,5 V to +16,5 V

Verification Method: A

ISIS

7.4.10.2. Receiver

ISIS-GDIR-REQ-70224 v: 1

ASM2 Receiver: Circuit Type shall be: Differential receiver

Verification Method: R

ISIS-GDIR-REQ-70225 v: 1

ASM2 Receiver: Differential nominal input voltage range, V_{in} shall be: -5 V to +5 V

Verification Method: A, T

ISIS-GDIR-REQ-70219 v: 2

ASM2 Receiver: ADC Resolution shall be: 12 bits

Verification Method: R

ISIS-GDIR-REQ-70220 v: 3

ASM2 Receiver: Measurement Chain Accuracy shall be: $\leq 1\%$ of the full scale, with details on offset and bias budget included in WCA.

Verification Method: A, T

ISIS-GDIR-REQ-70226 v: 1

ASM2 Receiver: Differential input impedance, Z_{is} shall be: During and outside acquisition: $\geq 1\text{ M}\Omega$

Verification Method: A

ISIS-GDIR-REQ-70227 v: 1

ASM2 Receiver: Differential input impedance, Z_{is} at power OFF shall be: $\geq 10\text{ k}\Omega$

Verification Method: A

ISIS-GDIR-REQ-70228 v: 1

ASM2 Receiver: Low pass filtering shall be: $\leq 1\text{ kHz}$ at 3dB

Verification Method: A

ISIS-GDIR-REQ-70229 v: 1

ASM2 Receiver: Fault voltage emission, V_{rfe} shall be: -16,5 V to +16,5 V with a series impedance 1,0 k Ω

Verification Method: A

ISIS-GDIR-REQ-70230 v: 1

ASM2 Receiver: Fault voltage tolerance, V_{rft} shall be: -17,5V to +17,5 V

Verification Method: A

7.4.10.3. Harness

ISIS-GDIR-REQ-70231 v: 1

ASM2 Harness: Wire type shall be: Twisted Shielded Pair (TSP) or Twisted Pair (TP), AWG 26

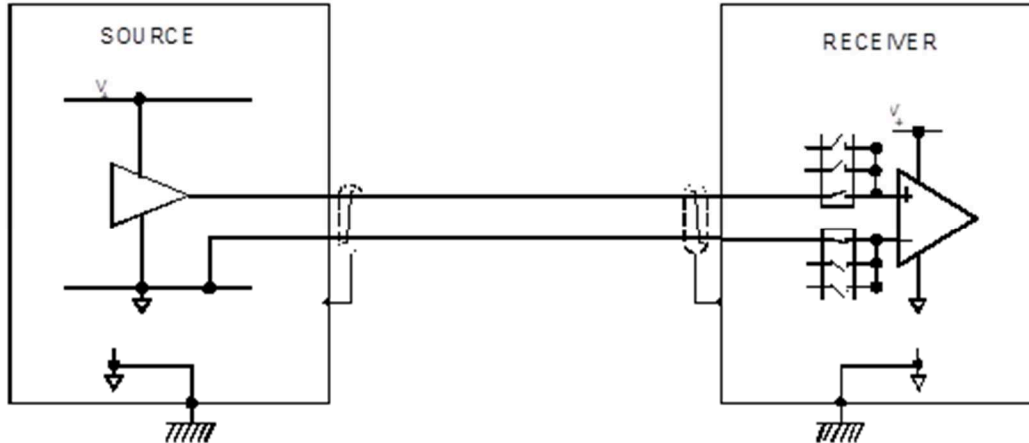
Verification Method: R

ISIS

7.4.10.4. Electrical schematic

ISIS-GDIR-REQ-70232 v: 1

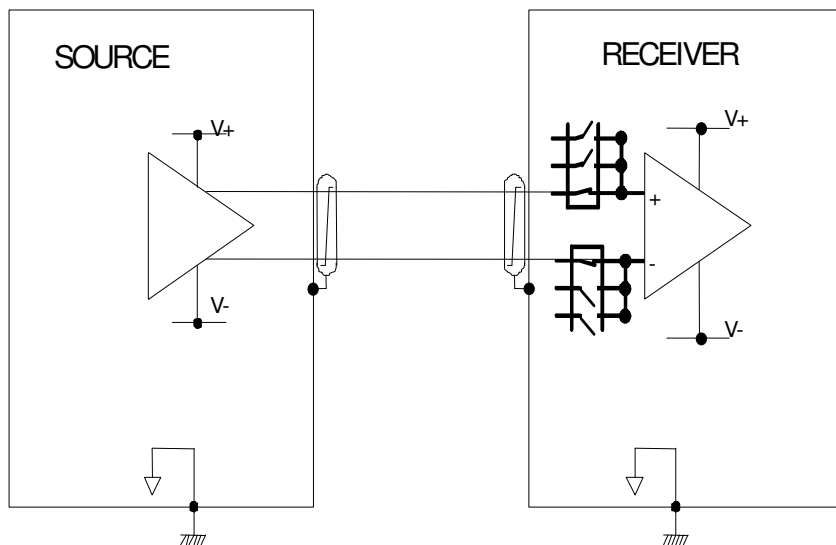
ASM2 Electrical schematic: The electrical schematic shall be:



Verification Method: R

ISIS-GDIR-REQ-70552 v: 1

ASM2 Electrical schematic in case of differential source shall be:



Verification Method: R

7.4.11. Analogue Signal Monitor ASM3

7.4.11.1. Driver

ISIS-GDIR-REQ-70233 v: 1

ASM3 Driver: Circuit type shall be: Single ended or differential

Verification Method: R

ISIS

ISIS-GDIR-REQ-70234 v: 1

ASM3 Driver: Transfer shall be: DC coupled

Verification Method: R

ISIS-GDIR-REQ-70235 v: 1

ASM3 Driver: Differential nominal output voltage range, Vout shall be: -10 V to +10 V

Verification Method: A, T

ISIS-GDIR-REQ-70238 v: 1

ASM3 Driver: Output impedance, Zout shall be: $\leq 5 \text{ k}\Omega$

Verification Method: A

ISIS-GDIR-REQ-70239 v: 1

ASM3 Driver: Fault voltage tolerance, Vsft shall be: -17,5 V to +17,5 V with an overvoltage source impedance $> 1,0 \text{ k}\Omega$

Verification Method: A

ISIS-GDIR-REQ-70240 v: 1

ASM3 Driver: Fault voltage emission, Vsfe shall be: -16,5 V to +16,5 V

Verification Method: A

7.4.11.2. Receiver

ISIS-GDIR-REQ-70241 v: 1

ASM3 Receiver: Circuit Type shall be: Differential receiver

Verification Method: R

ISIS-GDIR-REQ-70242 v: 1

ASM3 Receiver: Differential nominal input voltage range, Vin shall be: -10 V to +10 V

Verification Method: A, T

ISIS-GDIR-REQ-70236 v: 2

ASM3 Receiver: ADC Resolution shall be: 12 bits

Verification Method: R

ISIS-GDIR-REQ-70237 v: 3

ASM3 Receiver: Measurement Chain Accuracy shall be: $\leq 1\%$ of the full scale, with details on offset and bias budget included in WCA.

Verification Method: A, T

ISIS-GDIR-REQ-70243 v: 1

ASM3 Receiver: Differential input impedance, Zis shall be: During and outside acquisition: $\geq 1 \text{ M}\Omega$

Verification Method: A

ISIS-GDIR-REQ-70244 v: 2

ASM3 Receiver: Differential input impedance, Zis at power OFF shall be: $\geq 10 \text{ k}\Omega$

ISIS

Verification Method: A

ISIS-GDIR-REQ-70245 v: 1

ASM3 Receiver: Low pass filtering shall be: $\leq 1\text{ kHz}$ at 3dB

Verification Method: A

ISIS-GDIR-REQ-70246 v: 1

ASM3 Receiver: Fault voltage emission, V_{rfe} shall be: $-16,5\text{ V}$ to $+16,5\text{ V}$ with a series impedance $1,0\text{ k}\Omega$

Verification Method: A

ISIS-GDIR-REQ-70247 v: 1

ASM3 Receiver: Fault voltage tolerance, V_{rft} shall be: $-17,5\text{ V}$ to $+17,5\text{ V}$

Verification Method: A

7.4.11.3. Harness

ISIS-GDIR-REQ-70248 v: 1

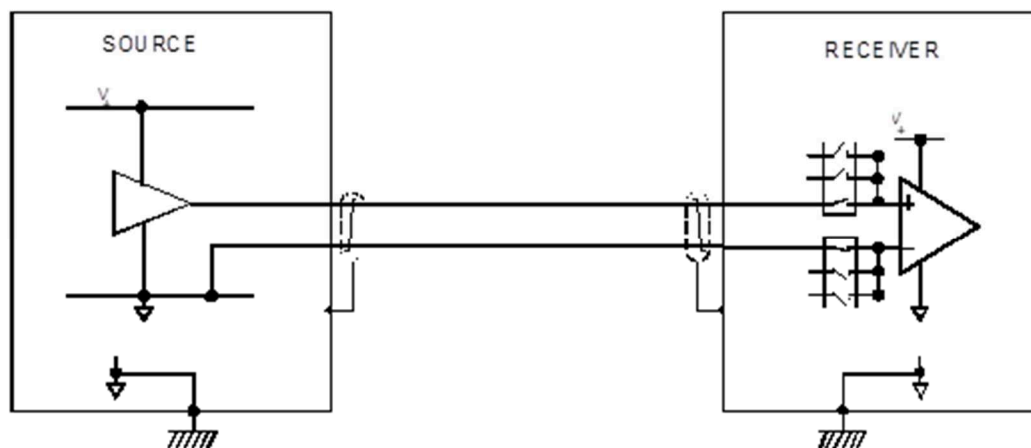
ASM3 Harness: Wire type shall be: Twisted Shielded Pair (TSP) or Twisted Pair (TP), AWG 26

Verification Method: R

7.4.11.4. Electrical schematic

ISIS-GDIR-REQ-70249 v: 1

ASM3 Electrical schematic: The electrical schematic shall be:

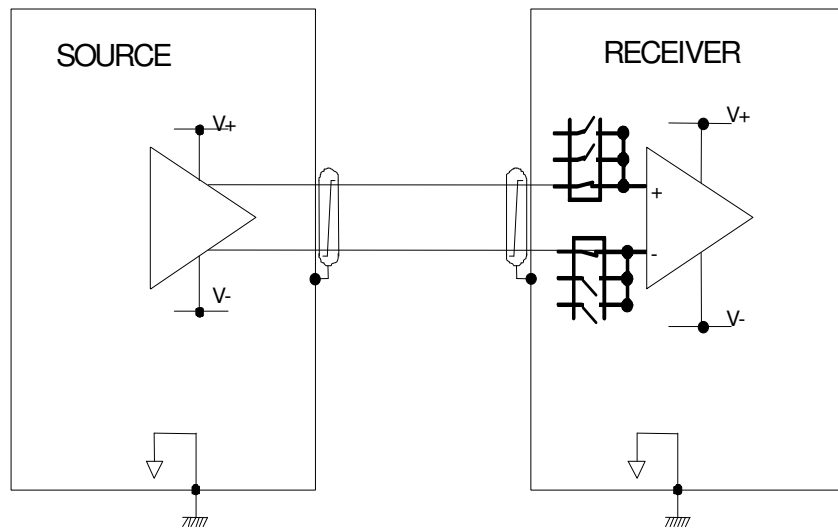


Verification Method: R

ISIS-GDIR-REQ-70553 v: 1

ASM3 Electrical schematic in case of differential source shall be:

ISIS



Verification Method: R

7.4.12. Temperature Sensor monitor TSM1

7.4.12.1. Driver

ISIS-GDIR-REQ-70250 v: 1

TSM1 Driver: Circuit type shall be: Floating Resistive sensor

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 5.3.5.1.3 a.1

ISIS-GDIR-REQ-70251 v: 2

TSM1 Driver: Temperature sensor type shall be within YSI-44900 series thermistors components: part numbers YSI-44907 or YSI-44908 (10 k Ω @ 25°C)

Verification Method: R

ISIS-GDIR-REQ-70252 v: 2

TSM1 Driver: Temperature sensor type shall be within Fenwall/Betatherm series thermistors components: (15 k Ω @ 25°C)

Verification Method: R

ISIS-GDIR-REQ-70253 v: 1

TSM1 Driver: Transfer shall be: DC coupled

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 5.3.5.1.3 a.2

ISIS-GDIR-REQ-70254 v: 1

TSM1 Driver: Resistance range, R_s shall be: 0 to $\infty \Omega$

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 5.3.5.1.3 a.3

ISIS

ISIS-GDIR-REQ-70255 v: 1

TSM1 Driver: Fault voltage tolerance, Vsft shall be: -17,5 V to +17,5 V with an overvoltage source impedance $\geq 1 \text{ k}\Omega$

Comment: Under failure of driver, the thermistance shall be inside max. rating (max T°C).

