



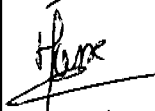
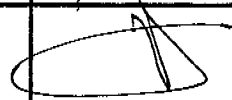
Herschel / Planck

GENERAL DESIGN AND INTERFACE REQUIREMENTS

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1. SCOPE

This specification establishes the general design and interface requirements that are to be met by the satellite units to ensure the correct hardware performances during assembly, integration, testing, launch and orbital operations.

Additional design and interface requirements specific to a subsystem are given in the relevant subsystem specification.

2. DOCUMENTS

2.1 APPLICABLE DOCUMENTS

AD- 1 Environment Requirements Specification
H-P-1-ASPI-SP-0030, June 2001

AD- 2 PA Requirements for subcontractors
H-P-1-ASPI-SP-0028, issue 1, June 2001

AD- 3 Safety Requirements for subcontractors
H-P-1-ASPI-SP-0029

AD- 4 Herschel/Planck EMC Specification
H-P-1-ASPI-SP-0037

AD- 5 Cleanliness Requirements Specification
H-P-1-ASPI-SP-0035

AD- 6 Radiation Requirements
ASPI-CN-11-E

AD- 7 ESA System Requirements Specification
SCI-PT-RS-05991, August 2000

AD- 8 General requirements for the delivered structural mathematical models
PL-AS-SP-011, Ed 1, Rev 1, 7/7/2000

AD- 9 Requirements for the delivery of thermal mathematical models
TBD

AD- 10 Requirements for the delivery of thermoelastic mathematical models

TBD

2.1.1 Applicable Standard Documents

2.1.1.1 Ariane Standards

- AD- 11 **ARIANE 5 User's Manual**
Issue 3 / Rev 0 Mar 2000

- AD- 12 **CSG Safety Regulations**
Volume 1 - General rules CSG-RS-10A-CN Issue/Rev/Date 5/1/ 03.03.99 (Volume 1 taken precedence)

- AD- 13 **CSG safety regulations**
CSG-RS-22A-CN issue 5/0 (Vol. 1) and CSG-RS-22A (Vol. 2) Edition 4, August 1991

- AD- 14 **CSG Volume 2 Part 1. Ground Installations**
GSG-RS-21A-CN Issue 5 / Rev 0 Dec 1997

- AD- 15 **Ariane General Specification for Payload Dynamic Model**
A5-SG-0-01, Issue 4

2.1.1.2 ESA standards

- AD- 16 **Telemetry Channel Coding Standard**
ESA PSS-04-103, Issue 1, Sept 1989

- AD- 17 **Ranging Standard**
ESA PSS-04-104 Issue 2, March 1991

- AD- 18 **Radio Frequency and Modulation Standard**
ESA-PSS-04-105 Issue 2.4, Nov 1996

- AD- 19 **Packet Telemetry Standard**
ESA-PSS-04-106, Issue 1, Jan 1988

- AD- 20 **Packet Telecommand Standard**
ESA-PSS-04-107, Issue 2, Apr 1992

- AD- 21 **Generic Specification for Silicon Solar Cells**
ESA PSS-01-604, Jan. 1998

AD- 22 Generic Specification for Gallium Arsenide Solar Cells
SPA-TS-0006, July 1997

AD- 23 ESA Power Subsystem Standard Specification
ESA-PSS-02-10, Nov 1992

AD- 24 Data for Selection of Space Materials
ESA-PSS-01-701, current issue

2.1.1.3 ECSS Standards

AD- 25 Space Mechanisms Standard Requirements Specification
ECSS-E-30-00 Part 2-3

AD- 26 ESA Fracture Control requirements
ECSS-E30-01A

AD- 27 A Thermal Vacuum Test for the Screening of Space Materials
ECSS-Q-70-02, Draft

AD- 28 A Thermal Cycling Test for the Screening of Space Materials and Processes
ECSS-Q-70-04

AD- 29 Material Selection for Controlling Stress Corrosion Cracking
ECSS-Q-70-36A

AD- 30 Determination of Susceptibility of Metals to Stress Corrosion Cracking
ECSS-Q-70-37

AD- 31 ESA Software Engineering Standards
ESA-ECSS-E-40

AD- 32 Time Code Format
CCSDS 301.0-B-2, issue 2

AD- 33 Software Product Assurance
ESA-ECSS-Q-80

AD- 34 Lossless data compression
CCSDS 121.0-B-1, May 1997

AD- 35 Space Engineering Standards – Mechanical - Thermal Control
ECSS-E-30-PART1A

2.1.1.4 Other Standards

AD- 36 MIL-HDBK-5

AD- 37 ESA Preferred Parts List
ESA-PSS-01-603, Issue 2

AD- 38 Crimping or High Reliability Electrical Connections
ESA PSS-01-726 Issue 1

AD- 39 The manual soldering of High Reliability Electrical Connections
ESA PSS-01-708 Issue 1

AD- 40 Derating requirements applicable to electronic, electrical and electro-mechanical
components for ESA space systems
ESA PSS-01-301 Issue 2

AD- 41 Packet Structure – Interface Control Document
SCI-PT-ICD-7527

2.2 REFERENCE DOCUMENTS

RD- 1 ESA Pointing Error Handbook
ESA-NCR-502, Issue 1, Feb 1993

RD- 2 Radiation Design Handbook
ESA-PSS-01-609, Issue 1, May 1993

RD- 3 Packet Utilisation Standard (PUS)
ECSS-E-70/41 Draft

RD- 4 Guide to Applying the ESA Software Engineering Standards to Small Project
BSSC (96)2, Issue 1, May 1996

RD- 5 Telecommand Decoder Specification
ESA-PSS-04-151

RD- 6 Straylight Evaluation for Planck

PT-05985, 23 June 1989

RD- 7 CCSDS Telemetry Channel Coding

CCSDS 101.0-B-4

3. GENERAL DESIGN AND INTERFACE REQUIREMENTS

3.1.1 Engineering standard units

GDGE-010: All drawings, specifications and engineering data shall only use the International System of Units (SI units).. (SGEN-010)

3.1.2 Interface control

GDGE-020: Each unit and subsystem shall be designed so as to ensure compatibility and proper interaction with other equipment and subsystems under all specified environmental conditions.

GDGE-030: Each unit interface will be controlled by Interface Control Documents (ICD) providing mechanical properties as well as electrical, telemetry, telecommand and thermal data. The ICD table of contents and the standard Interface Data Sheets (IDS) to be used within the ICD for interfaces description, are provided in Appendices 1.

3.1.3 Parts, Material and Processes

GDGE-040: For parts, the preference shall be given to the following:

- ESA preferred parts list,
- components qualified by ESA/SCC
- components approved for European Space Programmes
- components which have met qualification requirements of non European standards for space flight usage.

GDGE-050: The parts, materials and processes shall comply with the requirements, the environments and the quality assurance provisions as specified herein and with AD- 24. (SGEN-080)

GDGE-060: The selection of mechanical parts shall be justified by analyses, similarity, and if necessary, appropriate tests and their qualification for the required application shall be demonstrated. (SGEN-085)

GDGE-070: Materials which are not used inside pressurised volumes on the spacecraft shall have low outgassing properties with in general Total Mass Loss (TML) < 1% and Collected Volatile Condensable Material (CVCM) < 0.1% as determined by test method according to AD- 27. In case of materials used in the vicinity of critical (optical) elements, the more stringent requirement of Recovered Mass Loss (RML) < 0.1% and CVCM < 0.01% shall apply. It should be noted that outgassing characteristics are determined after a vacuum baking at 125°C for 24 hours. (SGEN-090)

GDGE-080: Materials shall not be flaking or dusting so that a high degree of cleanliness of the flight hardware can be achieved and maintained. This is also applicable to materials used on GSE. (SGEN-095)

- GDGE-090:** Materials and combinations of materials bonded to each other shall be resistant to the thermal cycling to which they will be exposed until the end of the mission. A standard thermal cycling method, is defined in AD- 28 but the contractor shall as necessary perform specific thermal cycling tests which are representative of the actual application (for qualification with at least a factor of 1.5 on the number of cycles expected until end of operational life). (SGEN-100)
- GDGE-100:** Materials shall be resistant to the radiation to which they will be exposed during their operational lifetime. The contractor shall determine what the anticipated radiation environment will be for materials used in various locations and as necessary demonstrate by appropriate testing that the properties shall not degrade below acceptable limits for significant properties. (SGEN-105)
- GDGE-110:** Materials which are in contact with each other shall be compatible with each other. Compatibility shall be demonstrated by test if insufficient data are available from standard references or previous applications. (SGEN-110)
- GDGE-120:** Materials shall be resistant to corrosion or they shall be suitably protected against corrosion. (SGEN-115)
- GDGE-130:** Materials shall have high resistance to stress corrosion cracking (SCC) for all structural applications but also for applications (like pretensioned springs or welded constructions which frequently include residual internal and assembly stresses) in which the materials are exposed for extended periods of time to tensile stresses in the terrestrial atmosphere or other potentially corrosive environments. The requirement also applies for GSE handling and lifting devices for loads higher than 30 kg.(SGEN-120)
- GDGE-150:** Metals which are in direct contact with each other shall not form a galvanic couple with a difference of more than 0.5 volts Electro-Motive Force; in corrosive environments it shall not be more than 0.25 volts EMF. (SGEN-125)
- GDGE-160:** As far as practicable, materials and mechanical parts shall be non-magnetic. In case magnetic materials must be used for a particular function the magnetic characteristics of the part will have to be determined and depending on the effects on system level, magnetic compensation methods might have to be applied. (SGEN-130)
- GDGE-170:** Materials that are nutrient for fungus shall not be used when their use can be avoided. Where used and not hermetically sealed, these materials shall be treated with a suitable fungicide agent. (SGEN-135)
- GDGE-180:** Materials which may constitute a safety hazard or can cause contamination shall not be used without specific approval by ESA (RFW). Examples of such materials are:
- B Beryllium-Oxide
 - Cadmium
 - Zinc
 - Mercury
 - Radioactive Materials

- PVC

(SGEN-140)

3.1.4 Hardware production requirements

GDGE-190: Each unit delivered for installation, assembly and integration into the satellite for qualification, flight and flight spare(s) shall meet the requirements of this specification and, in particular, will have passed the inspections and tests described in the applicable unit specification and in AD- 2.

3.1.5 Interchangeability

GDGE-200: Each item of the spacecraft shall be directly interchangeable in form, fit and function with another item of the same part number (configuration item number). The performance characteristics and dimensions of like units shall be sufficiently uniform to permit interchange with a minimum of adjustment and re-calibration (SGEN-170)

3.1.6 Lifetime

GDGE-210: For the Herschel mission, the spacecraft shall have a nominal lifetime of 3. 5 years. This duration is counted from the launch to end of mission. (SPER-005)

GDGE-220: For the Planck mission, the spacecraft shall have a nominal lifetime of 21 months. This duration is counted from the launch to end of mission. (SPER-010)

GDGE-230: The completely integrated satellite shall permit storage in a controlled facility before launch, prior to start of transport to the launch site, of 24 months. If required, helium refilling(s)/top-up(s) may be envisaged during this period. (SPER-020)

GDGE-240: The lifetime of items which degrade with time or usage shall be designed for 6 years. (SPER-025)

3.1.7 Maintainability, accessibility, reparability and testability

GDGE-250: The design of the spacecraft shall consider the need for accessibility and the method to be employed for removal of units, placement of test aids, for equipment requiring adjustment or maintenance with the aim of eliminating or minimising:

- the possibility of injury to personnel
- the possibility of damage to equipment or facility
- the possibility of incorrect assembly
- task complexity
- use of special tools or equipment
- use of non-standard hardware
- design complexity

- the need for special skills
- the activity duration

(SGEN-145)

- GDGE-260: It shall be possible to access or remove equipment if it requires maintenance control with minimum disturbance to and interference with spacecraft or payload. (SGEN-150).
- GDGE-270: Items to be removed before flight (red. tag items) shall be visible after integration with the spacecraft. (SGEN-155).
- GDGE-280: Items requiring integration for safety, logistical or life reasons, close to the launch, shall be accessible without removing any equipment from the spacecraft (SGEN-160).
- GDGE-290: Items which require adjustment, servicing or maintenance before launch shall be accessible without removing any equipment from the spacecraft (SGEN-165).
- GDGE-300: Periodic maintenance requirements during storage and ground life shall be minimised and declared. (SGEN-175)
- GDGE-310: The spacecraft and its constituting modules/assemblies and sub-assemblies shall survive all environmental testing without the need for refurbishment. (SGEN-180)

3.1.8 Reliability, Fault Tolerance and Single Point Failures

- GDGE-340: No single failure in the software or the hardware of a subsystem/unit shall cause the loss of that subsystem/unit. (MOFM-010)
- GDGE-360: Redundant units shall have a physical separation between them. If redundancy is implemented in the same box, a metallic separation is required. (MOFM-020)
- GDGE-370: Where redundancy is employed, the design shall allow to operate and verify the redundant item/function independently of the nominal use.. (MOFM-025)
- GDGE-380: Each redundant path or function shall meet the full performance requirements. (MOFM-030)
- GDGE-390: Autonomous failure recovery shall not be based on a single sensor readout. (MOFM-035)
- GDGE-400: Switch over to redundant units shall be possible without reconfiguration of unrelated units (MOFM-040)
- GDGE-410: The spacecraft shall suppress uncontrolled recycling of error reaction functions (MOFM-055)
- GDGE-420: Protection systems shall be intrinsically fail safe and shall be capable of being enabled and disabled by ground command. (SPER-080)
- GDGE-430: All relevant anomalies shall be properly detected and unambiguously reported and spurious anomaly detection (false alarm) shall be avoided. (MOFM-070)

GDGE-440: A clear and adequate fault reporting, shall be provided in the telemetry. (MOFM-075)

GDGE-450: A clear and adequate fault diagnosis and identification, shall be provided. (MOFM-080)

GDGE-470: Compliance to the fault tolerance requirements shall be verified by FMECA or by other suitable methods, which are subject to agreement with ESA. (SPER-110)

The following requirements apply to internally redundant units :

GDGE-480: Cross strapping shall be incorporated in between chains of redundant units so that maximum overall reliability is achieved. (SPER-085)

GDGE-490: Alternate or redundant paths shall be separated or protected such that an event that causes the loss of one functional path will not cause the loss or degradation of alternate, redundant serial paths.

3.1.9 Safety

GDGE-520: By design, the units shall be capable of sustaining a failure and retaining the property not to cause injury to personnel or damage to the launch vehicle and satellite.

GDGE-530: The units shall be designed and manufactured with compatible materials in such a manner that all hazards associated with the unit are eliminated or minimized and controlled.

GDGE-540: Applicable national standards on safety regulations or equivalent have to be observed.

3.1.10 Workmanship

GDGE-550: Workmanship shall be such that the design standard is not degraded or changed. At all points during manufacturing integration, test, handling, storage and transportation, the design standard shall be maintained.

GDGE-560: Manufacturing and process standard shall be in accordance with AD- 2

Wherever possible and appropriate, requirements in respect of layout, finish and cleanliness shall be defined in the relevant specifications, drawings and/or process specifications. For satellite subsystem of qualification of flight application, the requirements shall be to the standards normally associated with space hardware.

Particular attention shall be paid in the consideration, definition, implementation and inspection of workmanship standards to:

- contamination
- surface finish
- elimination of sharp edges and burns
- routing and layout of wiring
- part mounting

- joint including soldered connections
- connector assembly
- conformal coating.

3.1.11 Identification and product marking

GDGE-570: Each separately identifiable part or sub-assembly shall carry an identification consisting of at least the following information:

- a) Part/Unit Name
- b) End item number (this includes the Box Code)
- c) Serial number and modification index
- d) Name of the Manufacturer
- e) Date of manufacture

All marking shall be in English.

GDGE-580: The identification shall be mounted on the connector face, visible when installed on the unit and its location shall be noted on the Interface Control Drawing for the unit. The identification shall be legible with unaided eye from 0.5 m distance. The identification label shall meet all the requirements relevant to any equipment.

3.1.12 Cleanliness

GDGE-590: Edge of Honeycomb panels shall be covered by Kapton foil or foam FM410-1 in accordance with the cleanliness requirements

GDGE-600: External cleanliness is required for all satellite and GSE units to entered in clean room. Refer to AD- 5.

3.1.13 Handling, Packing and Transportation

GDGE-610: The design of the equipment shall make easy integration, transportation and access to connectors and fixation points for the operators during AIT.