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 5.3.5.1.3 a.4

7.4.12.2. Receiver

ISIS-GDIR-REQ-70256 v: 1

TSM1 Receiver: Circuit Type shall be: Single ended Receiver

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 5.3.5.1.4 a.1

ISIS-GDIR-REQ-70257 v: 3

TSM1 Receiver: Measurement chain accuracy (including temperature sensor and harness) for uncalibrated channel shall be: better than +/- 3K from -50°C to -5°C
better than +/- 2K from -5°C to +70°C

Verification Method: A, T

ISIS-GDIR-REQ-70258 v: 3

TSM1 Receiver: Measurement chain accuracy (including temperature sensor and harness) for calibrated channel shall be: better than +/- 1K from -50°C to -5°C
better than +/- 0.5K from -5°C to +70°C

Verification Method: A, T

ISIS-GDIR-REQ-70259 v: 1

TSM1 Receiver: Injected dissipation in driver shall be: $\leq 1 \text{ mW}$

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 5.3.5.1.4 a.3

ISIS-GDIR-REQ-70260 v: 1

TSM1 Receiver: Low pass filtering shall be: $\leq 500\text{Hz}$ at 3dB

Verification Method: A

ISIS-GDIR-REQ-70261 v: 1

TSM1 Receiver: Fault voltage emission, Vrfe shall be: -16,5 V to +16,5 V with a source impedance of $\geq 1 \text{ k}\Omega$

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 5.3.5.1.4 a.6

ISIS-GDIR-REQ-70262 v: 1

TSM1 Receiver: Fault resistance tolerance, Rrft shall be: Short circuit to ground

Verification Method: A

ISIS

Standard Origin Source: ECSS-E-ST-50-14C 5.3.5.1.4 a.7

7.4.12.3. Harness

ISIS-GDIR-REQ-70263 v: 1

TSM1 Harness: Wire type shall be: Twisted Pair (TP), AWG 26

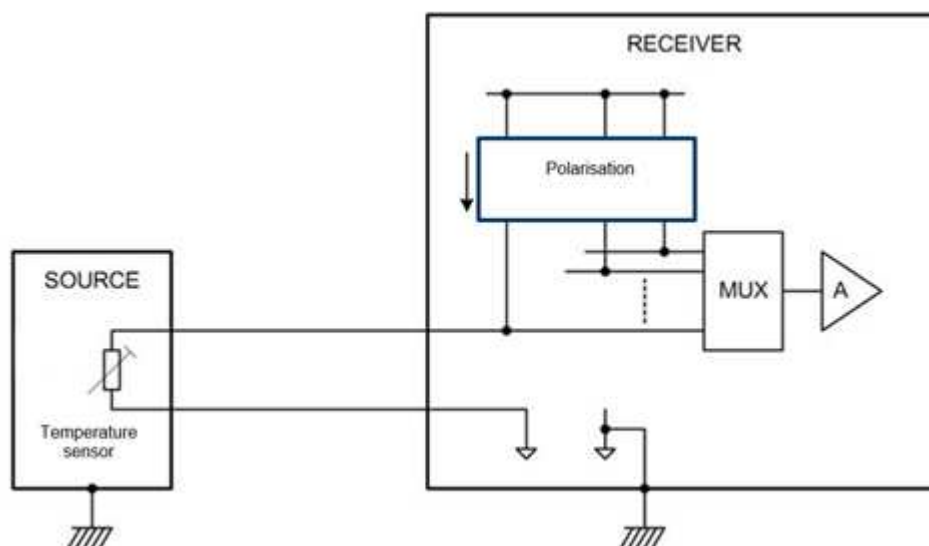
Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 5.3.5.1.5 a

7.4.12.4. Electrical schematic

ISIS-GDIR-REQ-70264 v: 2 w

TSM1 Electrical schematic: The electrical schematic shall be:



Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 5.3.5.1.6

7.4.13. Temperature Sensor monitor TSM2

7.4.13.1. Driver

ISIS-GDIR-REQ-70265 v: 1

TSM2 Driver: Circuit type shall be: Floating Resistive sensor

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 5.3.5.2.3 a.1

ISIS-GDIR-REQ-70266 v: 2

TSM2 Driver: Temperature sensor type shall be within GOODRICH Rosemount platinum resistance surface temperature sensor series: PT2000 (2kΩ @ 0°C)

ISIS

Verification Method: R

ISIS-GDIR-REQ-70267 v: 2

TSM2 Driver: Temperature sensor type shall be within GOODRICH Rosemount platinum resistance surface temperature sensor series: PT1000 (1k Ω @ 0°C)

Verification Method: R

ISIS-GDIR-REQ-70268 v: 1

TSM2 Driver: Transfer shall be: DC coupled

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 5.3.5.2.3 a.2

ISIS-GDIR-REQ-70269 v: 1

TSM2 Driver: Resistance range, R_s shall be: 0 Ω to 5k Ω

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 5.3.5.2.3 a.3

ISIS-GDIR-REQ-70270 v: 1

TSM2 Driver: Fault voltage tolerance, V_{sft} shall be: -17,5 V to +17,5 V with an overvoltage source impedance ≥ 1 k Ω

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 5.3.5.2.3 a.4

7.4.13.2. Receiver

ISIS-GDIR-REQ-70271 v: 1

TSM2 Receiver: Circuit Type shall be: Single ended Receiver

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 5.3.5.2.4 a.1

ISIS-GDIR-REQ-70272 v: 2

TSM2 Receiver: Measurement chain accuracy (including temperature sensor and harness) for uncalibrated channel shall be: better than +/- 2K from -150°C to +150°C

Verification Method: A, T

ISIS-GDIR-REQ-70273 v: 2

TSM2 Receiver: Measurement chain accuracy (including temperature sensor and harness) for calibrated channel shall be: better than +/- 1K from -150°C to +150°C

Verification Method: A, T

ISIS-GDIR-REQ-70274 v: 1

TSM2 Receiver: Injected dissipation in driver shall be: ≤ 1 mW

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 5.3.5.2.4 a.3

ISIS-GDIR-REQ-70275 v: 1

ISIS

TSM2 Receiver: Low pass filtering shall be: $\leq 500\text{Hz}$ at 3dB

Verification Method: A

ISIS-GDIR-REQ-70276 v: 1

TSM2 Receiver: Fault voltage emission, V_{rfe} shall be: -16,5 V to +16,5 V with a source impedance of $\geq 1\text{k}\Omega$

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 5.3.5.2.4 a.6

ISIS-GDIR-REQ-70277 v: 1

TSM2 Receiver: Fault resistance tolerance, R_{rft} shall be: Short circuit to ground

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 5.3.5.2.4 a.7

7.4.13.3. Harness

ISIS-GDIR-REQ-70278 v: 1

TSM2 Harness: Wire type shall be: Twisted Pair (TP), AWG 26

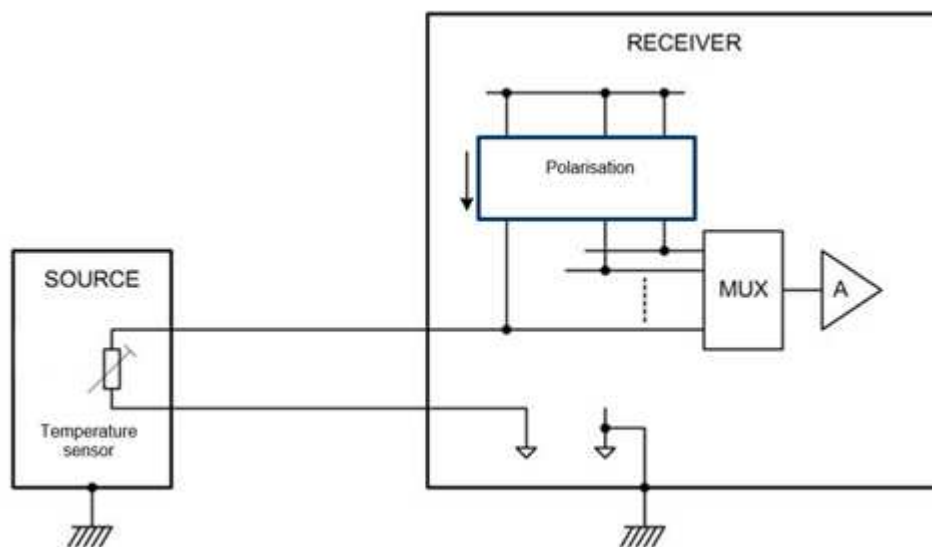
Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 5.3.5.3.1 a

7.4.13.4. Electrical schematic

ISIS-GDIR-REQ-70279 v: 2 w

TSM2 Electrical schematic: The electrical schematic shall be:



Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 5.3.5.4

ISIS

7.4.14. Bi-level Switch Monitor BSM

7.4.14.1. Driver

ISIS-GDIR-REQ-70280 v: 1

BSM Driver: Circuit type shall be: Floating Relay contact

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 6.2.2.1 a.1

ISIS-GDIR-REQ-70281 v: 1

BSM Driver: Transfer shall be: DC coupled

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 6.2.2.1 a.2

ISIS-GDIR-REQ-70282 v: 1

BSM Driver: Operating current, Iop shall be: Up to 10 mA

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 6.2.2.1 a.3

ISIS-GDIR-REQ-70283 v: 1

BSM Driver: Operating voltage (open circuit), Vop shall be: Up to 15 V

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 6.2.2.1 a.4

ISIS-GDIR-REQ-70284 v: 1

BSM Driver: Switch closed resistance, RC shall be: $\leq 50 \Omega$

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 6.2.2.1 a.5

ISIS-GDIR-REQ-70285 v: 1

BSM Driver: Switch open resistance, RO shall be: $\geq 1 M\Omega$

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 6.2.2.1 a.6

ISIS-GDIR-REQ-70286 v: 1

BSM Driver: Fault voltage emission, V_{rfe} shall be: -17,5 V to +17,5 V with a source impedance of 1,0 k Ω

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 6.2.2.1 a.7

7.4.14.2. Receiver

ISIS-GDIR-REQ-70287 v: 1

BSM Receiver: Circuit Type shall be: Single ended receiver with pull-up resistor

ISIS

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 6.2.2.2 a.1

ISIS-GDIR-REQ-70288 v: 1

BSM Receiver: Transfer shall be: DC coupled

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 6.2.2.2 a.2

ISIS-GDIR-REQ-70289 v: 1

BSM Receiver: Zero reference shall be: Signal ground

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 6.2.2.2 a.3

ISIS-GDIR-REQ-70290 v: 1

BSM Receiver: Output current, Iout shall be: 0,1 mA to 10 mA (when contacts closed)

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 6.2.2.2 a.4

ISIS-GDIR-REQ-70291 v: 1

BSM Receiver: Output voltage, Vout shall be: < 15 V (when contacts open)

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 6.2.2.2 a.5

ISIS-GDIR-REQ-70292 v: 1

BSM Receiver: Fault voltage emission, Vrfe shall be: -16,5 V to +16,5 V with a source impedance of $\geq 1,0 \text{ k}\Omega$

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 6.2.2.2 a.6

ISIS-GDIR-REQ-70293 v: 1

BSM Receiver: Fault tolerance, Vrft shall be: Short circuit to ground

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 6.2.2.2 a.7

7.4.14.3. Harness

ISIS-GDIR-REQ-70294 v: 1

BSM Harness: Wire type shall be: Twisted n-tuple, AWG 26

Verification Method: R

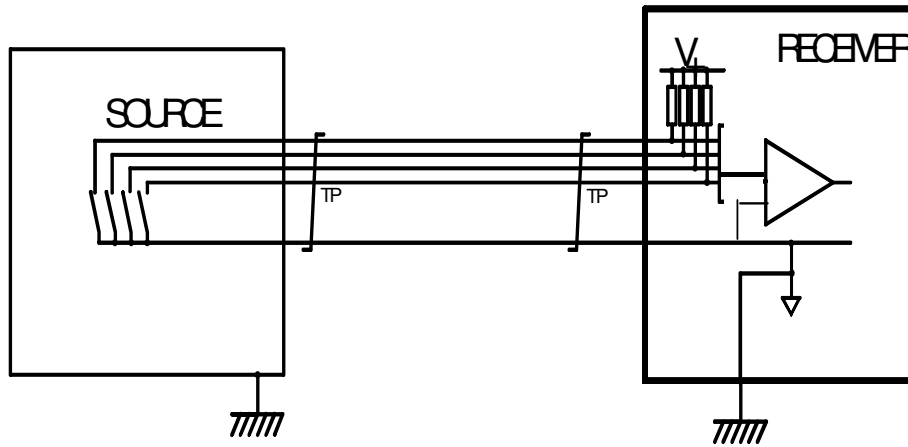
Standard Origin Source: ECSS-E-ST-50-14C 6.2.2.3.1 a

7.4.14.4. Electrical schematic

ISIS-GDIR-REQ-70295 v: 1

ISIS

BSM Electrical schematic: The electrical schematic shall be:



Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 6.2.2.4

7.4.15. Bi-level discrete monitor BDM

7.4.15.1. Driver

ISIS-GDIR-REQ-70296 v: 1

BDM Driver: Circuit type shall be: Single ended

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 6.1.2.2.1 a.1

ISIS-GDIR-REQ-70297 v: 1

BDM Driver: Transfer shall be: DC coupled

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 6.1.2.2.1 a.2

ISIS-GDIR-REQ-70298 v: 1

BDM Driver: Zero reference shall be: Signal ground

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 6.1.2.2.1 a.3

ISIS-GDIR-REQ-70299 v: 1

BDM Driver: Low output voltage, V_{Lout} shall be: 0 V to +0,5 V

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 6.1.2.2.1 a.4

ISIS-GDIR-REQ-70300 v: 1

BDM Driver: High output voltage, V_{Hout} shall be: 2.4 V to +5,5 V into receiver impedance Z_{in} load

Verification Method: A, T

ISIS

Standard Origin Source: ECSS-E-ST-50-14C 6.1.2.2.1 a.5

ISIS-GDIR-REQ-70301 v: 1

BDM Driver: Output impedance, Z_{out} shall be: $\leq 5 \text{ k}\Omega$

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 6.1.2.2.1 a.6

ISIS-GDIR-REQ-70302 v: 1

BDM Driver: Fault voltage emission, V_{sfe} shall be: -1 V to +7 V

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 6.1.2.2.1 a.7

ISIS-GDIR-REQ-70303 v: 1

BDM Driver: Fault voltage tolerance, V_{sft} shall be: -17,5 V to +17,5 V with an overvoltage source impedance of 1,0 k Ω

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 6.1.2.2.1 a.8

7.4.15.2. Receiver

ISIS-GDIR-REQ-70304 v: 1

BDM Receiver: Circuit Type shall be: Differential receiver

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 6.1.2.2.2 a.1

ISIS-GDIR-REQ-70305 v: 1

BDM Receiver: Transfer shall be: DC coupled

Verification Method: R

ISIS-GDIR-REQ-70306 v: 1

BDM Receiver: Low level differential input voltage, V_{Lin} shall be: 0 V to 0,9 V

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 6.1.2.2.2 a.3

ISIS-GDIR-REQ-70307 v: 1

BDM Receiver: High level differential input voltage, V_{Hin} shall be: 2,0 V to 5,5 V

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 6.1.2.2.2 a.4

ISIS-GDIR-REQ-70308 v: 1

BDM Receiver: Hysteresis ($V_{Hin} - V_{Lin}$) shall be: $\geq 1\text{V}$

Verification Method: A, T

ISIS-GDIR-REQ-70309 v: 1

BDM Receiver: Input impedance, Z_{in} shall be: During and outside acquisition: $\geq 100 \text{ k}\Omega$

ISIS

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-50-14C 6.1.2.2.2 a.6

ISIS-GDIR-REQ-70310 v: 1

BDM Receiver: Input impedance, Z_{in} at power OFF shall be: $\geq 10 \text{ k}\Omega$

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 6.1.2.2.2 a.6

ISIS-GDIR-REQ-70311 v: 1

BDM Receiver: Fault voltage emission, V_{rfe} shall be: -16,5 V to +16,5 V with a series impedance of 1,0 k Ω

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 6.1.2.2.2 a.7

ISIS-GDIR-REQ-70312 v: 1

BDM Receiver: Fault voltage tolerance, V_{rft} shall be: -2 V to +8 V

Verification Method: A

Standard Origin Source: ECSS-E-ST-50-14C 6.1.2.2.2 a.8

7.4.15.3. Harness

ISIS-GDIR-REQ-70313 v: 1

BDM Harness: Wire type shall be: Twisted Pair (TP) or Twisted Shielded Pair (TSP), AWG 26

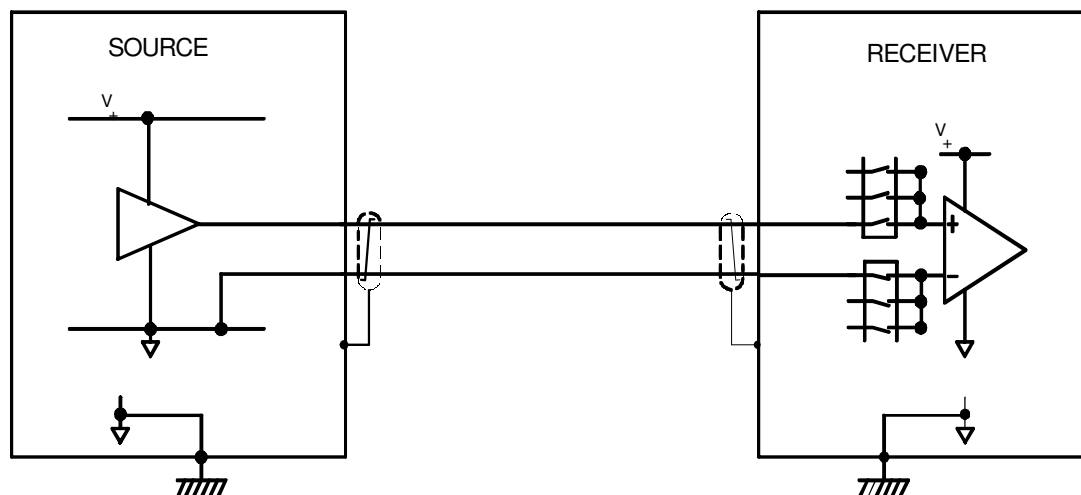
Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 6.1.2.3.1 a

7.4.15.4. Electrical schematic

ISIS-GDIR-REQ-70314 v: 1

BDM Electrical schematic: The electrical schematic shall be:



ISIS

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-14C 6.1.2.4

7.4.16. Low Level Differential Signal LVDS

7.4.16.1. Driver

ISIS-GDIR-REQ-70315 v: 1

LVDS Driver: Electrical characteristics shall be: Differential

Verification Method: R

ISIS-GDIR-REQ-70316 v: 1

LVDS Driver: Differential output voltage V_t shall be: $250 \text{ mV} \leq |V_t| \leq 450 \text{ mV}$ with $R_t = 100\Omega$

Verification Method: A, T

ISIS-GDIR-REQ-70317 v: 1

LVDS Driver: Differential output voltage variation ΔV_t shall be: $\Delta V_t \leq 0.2$. VSS with $R_t = 100\Omega$

Verification Method: A, T

ISIS-GDIR-REQ-70318 v: 2 w

LVDS Driver: Binary 1 state (see electrical schematic for A and B outputs) shall be: $V_A - V_B > 0$

Verification Method: A, T

ISIS-GDIR-REQ-70319 v: 1

LVDS Driver: Offset output voltage V_{os} shall be: $1.125\text{V} \leq |V_{os}| \leq 1.375\text{V}$ with $R_t = 100\Omega$

Verification Method: A, T

ISIS-GDIR-REQ-70320 v: 1

LVDS Driver: Short circuit output current, I_{SA} or I_{SB} shall be: $\leq 24 \text{ mA}$ for each terminal to ground

Verification Method: A

ISIS-GDIR-REQ-70321 v: 1

LVDS Driver: Short circuit output current, I_{AB} shall be: $\leq 12 \text{ mA}$ for output terminal shorted to other

Verification Method: A

ISIS-GDIR-REQ-70322 v: 3

LVDS Driver: Rise time (T_r) and fall time (T_f) shall satisfy:

$260 \text{ pico-seconds} \leq T_r \leq 0.3 * T_{ui}$

$260 \text{ pico-seconds} \leq T_f \leq 0.3 * T_{ui}$

with $T_r = 100\Omega$.

Verification Method: A, T

ISIS-GDIR-REQ-70323 v: 1

LVDS Driver: Output voltage change shall be: monotonically from 0.2 and 0.8 of VSS

ISIS

Verification Method: A, T

ISIS-GDIR-REQ-70324 v: 1

LVDS Driver: Fault voltage emission, Vsfe shall be: 0 V to 3.6 V

Verification Method: A

ISIS-GDIR-REQ-70325 v: 1

LVDS Driver: Fault voltage tolerance, Vsft shall be: 0 V to 3.6 V

Verification Method: A

7.4.16.2. Receiver

ISIS-GDIR-REQ-70326 v: 1

LVDS Receiver: Circuit Type shall be: Differential receiver

Verification Method: R

ISIS-GDIR-REQ-70327 v: 1

LVDS Receiver: Common Mode input voltage shall be: 0V to 2.4V

Verification Method: A, T

ISIS-GDIR-REQ-70328 v: 1

LVDS Receiver: Differential input voltage Vind shall be: 0.4V to 0.6V

Verification Method: A, T

ISIS-GDIR-REQ-70329 v: 1

LVDS Receiver: Input voltage threshold shall be: 100 mV (with VCM between +50mV and 2.35V)

Verification Method: A, T

ISIS-GDIR-REQ-70330 v: 1

LVDS Receiver: Input termination network shall be: 90Ω to 132Ω

Verification Method: R

ISIS-GDIR-REQ-70331 v: 1

LVDS Receiver: A high level shall be detected when the generator is not connected or in power off or when the interconnecting cable is in short circuit.

Verification Method: A, T

ISIS-GDIR-REQ-70332 v: 1

LVDS Receiver: Fault voltage emission, Vsfe shall be: 0 V to 3.6 V

Verification Method: A

ISIS-GDIR-REQ-70333 v: 1

LVDS Receiver: Fault voltage tolerance, Vsft shall be: ≤ 2.4V

Verification Method: A

ISIS-GDIR-REQ-70589 v: 1 w

ISIS

LVDS Receiver: Binary 1 state (see electrical schematic for A and B outputs) shall be: $V_A - V_B > 0$

Verification Method: A, T

7.4.16.3. Harness

ISIS-GDIR-REQ-70334 v: 1

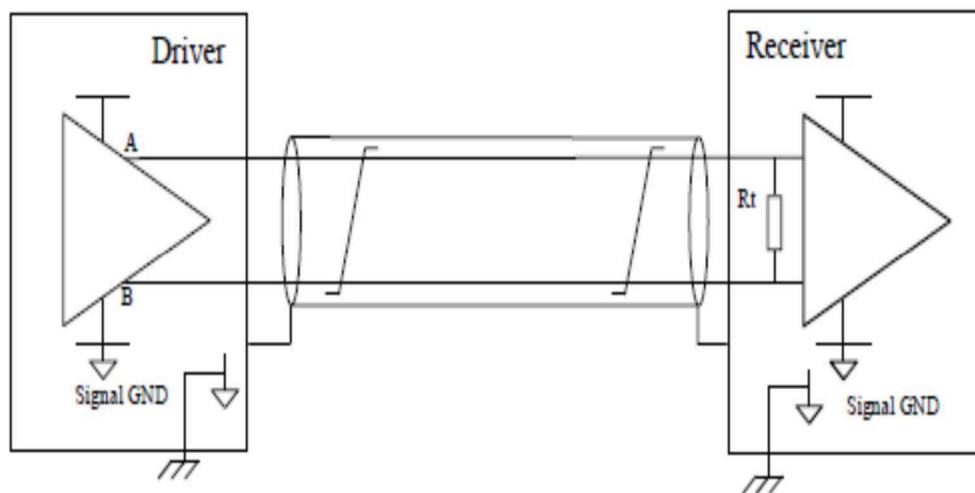
LVDS Harness: Wire type shall be: Twisted Shielded Pair (TSP)

Verification Method: R

7.4.16.4. Electrical schematic

ISIS-GDIR-REQ-70335 v: 1

LVDS Electrical schematic: The electrical schematic shall be:

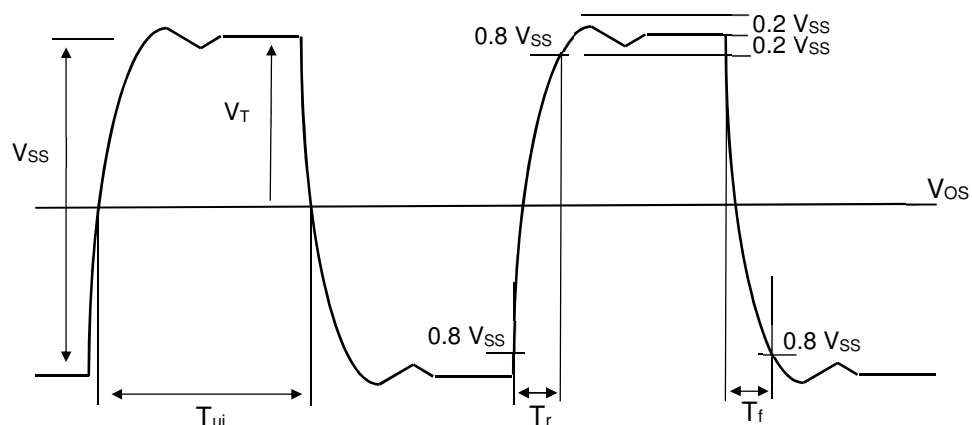


Comment: VA: Non inverted output (Out+)

VB: Inverted output (Out-)

Verification Method: R

Typical LVDS waveform:



ISIS

7.4.17. MIL-STD-1553

Reference document: MIL STD 1553B

ISIS-GDIR-REQ-70336 v: 2

| Data Handling units shall include redundant BC.

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-13 5.2.a

ISIS-GDIR-REQ-70555 v: 1

| Each data bus subscriber equipment shall comply with MIL-STD-1553 B + Notice 3 standard.

Verification Method: R

ISIS-GDIR-REQ-70556 v: 1

| All units (BC or RT) shall be configured in long stub, transformer-coupled connection.

Verification Method: R

ISIS-GDIR-REQ-70557 v: 1

| The maximum length of the long stub shall be 6 meters.

Verification Method: R

ISIS-GDIR-REQ-70558 v: 1

| Only one RT shall be connected to a stub cable.

Verification Method: R

ISIS-GDIR-REQ-70559 v: 1

| Each RT (N&R) shall be connected to both 1553 buses (N&R).

Verification Method: R

ISIS-GDIR-REQ-70560 v: 1

| Each stub shall be grounded inside each RT or BC derivation by a redundant resistor.

Verification Method: R

ISIS-GDIR-REQ-70561 v: 1

| Each RT shall be segregated by an individual RT address, which shall be programmable on an external connector of the units.

Verification Method: R

ISIS-GDIR-REQ-70562 v: 1

| The 1553-bus shall be connected on separate connectors. No other signals shall be on these connectors.

Verification Method: R

ISIS-GDIR-REQ-70563 v: 1

| Unless otherwise agreed with the Prime Contractor, the connection between a remote terminal equipment and the MIL-STD-1553 B bus stubs shall be performed via a Cannon 9P equipment connector, according to the following pin function:

ISIS

pin 1 1553 B bus Prime Signal
pin 2 not connected
pin 3 not connected
pin 4 not connected
pin 5 1553 B bus Redundant Signal
pin 6 1553 B bus Prime Return
pin 7 not connected
pin 8 not connected
pin 9 1553 B bus Redundant return
Backshell All cable shields

Verification Method: R

ISIS-GDIR-REQ-70565 v: 1

Unless otherwise agreed with the Prime Contractor, the remote terminal address definition shall be performed on a dedicated Cannon 9 S equipment connector, according to the following pin functions:

- pin 1 remote terminal address bit no. 4 (MSB)
- pin 2 remote terminal address bit no. 3
- pin 3 remote terminal address bit no. 2
- pin 4 remote terminal address bit no. 1
- pin 5 remote terminal address bit no. 0 (LSB)
- pin 6 remote terminal address parity bit
- pin 7 secondary 0V
- pin 8 secondary 0V
- pin 9 not connected

Concerning remote terminal address definition pins (bits 4 to 0 and parity), a logical << 1 >> level shall be obtained by floating the corresponding pin (no connection at harness connector level);

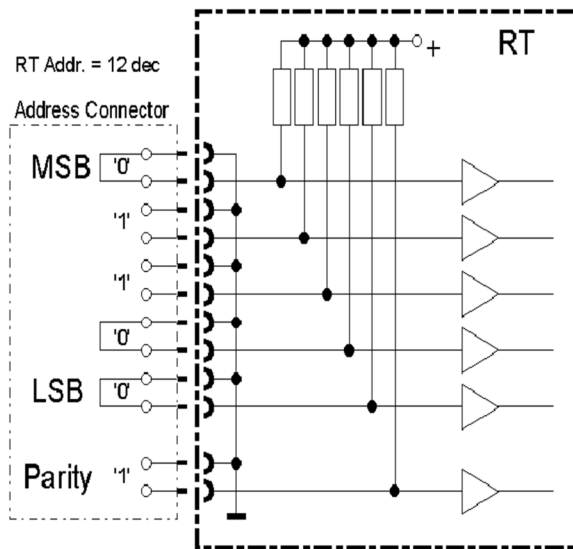
adequate filtering shall be provided inside the unit on those signals. A logical <<0>> level shall be obtained by connecting the corresponding pin to the secondary 0V pin at harness level;

the current in each remote terminal address definition pin shall not exceed 10 mA when programmed to logical level <<0>>.

Verification Method: R

An implementation example of an address coding connector is shown in next figure. All address and parity lines have pull-up resistors, so that a '0' on a line is coded by connecting it to a common secondary return (secondary 0 volt). The type of Parity is odd.

ISIS



7.4.17.1. BC/RT Test Requirements

ISIS-GDIR-REQ-70567 v: 1

Several levels of 1553-B bus interfaces are considered at this level depending on the level of qualification of each "chip set" implemented in the unit (each 1553 function being split in 3 parts: One ASIC or equivalent in charge of protocol handling, one transceiver in charge of the electrical driver/reception function and one transformer)

- A level: Both ASIC (or equivalent) and transceiver have already been qualified successfully in a space program towards the MIL 1553B standard validation test plan.
- B level: Only the ASIC (or equivalent) has been qualified.
- C level: ASIC has not been qualified.

Verification Method: R

ISIS-GDIR-REQ-70568 v: 1

For each part assessed as already qualified, the sub contractor shall provide the qualification documentation and shall demonstrate the qualification completeness.

Verification Method: A, R

ISIS-GDIR-REQ-70569 v: 2 w

The tests corresponding to SAE AS4111, AS4112, AS4113 and AS4114 test plans shall be performed for the unit validation (EQM or PFM) and production (FM).

Verification Method: A, R

ISIS-GDIR-REQ-70570 v: 2 w

These tests shall be performed in ambient conditions if qualification of the 1553B chip set has been demonstrated in an environment compatible with the project unit one. If not these tests will be performed during temperature qualification tests of the unit itself.

Verification Method: A, R

ISIS

7.4.18. Spacewire links

ISIS-GDIR-REQ-70359 v: 1

Spacewire links shall be conform with ECSS-E-ST-50-12C.