GDGE-620: During transportation of hardware, packing and special precautions shall be such that the environments specified in AD- 1 can be withstood. Packing provisions shall prevent damage and contamination during transportation. Special covers shall protect optics, connectors, mounting surfaces subject to alignment procedures and all sensitive parts.

GDGE-630: The container for the units shall be labelled, tagged or marked to allow detailed identification of the contents of the container.

3.1.14 Radiations

The radiation environment is defined in the Environment Requirements Specification (AD- 1). Due to the specificity of the mission around L2, the spacecraft will only cross the Earth's radiation belts once during LEOP. However, it will still be exposed to energetic protons and heavy ions from solar flares and cosmic rays.

The principal anticipated radiation effects are:

- Degradation of electronic components, detectors and materials (dose effect),
- Interference with detector operation (background)
- Cosmic rays induced upsets
- Latchup
- Electrostatic charging

3.1.14.1 Radiation Dose

- ENVR-010:** The satellite shall be designed to withstand the doses predicted for a 2 times the nominal lifetime of the spacecraft except for the solar array sizing.(SENV-085).
- ENVR-020:** The components and their shielding shall be compatible with the above requirement such that the radiation dose will not cause failures or produce unacceptable changes in performance. (SENV-090)
- ENVR-030:** For the design of the solar array and the determination of its degradation during the mission, the total equivalent fluence of 1 MeV electrons shall be taken into account for nominal lifetime plus one year. (SENV-095)
- ENVR-040:** Components shall be qualified (either based on existing or new test data) to withstand twice the expected level of radiation. Radiation testing shall be included in the lot acceptance testing, if the margin is small and if the variation of radiation resistance between lots is large or insufficiently known. An exception to this requirement is the solar cells which shall be qualified according to AD- 21 for Silicon Solar Cells and AD- 22 for Gallium Arsenide Solar Cells.(SENV-100)

3.1.14.2 Radiation induced background

Radiation impinging onto a detector or its associated electronics can produce an increase in noise, which in turn can produce a significant decrease of performance. Such changes can last until well after the radiation dose has stopped (remittances).

- ENVR-050:** The spacecraft design and component selection shall be such as to minimise these effects, including any necessary means to ensure the most rapid restoration of nominal performance. (SENV-105)

3.1.14.3 Single Event Effects

Single event effects are due to heavy ions and protons from galactic and extra galactic sources and solar flares protons. Its effects on electronic components may be destructive (latch-up) or non-destructive (bit flips).

The applicable environment curves are given in AD- 1.

The methodology to be applied for single events (SEL, SEU) rate prediction is provided inAD- 6.

3.1.14.3.1 Single event latch-up

Cosmic rays may cause latch-up in certain technologies, primarlily CMOS. Latch-up is permanent and potentially destructive.

- ENVR-060:** Devices which are known or proven to be susceptible to latch-up shall not be used.
- ENVR-070:** Components of technology sensitive to heavy ions or protons shall be submitted to evaluation in order to qualify their latch-up occurrence rate.
- ENVR-080:** In the case where technical demands can only be met using latch-up sensitive technologies, a de-latching device shall be implemented so as to avoid loss of the unit upon latch-up.

3.1.14.3.2 Single event burn-out and single event gate rupture

N channel power MOSFETs are sensitive to single event burn-out and single event gate rupture, while P channel ones are only sensitive to single event gate rupture.

- ENVR-090:** Appropriate derating rules shall be applied as per AD- 40.

3.1.14.3.3 Single event upset (SEU)

- ENVR-100:** When components sensitive to SEU are selected, the design shall take care that solutions to prevent the effects of SEU on the mission are implemented into the equipment as hardware solutions (particularly through component selection) or as software solutions.
- ENVR-110:** The availability computation shall account for possible SEU effects and shall demonstrate that the availability requirement is fulfilled.
- ENVR-120:** SEU shall not cause permanent failure or degradation either directly or as a consequence.
- ENVR-130:** All computers shall be protected against the effects of SEU.
- ENVR-140:** The computers memory architecture shall be such that a MEU inducing a flip of more than two (2) bits in the same word shall not lead to the loss of the mission.
MEU : Multiple Even Upset, i.e. the consequence of a heavy ion causing more than one simultaneous bit flip in the same chip.

4. MECHANICAL DESIGN AND INTERFACE REQUIREMENTS

4.1 MECHANICAL REFERENCE FRAMES

4.1.1 Satellite Axes Definition

4.1.1.1 Herschel

The Herschel satellite reference frame (O, X_s, Y_s, Z_s) is defined such that :

- O is located at the center of the launch vehicle interface ring, on the separation plane
- X_s coincides with the nominal optical axis of the Herschel telescope. Positive X_s axis is oriented towards the target source. The X_s axis coincides with the launcher longitudinal axis.
- Z_s is in the plane orthogonal to the X_s axis, such that nominally the Sun will lie in the (X_s, Z_s) plane (zero roll angle with respect to Sun). Positive Z_s axis is oriented towards the Sun.
- Y_s completes the right handed orthogonal reference frame.

See Figure 4.1-1.

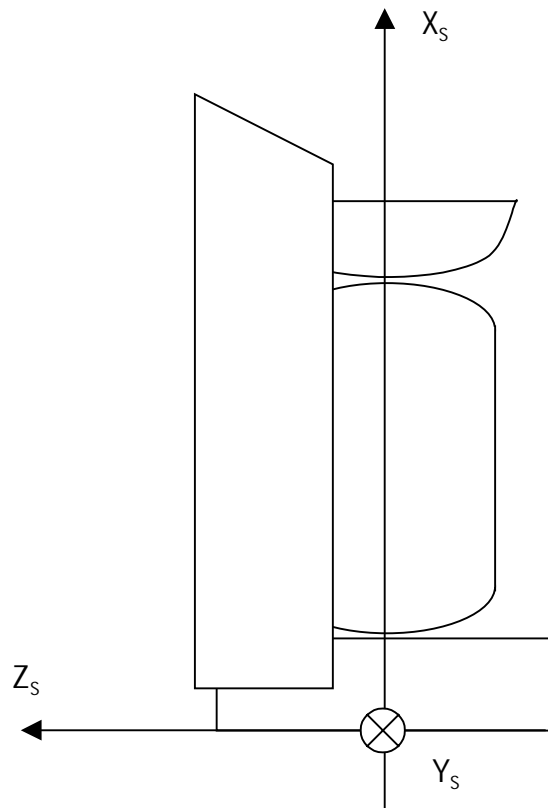


Figure 4.1-1: Herschel Spacecraft Axes

4.1.1.2 PLANCK

The PLANCK satellite reference frame (O, X_s, Y_s, Z_s) is defined such that :

- O is located at the center of the launch vehicle interface ring, on the separation plane
- X_s coincides with the nominal spin axis of PLANCK. Positive X_s axis is oriented opposite to the Sun in nominal operation. The X_s axis coincides with the launcher longitudinal axis.
- Z_s is perpendicular to X_s and contained in the symmetry plane of the telescope, with the positive direction on the concave side of the primary mirror of the telescope
- Y_s completes the right handed orthogonal reference frame.

See Figure 4.1-2.

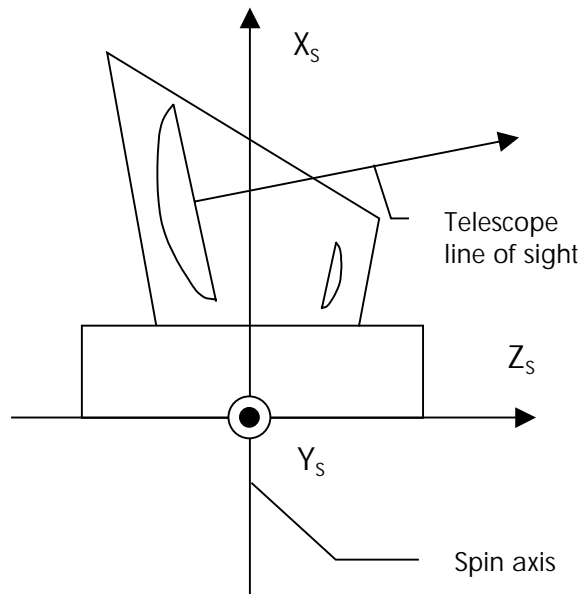
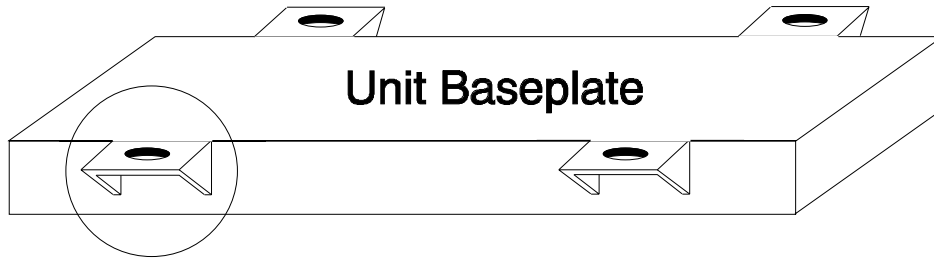


Figure 4.1-2: PLANCK Spacecraft Axis

4.1.2 Unit reference frame

A unit reference frame is defined with the (X_u, Y_u) plane defined as the plane of the unit mounting and the Z_u axis perpendicular to this plane in the direction from it to the unit. The origin of the unit reference frame is at the centre of the reference hole (see Figure 4.1-3).



Reference Hole

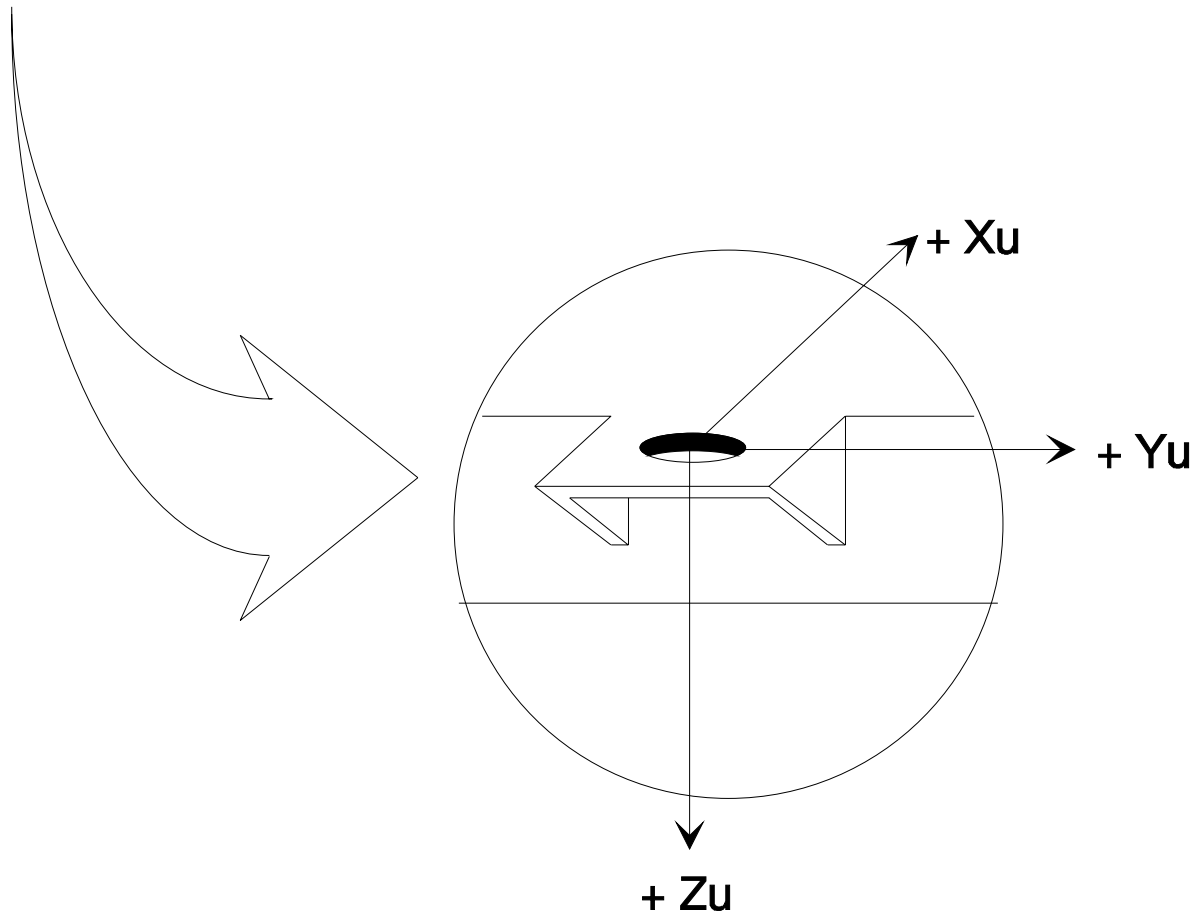


Figure 4.1-3: Unit Reference Frame

4.2 HANDLING PROVISIONS

- GDME-010:** Lifting and transportation interfaces shall be arranged such that, except for the points themselves, ground handling loads shall not be a design governing requirement for the Probe.
- GDME-020:** The satellites lifting points shall permit handling of the satellites as in all orientations necessary for assembly, integration, test and transport. Positioning of points shall be such that satellite integration shall not limit the handling capability of the integrated spacecraft.
- GDME-030:** 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.
- GDME-040:** Positioning of these points shall be such that unit integration shall not limit the handling capability of the integrated satellite

4.3 UNITS PHYSICAL CHARACTERISTICS

For mass properties (mass, center of mass, inertia) the term "nominal" refers to the current best estimate, either calculated or measured depending on the development progress.

4.3.1 Mass

GDME-050: The total spacecraft mass shall be minimised wherever reasonable and shall include, at the beginning of phase B, a margin on each spacecraft elements depending on the development status of those elements as follows :

- Completely new developments 20%
- New developments derived from existing hardware 15%
- Existing units requiring minor/medium modification 10%
- Existing units 5%

The propellant masses shall be determined on the basis of dry mass including the above contingencies and shall itself include the lifetime margins

- Orbit insertion propellant 10%
- Orbit maintenance propellant 50%
- Angular momentum management/attitude control 50%

(SCMD-080)

GDME-060: The nominal mass of each unit, with tolerances, shall be given in the unit Interface Data Sheet (see Appendix 1)

GDME-070: The actual mass of all units intended for Qualification, Flight and Flight Spare(s) shall not deviate from the nominal value by more than:

- 0.5% for masses > 20 kg

- 0.1 kg for masses > 10 kg and < 20 kg
- 1% for masses > 1 kg and < 10 kg
- 10 g for masses < 1 kg.

For the SVM structure, the actual mass of all units intended for Qualification, Flight and Flight Spare(s) shall not deviate from the nominal value by more than:

- 1% for the total SVM structure
- 2% for composite parts of the SVM structure (e.g. central tubes, lateral panels...)

The masses shall be measured with an accuracy of:

- - $\pm 0.1\%$ for masses > 50 kg
- - $\pm 0.05\%$ for masses > 10 kg and < 50 kg
- - ± 1 g for masses > 0 kg and < 10 kg.

4.3.2 Centre of mass

- GDME-080: The nominal center of mass of each unit, with tolerances, shall be given in the unit Interface Data Sheet (see Appendix 1)
- GDME-090: The location of the center of mass for equipment intended for EM, Flight and Flight Spare(s) must not deviate from the nominal location by more than 1.0 mm radius sphere.
- GDME-100: The centre of mass location shall be measured with an accuracy of 0.5 mm.

4.3.3 Moments of inertia

- GDME-110: Nominal moments of inertia of each unit, with tolerances, shall be recorded in the unit Interface Data Sheet (see Appendix 1).
- GDME-120: The value of the moments of inertia of equipment intended for Qualification, Flight and Flight Spare(s) must not deviate from the nominal value by more than 10% except for equipment having a moment of inertia lower than 0.1 kg.m² for which calculated values may be supplied.
- GDME-130: The moments of inertia shall be measured with an accuracy of $\pm 5\%$.

4.3.4 Size

- GDME-140: All interface dimensional properties must be indicated on Interface Control Drawings.
- GDME-150: The overall dimensions and associated tolerances of unit including interface assembly, shall not differ from the values stated in the Interface Data Sheets (see Appendix 1).

4.4 UNIT LAYOUT AND INTERFACES

The layout of each unit shall take into account:

- electrical requirements
- thermal control requirements
- alignment and centre of mass requirements
- vibration requirements
- easy access to electrical connectors
- easy access to fasteners
- easy mounting and removal
- provision to avoid mismatching
- flatness etc...