Verification Method: R

Standard Origin Source: ECSS-E-ST-50-12C

7.4.18.1. Driver

Spacewire links Driver: Electrical characteristics

7.4.18.2. Receiver

Spacewire links Receiver: Circuit Type

7.4.18.3. Harness

ISIS-GDIR-REQ-70360 v: 1

Spacewire links Harness: Wire type shall be: Twisted Shielded Pairs (TSP)

Verification Method: R

7.4.19. Electro Explosive Device and Non Explosive Actuator

This section describes the Electro Explosive Device (EED) and the Non Explosive Actuator (NEA) interface characteristics.

7.4.19.1. Driver

ISIS-GDIR-REQ-70361 v: 3 w

EED and NEA Driver: It shall be able to set the firing pulse duration from 20ms to 50ms

Verification Method: A, T

ISIS-GDIR-REQ-70363 v: 2 w

EED and NEA Driver: Firing current shall be: [5.0A ; 8.0A]

Verification Method: A, T

ISIS-GDIR-REQ-70364 v: 3 w

EED and NEA Driver: Bleeder resistors (connection between circuit and ground structure) shall be: 1MΩ typically

Verification Method: R

7.4.19.2. Receiver

ISIS-GDIR-REQ-70365 v: 2 w

ISIS

EED and NEA Receiver: No fired current shall be: 0,25A during 5 minutes

Verification Method: A

ISIS-GDIR-REQ-70366 v: 2 w

EED and NEA Receiver: Firing current shall be: 4A maximum during 40ms maximum

Verification Method: A, T

ISIS-GDIR-REQ-70367 v: 2 w

EED and NEA Receiver: Input resistance shall be: $\leq 2\Omega$

Verification Method: A, T

ISIS-GDIR-REQ-70368 v: 2 w

EED and NEA Receiver: Isolation resistance between filaments and actuator case before firing shall be: $\geq 1M\Omega$

Verification Method: A, T

7.4.19.3. Harness

ISIS-GDIR-REQ-70369 v: 2 w

EED and NEA Harness: Wire type shall be: Twisted Shielded Pair (TSP)

Verification Method: R

7.5. GROUNDING, BONDING AND ISOLATION

7.5.1. Structure Bonding

Structure bonding is the method by which all the conductive elements are electrically connected in order to minimise any potential differences and flow of electrical current.

See also ECSS-E-ST-20-07C §4.2.10

7.5.1.1. General bonding requirements

ISIS-GDIR-REQ-70370 v: 1

All electrical conductive components of the structure including all metallic or carbon fiber items shall be electrically connected.

Verification Method: R

ISIS-GDIR-REQ-70371 v: 1

The bonding requirements are such that all equipment primary and secondary structures supporting or containing electrical-electronic assemblies shall be bonded by one of the following methods, listed by order of preference:

- direct inherent bond by welding, brazing, soldering, etc...
- direct semi-permanent bond, where clean metal areas are mated with a fastening method that exerts sufficient pressure to withstand deforming stresses, shocks and vibrations

ISIS

- riveting joints where at least three rivets are driven tight per joint
- clamped metallic fittings, normally permanent and immovable after installation
- lock-threaded devices (bolts, nuts, studs, lock-washers)
- indirect bond, bonded to each of the members using a strap of solid flat metal.

Verification Method: A, R

ISIS-GDIR-REQ-70372 v: 2

If dissimilar materials are bonded, the relative areas of the anode and the cathodes are important and finishing shall be applied on both materials.

Verification Method: A, R

ISIS-GDIR-REQ-70373 v: 2 w

Bonding of dissimilar metals shall consider the compatibility matrix defined within following Table:

ISIS

Pure metals and alloys in alphabetical order (including carbon)	Aluminum-Copper alloys	Al (pure), Al-Zinc alloys	Cadmium	Cast iron (austenitic)	Chromium	Copper, Brasses	Cupro-Nickel, Al-bronzes, Si-bronzes	Gold, Platinum, Carbon, Rhodium	Gun-metal (CuZn10 alloy), P-bronzes, Sn-bronzes	Magnesium	Nickel, Monel, Inconel, Nickel/Molybdenum-alloys	Silver	Sn-Pb alloys (all), Tin, Lead	Stainless steel 18/8 (300 series)	Stainless steel 13Cr (400 series)	Steel (carbon, low alloy), Cast iron	Titanium and Ti-alloys	Zinc, Beryllium
Aluminum-Copper alloys		1	1	3	3	3	3	3	3	3	3	3	1	3	3	3	3	3
Al (pure)			1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Al-Zinc alloys				3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Cadmium				2	2	2	2	2	2	1	2	2	0	1	1	2	2	2
Cast iron (austenitic)					1	1	1	2	1	3	1	2	1	1	1	2	1	3
Chromium						1	0	0	1	3	1	0	2	0	0	2	0	3
Copper, Brasses							0	2	0	3	1	1	2	1	1	3	0	3
Cupro-Nickel																		
Al-bronzes								2	0	3	1	1	2	2	1	3	0	3
Si-bronzes																		
Gold																		
Platinum, Carbon, Rhodium									2	3	2	0	3	0	1	3	0	3
Gun-metal (CuZn10 alloy)																		
P-bronzes										3	1	1	1	0	0	3	0	3
Sn-bronzes																		
Magnesium											3	3	2	3	3	3	3	3
Nickel																		
Monel												2	2	1	0	2	1	3
Inconel																		
Nickel/Molybdenum-alloys																		
Silver													3	0	0	3	0	3
Sn-Pb alloys (all)														1	1	1	3	1
Tin, Lead																		
Stainless steel 18/8 (300 series)															1	3	0	3
Stainless steel 13Cr (400 series)																3	0	3
Steel (carbon, low alloy)																		
Cast iron																	0	3
Titanium and Ti-alloys																		3
Zinc																		
Beryllium																		

Key:
0 - Can be used without restriction.
1 - Can be used in a non-controlled environment (e.g. assembly area and general non-clean room environment).
2 - Can be used in a clean room environment.
3 - Needs specific measures to avoid galvanic corrosion when these combinations are selected.

Verification Method: A, R

ISIS-GDIR-REQ-70374 v: 2

Joint face shall be flat and clean before assembly ; the surface finishes for joint face shall be conform to REACH regulations.

Comment: This requirement can be either verified by inspection or by review. Verification using both methods is not mandatory.

Verification Method: A, R

ISIS-GDIR-REQ-70375 v: 1

Any other anti-corrosion finish, e.g. paint or anodising, shall be removed from the joint faces before bonding and joint faces shall be protected from corrosion.

Verification Method: A, R

ISIS

ISIS-GDIR-REQ-70376 v: 1

All bonding resistance values shall not rely upon cable shield connections.

Verification Method: R

ISIS-GDIR-REQ-70377 v: 1

A bonding design justification including a bonding diagram and applied processes shall be established.

Verification Method: R

ISIS-GDIR-REQ-70378 v: 1

The bonding diagrams shall identify all bonding connections (straps, mounting feet, connector attachments area, etc...) which are used.

Verification Method: R

ISIS-GDIR-REQ-70379 v: 1

Each identified bonding connection shall be described in detail: size, contact area, surface treatment, mounting holes, bond strap material, etc...

Verification Method: R

ISIS-GDIR-REQ-70380 v: 1

Each bond shall withstand vibration, expansion, contraction or relative movement of parts incident to normal service without breaking or loosening or causing a change in contact resistance.

Verification Method: A, R

ISIS-GDIR-REQ-70381 v: 1

All bonding resistance values shall apply for both directions of polarisation across the bond.

Verification Method: T

7.5.1.2. Electrical Ground reference Network EGRN

ISIS-GDIR-REQ-70382 v: 1

Spacecraft shall provide an electrical ground reference network EGRN in order to obtain an electrical reference and minimize any difference of potential.

Verification Method: I, R

ISIS-GDIR-REQ-70383 v: 1

The satellite EGRN shall provide electrical reference ground points EGRP on the main subassemblies (platform, payload, instrument) on which a test socket can be mounted and accessible.

Verification Method: I, R

Standard Origin Source: ECSS-E-ST-20-07 C 4.2.11.2.a

ISIS-GDIR-REQ-70384 v: 1

EGRP shall be assembled to the structure with a DC resistance lower than 2.5 mΩ (DC under 1A).

Verification Method: A, T

ISIS-GDIR-REQ-70385 v: 1

ISIS

The resistance between two any electrical ground reference points EGRP shall be less than 10 mΩ (DC under 1A).

Verification Method: A, T

ISIS-GDIR-REQ-70386 v: 1

All structural parts which contribute to the EGRN shall be electrically assembled either by metal – metal contact or by using of metal straps.

Verification Method: I, R

7.5.1.3. Ground Reference Rail GRR

ISIS-GDIR-REQ-70387 v: 1

Electrical bonding throughout non metallic structure (CFRP, SiC, etc) shall be achieved by means of a continuous metallic Ground Reference Rail (GRR). GRR can be implemented in the form of semi-rigid foil strip attached to the non metallic structural element.

Verification Method: I, R

ISIS-GDIR-REQ-70388 v: 1

GRR shall:

- be routed as close as possible to each unit mounted on the non-metallic structure,
- follow the harness routing,
- have a minimum of 1 cm width.

Verification Method: I, R

ISIS-GDIR-REQ-70389 v: 1

The resistance between any 2 adjacent parts of the GRR shall never exceed 2.5 mΩ (DC).

Verification Method: A, T

ISIS-GDIR-REQ-70390 v: 1

The resistance between any points of a subsystem or instrument GRR network and the relevant EGRP shall be <20 mΩ

Verification Method: A, T

ISIS-GDIR-REQ-70391 v: 1

The resistance between any two points of the GRR network shall be <20 mΩ

Verification Method: A, T

7.5.1.4. Bonding Electrical Electronic Units

ISIS-GDIR-REQ-70392 v: 1

The structure of electrical and electronic unit shall form a continuous conductive metallic shield for the electronics.

Verification Method: I, R

ISIS-GDIR-REQ-70393 v: 1

ISIS

All metallic sub-chassis, chassis and enclosures of each unit, including all connector shells and other fittings, shall be electrically conductive bonded.

Verification Method: I, R

ISIS-GDIR-REQ-70394 v: 2 w

All conductive parts of the electrical unit structure shall be electrically connected.

Verification Method: I, R

ISIS-GDIR-REQ-70395 v: 1

Openings for drainage, ventilation, etc... shall never exceed 5mm diameter per hole and distances between screws for lids, etc... shall never exceed 30mm for flat mounted lids. Conductive surfaces are required on each bonding surface (each screw).

Verification Method: I, R

ISIS-GDIR-REQ-70396 v: 1

Electric equipment chassis (case) mounted on a metallic structure shall be bonded to the structure or GRN by:

- direct metal to metal contacts through the mounting feet (metal to metal assemblies requirements),
- a bond strap.

Verification Method: I, R

Standard Origin Source: ECSS-E-ST-20-07 C 4.2.11.2.c

ISIS-GDIR-REQ-70397 v: 2

The bonding resistance between electrical equipment chassis and the EGRN structure shall not exceed 10 mΩ.

When mounted on non-metallic structure, the bonding resistance between electrical equipment chassis and the GRR network shall not exceed 20 mΩ.

Verification Method: A, T

Standard Origin Source: ECSS-E-ST-20-07 C 4.2.11.2.d/e/f

ISIS-GDIR-REQ-70398 v: 1

All electrical/electronic units shall provide a M4 bonding stud.

Verification Method: I, R

Standard Origin Source: ECSS-E-ST-20-07 C 4.2.11.2.b

ISIS-GDIR-REQ-70399 v: 1

This bonding stud shall allow connect a bonding strap with a contact area of more than 1cm².

Verification Method: I, R

Standard Origin Source: ECSS-E-ST-20-07 C 4.2.11.2.b

ISIS-GDIR-REQ-70400 v: 1

The bonding strap shall have the following characteristics:

- length-to-width (L / W) ratio shall be <5 to 1 assuming
- a strap thickness of 0.2 mm
- a resistance < 2.5 mΩ

ISIS

- an inductance < 30 nH
- be adequate in cross-sectional areas to carry permanent fault currents where applicable, without fusing, burning or arcing (150 % of circuit protection device rating).

Verification Method: A, I, R, T

Standard Origin Source: ECSS-E-ST-20-07 C 4.2.11.2.d/e/f

ISIS-GDIR-REQ-70401 v: 1

Each unit shall provide a grounding point, which is easily accessible even when all harness connectors have been installed.

Verification Method: I, R

Standard Origin Source: ECSS-E-ST-20-07 C 4.2.11.2.b

7.5.1.5. Structural Parts

ISIS-GDIR-REQ-70402 v: 1

The DC resistance between two mating metal parts of EGRN shall be <2.5mΩ. The minimum size of the contact area shall be 1cm².

Verification Method: I, R, T

ISIS-GDIR-REQ-70403 v: 1

A bonding conductor shall be implemented across movable parts (e.g. movable parts of mechanism) with a resistance < 25 mΩ in case of bonding electrical/electronic functions and otherwise with a resistance < 100kΩ.

Verification Method: A, R, T

Standard Origin Source: ECSS-E-ST-20-06 C 6.3.1.b

ISIS-GDIR-REQ-70404 v: 1

Where structural ground is carried across slip-rings on a rotating joint, at least two slip-rings shall be dedicated to the structural ground path.

Verification Method: R

Standard Origin Source: ECSS-E-ST-20-06 C 6.3.1.c

ISIS-GDIR-REQ-70405 v: 1

The bonding connections shall be installed not to interfere with the operation of movable components.

Verification Method: A, R, T

ISIS-GDIR-REQ-70406 v: 1

Mechanical Parts without electrical or shielding function shall show a bonding resistance of less than 100 kΩ between any adjacent parts and the local GRR.

Verification Method: A, R, T

ISIS-GDIR-REQ-70407 v: 1

Mechanical Parts used for electromagnetic shielding or bonding electric/electronic units shall show a bonding resistance of less than 5 mΩ between any adjacent parts and the local GRR.

Verification Method: A, R, T

ISIS

ISIS-GDIR-REQ-70408 v: 1

Aluminium honeycomb shall be bonded to the structure with a DC resistance of $< 100 \text{ k}\Omega$.

Verification Method: A, R, T

ISIS-GDIR-REQ-70409 v: 1

The bonding with the GRR of tubular members or conduits, if not inherently bonded, shall present a resistance of less than $100 \text{ m}\Omega$.

Verification Method: A, R, T

ISIS-GDIR-REQ-70410 v: 1

Shielding and bonding of cut-outs protections is mandatory, if non-conductive material is used as a cover.

Verification Method: I, R

ISIS-GDIR-REQ-70411 v: 1

Floating surface conductors shall not be used unless they are less than 1 cm^2 and 10 pF and not part of a multi-conductor elements structure.

Comment: Multi-conductor structures exist where at least two conductive elements are separated by a dielectric surface of less than 100 cm^2 .

Verification Method: I, R

Standard Origin Source: ECSS-E-ST-20-06 C 6.3.1.d

7.5.1.6. Mechanical Parts within TCS (MLI, Shields and radiators)

ISIS-GDIR-REQ-70412 v: 2

Each MLI foil shall carry at least 1 conductive coating (e.g. Kapton foil aluminized on both faces) and each conductive coating shall be bonded to structure to avoid electrical charge differential.

Verification Method: A, I, R

Standard Origin Source: ECSS-E-ST-20-06 C 6.3.3.3.a

ISIS-GDIR-REQ-70413 v: 1

The grounding points shall be in a minimum of 2 locations (opposite corners), such that no piece of blanket is $> 1 \text{ m}$ away from a grounding point. For small MLI pieces below 0.01 m^2 , bonding at one point is sufficient.

Verification Method: A, I, R

Standard Origin Source: ECSS-E-ST-20-06 C 6.3.3.3.b

ISIS-GDIR-REQ-70414 v: 1

The resistance between each bonding point and the structure (or EGRN) shall be lower than 1 Ohm .

Verification Method: A, R, T

ISIS-GDIR-REQ-70415 v: 2

Each metallized face of each thermal shield stage shall be connected to the structure (or EGRN). Bonding requirements are as for MLI.

Verification Method: A, I, R

ISIS

ISIS-GDIR-REQ-70416 v: 1

The conductive part of the radiator coating shall be electrically connected to the electrical ground reference network.

Verification Method: A, I, R

ISIS-GDIR-REQ-70417 v: 2

For MLI or thermal shields, the resistance between each bonding point and each point of a metallized face shall be lower than 100Ω.

Verification Method: A, R, T

7.5.1.7. Bonding CRFP

ISIS-GDIR-REQ-70418 v: 1

For CFRP structure without shielding function, the bonding resistance between any CFRP parts and the local GRR shall be less than 100 kΩ measured in DC.

Verification Method: A, R, T

ISIS-GDIR-REQ-70419 v: 1

For CFRP structure used for electromagnetic shielding, the bonding resistance shall be less than 10 Ω between any adjacent parts and the local GRR.

Verification Method: A, R, T

ISIS-GDIR-REQ-70420 v: 1

Metal fittings (eg inserts) shall be bonded to the CFRP with a DC resistance of < 100 Ω

Verification Method: A, R, T

ISIS-GDIR-REQ-70421 v: 1

The DC resistance between any other conductive component that does not perform an electrical function, i.e. CFRP, CFK, conductive coatings etc. and the spacecraft structure shall be < 100 kΩ.

Verification Method: A, R, T

7.5.1.8. Isolation material

ISIS-GDIR-REQ-70422 v: 1

Space exposed Insulating material having a surface resistivity higher than 10⁹ Ω/square or having a bulk resistivity higher than 10¹² Ω.m shall not be used .

Verification Method: A, R, T

Standard Origin Source: ECSS-E-ST-20-06 C 6.3.3.6.b

7.5.1.9. Harness

ISIS-GDIR-REQ-70423 v: 1

Metallic receptacles of connectors shall be electrically bonded to the equipment case with a DC resistance < 2.5mΩ.

Verification Method: A, R, T

ISIS

Standard Origin Source: ECSS-E-ST-20-07 C 4.2.13.2.c

ISIS-GDIR-REQ-70424 v: 1

Cable conductor and connector pin shall not be floating. When double insulation is required grounding pins shall be done through a resistance from 100kohm to 10Mohm.

Verification Method: I, R

Standard Origin Source: ECSS-E-ST-20-06 C 6.3.1.f

7.5.1.10. Bonding general summary

Bonding connections characteristics:

EGRP assembly to the structure	$\leq 2.5 \text{ m}\Omega$ under 1ADC
Between two any EGRP	$\leq 10 \text{ m}\Omega$ under 1ADC
Between two mating metal structural parts (meta-metal assembly)	$\leq 2.5 \text{ m}\Omega$ under 1ADC
Between any adjacent parts of one piece of GRR	$\leq 2.5 \text{ m}\Omega$ under 1ADC
Between any points of a GRR network and the EGRP	$\leq 20 \text{ m}\Omega$ under 1ADC
Between any two points of the GRR network	$\leq 20 \text{ m}\Omega$ under 1ADC
Between electrical equipment chassis and EGRP	$\leq 10 \text{ m}\Omega$ under 1ADC
Between two movable parts without electrical units	$\leq 100 \text{ k}\Omega$
Between two movable parts supporting electrical function	$\leq 25 \text{ m}\Omega$ under 1ADC
Between mechanical Parts without electrical or shielding function and local the GRR	$\leq 100 \text{ k}\Omega$
Between mechanical Parts used for electromagnetic shielding or bonding electric/electronic units and the local GRR	$\leq 5 \text{ m}\Omega$ under 1ADC
Between aluminum honeycomb and the structure	$\leq 100 \text{ k}\Omega$
Assembly of tubular members or conduits	$\leq 100 \text{ m}\Omega$ under 1ADC
Between MLI bonding point and structure (or EGRN or EGRP)	$\leq 1 \text{ }\Omega$
Between MLI bonding point and any point of conductive layer or metallized foil	$\leq 100 \text{ }\Omega$
Between any CFRP parts without electrical unit and the local GRR	$\leq 100 \text{ k}\Omega$
Between any CFRP parts with electrical unit or shielding function and the local GRR	$\leq 10 \text{ }\Omega$ under 1ADC
Assembly of Metal fittings (eg inserts) to the CFRP	$\leq 100 \text{ }\Omega$
Between any other conductive component that does not perform an electrical function, i.e. CFRP, CFK, conductive coatings etc. and the spacecraft structure	$\leq 100 \text{ k}\Omega$
Between metallic receptacles of connectors and unit case or bracket	$\leq 2.5 \text{ m}\Omega$ under 1ADC
Between cable shield (at backshell level) and unit chassis (when the connector is mounted).	$\leq 10 \text{ m}\Omega$ under 1ADC
Between solar generator structure and satellite EGRP	$\leq 100 \text{ k}\Omega$

ISIS

Between Antenna feed or OMUX and EGRP	$\leq 10 \text{ m}\Omega$ under 1ADC
Between Antenna reflector and EGRP	$\leq 100 \Omega$

7.5.2. Electrical Circuit

7.5.2.1. Electrical Reference Network

ISIS-GDIR-REQ-70450 v: 1

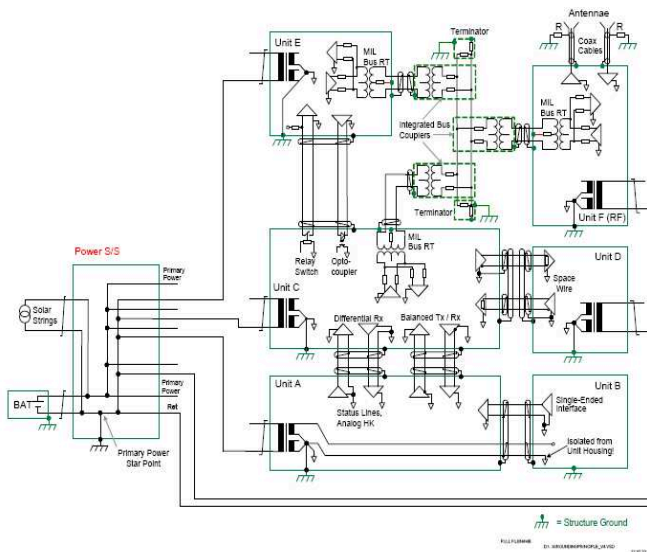
The grounding concept shall be "Distributed Single Point Grounding" (DSPG) system. The principle is to realize a single point grounding of each independent power network (primary and secondary power) and galvanic isolation between those networks.

Verification Method: A, R

ISIS-GDIR-REQ-70451 v: 2

Grounding diagram including zero volts interconnections and detailed implementations shall be provided at unit level, subsystem level, PF level, PL level and satellite level in the EICD.

Comment: Figure: Example of Distributed Single Point Grounding (DSPG) Scheme



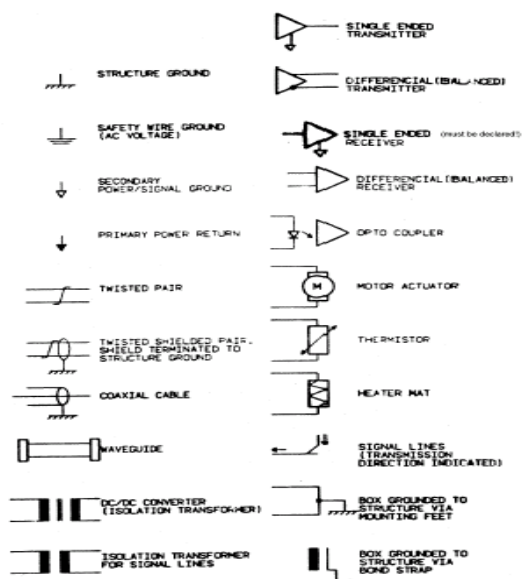
Verification Method: A, R

Standard Origin Source: ECSS-E-ST-20-07 C 4.2.10.2.a

ISIS-GDIR-REQ-70452 v: 1

The symbols below shall be used in the production of grounding diagram in order to obtain unified drawings

ISIS



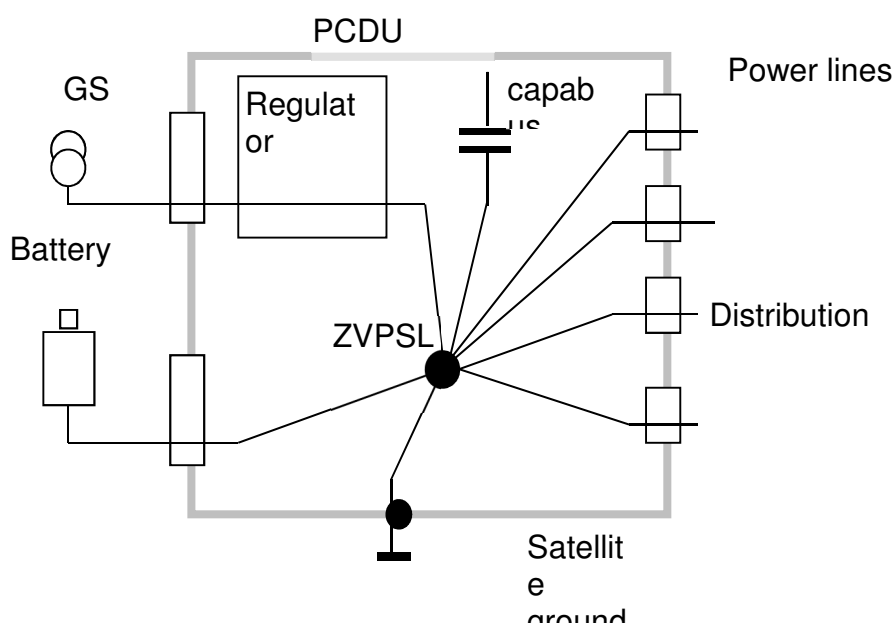
Verification Method: A, R

Standard Origin Source: ECSS-E-ST-20-07 C 4.2.10.2.a

7.5.2.2. Primary Network

Primary power buses are supplied by the platform PSS (Power Sub-System) and will be bonded to the structure at one point only within the PSS. This grounding shall be within the power control and distribution unit (PCDU).

Single point grounding:



ISIS-GDIR-REQ-70453 v: 2

All units (except PCDU) shall maintain a galvanic isolation of at least 1MΩ shunted by not more than 150 nF between:

Primary power positive and chassis,

ISIS

Primary power return and chassis

Primary power and secondary power (line and return).

Verification Method: A, R, T

ECSS DOORS Req ID: [ECSS-E-ST-20_0020206], [ECSS-E-ST-20_0020207]

ISIS-GDIR-REQ-70454 v: 1

The parasitic capacitance between primary and secondary windings without EMI filters shall be less than 1 nF. It is recommended to use static shields between primary and secondary windings of transformers to reduce the capacitive coupling between primary and secondary side. This static shield should be connected to the primary power return line by means of a low inductance strap.

Verification Method: A, R

ISIS-GDIR-REQ-70455 v: 1

The AC common mode impedance shall not be less than 5 Ohm when measured between primary power lines and chassis in the frequency range [10 kHz - 1 MHz] (to be verified by review of design and during the conducted susceptibility tests).

Comment: This requirement can be verified either by Test or by Analysis. It is not mandatory to verify this requirement using both methods.

Verification Method: A, R, T

ISIS-GDIR-REQ-70456 v: 1

No intentional electrical current shall be flown through the structure

In particular, the structure shall not be used as a current return path for primary.

Verification Method: A, R, T

7.5.2.3. Secondary Network

ISIS-GDIR-REQ-70457 v: 1

Each secondary electrical network return shall be connected to the EGRN via a single path (ground point / ground plane).

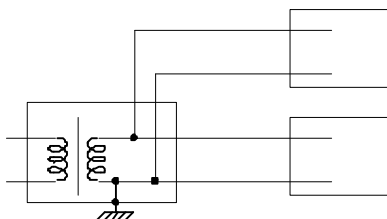
Comment: The connection between the secondary 0 volt and the unit chassis can be made either a single bonding strap or via multi-points bonding at PCB/chassis interface.

Verification Method: A, R

Three main secondary power distribution configuration can occur:

ISIS-GDIR-REQ-70459 v: 1

1. Secondary distribution: 1 secondary power supplier for several receivers (nominal case):



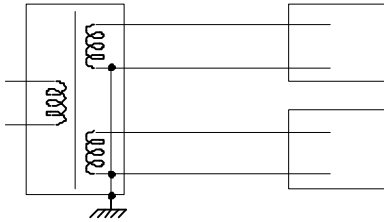
ISIS

In this case the connection of the secondary 0 volt to the EGRN shall be performed at the supplier level.

Verification Method: A, R

ISIS-GDIR-REQ-70460 v: 1

2. Secondary distribution: several secondary power suppliers for several receivers (nominal case):

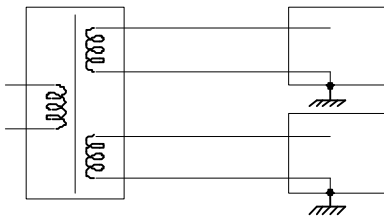


In this case the connection of the secondaries 0 volt to the EGRN shall be performed at the suppliers level.

Verification Method: A, R

ISIS-GDIR-REQ-70461 v: 1

3. Secondary distribution: 1 secondary power supplier for one receiver (specific case for sensitive payloads):



In this case the connection of the secondary 0 volt to the EGRN shall be performed at the receivers level.

However, Both units (supplier and receivers) shall provide the capability of this grounding point. Implementation of this point will be defined at Project level.

Verification Method: A, R

ISIS-GDIR-REQ-70462 v: 1

After grounding, the impedance between the unit secondary zero volt taken at the level of the transformer and the unit structure (bonding stud) shall be less than $5\text{m}\Omega + 50\text{ nH}$. Tested at board level.