GDME-160: The unit layout and method of fixation shall be indicated on the Interface Data Sheets (see Appendix 1).

4.5 STRUCTURAL DESIGN

4.5.1 Definitions

- Primary structures

The primary structures are the main flight Loads paths and define the major structural frequencies

- Secondary structures

The secondary structures are not responsible for the main load transfer. They are fastened to the primary structure, and transfer unit Loads to the primary structure

- Unit/Equipment structures

Unit/Equipment structures are those belonging to self standing items such as experiment units and sensors, mechanisms, subsystem components and electronic boxes.

4.5.2 Stiffness requirements

GDME-180: The eigenfrequencies of compact equipment and boxes in hard-mounted condition shall be above 140 Hz. (SCMD-010)

4.5.3 Strength requirements

GDME-200: The spacecraft shall be able to withstand the mechanical environment as deduced from the coupled analysis with the launcher(SCMD-015)

GDME-220: The structure shall withstand at element, subassembly; or complete spacecraft level the following:

- the ultimate loads without rupture, collapse or permanent deformations that impact the integrity of other parts or the system performance
- the yield loads, where applicable, without permanent deformation or any plastic deformation resulting in performance degradation
- the buckling loads without elastic buckling or collapse taking into account a non perfection of the failing element, e.g. by knock-down factor

(SCMD-025)

GDME-230: The spacecraft structure shall withstand the complete set of tests at qualification level with sufficient margins without the need of any refurbishment for flight. (SCMD-035)

4.5.4 Safety factors

GDME-240: Safety Factors (SF) shall account for inaccuracies in predicted allowable and applied stresses due to:

- analysis uncertainties,
- manufacturing tolerances,
- scatter in material properties,
- setting at interface.

The safety factors as presented in Table 4.5-1 shall be used (SCMD-040, SCMD-045):

Item	Yield SF	Ultimate SF	Buckling SF
Conventional metallic materials	1.1	1.5	2.0
Unconventional materials	1.4	2.0	2.0
Inserts and joints	1.5	2.0	NA

Table 4.5-1 : Basic Safety Factors

GDME-250: If structural integrity cannot be demonstrated by test for practical reasons, use of unconventional materials is forbidden and an additional safety factor of 1.5 shall apply. (SCMD-050)

The conventional and non-conventional materials are defined as follows :

Conventional materials:

All materials, also composites, provided sufficient statistical data are available to derive A values as defined in the MIL-HDBK-5 section 1.4.11.

Unconventional materials:

All those materials for which sufficient statistical data are not available.

4.5.5 Loads and margins of safety

The following loads are defined

- Limit Loads: limit loads are the load combinations which have a 99% probability of not being exceeded during the entire life of the structure, including manufacturing, handling, transportation, ground testing, launch and in-orbit operations
- Design Loads: design loads are simplified load cases which shall envelope the limit loads and the qualification loads of the environmental testing
- Preliminary Design Loads: preliminary design loads are the design loads to initiate the design phase.
- Yield loads: yield loads are design loads multiplied by the yield safety factor.
- Ultimate loads: ultimate loads are design loads multiplied by the ultimate safety factor
- Buckling loads: buckling loads are design loads multiplied by the buckling safety factor.

GDME-260: The Margin of Safety (MOS) is calculated as follows:

$$MOS = \frac{(Relevant\ Strength\ Capability)}{(Relevant\ Load)} - 1$$

The Yield Margin of Safety (YMOS) compares the yield strength capability of the structural elements to the yield loads.

The Ultimate Margin of Safety (UMOS) compares the ultimate strength capability of the structural elements to the ultimate loads.

The Buckling Margin of Safety (BMOS) compares the buckling strength capability of the structural elements to the buckling loads.

The Strength Capability is the load which exactly induces the design allowable stresses for the material. (SCMD-070)

GDME-270: The material Design Allowable shall correspond to the A-values as defined in document MIL-HDBK-5. The Contractor shall perform material testing as necessary to establish the Design Allowable. The test programme and interpretation of the results are subject to ESA approval. (SCMD-075)

4.5.6 Preliminary design loads

GDME-280: Table 4.5-2 gives preliminary quasi static load Herschel and Planck components.

These levels are qualification levels and for each equipment, the load cases are not to be considered simultaneously.

	Case	Qualification level
Secondary structure Unit brackets and attachments Antenna booms, flexible units Solar Array		30 g spherical envelope (TBC) ^(*) 30 g spherical envelope (TBC) ^(*) 15 g spherical envelope (TBC) ^(*)
Electronic boxes in Herschel and Planck SVM	1 2	25 g in box mounting plane 30 g perpendicular to box mounting plane
Fuel tanks	1	12 g axial combined with 8g lateral

^(*) according to SRS, SCMD-065

Table 4.5-2: Preliminary design loads

4.6 ALIGNMENT

4.6.1 Alignement provisions

GDME-290: The following points shall be observed for any equipment requiring positioning accuracy on the structure:

- at least 2 positioning levels and when necessary shims shall be provided with location and tolerance consistent with positioning requirements
- the Contractor for the equipment shall specify the alignment tolerances between the mating and the sensitive axis as well as between the dowel line and the sensitive axis (e.g. thrust axis)
- the Contractor for the equipment shall provide the Contractor for the structure with a drilled template in accordance with the dowel positioning
- should some accurate items require alignment adjustment in situ the relevant Contractor shall formulate a request to the Prime Contractor with proper justification. The adjustment process shall be defined in each case by common agreement between the Contractor and the Prime Contractor.

4.6.2 Alignment with mirror

GDME-300: Any unit that requires an accuracy of alignment of $\pm 0.15^\circ$ or better shall have optical reference reflectors. The location of the mirror shall be identified in assembly drawings and Interface Control Drawings.

GDME-310: The following points shall be observed in designing unit optical references:

- each unit requiring alignment about 2 axis shall carry a reflecting mirror parallel to the plane containing those 2 axes or two reflecting mirrors (see note (1)), each one perpendicular (see note (3)) to the relevant axis; details will be as specified in Interface Control Drawings
- each unit requiring alignment about 3 axis shall carry two (see note (2)) perpendicular (see note (3)) reflecting mirrors
- the direction of the axes of the optical reference shall be known relative to the direction of the unit axis to an accuracy as described in the unit Specification

- the reflecting surfaces shall be optically polished and flat to within $\Lambda/4$ (Λ : wevelength of the sodium yellow line)
- when two or more reflecting surfaces are provided, it is preferable to use an optical cube. Notes (1) to (3) apply
- the optical references shall have a minimum diameter of 15 mm and a minimum thickness of 4 mm.

The fixation of the alignment mirrors shall allow the alignment of the concerned unit on the integrated spacecraft (see note (1)). The fixation of the alignment mirrors shall be compatible with mechanical and thermal vacuum testing environment, and with outgassing requirements.

- NOTES:
- (1) The two reflecting mirrors shall be positioned after agreement of the Prime Contractor in order to ensure they can be used when integrated on the satellite.
 - (2) If only two or three reflecting mirrors are provided the note (1) shall apply.
- If four or five reflecting mirrors are provided, the note (1) does not apply.
- (3) Perpendicularity of reflecting surfaces shall be ± 10 arc sec.

4.7 UNIT FIXATION

4.7.1 Functional requirements

GDME-320: 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.

4.7.2 Lug general design characteristics (boxes)

GDME-330: The lugs shall be designed according to Figure 4.7-1.

GDME-340: One of the holes shall be identified as reference hole and shall be marked with the capital letter R on the Interface Control Drawing.

GDME-350: The box co-ordinates and the centre of mass co-ordinates shall be related to the reference hole. The positive Z-axis shall be normal to the mounting surface, as defined in § 4.3-2.

GDME-360: Boxes with a mass < 1.5 kg shall not have more than 4 attachment points.

The definition of the boxes attachment points shall comply with the following mechanical requirements, under application of the worst case of mechanical and thermal environments:

- no sliding at support structure interface, according to the following criteria:

$$((P + (Q/\rho))/P_m) \times SF \leq 0.9, \text{ using SF for yield loads}$$

- limit loads at attachment points compatible with inserts loads capabilities as defined in §4.7.4, according to the following criteria:

$$SFx\sqrt{((P/P_m)^2 + (Q/Q_m)^2)} \leq 0.9 , \text{ using SF for joints}$$

where,

- ρ is the friction coefficient between the box and its support structure, as defined in Table 4.7-1.

support structure	Aluminium box	
	with alodine 1200S coating	plated A5
aluminium with alodine 1200S coating	$\rho \text{ max} = 0.23$	$\rho \text{ max} = 0.23$
aluminium plated A5	$\rho \text{ max} = 0.23$	$\rho \text{ max} = 0.23$
CFRP	$\rho \text{ max} = 0.2$	$\rho \text{ max} = 0.2$

Table 4.7-1: Friction coefficient values

- P and Q are the actual values of axial and lateral loads applied to the attachment bolt.
- P_m and Q_m are the typical insert strength capability specified in §4.7.4 Table 4.7-2 and Table 4.7-3.
- P_m in tension to be used to check no sliding criteria.
- P_m in tension or compression to be used, depending of the equipment feet design, to check compatibility with inserts loads capabilities.

The equipment design shall prevent single inserts loading in bending and torsion.

The number and pattern of boxes attachment points is to be approved by the Prime Contractor.

GDME-370: For highly dissipative equipment the number and location of attachment point shall be chosen according to thermal considerations.

4.7.3 Lug interface

GDME-380: The distance Between two adjacent lugs shall be smaller than 300 mm but not closer than 30 mm and in accordance with the Interface Control Drawings (ICD).

GDME-390: The location of each attachment hole centre w.r.t. the Reference Hole, shall be within a 0.2 mm diameter circle centred on the theoretical position.

GDME-400: The lugs and clearance for mounting shall be dimensioned as shown in Figure 4.7-1. No part of the box shall be in the volume above the lugs indicated as "free access required".

- GDME-410: The contact area shall be specified on the ICD for each attachment point.
- GDME-420: For highly dissipative equipment, this area shall have to be agreed by Prime Contractor according to thermal subsystem needs. The Lug edge shall be rounded to minimum radius of 0.2 mm to avoid structural damage.
- GDME-430: The coplanarity of the lugs shall be within 0.1 mm/100 mm.

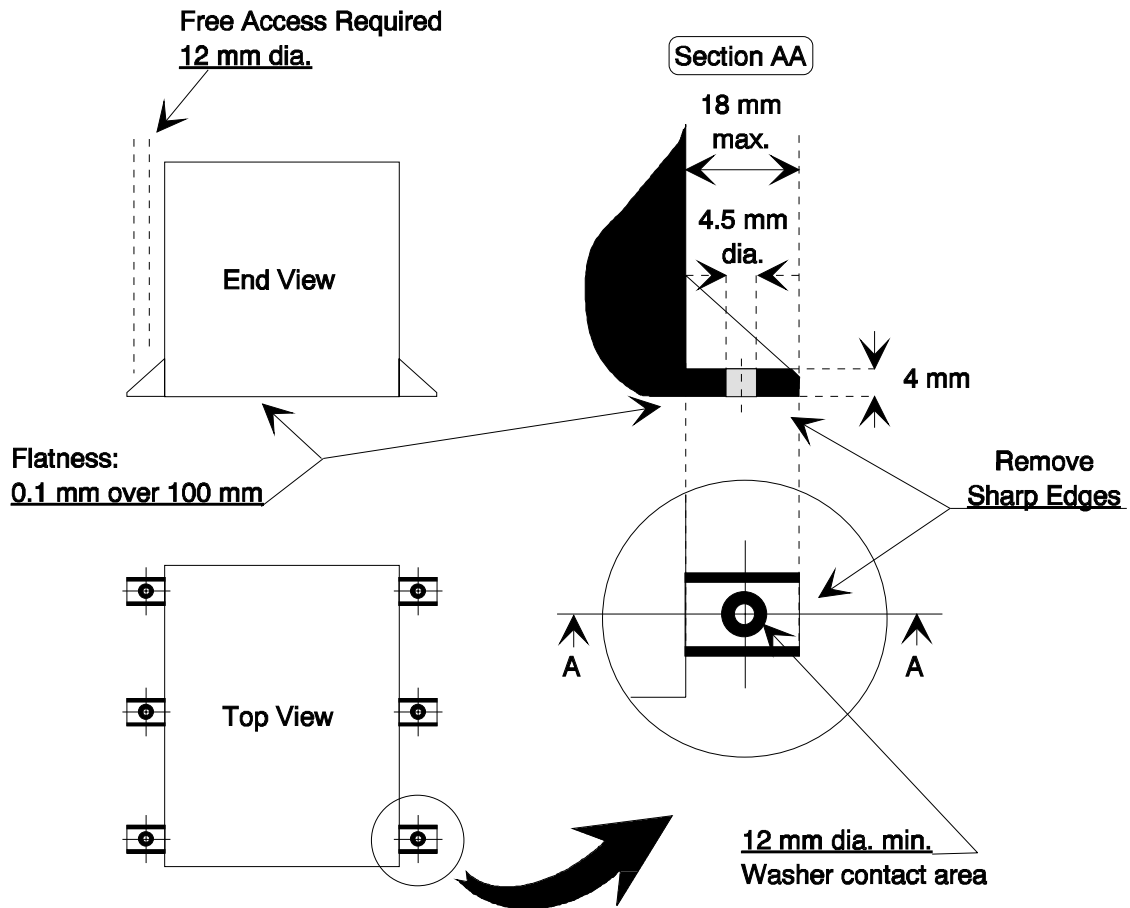


Figure 4.7-1: Unit Lug Interface Design

4.7.4 Fixation hardware

- GDME-440: For mounting of equipment, M4 screws shall be used (female bi-hexagonal).
- GDME-450: Spacecraft equipment fixation points (e.g. single inserts as shur-lok inserts) shall provide a minimum insert strength capability in accordance with Table 4.7-2 and Table 4.7-3 without yield or failure.

Herschel	Compression (P_m) (N)	Tension (P_m) (N)	Shear (Q_m) (N)
SVM structure			
PLM sub-platform	TBD	TBD	TBD
Upper platform	TBD	TBD	TBD
Lower platform	TBD	TBD	TBD
Lateral panel standard	TBD	TBD	TBD
shear webs	TBD	TBD	TBD
PLM			
Sunshield	TBD	TBD	TBD
Sunshade	TBD	TBD	TBD

Table 4.7-2: Insert Strength capability for Herschel

Planck	Compression (N)	Tension (N)	Shear (N)
SVM structure			
PLM sub-platform	TBD	TBD	TBD
Upper platform	TBD	TBD	TBD
Lower platform	TBD	TBD	TBD
Lateral panel standard	TBD	TBD	TBD
Lateral panel SCC	TBD	TBD	TBD
shear webs	TBD	TBD	TBD
PLM			
Primary reflector support panel	TBD	TBD	TBD

Table 4.7-3: Insert Strength capability for Planck

GDME-460: Single inserts located near to a free panel edge shall provide a minimum strength capability as expressed hereafter:

$$P'_m = P_m n_{EN}$$

$$Q'_m = Q_m n_{EQ}$$

where n_{EN} and n_{EQ} are extracted from Figure 4.7-2 (issued from Insert Design Handbook ESA-PSS-03-102).

For a inserts group, inserts shall provide a minimum strength capability as expressed hereafter:

$$P''_m = P'_m n_G$$

where n_G is extracted from Figure 4.7-3(issued from Insert Design Handbook ESA-PSS-03-102).

GDME-470: Compliance with these load requirements shall be shown in the ICD. Any exception must be approved by the Prime Contractor.

GDME-480: Spacecraft equipment fixation points shall provide threads characteristics as defined in Table 4.7-4 and Table 4.7-5.

Standard	Usable thread length (mm)	Bolt penetration (mm)	Helicoil	Locking device
M4	7.5	7.5	w/o	w/o
M5	9.5	9.5	w/o	w/o
M8 x 1	15.9	15.9	w/o	w/o

Table 4.7-4: thread characteristics for single inserts at external interfaces

Standard	Usable thread length	Bolt penetration	Helicoil	Locking device
M4	1.5 D	2 D (1)	with	w/o
M5	1.5 D	2 D	with	w/o
M6	1.5 D	2 D	with	w/o
M8 x 1	1.5 D	2 D	with	w/o

Table 4.7-5: thread characteristics for special inserts (e.g. face-to-face inserts) at external interfaces

GDME-485: Spacecraft equipment fixation points shall be provided with the following positional tolerances, as defined in Table 4.7-6.

		Shur-lok insert	Face-to-face insert
Reference hole of the equipment in the platform drilling frame	* committing value	$\boxed{\begin{matrix} \oplus \\ \ominus \end{matrix} \quad \boxed{\varnothing \quad 0.4}}$	$\boxed{\begin{matrix} \oplus \\ \ominus \end{matrix} \quad \boxed{\varnothing \quad 0.2}}$
Remaining holes with regard to the equipment reference hole	* committing value	$\boxed{\begin{matrix} \oplus \\ \ominus \end{matrix} \quad \boxed{\varnothing \quad 0.3}}$	$\boxed{\begin{matrix} \oplus \\ \ominus \end{matrix} \quad \boxed{\varnothing \quad 0.2}}$
	* target	$\boxed{\begin{matrix} \oplus \\ \ominus \end{matrix} \quad \boxed{\varnothing \quad 0.25}}$	

Table 4.7-6: inserts positional tolerances



Figure 4.7-2: Influence of edge distance on the static strength capability of inserts

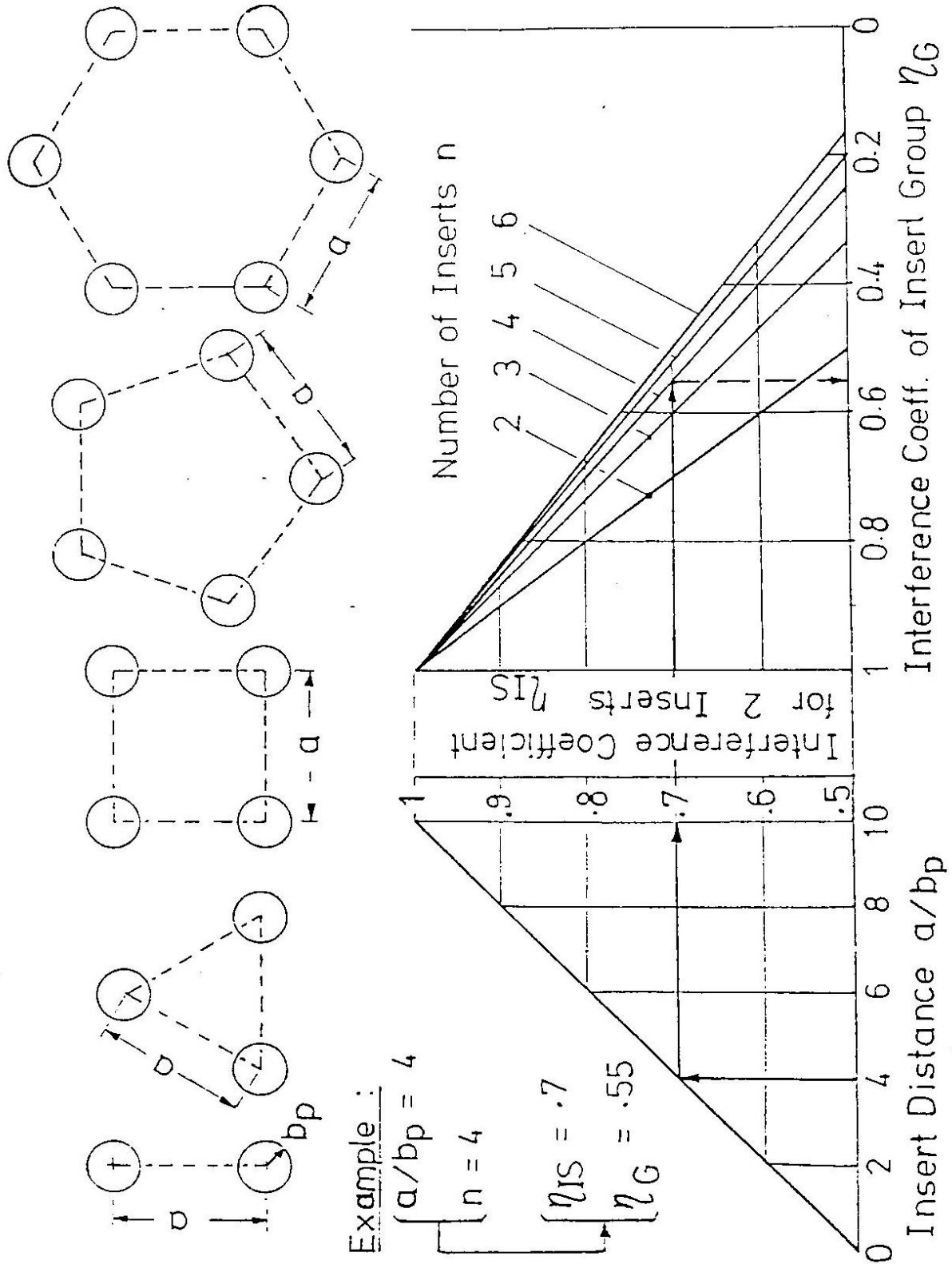


Figure 4.7-3: Interference in a group of equal & equidistant inserts

GDME-490: The use of blind rivets, minimum 3 mm diameter shall be allowed for the followed items:

- harness and RF cabling brackets
- pipe brackets.

GDME-500: The rivets shall be of the set head type. Tools used for riveting shall prevent any damage to structural parts.

GDME-510: The responsible of structural connection of removable parts (e.g. brackets) shall define:

- screws number
- screws size to be between M4 and M6 (female bi-hexagonal screws)
- type of washers
- torque's to be applied to the screws in accordance with type of inserts, washers and screws
- inserts to be M4; M5 or M6.

GDME-520: All these fixation hardware definitions have to be approved by the Prime.

GDME-530: Resistance to vibration will be ensured by effective locking provisions.

GDME-540: These locking provisions must be capable of being subjected to a minimum of 5 tightening and slackening operations without any significant effect on its bracking power.

4.7.5 Baseplate/Surface finish

4.7.5.1 General

GDME-550: The contact area between boxes and structure shall be at the area of the lugs. it shall be flat with no protrusion below the mounting plane.

GDME-560: The contact area or spot faces area shall be unpainted.

GDME-570: If for thermal reasons larger areas are requested, the contact area (complete bottom face) must meet the following requirements unless there are other mechanical or electrical constraints:

- flatness of 0.1 mm/100 mm (for mounted box and structure in area of mounting plane)
- roughness < 3.2 micrometers.

Exceptions are subject to approval by the Prime Contractor.

GDME-580: Unit baseplate thickness and dimensions shall be specified on ICD. All mating surfaces between equipment and spacecraft structure shall be left bare.

4.7.5.2 Surface finish treatment

No surface treatment is necessary for stainless steel (only passivation), beryllium, silver, fiberglass or carbon fiber, except for the needs of thermal control (if applied to external surfaces) or unless otherwise specified in AD- 4 (EMC/ESD purpose).

Surfaces treatment is necessary for:

- aluminium alloys (except alloys of serie 5000 with magnesium)
- magnesium and its alloys (mandatory).

Surfaces treatment may be necessary for:

- titanium and its alloys
- copper.

Requirements for these treatments are defined in AD- 2. Surface treatment of other materials must be approved by the Prime Contractor.

Cadmium an Tin plating is not acceptable.

4.7.6 Electrical bonding

GDME-590: Bonding of units and supports shall be performed according to section 6.2.

4.7.7 Grounding

GDME-600: It is required to ground all units to the structure according to section 6.2.

4.7.8 Damping supports

GDME-610: No damping supports external to the unit shall be used.

4.8 VERIFICATION OF THE MECHANICAL DESIGN

4.8.1 Modelling

GDME-620: Any structural Finite Element Model (FEM) shall be delivered in NASTRAN format (SCVE-010).

GDME-630: A structural Finite Element Model shall be delivered for subsystem and units with a principal mode below 140 Hz. Principal modes are those modes with an effective modal mass > 5%.

GDME-640: The FEM shall be detailed enough to ensure an appropriate derivation/verification of the design loads and the modal response for all important modes with an effective mass > 5 % of the total mass up to 140 Hz (SCVE-015).

GDME-650: It shall be supported by additional and more detailed models for the analysis and design of specific aspects (strength verification, thermal stress analysis, thermo-elastic analysis, interface stiffness analysis, optical analysis, as required) (SCVE-020).

GDME-660: At system level, the FEM shall be reduced to an Interface FEM (IFEM) for the Launcher Coupled Dynamic Analysis (LCDA). The IFEM shall fulfill the requirements established by the Launch Vehicle Authorities as defined in AD- 15 (SCVE-025).

GDME-670: The FEM's shall be correlated against the results of the modal survey tests carried out at component, subassembly and complete spacecraft level. As a result of that, the following criteria shall be satisfied:

- for the modes with an effective mass greater than 10% of the total mass:
 - frequency deviation less than 3%,
 - error for damping factor less than 20%,
 - Modal Assurance Criterium (MAC) greater than 0.9.
- for the modes with an effective mass greater than 5% of the total mass and an eigenfrequency below 100 Hz:
 - eigenfrequency deviation less than 5%,
 - MAC greater than 0.9.

(SCVE-030)

4.8.2 Analyses

GDME-680: All the design loads applicable to the various parts, subassemblies or complete spacecraft shall be substantiated by analyses of significant events during the complete lifetime. They shall be reassessed after each test at subassembly or system level. (SCVE-035)

GDME-690: The stiffness analysis shall demonstrate compliance with the requirements as indicated in section 4.5.2. The analytically predicted frequencies shall be higher than the minimum requirement specifications by the following percentages:

- at start of Phase B: 20 %
- at start of Phase C/D: 15 %
- after S/C Structural Model test: 10%
- at PFM test: 0%

(SCVE-040)

GDME-700: The stress analysis shall yield positive MOS, and cover loads originating from mechanical, thermal and moisture desorption effects combined adequately together. In case of proto-flight approach, the various MOS shall be greater than 0.2. (SCVE-045, SPER-050)

GDME-710: Strength values for mechanical parts shall not be assumed higher than the values specified for the relevant qualification and acceptance tests. (SCVE-055)

GDME-720: Fatigue analysis shall be carried out where relevant, and demonstrate a positive reserve after application of 4 times the most constraining life cycles. (SCVE-060)

GDME-730: Fracture mechanics analysis shall be carried out for the items which are potentially hazardous for the ground operations and meet the requirements specified in AD- 26. (SCVE-065)

4.8.3 Testing

GDME-740: Verification of the mechanical performance shall be possible by test at element, subassembly or system level (SCVE-070)

GDME-750: At system level static tests (including the primary structure and high loaded interface structures), the following test factors shall be used with respect to the maximum expected Limit Loads, unless otherwise specified:

- 1.25 for qualification
- 1 for acceptance

(SCVE-075)

GDME-760: All standard potted inserts shall be proof-tested up to 110% of their allowable loads before delivery of the assembly. The special inserts shall be qualified independently up to their relevant design loads. (SCVE-090)

5. THERMAL DESIGN AND INTERFACE REQUIREMENTS

5.1 GENERAL

5.1.1 General requirements

GDTH-010: All satellite modules and equipment shall be designed to withstand the extreme temperatures which may be experienced during transportation, ground testing and storage, and which are expected to be experienced during launch and in-orbit life.

GDTH-020: In order to ensure compatibility of equipment designs with the Herschel/Planck thermal control, each equipment shall be designed according to the following requirements:

- To comply with operating, non-operating, minimum switch-on/off and qualification level temperatures, as specified in § 5.1.2.
- To comply with requirements specified in section 5.3.
- To withstand the thermal environment as specified in AD- 1.
- To withstand the unit qualification tests.
- To comply with any special requirements identified in the applicable subsystem or equipment specifications.

5.1.2 Equipment Temperature limits

GDTH-030: The thermal design of satellite and equipment shall comply with temperature limits and temperature margins as defined hereafter.

The required values for operating, non-operating, switch-on and storage temperature limits are indicated in AD- 1.

GDTH-040: Temperature ranges definition (see Figure 5.1-1).

Calculated temperature limits

The calculated temperature limits of a unit are the extreme temperatures, temperature gradients and transients that can be expected during the various mission phases

These temperatures are calculated for all mission phases by a Thermal Mathematical Model (TMM). These calculations include the effects of extreme case combination w.r.t. environmental and operating mode conditions (BOL/EOL conditions, unit dissipations, voltage of power available for heaters...). These worst case conditions will be determined and justified by the thermal control responsible.

Predicted temperature limits

The predicted temperature limits of a unit are equal to the calculated temperature extended at both ends of the range by an appropriate uncertainty margin (U.M.). These predicted temperatures shall remain within the specified design temperature limits.

This margin represents the temperature uncertainty resulting from uncertainties in thermal mathematical modelling, thermal parameters or tolerances and shall be estimated by performing a sensitivity analysis.

Design temperature limits

The design temperature limits of a unit are the extreme temperatures, temperature gradients and transients that the unit shall tolerate during its specified lifetime for the various modes (operational, non-operational, switch-on). This temperature range represents the requirements for the unit internal thermal activities.

Acceptance temperature limits

The operating and non-operating acceptance temperature limits of a unit are equal to the design temperatures limits over the lifetime extended at both ends of the range by the Acceptance Margin (A.M.) of 5°C.

Qualification temperature limits

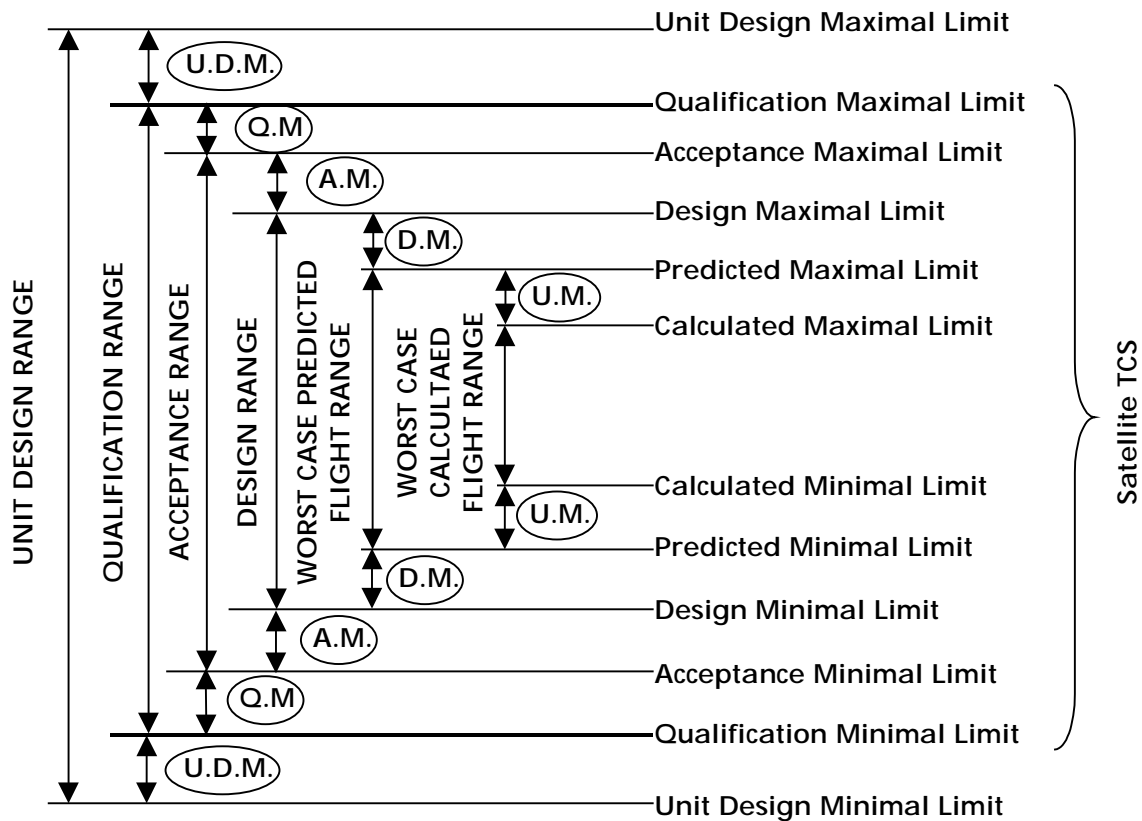
The operating and non-operating qualification temperature limits of a unit are equal to the design temperatures limits over the lifetime extended at both ends of the range by the Qualification Margin (Q.M.) of 10°C.