Verification Method: A, R, T

ISIS-GDIR-REQ-70463 v: 1

The ground path from the secondary coil of the DC/DC converter transformer to the chassis ground point shall be sized to carry a current equal to 1,5 times the fault current expected to be derived into the unit structure.

ISIS

Comment: The fault current from primary shall be limited by the LCL. Others internal fault currents shall be defined by the manufacturer taking into account the possible failure cases of the unit.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-20-07 C 4.2.11.2.h

ISIS-GDIR-REQ-70464 v: 1

Secondary electrical network in a unit where the grounding is not made internally shall be isolated from the unit chassis with a resistance > 1MΩ shunted by not more than 150 nF.

Comment: Case where the grounding path of the secondary 0 volt is made via an external stud on the unit. Or case where the grounding is made by another unit with the same distributed secondary network.

Verification Method: A, R, T

ECSS DOORS Req ID: [ECSS-E-ST-20_0020206], [ECSS-E-ST-20_0020207]

7.5.2.4. Thermal Control Circuits

ISIS-GDIR-REQ-70465 v: 2

Heaters, temperature sensors and other discrete thermal EEE components shall be isolated from structure with a Resistance of 10 MΩ.

Verification Method: A, R, T

7.5.2.5. Galvanic Isolation

ISIS-GDIR-REQ-70466 v: 1

Harness shall be tested up to connector brackets under 500 V DC between conductors, conductors and structure, conductors and shielding. Unless voltage limitation constraints imposed by a specific cable or connector technology.

Comment: 500 V DC is selected in order to detect insulation defects potentially induced by air voltage breakdown.

Verification Method: T

ECSS DOORS Req ID: [ECSS-E-ST-20_0020237]

ISIS-GDIR-REQ-70467 v: 3

If a unit is connected to a non-protected section of a main bus distribution system, it shall be internally protected as a minimum by double insulation (including harness, connector, wiring and PCB) up to the first protection device (current breaker or current limiter).

Verification Method: A, I, R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020218]

ISIS-GDIR-REQ-70468 v: 1

The pieces of S/C harnesses or equipment internal harness for which a loss of insulation has been identified as critical, will be additionally insulated while keeping compliance with the thermal requirements.

Verification Method: A, I, R

ISIS-GDIR-REQ-70469 v: 1

Double insulation rules implemented by the supplier shall be specified by the Prime Contractor.

ISIS

Verification Method: A, I, R

7.5.2.6. Floating voltage on electronic components

ISIS-GDIR-REQ-70573 v: 1

For non-programmable electronic components:

- no input pin shall be left to a floating voltage,
- this voltage shall be set to zero volts through a pull-down resistor or to the supply voltage through a pull-up resistor.

ISIS-GDIR-REQ-70575 v: 1

For programmable electronic components (FPGA, DSP, ...), and for pins which are not functionally used, the designer:

- shall refer to the datasheet to get information on how to connect them and if necessary shall contact the manufacturer (the pins supported by the software in the programmable component do not need to be systematically connected to a pull-up or a pull-down resistor),
- shall check that if the software in the programmable component must also take into account the pins which are not connected, it really performs this task.

7.5.3. EGSE Grounding and Isolation

ISIS-GDIR-REQ-70470 v: 1

Precautions shall be taken during satellite, subsystem or unit testing to prevent accumulation of electrostatic charges. In particular this shall be achieved by ensuring that the satellite, subsystem or unit is connected to the local earth.

Verification Method: A, R

ISIS-GDIR-REQ-70471 v: 1

On any test setup used during unit integration and test, earth connections shall be sized to carry a current of 1.5 times the fault current.

Verification Method: A, R

7.5.4. TM/TC Signals

ISIS-GDIR-REQ-70472 v: 2

Signal return path shall not be made intentionally through the structure.

Verification Method: A, R

ISIS-GDIR-REQ-70473 v: 1

Where single-ended signal transmitters are used, independent signal returns are required. Ground reference lines shall not be used as signal returns. The signal receivers shall present high common mode impedance (differential amplifier, opto-coupler, solid state relay, transformer).

This is not applicable for RF signals.

Verification Method: A, R

ISIS

ISIS-GDIR-REQ-70474 v: 1

Any output signal referenced to the primary 0V inside a unit shall be isolated from the secondary network.

Comment: Exception for the PCDU.

Verification Method: A, R

ISIS-GDIR-REQ-70475 v: 1

The use of common signal return paths is only permitted for groups of signals belonging to the same family (analogue, digital, etc.) and originating from the same unit.

Verification Method: A, R

7.6. HARNESS

7.6.1. Classification

The classification is made on the basis of the characteristics of the signals flowing in the wire, and hence the interference generated, and on the susceptibility of the wire with its associated interface circuits to interference.

ISIS-GDIR-REQ-70476 v: 2

The main following EMC classification shall be made:

- Primary Power, Secondary Power, relay command, motor line, heating line,
- Digital signals, high level analogue signals,
- Data buses (1553, Space Wire),
- Pyrotechnic command or one shot actuator command,
- Sensitive "High Quality" secondary power,
- Sensitive lines (low level analogue),
- RF signals

Verification Method: R

Standard Origin Source: ECSS-E-ST-20-07 C 4.2.13.1.a

ISIS-GDIR-REQ-70477 v: 1

Different classes of wire shall use different connectors.

If it is not feasible, non critical classes of wire shall be separated in the connector by a set of unused pins.

Verification Method: I, R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020055], [ECSS-E-ST-20_0020056]

ISIS-GDIR-REQ-70478 v: 2

Power, relay command, heating lines, temperature sensors shall be twisted pairs (hot line twisted with return line), except otherwise specified by the prime contractor.

Verification Method: I, R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020234]

ISIS

ISIS-GDIR-REQ-70479 v: 1

Shielded Twisted pair shall be used for all signal the following signals:

- Pyrotechnic command or one shot actuator command,
- Digital signals, high level analogue signals,
- Data buses (1553, Space Wire)
- Sensitive "High Quality" secondary power
- Sensitive lines (low level analogue).

Verification Method: I, R

ISIS-GDIR-REQ-70480 v: 1

RF signals shall use coaxial cables or waveguide.

Verification Method: I, R

ISIS-GDIR-REQ-70481 v: 1

The use of shielded wires when not required in the present standard or bundle overshielding shall only occur when specified in the relevant subsystem specification, or when the necessity is proven by analysis.

Verification Method: R

7.6.2. Cable routing

ISIS-GDIR-REQ-70482 v: 1

Wires falling into one category shall be assembled into a same bundle.

Verification Method: I, R

Standard Origin Source: ECSS-E-ST-20-07 C 4.2.13.1.b

ISIS-GDIR-REQ-70483 v: 1

The routing of wires of different classes shall be made in order to limit electromagnetic coupling by the following possible implementations:

- separation of bundles with a minimum distance of 5cm,
- separation by metallic screen,
- overshielding of bundle.

Verification Method: I, R

Standard Origin Source: ECSS-E-ST-20-07 C 4.2.13.1.c

ISIS-GDIR-REQ-70484 v: 1

Where bundles of different classes must cross each other the crossing angle shall be approximately 90 degrees.

Verification Method: I, R

ISIS-GDIR-REQ-70485 v: 1

Cables and cable bundles shall be routed as close as possible to the structure or the spacecraft, preferably less than 1cm.

Verification Method: I, R

ISIS

ECSS DOORS Req ID: [ECSS-E-ST-20_0020233]

ISIS-GDIR-REQ-70486 v: 1

Bundles thicker than 5 cm (in diameter) shall be avoided. Any deviation shall be subject to the Prime Contractor approval.

Verification Method: I, R

ISIS-GDIR-REQ-70487 v: 2

Contact of cables with sharp rough and hard edges shall be forbidden.

Verification Method: I, R

ISIS-GDIR-REQ-70488 v: 1

Equipment and harness layout shall be planned to minimize the need for cable looms crossing.

Verification Method: I, R

ISIS-GDIR-REQ-70489 v: 1

Where "flying leads" are used, provision for securing these cables to the interface structure or to the unit to which they are connected, is to be ensured.

Verification Method: I, R

ISIS-GDIR-REQ-70490 v: 1

The free length of cable from the last cable clamp to the connector shall be kept to a minimum.

Verification Method: I, R

ISIS-GDIR-REQ-70491 v: 1

The harness shall be fixed onto the structure in order to avoid any possibility of mechanical stress on wires, wire terminations and connectors during all ground operations and mission phases.

As a general rule, it will be fixed:

- at equipment level: the harness connector shall be fitted onto the equipment connectors by appropriate locking systems
- at the structure level
- at interface level: the connectors shall be fixed on metallic brackets themselves fixed onto the structure.

Verification Method: I, R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020079], [ECSS-E-ST-20_0020238]

ISIS-GDIR-REQ-70492 v: 2 w

No piece of harness shall be used to transfer mechanical loads.

Verification Method: I, R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020232]

7.6.3. Cable shield

ISIS-GDIR-REQ-70493 v: 1

Cable shields shall not be used as an intentional current carrying conductor, except coaxial cables in radiofrequency circuits and high-speed data links using coaxial cables.

ISIS

Verification Method: I, R

Standard Origin Source: ECSS-E-ST-20-07 C 4.2.13.2.a

ISIS-GDIR-REQ-70494 v: 1

Cable shields, other than overshields, shall have an insulated sheath to prevent uncontrolled grounding.

(Area where double isolation is not required)

Verification Method: I, R

Standard Origin Source: ECSS-E-ST-20-07 C 4.2.13.2.b

ISIS-GDIR-REQ-70495 v: 1

Cable shield shall be bonded at both ends to the connector body. The bonding shall be made by using connector backshell or castellated backshell. (the electrical bonding to the structure is insured through the backshell, connector body, unit chassis where the connector is mounted).

Verification Method: I, R

Standard Origin Source: ECSS-E-ST-20-07 C 4.2.13.2.d

ISIS-GDIR-REQ-70496 v: 1

Daisy chaining of shield terminations shall be avoided.

Verification Method: I, R

ISIS-GDIR-REQ-70497 v: 2

The DC resistance between the cable shield (at backshell level) and unit chassis shall be lower than 10mΩ (when the connector is mounted).

Verification Method: I, R

Standard Origin Source: ECSS-E-ST-20-07 C 4.2.13.2.c

ISIS-GDIR-REQ-70498 v: 1

Grounding cable shield by connector pins shall be avoided.

Verification Method: I, R

ISIS-GDIR-REQ-70499 v: 1

Overshields shall be bonded to the connector case and then to the unit chassis at both ends. It shall be provided 360° direct contact between connector backshell and the overall bundle.

Verification Method: I, R

Standard Origin Source: ECSS-E-ST-20-07 C 4.2.13.2.e

ISIS-GDIR-REQ-70500 v: 1

Overshields shall be bonded to chassis ground at intermediary points with a separation distance less than 1m between two grounding points.

Verification Method: I, R

Standard Origin Source: ECSS-E-ST-20-07 C 4.2.13.2.f

ISIS-GDIR-REQ-70501 v: 1

Where shielded cable passes through an intermediate connector, the shield shall be grounded to the bracket.

ISIS

Verification Method: I, R

ISIS-GDIR-REQ-70502 v: 1

Every cable submitted to the external environment (i.e. external to the Spacecraft) shall be overshielded. The overshield shall be bonded to the structure externally of the spacecraft.

Verification Method: I, R

Standard Origin Source: ECSS-E-ST-20-07 C 4.2.12.2.a

ISIS-GDIR-REQ-70503 v: 1

Where braided shielding is used, it shall be selected to provide an optical coverage of at least 85% homogeneously over the entire cable length.

Verification Method: I, R

7.6.4. Wiring redundancy

ISIS-GDIR-REQ-70504 v: 1

When unit uses redundant functions, the associated wiring shall be redundant in the same manner and it shall be routed through separate connectors and wire bundles. This includes primary power interfaces.

When not applied, this shall be tracked in the Critical Item List.

Verification Method: I, R

ISIS-GDIR-REQ-70505 v: 1

Redundant wire bundles shall be routed separately wherever possible.

Verification Method: I, R

ISIS-GDIR-REQ-70506 v: 1

Cross strapping of redundant paths and circuits shall not be carried out in the harness.

Except otherwise specified by the prime contractor.

Verification Method: I, R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020241]

7.6.5. Connectors

ISIS-GDIR-REQ-70507 v: 1

Connector types and the list of connector references which are authorized to be used shall be given by the prime contractor. All connector references and associated accessories, compatibility between unit and harness connectors shall be approved by the prime contractor.

Verification Method: R

ISIS-GDIR-REQ-70508 v: 1

Connectors shall be made of non-magnetic material.

Verification Method: R

ISIS-GDIR-REQ-70509 v: 1

ISIS

Connector shells shall be made of metallic material or covered by metallic material.

Verification Method: R

ISIS-GDIR-REQ-70510 v: 1

RF coaxial links shall use dedicated coaxial connectors.

Verification Method: R

ISIS-GDIR-REQ-70511 v: 1

Connectors at interfaces shall be clearly identified. That applies to equipment connectors as well to interface brackets connectors

Verification Method: I, R

ISIS-GDIR-REQ-70512 v: 1

The connector type used for primary power shall not be used for any other signal on the same unit

Verification Method: R

ISIS-GDIR-REQ-70513 v: 2 w

Signal interfaces shall withstand without damage positive or negative nominal voltages that are accessible on the same connector on adjacent pins, coming from the unit itself, from the interfaced units or from EGSE.

Comment: It is expected that the design of the EGSE incorporates protections limiting the fault voltage emission to a level acceptable by the unit.

Verification Method: R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020006], [ECSS-E-ST-20_0020068]

7.6.6. connector implementation

ISIS-GDIR-REQ-70514 v: 1

For units or unit assemblies located close to each other, every effort shall be made to minimize the risk of an operator making a wrong connection. Mechanical method and identification markings shall be used to prevent incorrect connection.

Verification Method: R

ISIS-GDIR-REQ-70515 v: 1

All electrical connectors shall be implemented at a minimum of distance of 25mm from the unit mounting plane in order to avoid problem with cable routing and harness fixation.

Verification Method: I, R

ISIS-GDIR-REQ-70516 v: 1

Unit connectors shall be implemented in such a way that harness connectors can be mated and demated without the need of special tools (except screwdriver) and without touching any neighbouring connectors. In particular; the minimum free space between neighbouring connectors shall be at least 10 mm. Possible insertion of a breakout box for trouble shooting should be considered.

Verification Method: R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020054]

ISIS-GDIR-REQ-70517 v: 1

ISIS

Inadvertent disconnection shall be avoided by using mechanical locking system in connectors.

Verification Method: R

ISIS-GDIR-REQ-70518 v: 1

Connector type, size, gender, position, orientation, keying, marking shall be selected in order to avoid mismatching.