Switch-on temperature limit

The switch-on temperature limit is the lowest temperature at which an equipment may have power applied to it, or be activated. The thermal design of the equipment shall be such that upon such power application or activation, the equipment temperature soon moves into the operating temperature limit range

Switch-on qualification temperature

The switch on qualification temperature is the lowest temperature at which an equipment may have power applied to it, or be activated during thermal qualification test.



Notes:

- U.M.= Modelling Uncertainty Margin
- D.M.= Thermal Control Design Margin / ABS (D.M.) > 0 °C
- A.M.= Acceptance Margin / A.M. = 5 °C
- Q.M.= Qualification Margin / Q.M. = 5 °C
- U.D.M.= Unit Design Margin / U.D.M > 0°C

with

- U.M. + D.M. = 7°C for internal equipment at conventional temperature range (for Phase B)
- U.M. + D.M. = 10°C for external (antennas, thrusters) (for Phase B)

A 10% margin on Power as been included in the calculated limits.

Figure 5.1-1: Temperature limits definition

5.1.3 Temperature reference points

GDTH-060: All temperature requirements of units shall refer to specific points of these units. The location of these reference points shall be defined by the unit Contractor such that their temperatures can be related to the general thermal status of the unit and the critical unit components.

GDTH-070: Preferably one of the unit reference points shall be located on the baseplate close to unit fixation points.

The number of these reference points has to be minimised.

5.2 SATELLITE THERMAL DESIGN

5.2.1 General

GDTH-080: The TCS shall ensure that all equipment temperatures remain within the thermal design limits defined for each unit, during all phase of the mission, including ground testing. If applicable, it shall also ensure the required temperature stability for equipment. It shall maintain the structural parts within the required temperatures and temperature stabilities such that the necessary alignments are met between units involved in the pointing or alignment required performances. (STHE-080)

GDTH-090: The thermal design shall comply with the requirements of the Herschel and Planck IID's part B (STHE-075). In particular, for the Herschel cryogenic subsystem, all thermal requirements as specified in IID's Part B for the Focal Plane units and any other payload or spacecraft unit requiring cryogenic cooling for at least the nominal lifetime until all helium has been consumed shall be met (STHE-070).

GDTH-100: The Herschel and Planck thermal design shall:

- be as simple as possible. MLI and radiators with thermal coatings control the Sun, Earth and albedo effects and the internal heat distribution and rejection. Internally, thermal coatings and conductive paths will be used to control the temperature of critical units (STHE-105)
- be compatible with all solar aspect angles and albedo and any radiated inputs which are foreseen during all mission phases (STHE-085)
- use heaters when necessary. All heaters shall be capable of being commanded from ground (STHE-110). Grouping of heaters circuit shall be implemented whenever feasible in order to minimise the total number of needed ON-OFF commands (STHE-140)
- achieve modularity between SVM and PLM thermal control. It shall be possible to develop, integrate and test the spacecraft at module level with minimum interaction from the other modules. The modules shall therefore be thermally de-coupled as much as possible (STHE-135)
- use proven components and techniques
- be simple by using the inherent or designed-in thermal properties of structure and units, a minimum of additional thermal control components and the satellite geometry to maintain temperature levels and distributions within the specified limits for allowable satellite orientations. (STHE-060)
- be designed in order to minimise the uncertainties (i.e. the sensitivity to the design parameters). It shall permit reliable mathematical modelling of external and internal features

- optimise the heating and mass budgets
- be independent from subsystems and equipment
- include sufficient thermal sensors for in-flight monitoring of equipment temperatures. These sensors shall provide information about spacecraft health and shall serve as reference for heater control. (STHE-065)

GDTH-110: The thermal control shall be such designed to:

-
- accommodate variations of units dissipation, as defined in the ICD
- accommodate variations of coatings thermal properties (α , ϵ), due to thermal surface degradation resulting from exposure to environments (STHE-095). Protective covers, cleaning procedures and surface property measurements will be employed to insure that external coatings properties will be optimum at launch.

GDTH-130: The thermal control subsystem design shall incorporate sufficient flexibility to accommodate foreseeable changes in lay-out, power dissipation (amount and location), mission requirements and required temperature ranges (STHE-120)

GDTH-140: The thermal design shall be such that easy repair and minor changes in design are possible through simple removal and replacement of insulation blankets, foils, heaters and/or by in-place refurbishment of thermal control coatings and surface treatments. (STHE-125)

GDHT-150: The thermal design shall minimise the need for ground operational testing and subsystem level thermal vacuum tests. It shall not impose unacceptable constraints on other spacecraft elements nor on mission operation (STHE-130)

GDTH-160: All Herschel and Planck thermal and geometrical mathematical models shall be established and delivered to Prime Contractor and/or ESA according to requirements defined in AD- 9.

GDTH-170: At the start of the design and analysis process, design margins shall be established to cover modelling and hardware uncertainties and to indicate the sensitivity of the design to variations of various parameters.

5.2.2 Material and components

GDTH-180: As far as possible, materials will be chosen in order to limit stresses induced by thermal cycling i.e. with a low thermal expansion coefficient.

GDTH-190: Couple of materials will be chosen to decrease differential thermal deformation i.e. with thermal expansion coefficients of the same order of magnitude.

GDTH-210: Use of OAC (Chromic Anodised Oxidation) or OAS (Sulphuric Anodised Oxidation) protective coatings on external surfaces shall be approved by the Prime Contractor.

GDTH-220: Paints and coatings must satisfy outgasing criteria, optical requirements and resistance to thermal cycling requirement and environment (UV...).

- GDTH-230: All external surfaces (MLI's, coatings, paints, OSR's, SSM's,..) shall comply with ESD requirements as defined in AD- 4.
- GDTH-240: All external Kapton foils of ITO MLI, if any, shall have a thickness of 50 µm.
- GDTH-250: MLI's efficiency shall be guaranteed at $\pm 50 \%$ at conventional temperature range (AD- 35). This figure is to be determined by analysis on a case by case basis for cryogenic temperature range.
- GDTH-260: Edge of Honeycomb panels shall be covered by Kapton foils.
- GDTH-270: Thermophysical properties of any interface filler material or of any adhesive tape or similar materials shall be or shall have been determined and/or verified experimentally.
- GDTH-280: Thermal elements for which dismountability is required during integration and verification shall be removable without degradation of their thermal characteristics.
- GDTH-290: The method of application of any thermal coating shall be such that, in event of damage occurring to any thermal surface, the rework/repair shall be capable of being performed outside equipment manufacturer premises (rework/repair carried out in Prime Contractor premises or on launch pad).

5.3 EQUIPMENT THERMAL DESIGN

5.3.1 General requirements

- GDTH-300: Each unit shall be designed so that all internal heat sources have the required insulation or heat flow to the external surfaces of the unit, when the average temperature of these surfaces is within the applicable acceptance or qualification temperature range defined in the relevant unit specification.
- GDTH-310: In designing the unit and ascertaining the optimum heat flow paths, the equipment Contractor shall take into account the mounting method and the exchanges with the environment by both conduction convection and radiation.
- GDTH-320: The Unit Contractor shall carry out a thermal analysis of the unit internal temperature distribution and hot points in sufficient detail to demonstrate that temperature requirements for all thermally critical components are met even under single failure conditions.

5.3.2 Design requirements

- GDTH-330: To give maximum flexibility in location and application of each unit the equipment shall be designed for the worst most general, environments i.e. that given is AD- 1.
- GDTH-340: Geometrical, thermo-optical and thermal properties, contact area, dissipated power for various modes and qualification temperature range shall be defined in IDS and/or ICD.

- GDTH-350:** The location of the Reference Temperature points where thermocouples and thermistances are mounted shall be indicated on the ICD. One of this point shall be located on the baseplate close to a fixation point; when not indicated, the Reference Hole shall be the Reference Temperature point.
- GDTH-360:** The thermo-optical characteristic of the units shall be defined by the thermal control subsystem. Unit supplier is responsible for the application of a coating compliant with thermal requirements. Effect of age and radiation shall be taken into account to estimate thermo-optical characteristics.
- GDTH-380:** As a general requirement any thermo-optical and thermal properties defined in IDS and/or ICD shall be demonstrated by thermo-optical coating manufacturer data and process qualification report or measurement on sample or measurement on the equipment itself. Justification of the specified values shall be supplied to the Prime Contractor on request.
- GDTH-390:** Specific dissipation power and radiative area must be guaranteed at $\pm 5\%$ as a general rule (TBC value for subsystems requiring high Temperature stability).
- GDTH-400:** Special care must be taken for low thermal conductivity elements with high temperature gradient ($> 100^{\circ}\text{C}$) for which estimate of radiative and conductive heat transfer shall be justified by measurement. MLI efficiency and conductance values shall be justified and agreed by the Prime Contractor.
- GDTH-410:** Concerning unit fixation, all units working in the 0°C - 80°C temperature range with a skin radiated power larger than 65 W/m^2 (or 50 W/m^2 when the maximal operational temperature is inferior or equal to 45°C) shall have a flat baseplate contact with support structure. All other units shall comply with the requirements included in § 4.7.

5.4 VERIFICATION OF THERMAL DESIGN

Unit thermal control is under their manufacturer's responsibility. Analysis of units thermal control shall be conducted using mathematical models.

5.4.1 Modelling

- GDTH-420:** Detailed Thermal Mathematical Models (DTMM) and Detailed Geometrical Mathematical Models (DGMM) of the spacecraft shall be created for analytical predictions representative of all the phases of the mission, including ground tests. Parametrical modelling approach is recommended to ease follow up of design definition. (SCVE-100)
- GDTH-430:** The models shall unambiguously identify the flight and the test monitoring points (SCVE-105)
- GDTH-440:** Any DTMM shall be delivered as ESATAN file (version 8.5 or higher). Sub-modelling techniques shall be used down to a level agreed with the Agency (SCVE-110)
- GDTH-450:** The Geometrical Mathematical Model (GMM) shall be delivered as ESARAD file (version 4.3.2 or higher). The ESARAD files shall consist as a minimum of the geometrical files, the kernel files and the ESATAN formatting file where the merging of the surfaces is described (SCVE-115)

GDTH-460: The detailed DTMM and DGMM shall be correlated against the environmental test results. After correlation, the temperature differences between predictions and measurements shall be analysed for all the measurement points. (SCVE-120)

5.4.2 Analysis

GDTH-470: The compliance with the thermal performance requirements shall be demonstrated by analysis for the nominal operational and non-operational cases. (SCVE-140)

GDTH-500: The differences between the test measurements and the test simulated by the correlated DTMM shall be taken into account for the final flight predictions. (SCVE-155)

5.4.3 Testing

GDTH-520: The thermal design of the spacecraft shall be validated by a thermal balance test (SCVE-175)

GDTH-530: The test cases shall cover, as far as practical, the extreme environmental conditions envisaged for the complete mission and the most critical predicted thermal situations (SCVE-180)

GDTH-540: The spacecraft thermal sensors shall be continuously monitored during the test and be used for the assessment of the stabilisation. In addition, they shall be used for the correlation. Additional measurement points shall be provided by test thermal sensors, mainly for complementing the flight measurement plan and monitoring local or general environmental data. (SCVE-185)

GDTH-550: The environment induced by the test facility shall be continuously monitored during the test with the level of detail, as it will be required by the thermal mathematical model for the prediction of the test. (SCVE-190)

6. ELECTRICAL DESIGN AND INTERFACE REQUIREMENTS

6.1 GENERAL

GDEL-010: The electrical compatibility of equipment/subsystem shall be ensured: the equipment/subsystem shall be able to operate without degradation of performance in all specific ground and flight environments, both independently and together.

6.2 GROUNDING BONDING AND ISOLATION

6.2.1 General

The general objective of electrical grounding is to produce an equipotential surface, through the reduction of potentials acquired from the ambient plasma and currents flowing in the structure. Proper Satellites System electrical grounding requires attention to structure grounding (electrical bonding) and circuit grounding.

GDEL-015: Practices for grounding and bonding of devices, cables, equipment and systems shall incorporate the following:

- Prevention of hazards in the events of an equipment frame developing a high potential from internal equipment faults or from induced fields
- Prevention of build-up of static electricity
- Reduction of electromagnetic interference due to electric field or other forms of mutual coupling
- Protection of the Spacecraft System from hazards associated with lightning discharges and induced effects from lightning
- Provision of an equipotential surface to serve as a zero signal reference plane for electrical/electronic system.

GDEL-025: An overall zero volt and grounding diagram shall be provided in the IDS/ICD for establishing functional and electromagnetic compatibility. This diagram shall indicate any AC or DC loop, the type of isolation/insulation used, any impedance coupling between zero volt and structure, and the type of connection between secondary 0 V and mechanical ground (if any).

GDEL-030: The Equipment Supplier and/or Subsystem Supplier shall provide a grounding diagram (symbols described in Figure 6.2-1 shall be used to draw it).

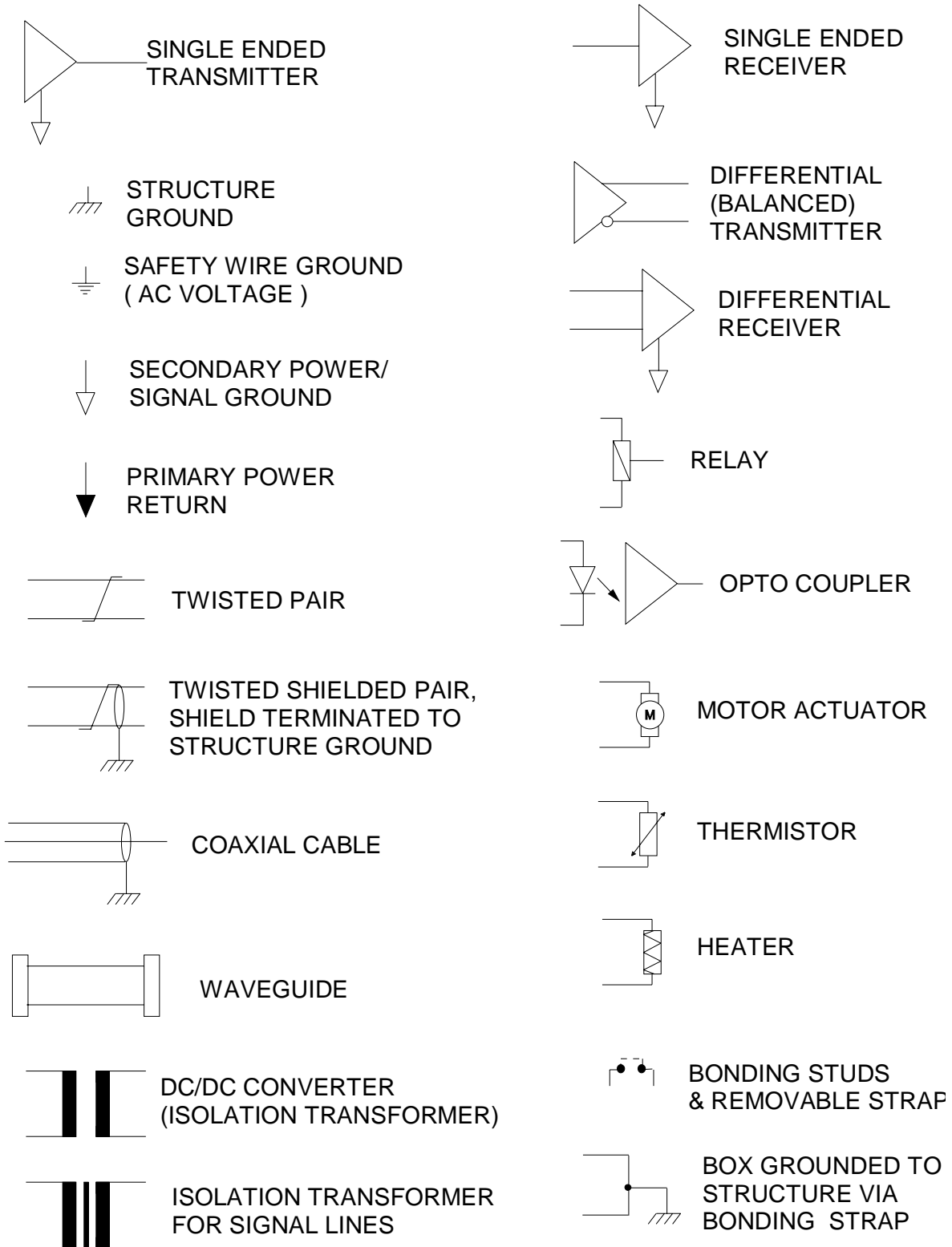


Figure 6.2-1: Symbols for Grounding Diagrams

6.2.2 Structural grounding and bonding

6.2.2.1 Bonding

6.2.2.1.1 Bonding requirements

- GDEL-035:** To provide electrical continuity throughout the Satellites structure, electronic frames and other conductive parts, adequate bonding (electrical conductivity) shall be realized.
- GDEL-040:** All electrically conductive components of the structure including all metallic or carbon fiber items shall be electrically connected.
- GDEL-045:** The bonding resistance between any adjacent metallic structure parts shall be lower than 5 m Ω .
- GDEL-050:** The bonding resistance between conductive non metallic parts and the metallic structure (electrical reference) of the Spacecraft shall be lower than 100 k Ω .

Refer to Figure 6.2-3 for preferred bonding methods.

GDEL-055: The bonding of an equipment shall provide a low and stable impedance path between two metallic parts by the use of a bond strap as detailed hereafter, in addition to the direct contact.

GDEL-060: Requirements for bond strap:

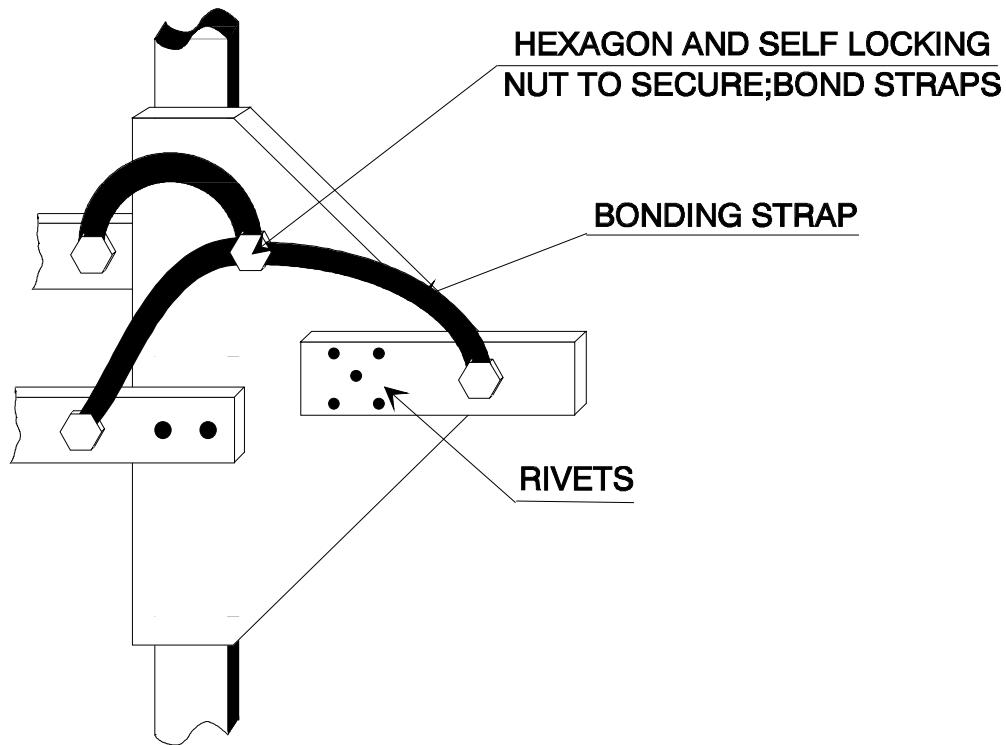
- Bonds shall be as direct and short as possible (different length can be used to cope with all situation, maintaining length to width ratio lower or equal to 5:1. The minimal width to be used is 8 mm with)
- Each bond shall have a resistance ≤ 2.5 mOhms
- Bonds shall be adequate in cross-sectional areas to carry fault currents where applicable, without fusing, burning or arcing (150 % of circuit protection device rating) with a temperature limit of 50°C max for an indefinite time
- Each bond shall be sufficiently robust to withstand vibration, expansion, contraction or relative movement of parts incident to normal service without breaking or loosening the bond or causing a change in contact resistance
- Weakening of vital structures shall not occur as a result of bond application
- Self-tapping screws shall not be used for bonding purposes.
- Bonding connections shall be installed in such a manner as not to interfere in any way with the operation of movable components
- Bonding of tubular members or conduits, if not inherently bonded shall be achieved by means of a plain metallic clamp and jumper without crimping or damaging the member
- Outer and inner metallized layers of thermal insulation shall both be bonded to the structure (ref. section 6.2.2.2)

- Where dissimilar metals are to be bonded, the elements of the bonding connections shall be selected to minimize the possibility of corrosion, and to assure that if corrosion occurred, it would be in replaceable elements, such as washers, jumpers or separators, rather than in the system basic structure.

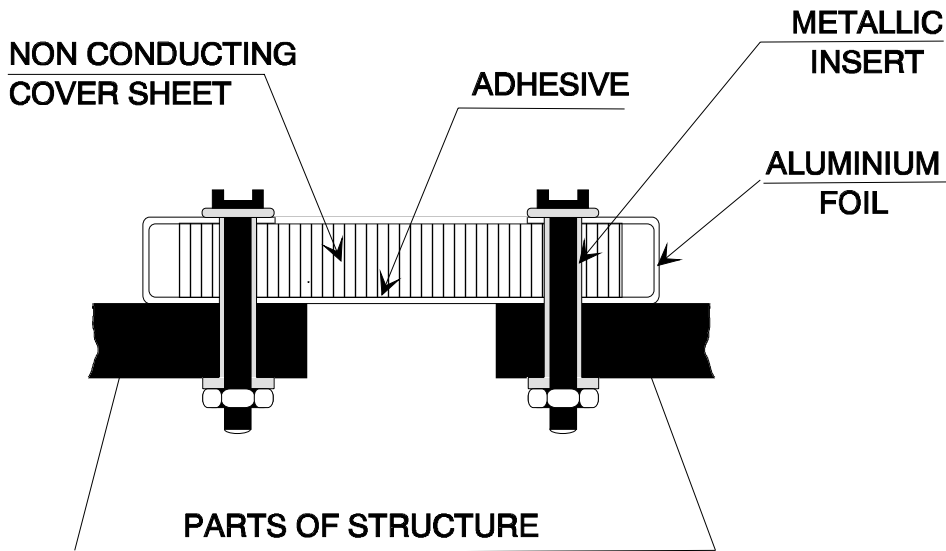
Group No.	Metallurgical Category	EMF (Volt)	Anodic Index (0.01V)	Compatible Couples (see note below)
1	Gold, solid and plated; gold platinum alloys; wrought platinum	+.015	0	○
2	Rhodium plated on silver-plated copper, graphite	+.005	10	↓ ○
3	Silver, solid or plated; high silver alloys	0	15	↓ ↓ ○
4	Nickel, solid or plated; monel metal high nickel-copper alloys, titanium	-.015	30	↓ ↓ ○
5	Copper, solid or plated; low brasses or bronzes; silver solder; German silver; high copper-nickel alloys; nickel-chromium alloys; austenitic corrosion resistant steels	-.020	35	↓ ↓ ↓ ○
6	Commercial yellow brasses and bronzes	-.025	40	↓ ↓ ↓ ○
7	High brasses and bronzes: naval brass; Muntz metal	-.030	45	↓ ↓ ↓ ↓ ○
8	18 percent chromium type corrosion-resistant steels	-.035	50	↓ ↓ ↓ ↓ ↓ ○
9	Chromium, plated; tin, plated; 12 percent chromium type corrosion-resistant steels	-.045	60	↓ ↓ ↓ ↓ ↓ ↓ ○
10	Tin-plate; terneplate, tin-lead solder	-.050	65	↓ ↓ ↓ ↓ ↓ ↓ ↓ ○
11	Lead, solid or plated; high lead alloys	-.055	70	↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ○
12	Aluminium, wrought alloys of the duralumin type	-.060	75	↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ○
13	Iron, wrought, gray or malleable; plain carbon and low alloy steels, armco iron	-.070	85	↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ○
14	Aluminium, wrought alloys other than duralumin type; aluminium, cast alloys of the silicon type	-.075	90	↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ○
15	Aluminium, cast alloys other than silicon type; cadmium, plated and chromated	-.080	95	↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ○
16	Hot-dip-zinc plate; galvanized steel	-.105	120	↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ○
17	Zinc, wrought; zinc-base die-casting alloys; zinc, plated	-.110	125	↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ○
18	Magnesium and magnesium-base alloys, cast or wrought	-.160	175	●

Note:
 ○' = Indicates the most cathodic members of the series
 ●' = Indicates an anodic member
 Arrows indicate the anodic direction

Figure 6.2-2: Dissimilar metals EMF compatibility table.



BONDING STRAP ARRANGEMENT



Shielding and bonding of cut-outs is mandatory, if non conductive material is used as a cover.

Figure 6.2-3: Typical Bonding Methods

6.2.2.1.2 Internal equipment assembly requirements

GDEL-065: The equipment chassis material shall be electrically conductive.

GDEL-070: The electronic equipment boxes shall be fitted with an attachment point for bonding purpose; when defined, that attachment point is called reference bonding point.

A bonding strap will connect it to the Satellites structure (as described in previous section)

GDEL-075: All part of the unit structure shall be electrically connected.

GDEL-080: The DC resistance between two points of a metal case shall be less than 5 m Ohm (test at 1 A).

This includes the resistance between any point of the case and any point of a cover or connector or bonding point.

6.2.2.1.3 Internal equipment assembly bonding implementation

GDEL-085: All metallic subchassis, chassis and enclosures of each unit, including all connector shells and other fittings, shall be bonded.

GDEL-090: 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, in 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
- 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
- The use of two or more bonding straps or jumpers in series is not permitted.

6.2.2.2 Thermal control parts

Blankets and coatings

GDEL-095: Material used as blanketing $\geq 0.5 \text{ cm}^2$ shall be metalized or conductively coated on at least one side of each blanket layer.

GDEL-100: Use of nonconductive material $\geq 0.5 \text{ cm}^2$ shall be justified.

Design requirements to prevent charging and Electrostatic discharging are presented in section 6.3.

- GDEL-105: There shall be at least one ground point for all layers for every square meter of blanket surface area, and at least two points for each blanket, except that only one point is required for a blanket that is completely covered by other blanketing.
- GDEL-110: Provision of only one grounding point for small pieces (up to some tens of cm²) shall be subject to the Prime Contractor approval.
- GDEL-115: For MLI larger than 50 cm length, grounding points shall be provided every 50 cm.
- GDEL-120: The DC resistance between one of these points and the structural reference shall be less than 100 m Ohm (test at 1 A).
- GDEL-125: Moreover, each metallized foil shall be electrically connected to the grounding point of the MLI piece.
- GDEL-130: The DC resistance between this point and any point belonging to a metallized face of any foil shall be less than 10 Ohm (test at 100 mA).
- GDEL-135: The edges of the blanket shall be bound with material having a conductive outer side, which is bonded to the blanket ground points.

A typical method is presented in Figure 6.2-4.

- GDEL-140: Each blanket ground point shall be connected to the nearest practical point on the structure, with a minimum length grounding wire.
- GDEL-145: As a goal, the blanket grounding wire length shall be less than 15 cm.
- GDEL-150: Single layer blanketing external to the bus, e.g., thermal tape applied to cabling, shall be electrically conductive on the outer side.
- GDEL-155: Each metallized face of a thermal shield internal as well as external (e.g. Kapton aluminized in both faces) shall be connected to the structure even if the thermal shield is made by only one foil. Bonding requirements are as for MLI.

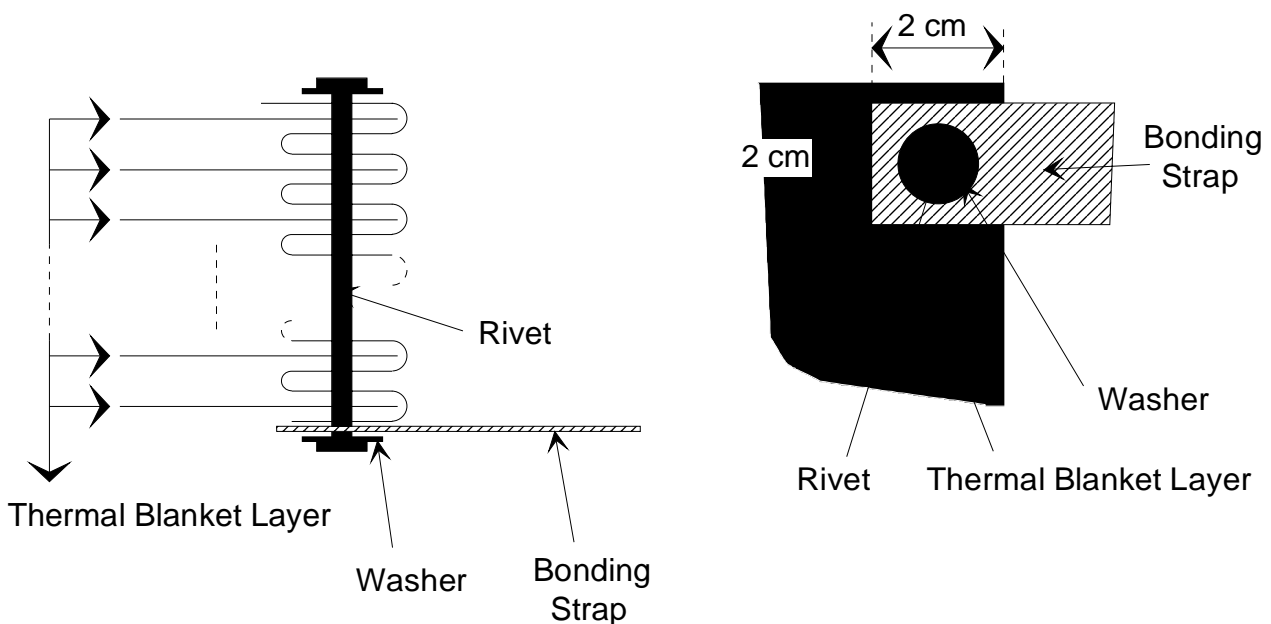


Figure 6.2-4: Bonding of Thermal Blankets (Guideline)

OSR

- GDEL-160: The conductive part of the OSR shall be electrically connected to the electrical ground reference network by means of conductive glue.
- GDEL-165: The DC resistance between the conductive OSR surface and the electrical ground reference network shall be less than 3 kΩ tested at 10 mA.

Heaters and Thermistors

- GDEL-170: Heaters and thermistors shall be galvanically isolated from the satellite structure with

Resistance $\geq 10\text{ M}\Omega$
Capacitance $\leq 50\text{ nF}$

6.2.2.3 Exposed conductors

- GDEL-175: All unmated connectors shall be completely capped with conductive covers prior to launch.
- GDEL-185: No dielectric parts of disconnected electrical conductors shall be exposed to space.

6.2.2.4 Conductive element grounding

1. GDEL-190: All radiation shields, circuit traces and conductors with a surface greater than 3 cm² shall be electrically grounded unless it can be demonstrated that their resistance w.r.t. structure is $\leq 10\text{ Mohms}$.
- GDEL-195: Braided overshields with greater than 85 % coverage shall be required on all cabling outside of the spacecraft.
 - GDEL-200: Diameter of braid strands shall be 0.1 mm or larger.
 - GDEL-205: Each overshield shall be grounded to structure prior to entering the spacecraft or any external, closed Faraday chamber.

6.2.2.5 External electronic component

- GDEL-210: All electronic components external to a closed Faraday chamber shall be EMI shielded.

6.2.3 Circuit grounding

The insulation values are summarized in Table below.

BONDING RESISTANCE	INSULATION VALUES
Between any primary power supply pin and the bonding stud	R $\geq 1\text{ MOhm}$ C $\leq 50\text{ nF}$
Between primary power and secondary power	R $\geq 1\text{ MOhm}$ C $\leq 50\text{ nF}$
Between secondary power lines and the box structure (applies only when the secondary power return is disconnected from the ground)	R $\geq 1\text{ MOhm}$ C $\leq 50\text{ nF}$

6.2.3.1.1 Power bus grounding

- GDEL-215: Structure shall not be used as a return current path.
- GDEL-225: The star grounding point shall be located in the power subsystem on the spacecraft (primary return to chassis star point).
- GDEL-235: The resistance between the star grounding point and the structure shall be less than 2.5 mOhm.