Verification Method: R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020053]

7.6.7. connector savers

ISIS-GDIR-REQ-70519 v: 1

Connector savers shall be used on all flight standard connectors and shall be a flight type connector (same part number and same quality level)

Verification Method: R

ISIS-GDIR-REQ-70520 v: 1

The use of a connector saver for ground testing shall not alter the performance of the equipment.

Verification Method: A, R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020052]

ISIS-GDIR-REQ-70521 v: 2 w

The number of matings / dematings of flight connectors shall not exceed 10 up to unit delivery.

Verification Method: I, R

ISIS-GDIR-REQ-70522 v: 1

The flight connectors shall sustain in total at least 50 mating / demating applications without degradation.

Verification Method: R

7.6.8. Connector contacts

ISIS-GDIR-REQ-70523 v: 2

Connectors used for harness shall have removable crimp contacts (pins, sockets) and shall not have solder contacts.

Crimping methods and procedures shall be submitted and approved by the prime contractor.

Verification Method: R

ISIS-GDIR-REQ-70524 v: 1

Crimping of more than one wire per connector contact shall be covered by qualified process.

Verification Method: R

ISIS-GDIR-REQ-70525 v: 2

Each signal and its corresponding return shall wherever possible be located on adjacent contacts. Pins dedicated to the same twisted pair or triplet shall be adjacent.

ISIS

For primary power lines specific pin allocations shall submitted to prime contractor.

Verification Method: R

ISIS-GDIR-REQ-70526 v: 1

For new developments, when the connection is not aligned to a defined standard, 10% spare contacts at unit PDR and at least 5% at CDR shall be achieved with in any case a minimum of two spare contacts available at CDR.

Verification Method: R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020057], [ECSS-E-ST-20_0020058]

ISIS-GDIR-REQ-70527 v: 1

When connector have interfaces referenced with the secondary zero volt (TM/TC, synchro, clock signals...) or differential line signals, connector shall provide one free pin internally connected to the secondary 0V point of the unit if not available from a single ended signal.

Verification Method: R

ISIS-GDIR-REQ-70528 v: 3 w

For a unit, a connector carrying power supply or external test connectors on units shall have no contact areas exposed to possible short circuit during mating and de-matin process.

Comment: They generally are female type connectors for output and male type connectors for input.

Verification Method: R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020049]

ISIS-GDIR-REQ-70529 v: 1

All coaxial connectors carrying RF source signals shall be female.

Verification Method: R

ISIS-GDIR-REQ-70530 v: 1

Connector pins dedicated to the same signal as defined in the EICD shall be interconnected inside the unit, e.g. primary power supplied via more than one pin.

Verification Method: R

ISIS-GDIR-REQ-70531 v: 1

The number of unused contacts without inserts (pins or sockets) shall be limited in the connector in order to be compliant with mechanical integrity.

Verification Method: I, R

ISIS-GDIR-REQ-70532 v: 1

All individual wire-to-pin interfaces shall be covered with heat shrink sleeves or isolated with grommet.

Verification Method: I, R

7.6.9. Test connectors

ISIS-GDIR-REQ-70533 v: 2 w

Where test or stimulus points are required at equipment level, dedicated test connectors shall be implemented. Test-stimulus points shall be designed to be compliant with all in flight conditions (radiations, EMC, ESD, pollution).

ISIS

Verification Method: R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020064], [ECSS-E-ST-20_0020066]

ISIS-GDIR-REQ-70534 v: 1

Signal interfaces on test connectors shall withstand without damage any unintentional connections to ground or GRP.

Verification Method: A, R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020069]

ISIS-GDIR-REQ-70535 v: 1

Electrical Test, Safe and Arming plugs shall be provided for disabling on ground hazard functions.

Verification Method: R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020240], [ECSS-E-ST-20_0020071], [ECSS-E-ST-33-11_0280191]

ISIS-GDIR-REQ-70536 v: 2

All external test connectors on a unit and all structure-mounted test connectors shall be female type, except for rectangular microminiature connectors MDM in accordance with ESA SCC 3402-029 or with MIL-PRF-83513, which shall be male.

Verification Method: I, R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020049]

ISIS-GDIR-REQ-70537 v: 1

Test connector shall be protected by EMC effects by metal covers, particularly in flight configuration.

Verification Method: I, R

ECSS DOORS Req ID: [ECSS-E-ST-20_0020050], [ECSS-E-ST-20_0020051], [ECSS-E-ST-20_0020065]

ISIS-GDIR-REQ-70538 v: 1

Metallic protection cover of test connector shall be supplied by the unit supplier.

Verification Method: R

ISIS-GDIR-REQ-70539 v: 1

The electrical interfaces between the ground test equipment and the equipment under test shall not contravene the rules on grounding and isolation.

Verification Method: A, R

7.7. ELECTRICAL INTERFACE CONTROL DOCUMENT

7.7.1. ElCD contents

ISIS-GDIR-REQ-70540 v: 3 w

The Electrical Interface Control Document shall be established in conformance with the following summary and content For UNIT:

§1 Connector List

ISIS

List of all connectors with their identification.

§2 Pin allocation Data Sheet

Pin function name

Pin signal type

Pin max current

Pin max voltage

Pin source or load

Pin impedance (with the return or reference pin)

Pin carrying N/R signal

List of other pins connected with inside the unit

Pin where double insulation is applied

EMC category

§3 Electrical Interface Circuit Diagram

Circuit diagram of the electrical interface

Featuring of the components and references

Voltages/currents values

§.4 Internal Protections

Description of the electrical characteristics of all active or passive protection functions.

§.5 Inrush profile

Inrush profile with current and voltage of the unit supplied by a primary line or secondary line.

§.6 Power consumption

NOM Power

Minimum Power

Maximum Power

Peak Power

Power in failure case

§.7 Zero volt grounding diagram

Primary power grounding

Secondary power grounding

Signal and Interface grounding

Electronic unit grounding

Isolation between different grounds or references

Main interface circuit diagram

§.8 Frequency plan

Frequency plan

§.9 Static impedance curve

Static impedance curve

Verification Method: R

ISIS

ISIS-GDIR-REQ-70541 v: 2 w

The Electrical Interface Control Document shall be established in conformance with the following summary and content FOR HARNESS:

§1 Connector List

List of all connectors with their identification.

§2 Pin allocation Data Sheet

Pin function name

Pin signal type

Pin max current

Pin max voltage

Pin source or load

Pin to pin impedance

Pin line impedance characteristic (with the return associated)

Pin carrying N/R signal

List of other pins connected with inside the unit

Pin where double insulation is applied

EMC category

§3 Electrical Interface Circuit Diagram

Circuit diagram of the electrical interface

Featuring of the components and references

Voltages/currents values

§.4 Zero volt grounding diagram

Wiring diagram

Cable shield grounding

Verification Method: R

7.7.2. Power consumption

ISIS-GDIR-REQ-70542 v: 2

NOM Power shall be the steady state power consumed by the unit when power bus is set at a voltage of <VBNRNOMN> and <VBNRNOMX> and with ambient temperature.

Parameter: VBNRNOMN = 31 V

VBNRNOMX = 34 V

Verification Method: R

ISIS-GDIR-REQ-70543 v: 2

Minimum Power shall be the minimum steady state power consumed by the unit as a function of power bus input voltage from <VBNRMIN> to <VBNRMAX> and temperature.

Parameter: VBNRMAX = 39 V

VBNRMIN = 21 V

Verification Method: R

ISIS

ISIS-GDIR-REQ-70544 v: 2

Maximum Power shall be the maximum steady state power consumed by the unit as a function of power bus input voltage from <VBNRMIN> to <VBNRMAX> and temperature.

Parameter: VBNRMAX = 39 V

VBNRMIN = 21 V

Verification Method: R

ISIS-GDIR-REQ-70545 v: 2

Peak Power shall be the power consumed during a peak by the unit when power bus input voltage is set at its mean voltage and with ambient temperature. The peak duration and/or the peak duty cycle in case of periodic event shall be provided.

Verification Method: R

ISIS-GDIR-REQ-70546 v: 2

Power in failure case shall be the power consumed by the unit in case of a single failure inside.

Verification Method: R

7.7.3. Static impedance curve

ISIS-GDIR-REQ-70547 v: 1

The static impedance curve $I = F(V)$ shall be provided for every unit or function connected to the primary power bus. This curve shall be measured from 0V to maximum voltage and from maximum voltage down to 0V.

Verification Method: R

7.7.4. Connectors

ISIS-GDIR-REQ-70548 v: 1

The type of connectors must be defined separately for equipment connectors, RF connectors, skin connectors, harness connectors, test connectors and circuit connectors for EED's (Electro Explosive Device).

Verification Method: R

ISIS-GDIR-REQ-70549 v: 1

The physical position shall be indicated on Interface Control Drawings.

Verification Method: R

ISIS

8. OPERATIONS DESIGN AND INTERFACE REQUIREMENTS

8.1. INTERFACE REQUIREMENT

8.1.1. Commands

ISIS-GDIR-REQ-80001 v: 1

Every command (intended to be sent to the equipment) shall be assessed for criticality at equipment level.

Comment: The criticality of a command is measured as its impact on the mission in case of inadvertent function (erroneous transmission), incorrect function (aborted transmission) or loss of function. The definition of criticalities can be found in ECSS-Q-ST-30.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-20C 4.1.3a

ECSS DOORS Req ID: [ECSS-E-ST-20_0020007]

ISIS-GDIR-REQ-80002 v: 1

The execution of any commands shall be explicitly observable by telemetry.

Verification Method: R, T

Standard Origin Source: ECSS-E-ST-20C 4.1.3b

ECSS DOORS Req ID: [ECSS-E-ST-20_0020008]

ISIS-GDIR-REQ-80003 v: 1

With the exception of specific commands defined at system level, the function of any an executable command shall:

1. not change throughout a mission, and
2. not depend on the history of previous commands.

Comment: Exceptions address one shot devices e.g. pyrotechnic commands, or end of life passivation, which require and Arm&Fire mechanism

Verification Method: R

Standard Origin Source: ECSS-E-ST-20C 4.1.3d

ECSS DOORS Req ID: [ECSS-E-ST-20_0020010]

ISIS-GDIR-REQ-80004 v: 1

For commands of category 1 and 2 criticality at system level, at least two separate commands for execution: an arm/safe or enable/disable followed by an execute command shall be used.

Comment: For criticality categories, see ECSS-Q-ST-30.

Verification Method: R

Standard Origin Source: ECSS-E-ST-20C 4.1.3e

ECSS DOORS Req ID: [ECSS-E-ST-20_0020011]

ISIS-GDIR-REQ-80005 v: 1

ISIS

Repetition of the same command shall not result in any permanent degradation or loss of equipment functionality.

Verification Method: A, R, T

Standard Origin Source: ECSS-E-ST-20C 4.1.3f

ECSS DOORS Req ID: [ECSS-E-ST-20_0020012]

ISIS-GDIR-REQ-80006 v: 1

In case of critical commands of category 1 and 2 at system level, at least two physically independent electrical barriers, including associated control circuits, are mandatory for arming and executing the command.

Comment: Note 1: For criticality categories, see ECSS-Q-ST-30.

Note 2: Mechanical barriers can be considered.

Note 3: Physically independent electrical barriers and associated control circuits are the ones not sharing any hardware function and without risk of reciprocal failure propagation.

Verification Method: R

Standard Origin Source: ECSS-E-ST-20C 4.1.3g

ECSS DOORS Req ID: [ECSS-E-ST-20_0020013]

ISIS-GDIR-REQ-80007 v: 1

Processor and simple logic circuits shall not be able to issue category 1 and 2 critical at system level commands without a ground commanded arm/safe or enable/disable command.

Comment: To avoid inadvertent activation of processes enabled/disabled by category 1 or 2 critical commands during ground operations and in low earth orbit phases, it is necessary to foresee safety barriers (arm/safe commands) to inhibit the execution of such critical commands. Such safety barriers might be spacecraft skin connections (to be established or broken just before flight) or connections/disconnection plugs to be activated by launcher stages release (in flight). The activation/deactivation of such barriers has to be independent from on board processor.

Verification Method: R

Standard Origin Source: ECSS-E-ST-20C 4.1.3h

ECSS DOORS Req ID: [ECSS-E-ST-20_0020014]

8.1.2. Telemetry

ISIS-GDIR-REQ-80008 v: 1

Telemetry data supplied by the equipment shall allow:

1. the retracing of the overall configuration at least up to all reconfigurable elements.
2. the location of any failure able to impact the mission performances and reliability at least up to all reconfigurable elements.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-20C 4.1.4a

ECSS DOORS Req ID: [ECSS-E-ST-20_0020017]

ISIS-GDIR-REQ-80009 v: 1

ISIS

The operational status (On/Off, enabled/disabled, active/not-active) of each element of any telemetry acquisition chain shall be provided to the on-board computer in order to determine without ambiguity the validity of the telemetry data at the end of the overall chain.

Verification Method: A, R, T

Standard Origin Source: ECSS-E-ST-20C 4.1.4b

ECSS DOORS Req ID: [ECSS-E-ST-20_0020018]

8.1.3. Data processing

ISIS-GDIR-REQ-80010 v: 1

In the absence of specific mission requirements the following applies: After error correction, reset or data corruption of main functions at equipment level shall be kept to a rate of occurrence less or equal to 10⁻⁴ per day for worst case conditions of environment.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-20C 4.2.2.2d

ECSS DOORS Req ID: [ECSS-E-ST-20_0020390]

ISIS-GDIR-REQ-80011 v: 1

For programmable logic devices, the available margin of unused blocks and margin with respect to clock frequency and propagation time shall be, for new developments, 50 % as a minimum at PDR.

Verification Method: A, R

Standard Origin Source: ECSS-E-ST-20C 4.2.2.2e

ECSS DOORS Req ID: [ECSS-E-ST-20_0020391]

ISIS

9. APPENDIX

9.1. ICD FORMATS

9.1.1. Mechanical ICD

If the mechanical ICD is a new one (for example for a category D product), the supplier applies the present guideline to write it. If the mechanical ICD exists (for example for an off-the-self product), the customer can request to the supplier any missing information about I/F items listed in the present guideline.