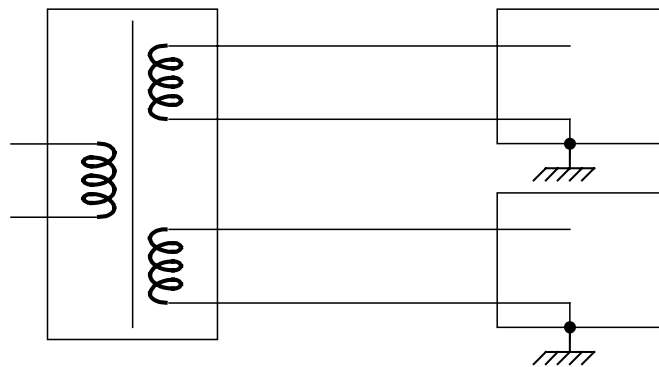
6.2.3.1.2 Secondary power grounding

- GDEL-240: Each user secondary power return shall be connected to a single ground (ground point / ground plane). This ground point / ground plane shall be connected to chassis.

In the case, of low power consuming unit the connection between secondary power reference and structure could be made via a loop on a connector (one pin is connected to the structure as near as possible, another is connected to the secondary power reference, they will be strapped on the connector). This design needs the Prime Contractor approval.

- GDEL-270: When a single converter via multiple windings supplies one or more equipment, the secondary power return shall be grounded to a single location within the supplied unit(s); one secondary power output shall not be distributed to more than one unit.

OK :



NOT OK :

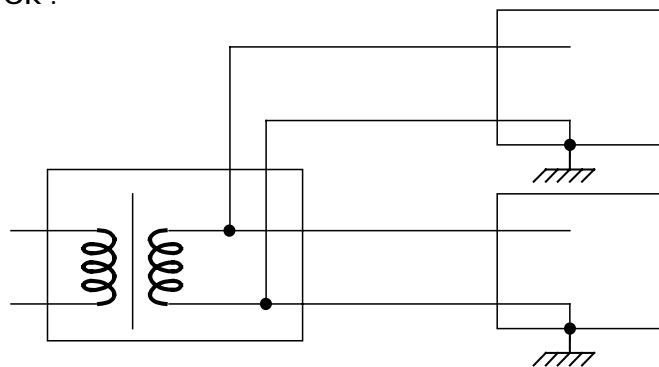


Figure 6.2-5: Secondary power output grounding rules.

GDEL-275: Signal interfaces between these units or common interfaces with other boxes must provide appropriate isolation to avoid grounding loops.

Alternative concepts shall take into account return line voltage drops and shall be subjected to the Prime Contractor approval.

This applies to the converters located in the various subsystems/equipment's and in the power subsystem.

6.2.3.2 Signal return grounding

The basic concept for signal return configuration is depicted in Figure 6.2.3-1

GDEL-280: Any deviation w.r.t. this general concept (interface with or internal to the subsystem) shall be reported to the Prime Contractor through IDS's and approved prior implementation.

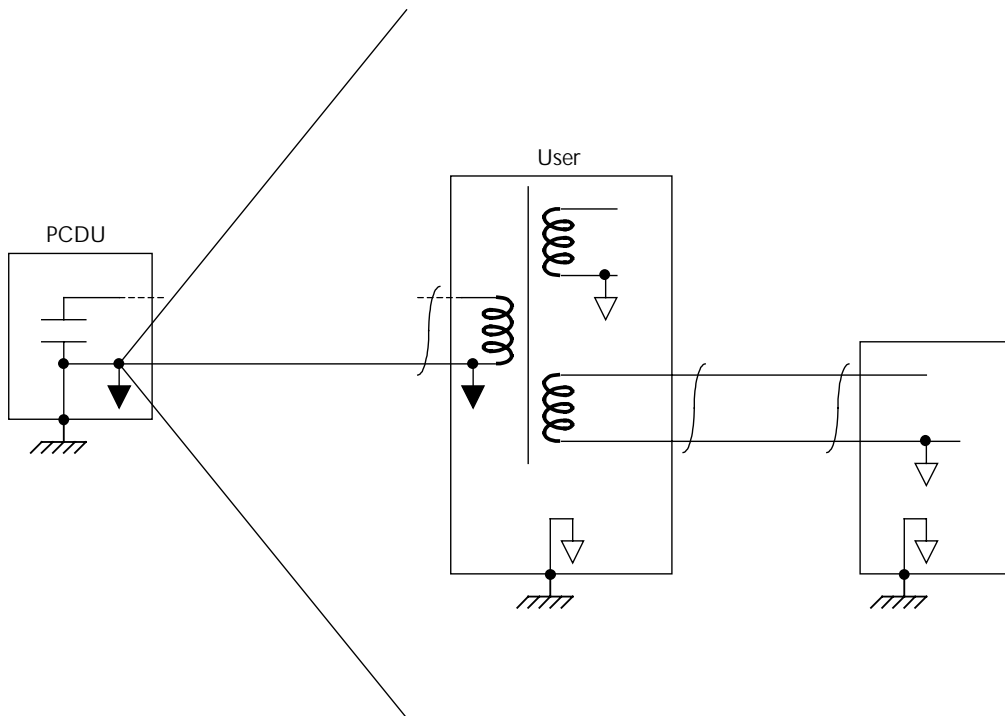


Figure 6.2.3-1: Satellites System Grounding and Insulation scheme

6.3 CHARGING/ELECTROSTATIC DISCHARGE PROTECTION

Refer to EMC/ESD Specification (AD- 4).

6.4 ELECTROMAGNETIC INTERFACE REQUIREMENTS

Refer to EMC/ESD Specification (AD- 4).

6.5 MAGNETIC CLEANLINESS

GDEL-285: The magnetic cleanliness shall be carefully controlled. The following magnetic fields shall be minimised:

- Permanent fields originating from magnetically hard ferromagnetic materials
- Stray-fields generated by current loops in the harness and inside electronic boxes
- Fields generated by electromagnetic actuating devices such as relays, valves, etc...

GDEL-290: Also the use of soft magnetic materials with high permeability shall be avoided as far as possible

GDEL-295: The maximum allowed radiated H-field at the location of each equipment shall be as defined in the EMC/ESD Specification (AD- 4).

6.6 WIRING AND CONNECTIONS

6.6.1 General

GDEL-300: Physical separation along common runs of the categories listed below (power, signals and lines for the mechanisms, if applicable, RF coaxial cable and waveguide excluded) shall be retained between these categories up to and inclusive of the module interface connectors. Exceptions can be only the routing of harnesses down to connectors in the satellite separation plane.

- Category 1: power
 - primary power lines and heaters
 - solar array/power supply link
 - batteries/power supply link
- Category 2: digital signals and non sensitive analogue signals
 - TC signals
 - TM signals
 - DATA HANDLING links
 - Video signal links
- Category 3: lines for the mechanisms/pyrotechnics

- Category 4: sensitive analogue signals

(SMHA-045)

- GDEL-305: All equipment shall use a separate connector dedicated to its functional interface, according to the categories listed above. (SMHA-050)
- GDEL-310: Wiring of redundant systems, subsystems or units of subsystems shall be routed through separate connectors and wire bundles. (SMHA-055)
- GDEL-315: Redundant wire bundles shall be routed differently wherever possible. (SMHA-060)
- GDEL-320: Cross strapping of redundant paths and circuits shall not be carried out in the harness. (SMHA-065)
- GDEL-325: The pyrotechnic harness shall satisfy the applicable safety requirements. (SMHA-070)
- GDEL-330: Connections to the initiators shall be capable of being mechanically broken during ground handling by safe/arm connectors accessible from the outside of the spacecraft. (SMHA-080)
- GDEL-335: The shields of cables shall not be used as return lines (SMHA-085)
- GDEL-337: All hot/return lines shall be twisted together. (SMHA-090)
- GDEL-340: All harness and all box and bracket mounted connectors supplying power shall have socket contacts (SMHA-095)
- GDEL-345: Where it is necessary to have a shield connection through a connector, separate pins shall be used (SMHA-100)
- GDEL-350: The initial design shall ensure that sufficient (including spare) pins are available for all foreseeable subsystem and experiment functions. (SMHA-105)
- GDEL-355: All individual wire-to-pin interfaces shall be covered with transparent heat shrink sleeves (SMHA-110)
- GDEL-360: The possibility of incorrect mating of connectors shall be excluded by design. (SMHA-115)
- GDEL-365: The harness connectors shall be easily accessible, attachable, and removable from the corresponding unit connectors; removal of units or disconnection of adjacent connectors shall not be necessary. (SMHA-120)
- GDEL-370: The harness shall be fixed onto the structure in order to avoid any damage during launch phase. 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.

(SHMA-125)

- GDEL-375: Fixation of sensitive signal lines shall be such as to avoid micro-phonic noise. (SHMA-130)
- GDEL-380: The harness restraining systems on the structure shall not bring about any stress at connector level. (SHMA-135)
- GDEL-385: The harness linking equipment mounted in or on the payload module, with the service module shall be such that the heat transferred by conduction is optimised for electrical and thermal performances (SHMA-140).
- GDEL-390: Permanent connections installed for the purposes of test at integrated satellite level shall be routed to skin connectors of the modules concerned (module interface connectors are no longer accessible at that level). (SHMA-145)
- GDEL-395: Skin connectors shall also be provided to make-or-brake power circuits. (SMHA-150)
- GDEL-400: All these skin connectors shall be closed by caps, bridging connectors, and thermal insulation for flight. (SMHA-155)

6.6.2 Connectors

- GDEL-410: Electrical connectors shall provide a low impedance path for all internal wires, and a low impedance bond when an outer shell is used.
- GDEL-415: Connectors shall not be placed in any single point failure location. In particular, the demating of any connector shall not cause the loss of the mission (exceptions, if any, have to be agreed with the Prime Contractor).

6.6.2.1 Connector types

- GDEL-420: Connectors shall be selected from the EEE part list (AD- 37) and contain only gold plated contacts.
- GDEL-425: The type of connectors must be defined separately for equipment connectors, RF connectors, skin connectors, harness connectors, test connectors

6.6.2.2 Characteristics

- GDEL-430: Connectors at interfaces shall be clearly identified.
- GDEL-435: That applies to equipment connectors as well to interface brackets connectors:
- Pyrotechnic circuit connectors shall be separated from all other circuit connectors
 - The housing of connectors shall be electrically connected to the equipment structure
 - Type of connectors at interfaces must comply with the type of associated cable conductors
 - Connector pins and sockets shall be removable on the harness connectors

- Male and female connectors shall be mechanically locked together, to prevent inadvertent disconnection
- Final selection of all connectors and connector accessories shall be submitted for approval by the Prime Contractor.

6.6.2.3 Connector mounting and identification

- GDEL-440:** Equipment and bracket mounted connectors shall be located in easily accessible positions. The physical position is to be indicated on Interface Control Drawings and must be compliant with the minimum distances between connectors and mounting plane as described in Figure 6.6-1 (DxMA type only).
- GDEL-445:** The harness connector identification shall comply with requirements below :
- each connector shall have its identification number marked on the shell or on a sleeve around the wires whichever is most appropriate
 - the identification number shall be an unique seven characters number:
 - the first four for unit or bracket identification
 - the fifth for plug (P) or jacket (J) identification
 - the two last for unit or bracket connector identification.
- GDEL-450:** Mechanical methods in conjunction with identification markings shall be employed to prevent incorrect mating of connectors. Color coding may be used as an aid to identification.

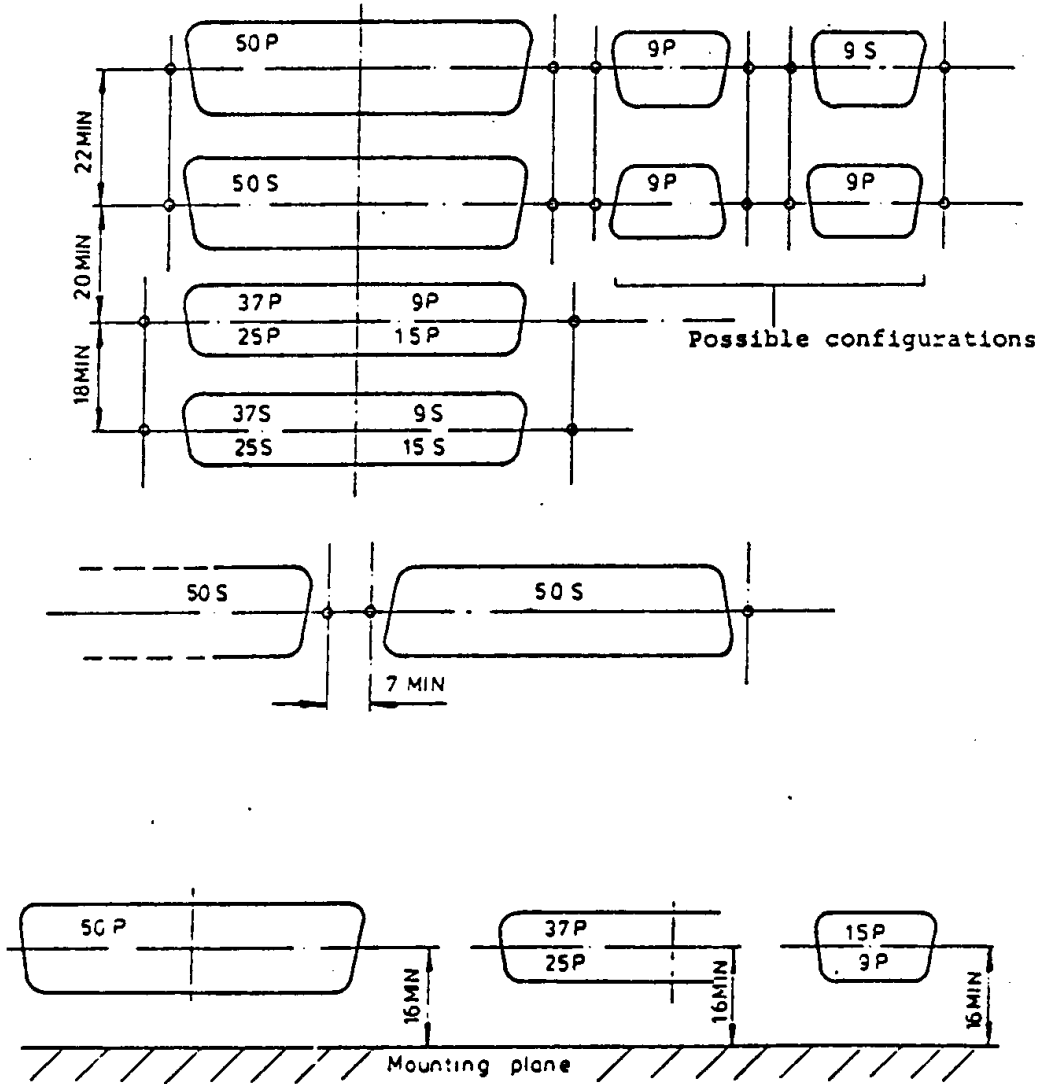


Figure 6.6-1: Location of Connectors

6.6.2.4 Connector pin assignment and interface circuit data

GDEL-455: To establish the electrical configuration at interfaces, the Interface Data Sheets shall include the following (this applies also to equipment test connectors) :

- type, the connector manufacturer's designation
- total number of pins, the number of pins capable of use in the connector, whether or not they are utilized in the particular interface configuration
- interface, the designation of the equipment (unit, assembly) interfacing
- subsystem, the subsystem associated with the connector
- mating connector, the designation (complete manufacturer reference) of the mating interface connector
- function, an explicit statement of the pin functions.
- For return lines, however, the exact zero volt reference which the contact is connected to, shall be clearly indicated with reference to the grounding diagram:
- pin, the pin number or letter to which a connection is made
- cable screens, a simple drawing of the cable and screening arrangements at the connector.

GDEL-460: This information shall be generated, maintained, validated and transmitted to the prime using an ACCESS (TBC) Data Base, according to the format specified in Appendix 1. (TBC)

GDEL-465: In addition, a description diagram of optional detail shall indicate the layout of connectors and their position relative to the structure.

GDEL-470: The connector designation of design authority and manufacturer, including keyway and insert arrangements, shall be indicated.

GDEL-475: Critical cable lengths, for voltage drop reasons for instance, must be shown where applicable.

6.6.2.5 Connector savers

GDEL-480: For test purpose, flight connectors shall be protected against multiple mating/demating operations by connector savers.