- a. Reference coordinate system definition and reference hole
- b. Geometry information to be provided on the interface drawings showing also the reference coordinate system and the reference location
 - 1. Configuration and layout
 - 2. Envelope dimensions
 - 3. Geometrical tolerances
 - 4. Mounting holes size and location
 - 5. Mounting pads thickness for screw length definition
 - 6. Bonding, grounding studs, type identification and fixing point location
 - 7. Contact surface flatness
- c. Mass, Centering and Inertia information
 - 1. Mass (nominal, uncertainty, dispersion)
 - 2. Centre of gravity (nominal, uncertainty, dispersion)
 - 3. Moments of inertia (nominal, uncertainty, dispersion)
- d. Description of the external surfaces
 - 1. Contact area materials, coatings and finishing
 - 2. External material and coating per zone
 - 3. Connector locations (location should also be provided on the interface drawings)
 - 4. Venting holes location (location should also be provided on the interface drawings)
 - 5. RF ports location and orientation (this information should also be provided on the interface drawings)
 - 6. RF ports geometry
- e. Integration information
 - 1. Special mounting and maintenance geometrical constraints
 - 2. Mounting hardware definition (standard)
 - 3. Torques applied (fixed part) and recommended (mobile part)
 - 4. Adjustment and alignment information
 - 5. Alignment devices location and definition
 - 6. Interface description for special handling and installation
- f. Mechanical qualification information

ISIS

1. Static loads, dynamic loads, shock, acoustic vibration
2. Acoustic noise (frequency, spectrum, level)
- g. Miscellaneous
 1. Related loose parts (bolts, nuts, washers, ...)
 2. Mechanical mathematical models with their description as described in ECSS-E-ST-32C annex I
- h. Pneumatic interface geometrical definition
- i. Hydraulic interface geometrical definition

9.1.2. Thermal ICD

9.1.2.1. Thermal interface control document PURPOSE

The thermal interface control document encompasses the thermal interfaces description and the status of verification of each thermal interface requirement.

9.1.2.2. Thermal design characteristics

Unit category
..... <i>homogeneous /non homogeneous in temperature as defined by GDIR in section "Thermal Design and Interface requirements"</i>
TRP location
..... <i>drawing or MICD reference</i>
Heat transfer type through unit boundaries
..... <i>Conductive / Radiative / Mixed (% conductive/radiative)</i>
Internal heaters
..... <i>number, type, resistance, power density, location</i> <i>control law</i>
Internal temperature sensors
..... <i>number, type, location</i>
Special thermal provisions
..... <i>MLI, Low conductance I/F,...</i>

9.1.2.3. Physical properties

Unit base plate size: L(mm) * W (mm) * Thick (mm)
.....
Contact effective area (mm ²)

ISIS

.....
Radiative effective area (mm ²)
.....
Coating definition
..... % of unit total area for each finish type, paint free area
Hemispherical IR emissivity
..... for each coating listed above
Hemispherical solar absorptivity BOL/EOL
..... applicable for external units only
Mass
..... tolerance shall be identified
Heat capacity
..... tolerance shall be identified

9.1.2.4. Heat dissipation

Minimum, Typical and Maximum unit heat dissipation values shall be provided for each operating mode.

Tolerance taken on these values, if any, shall be identified.

When applicable, heat dissipation profile shall be provided.

Hot failure dissipation shall be provided when necessary.

Heat nature (for example, electrical, mechanical, RF ...)

Heat dissipation variation according to temperature or voltage.

Heat dissipation distribution along units chain (For example RF or optical chain such as STR with its electrical box & optical head)

9.1.2.5. Temperature limits AT TRP

Operating temperature	T min (°C)	T max (°C)
Acceptance		
Qualification		
Start-up temperature	T min (°C)	T max (°C)
		
Non-operating temperature	T min (°C)	T max (°C)
Acceptance		
Qualification		
Ground Storage Temperature	T min (°C)	T max (°C)
		

ISIS

Nota: As required in the GDIR

Qualification margin: +5/-5°C on the upper and lower operating/non-operating Acceptance temperature, respectively.

9.1.2.6. Other thermal requirements

e.g: Stability, homogeneity requirements...

9.1.2.7. Thermal model

Thermal model document reference if any.

9.1.2.8. OPERATION CONSTRAINT

...

9.2. INTERFACE THERMAL AND GEOMETRICAL MODELS SPECIFICATION

The present annex specifies the construction & validation of IGMM and ITMM models.

ISIS-GDIR-REQ-90001 v: 1

ITMM and IGMM shall use the International System (SI) of Quantities and Units with in particular:

- temperature in degree Celsius or in Kelvin (°C or K)
- length in meter (m)
- mass in kilogram (kg)
- time in second (s)
- heat in Joule (J)
- heat flow rate and heat dissipation in Watt (W)
- heat flow rate density in Watt per square meter (W/m²)
- heat capacity in Joule per Kelvin (J/K)
- radiative coupling in square meter (m²) (Stefan-Boltzmann constant not included)
- conductive coupling in Watt per Kelvin (W/K)
- thermal conductivity in Watt per meter and per Kelvin (W/(m.K))
- surface coefficient of heat transfer in Watt per square meter and per Kelvin (W/(m².K))

Comment: Note: for the Thermal Control field, the applicable standard is ISO 80 000-5 (Thermodynamics).

Verification Method: R

ISIS-GDIR-REQ-90002 v: 1

ISIS

The IGMM format shall be agreed in a case by case basis with the customer.

Comment: Note: Step, Thermica or Esarad may be requested.

Verification Method: R

ISIS-GDIR-REQ-90003 v: 2

The ITMM shall be written in a Esatan format as shown hereunder.

```
$MODEL NAME
#To facilitate the understanding of the thermal models,
#the assumptions shall be indicated with comment lines when calculating :
# - conductive and radiative couplings between thermal nodes
# - inertia of thermal nodes.
# - profile of dissipation

$LOCALS
#
# D for diffusive node number 10, T for initial temperature, C for heat capacitance, A for surface area
# B for Boundary node number (remain at constant temperature - heat sink)
#
D 10 = 'Baseplate', T = 20., C = 2000., A= 0.02 ;
D 20 = 'Housing', T = 20., C = 200.; # C= 100 J/w.kg x 2 kg.
D 30 = 'PCB', T = 20., C = 20.; # any relevant comments regarding T or C.
B 40 = 'Conductive interface', T = 40.; # Boundary node temperature given by the specification name
...

$CONDUCTORS
# GL for conductive couplings
GL(10,20)= 960 x 0.0001x 0.05; # Conductivity x SectionArea / length
GL(30,10)= 0.5 x 10.0 ; # conduction through one bolt x number of bolts
GL(30,20)= 0.5 ; # equivalent conduct' 1/Cequi = 1/qualityofContact + 1/LinearConduct'Housing + 1/LinearConduct'Baseplate
GL(40,30)= parameter1 x parameter2 ; # conductivity x lenth
...

# GR for radiative couplings
GR(10,20)= 0.0123; # any relevant comments
GR(10,30)= 0.0256;
GR(30,20)= 0.0253;
GR(30,10)= 0.0896;
...

# Multi-Layer Insulation Blanket efficiacy if any
GR(10, 11)= 0.005 x 1.0 # Efficiency x surface of MLI
...

$CONSTANTS
#
parameter1 = 150.0 ; # w/m/^C
parameter2 = 0.1 ; # meter
...

$VARIABLES1
#
QI30 = 76.0+21.3 # Dissipation component 1 and component 2
QI20 = (10+2.5)/2 # Dissipation component 3 with 50%of duty cycle.
...
# heating line regulation if any
TC10 = 10.00 # Target temperature
QR10 = 1.0 # QR for injection of power (w) on node number 10 if the temperature remain under the target.
# Indicate the injection of power (proportional, proportional intergral...)
$ENDMODEL
```

Verification Method: R

ISIS-GDIR-REQ-90004 v: 1

In order to ease the configuration management of the different models, ITMM & IGMM files shall be named as follow: NAMETUXX.TYP_ZZ with:

- NAME is the generic name of the model (a maximum of 6 letters shall be respected)
- T represents the type of model
 - o D for design model
 - o I for interface model
- U represents the model configuration (for example O for operational configuration, L for launch configuration)
- XX is the version number of the model (for example 01 for the 1st version)
- TYP iis the extension or file type
- ZZ represents the enclosure number if any.

Verification Method: R

ISIS

ISIS-GDIR-REQ-90005 v: 1

In order to ensure the compatibility between the analyses performed at the different levels, each model (ITMM & IGMM) shall be clearly identified with a comment header using following rules:

- the first comment shall be the model name
- the version number and date
- the company name
- a brief description identifying the status and modification of the model

Verification Method: R

ISIS-GDIR-REQ-90006 v: 1

The coordinate axis system used for the definition of geometrical models shall be the Unit Reference System, as defined in its Mechanical Interface Control Document (MICD).

Verification Method: R

ISIS-GDIR-REQ-90007 v: 1

The reference frame origin shall be located at unit reference hole as defined in its Mechanical Interface Control Document (MICD).

Verification Method: R

ISIS-GDIR-REQ-90008 v: 1

The convergence of the models (ITMM & IGMM) shall be checked (in particular, geometrical calculation parameters such as number of rays) and selected to have an acceptable independence of the temperature results with regard to these parameters.

Verification Method: A, R

ISIS-GDIR-REQ-90009 v: 1

Justification of the models (ITMM & IGMM) convergence shall be provided.

Verification Method: R

ISIS-GDIR-REQ-90010 v: 1

Any automatic or manual treatment of the results from radiative calculation software, such as specific GR deletion or trimming area coefficients (performed outside Esatan file) inputs shall be fully and clearly described in the models documentation.

Verification Method: R

ISIS-GDIR-REQ-90011 v: 1

Any comment in ITMM & IGMM models shall use the English language.

Verification Method: R

ISIS-GDIR-REQ-90012 v: 2

The IGMM shall include the modelling of all surfaces with their thermo-optical properties (BOL & EOL) which participate to radiative exchanges in accordance with a configured issue of ICD (in particular, concerning dimensions).

Verification Method: R

ISIS-GDIR-REQ-90013 v: 1

ISIS

When using an interpolation table giving a physical property value as a function of temperature, all computed temperatures shall be within the temperature range of this table.

Verification Method: R

ISIS-GDIR-REQ-90014 v: 2

The temperature results obtained with transient calculation shall be stabilized with accuracy:

- better than 0.1°C on orbital temperature profile
- better than 0.1 °C/hour for asymptotic temperature stabilization

Comment: - Note 1: switching element should have a repetitive pattern

- Note 2: accuracy of temperature calculation is mainly linked to the accuracy & good modelling of the unit heat transfers through the mounting structure (conductive exchanges) and with the unit radiative environment (radiative exchanges)

- Note 3: Plots or table of temperature are used to show that the accuracy criteria is met

Verification Method: A

ISIS-GDIR-REQ-90015 v: 1

For internal units the interface models (ITMM & IGMM) shall include no more than 5 nodes excluding boundary nodes

Note: If this number is insufficient to reach the model correlation requirement **X**, the supplier will propose an alternative figure, lower than 15 nodes, and submit for customer approval.

Verification Method: R

ISIS-GDIR-REQ-90016 v: 1

Each unit interface models (ITMM & IGMM) shall include:

- One or several baseplate nodes including TRP.
- One or several housing nodes including TRP if any
- If relevant, one or several internal nodes representative of critical hot points and of internal sensors.

Verification Method: R

ISIS-GDIR-REQ-90017 v: 1

Each unit interface models (ITMM & IGMM) shall include as boundary nodes:

- One or several conductive interface nodes representative of the heat transfer through the unit fixation
- One or several radiative sink nodes representative of the heat transfer through the unit housing
- If any, space node representative of the heat transfer to space.

Verification Method: R

ISIS-GDIR-REQ-90018 v: 1

The thermal nodes numbering shall respect two digits as a maximum.

ISIS-GDIR-REQ-90019 v: 1

The maximal number of external surfaces for external IGMM shall not exceed 20 surfaces.

Comment: Note: If this number is not satisfactory for relevant representativity, the supplier will propose an alternative figure, lower than 100 surfaces, and submit for customer approval.

Verification Method: R

ISIS

ISIS-GDIR-REQ-90020 v: 1

Heat dissipation values shall be provided for all modes.

Comment: Note: typically operating mode, standby mode...

Verification Method: R

ISIS-GDIR-REQ-90021 v: 1

Heat dissipation values for each mode shall be provided for Typical, Minimum and Maximum cases.

Verification Method: R

ISIS-GDIR-REQ-90022 v: 1

The calculation of each heating line consumption (if any) shall be expressed using voltage & resistance parameters.

Verification Method: R

ISIS-GDIR-REQ-90023 v: 1

The interface models (ITMM & IGMM) shall be correlated with the design models (DTMM & DGMM) by comparing computation results from the specified test cases:

- operating mode worst hot case(s),
- operating mode worst cold case(s) if relevant.

Comment: Note: these test cases are steady state or transient cases if the design thermal analyses are based on a mission profile.

Verification Method: R

ISIS-GDIR-REQ-90024 v: 1

The validation of the interface models (ITMM & IGMM) shall satisfy the following constraints between interface and design mathematical models:

- The total unit dissipations shall be equal to the DTMM ones
- The total model unit heat capacities shall be equal to the DTMM ones
- The difference between ITMM temperature results for each node and corresponding DTMM nodes temperature results are within:
 - ±2 °C for units temperature reference point
 - ±3 °C for radiators
 - ±3 °C for structural parts
 - ±10 °C for internal MLI blanket and ±15 °C for external MLI blankets
- Less than 10% of difference on temperature difference between TRP and other nodes.
- Less than 5% of difference on power exchanges with the environment
- Less than 5% and not greater than ±2W of difference on average orbital heating/cooling power consumption
- if relevant less than 10% of difference on the instantaneous heating/cooling power consumption.
- if relevant less than 10% of difference on orbital temperature variation.

Verification Method: A, R

ISIS-GDIR-REQ-90025 v: 1

The delivery of each model (ITMM & IGMM) shall be composed of:

ISIS

- A single zipped electronic file containing all geometrical and thermal model data, allowing the computation of radiative couplings, absorbed fluxes and temperatures for all the mission modes and test calculation results.
- A document with the description of the geometrical and thermal models allowing a better understanding of the models and with the results of their validation.

Verification Method: R

ISIS-GDIR-REQ-90026 v: 1

The interface models (ITMM & IGMM) description and delivery report shall at least include the following information and data:

- Number and list of thermal nodes, including node designation, internal or external location and heat capacity
- Temperature specifications
- Internal heat dissipation (steady state and transient) of all studied cases
- Heater power consumptions of nodes for all studied cases, including in case of active control switching:
 - .The control law
 - .The temperature threshold
 - . The definition of node used for heater monitoring
- List of heating line and heater resistances.
- List of assumptions taken into account for thermal interface modelisation
- List of coating thermo-optical properties (BOL/EOL values)
- List of used materials with their characteristics (thermal conductivity, specific heat, density)
- Mass budget corresponding to the ITMM
- Summary of orbit and thermal environment data used for external heat flow rates calculation
- Detailed drawings showing the nodal distribution and the mesh of the IGMM with thermo-optical properties.

Verification Method: R

ISIS-GDIR-REQ-90027 v: 1

The interface models (ITMM & IGMM) description and delivery report shall include in addition:

- The version number of the design models used to establish the interface models.
- Assumptions made to “condense”, “simplify” or “reduce” the model.
- Demonstration of the correlation between the design and the interface models.
- correlation cases with obtained temperature results.
- A compliance matrix to the current specification.

Comment: Note: these inputs will allow the customer to check the model delivery.

Verification Method: R