GDEL-485: Such connector savers shall be a flight type connector (same part number and same quality level):

- For test at unit or subsystem level, this applies to every equipment mounted connectors. In that case, each subsystem supplier is responsible for the procurement of those savers. These savers shall be delivered with the subsystem/unit. Those savers will be reused at system level if necessary.
- For system level tests, the following applies:

- i. 1 saver for each test connector at system level
- ii. 1 saver per interface connector if any
- iii. 1 saver per separation plug (umbilical)

These last types of savers (i. to iii.) shall be procured by the harness subsystem and delivered as part of the Spacecraft System.

6.6.3 Shielding, redundancy and identification

6.6.3.1 Twisted and shielded lines / Overshielding

6.6.3.1.1 Twisted and shielded lines

- GDEL-490:** The twisted wires shall be routed through a connector on adjacent pins to minimize the wire loop.
- GDEL-495:** Signal interface harnesses, in general shall be constructed using twisted shielded wires. However, some pulse commands, thermistors lines and relay driver lines will not be shielded in order to save weight on the satellite. In this case, EMI analysis shall be performed to ensure EMC/ESD requirement compliance.
- GDEL-500:** Power lines shall be twisted pairs. If however any supplier intends to use shielded wires for power or high power ON/OFF command lines, it shall be submitted to prime Contractor.
- GDEL-505:** The pyrotechnic harness shall consist of twisted pairs of wires with an overall shield being continuous and connected to the conductive connector shells at all interfaces and grounded to the structure at all intermediate attachment points (SMHA-075)
- GDEL-510:** Neither the structure nor any cable shield shall be used to carry bus power return. This will minimize common mode noise input to the units.
- GDEL-515:** Shields shall always be connected to connector shells which will be grounded at any intermediate connectors.

Daisy chaining of shield connections to ground is prohibited.

- GDEL-525:** The resistive between cable shield and the adjacent grounding point shall be less than 2.5 mΩ.

6.6.3.1.2 Overshielding

- GDEL-530:** For sensitive and critical functions, overshield shall be added that is continuous from the backshells of each of the associated unit connectors. All shields shall be terminated to chassis external to the unit enclosure.
- GDEL-535:** Every cable submitted to the external environment (i.e. external to the Spacecraft) shall be overshielded. Where external cables penetrate the enclosure of the spacecraft main body, they shall be terminated to the structure externally.

All these Overshield shall be grounded :

- All overshielded grounding shall be accomplished with 360 deg conductive backshells. These backshells shall make use of connectors that have circumferential "grounding" fingers that coaxially enclose all pins and provide the ground path for the shield to structure
- Those overshields not under MLI blanketing (and therefore visible from outside the Spacecraft shall have their jacketing material wrapped with a material having a metallized outer layer. This layer shall be grounded to structure (usually by the backshell).

6.6.3.2 Wiring Redundancy

GDEL-540: The wiring including pins and sockets of connectors shall be made redundant at all critical interfaces, a failure of which would cause catastrophic failure of the spacecraft system.

GDEL-545: When equipment is made redundant, the associated wiring shall be redundant in the same manner.

This includes primary power interfaces.

6.6.4 Wiring rules

6.6.4.1 Crimping of wires

GDEL-550: Crimping method shall meet the requirements of AD- 38.

GDEL-555: Everywhere crimping and soldering methods are usable, for the same type of connectors, crimping ones shall be preferred.

Smaller gauges of wire than those specified for particular connector pins are not to be used.

Folding over of wires for crimping is not allowed.

GDEL-560: During the design phase each connector shall have 10% of spare pins.

Procedures must be prepared to define adequately the inspection techniques which must be used to verify the reliability of braided shield and coaxial screen connections.

6.6.4.2 Soldering of wires

GDEL-565: Soldering method shall meet the requirements of AD- 39.

6.6.4.3 Current derating of wires

GDEL-570: The maximum current allowed per type of gauge shall not exceed the value given in Table 6.6-1

Maximum supplied voltage = 50% of the specified maximum insulation voltage														
Wire size AWG	30	28	26	24	22	20	18	16	14	12	10	8	6	4
Isw (A)	1.1	1.8	2.5	3.3	4.5	6.5	9.2	13.	17.	23.	33.	44.	60.	81.

Isw = Maximum applied current versus the wire size in a maximum ambient temperature of **85 °C for a single wire**

Ibw = Maximum applied current versus the wire size in a maximum ambient temperature of **85 °C when wires are bundled.**

The relationship between **Ibw** and **Isw** is given by the following formula :

Ibw = Isw x (29 - N) / 28 for 1 ≤ N ≤ 15

N = Number of wires in the bundle

or **Ibw = 1/2 x Isw for N > 15**

Table 6.6-1: Wires Current Derating Criteria

6.7 ELECTRICAL POWER SYSTEM INTERFACE

6.7.1 Power supply voltages

The DC main bus is regulated to 28 V with a maximum tolerance at the source (regulation point) of +1 %/-2 %. This tolerance includes effects of load regulation, temperature and ageing.

Each Distribution Unit output is protected by a Latch Current Limitr (LCL) or Fall-back Current Limiter (FCL).

In case of a redundant user, a non-redundant protection is provided for each redundancy.

In case of a non-redundant user, a redundant protection is provided for the user.

GDEL-575: Each satellite user Subsystem/Equipment shall be able to operate nominally within the following steady state voltage limits (applicable to S/C harness-Subsystems interface i.e. the voltage drop inside the Subsystem harness is not covered by these limits)

- 26 V as minimum voltage (mean voltage excluding any noise, ripple and spikes)
- 29 V as maximum voltage (mean voltage excluding any noise, ripple and spikes)

This range shall be used to establish Subsystem or Unit power budgets as reported in the IDS.

GDEL-580: All the users shall safely survive when being supplied with any continuous or fluctuating voltage in the full range 0V ↔ 35 V. In this case, survive means that equipment have to recover their nominal performance capabilities when the main bus recovers its nominal voltage.

6.7.2 Voltage transients and ripple

Transients and overvoltages are specified in the EMC Specification (document AD- 4)

GDEL-585: The ripple and spikes shall be less than (at Distribution Unit output connectors):

- 300 mV peak to peak on 28 V lines.

This peak to peak value is defined in a 50 MHz bandwidth.

6.7.3 Bus output impedance

GDEL-590: The primary bus impedance at S/C harness-Subsystem interface level (interface connector level) is specified in Figure 6.7-1.

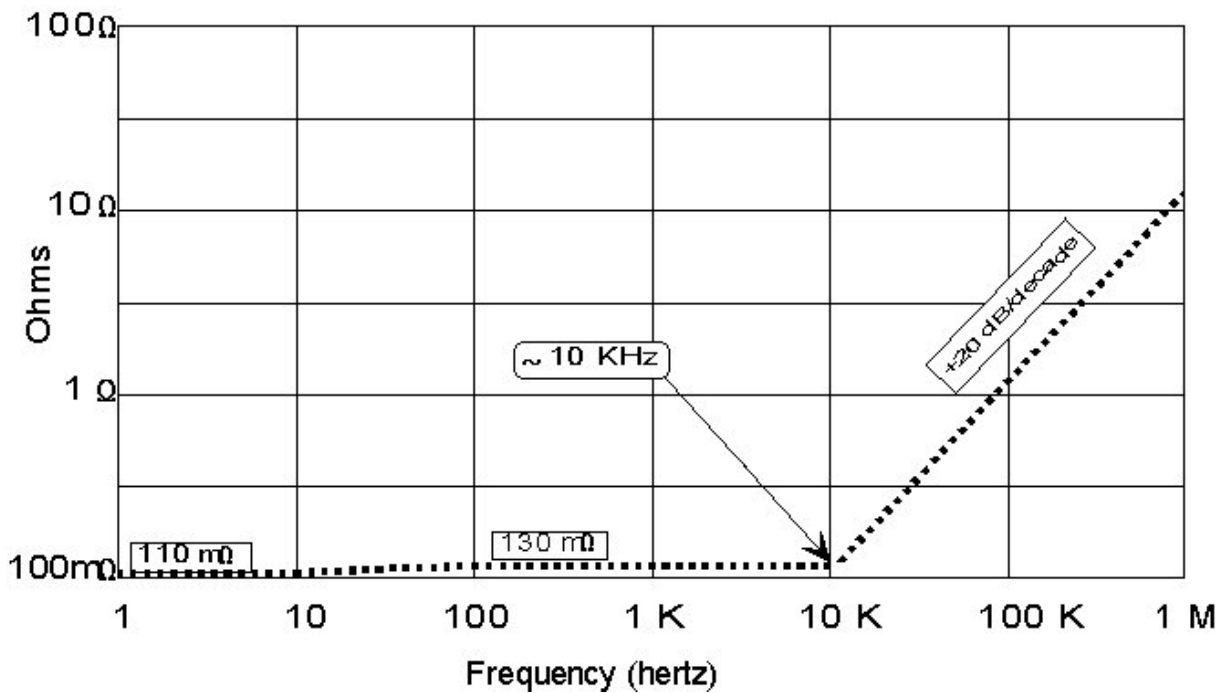


Figure 6.7-1: Bus Impedance at S/C Harness-User Subsystem Interface

GDEL-595: In addition, the Subsystem internal power harness (if exists) impedance from Subsystem interface connector level up to input connector sockets of the equipment (user) shall be considered as follows :

- The maximum ohmic component shall be such that the voltage drop (including forward and return lines) does not exceed 1% of the nominal supply voltage when the maximum current is drawn by the user. In no case it shall exceed half of the concerned bus DC output impedance (specified in Figure 6.7-1).

6.7.4 Current limiter characteristics

GDEL-600: The current limiters used in the power subsystem (equipments and instruments power supply lines) shall have the following characteristics:

- current limitation at a value I_l , with $1.2 I_{max} \leq I_l \leq 1.5 I_{max}$ (TBC) except during first 50 μ s
- If I_l is exceeded I_l for a time greater than 10 ms (TBC) then the LCL will automatically switch-off .
- Controlled di/dt during switch on of LCL . max $di/dt =$ TBD A/s, min $di/dt =$ TBD A/s
- Undervoltage protection – LCL switches OFF if bus voltage is <23.5V (TBC)
- ON/OFF function shall be provided as well as its status and current telemetry for monitoring.

GDEL-602: Three types of current limiters shall be available:

- ON/OFF switchable current limiters (LCL) for “non-essential” loads, i.e; those items which if they are switched OFF do not jeopardise the spacecraft.
- Permanent ON foldback current limiters (FCL) for essential loads (receiver, decoder....)
- Electronic fuse + electronic switch (EF/ES) for resistive loads (heaters)
- Two levels of OFF command shall be provided within the LCL for those LCLs whose users cannot tolerate a failed permanent ON condition.

I_{max} is the current related to peak power calculated assuming the minimal supply voltage as defined in 6.7.6 short peak definition..

6.7.4.1 Heaters line

The PCDU will provide switchable power lines protected by an electronic fuse suitable to drive a resistive heater load.

GDEL-603: The maximum voltage drop due to the electronic fuse + electronic switch shall be $V_{drop} \leq 0.9V$ (TBC)

6.7.5 Average power demand definition

The **average power** demand is defined for an equipment as the maximum average power drawn from its dedicated power lines in the worst case voltage conditions of paragraph 6.7.1.

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

GDEL-605: Each subsystem shall define its average power requirement per power line.

6.7.6 Peak power demand definition

a. Long peak

Long peak power demand is defined for an equipment as the maximum peak drawn from its dedicated power lines, in the worst case voltage conditions of paragraph 6.7.1.

Specifically, the maximum long peak is defined using the integral during a period of 5minutes shifted to any point in time over 100 minutes where the integral will yield a maximum.

b. Short peak

Short peak power demand is defined for an equipment as the maximum peak drawn for its dedicated power lines in the worst case voltage conditions of paragraph 6.7.1.

Specifically, the maximum short peak is defined using the integral during a period of 1 ms shifted to any point in time where the integral will yield the maximum.

To be defined as a short peak, the power demand shall last less than 100 ms.

The I_{max} defined for the LCL characteristics in 6.7.4 shall correspond to the current drawn during the short peak condition.

GDEL-610: Each subsystem shall define its long and short peak power requirement per power line.

6.7.7 Distribution and Protection Requirements

GDEL-615: Any standing or variable current drawn by any unit from the supply lines shall be limited by the Power Supply to a value I_l defined in 6.7.4 under nominal conditions.

Such a limitation is achieved by active current limiter on the power lines.

GDEL-620: In particular, this limit shall be sustained for a single part failure at user's input and for the full voltage range specified (see paragraph 6.7.1).

GDEL-625: The use of current protection circuits on the primary side of user DC/DC converters shall be avoided since the PCPU LCLs will provide all the necessary protection. If the use of protection circuits cannot be avoided , then the protection threshold shall be set lower than the PCPU LCL and tests must be performed with a representative PCPU LCL as early as possible.

GDEL-627: Overvoltage/Undervoltage protection circuits on the primary side of user DC/DC converters shall be avoided since the PCPU LCLs will provide all the necessary protection. The user may incorporate overvoltage protection on the secondary side of the DC/DC converter.

6.7.8 Load current transitions

6.7.8.1 In-rush current

At power ON of the Distribution Unit power line via the LCL, the inrush current is limited to a value comprised between $1.2 I_{max}$ (TBC) and $1.5 I_{max}$ (TBC) during a duration t (minimum value guaranteed: 10 ms)

If the inrush current demand from the user is not under limitation value at $t_{tripoff}$ the equipment will be switched off.

Figure 6.7-2 gives the nominal current envelope.

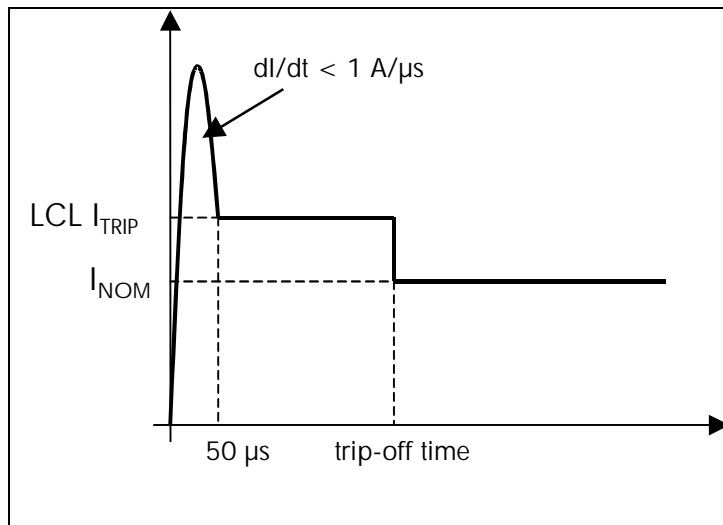


Figure 6.7-2: Nominal current envelope

- GDEL-630: The instantaneous rate of change of current (di/dt) variation shall not exceed 10^6 A/s either positive or negative.
- GDEL-635: When connected to a non limiting current source (in test configuration) the inrush current at switch-on of the equipment shall be within the envelop defined in AD-4, § 3.2.4.8.2.
- GDEL-640: When connected to the current limiter the inrush current at switch-on will be constrained to the envelope shown in Erreur! Source du renvoi introuvable. by the Power Distribution Unit.

In this condition the user shall operate nominally (I nominal under nominal voltage) before $t_{tripoff}$.

6.7.8.2 Load current transitions

In case of step or pulse transitions of supply current demand the transient voltage remains into limits given in EMC/ESD specification (AD- 4).

- GDEL-645: Users shall not exceed their I_{max} during any planned operations.

In case of inadvertant user overload the supply current will be limited (by the Distribution Unit) to I_l in a period $< 50 \mu s$. It is from user responsibility to limit by itself the di/dt to 10^6 A/s during this transient phase.

If the overload lasts more than t ($t > 10$ ms) the user will be switched off.

- GDEL-650: The instantaneous rate of change of current (di/dt) variation shall not exceed 10^6 A/s either positive or negative.
- GDEL-655: Pulse repetition frequency shall not exceed 1 Hz unless confined to the limits of admissible ripple current as specified in EMC/ESD specification (AD- 4).

6.7.9 Insulation of the power lines

GDEL-660: Prior to the mating of power line and equipment connectors, the galvanic insulation between any power supply pin and the bonding stud of the equipment housings in functional configuration shall be equivalent to:

- a resistor of 1 Mega Ohm minimum
- a capacitor of 50 nano Farad maximum.

GDEL-665: Insulation quality shall be as specified for 100 VDC at both polarities.

GDEL-670: For purposes of verification, this 100 VDC (+ 5 V, - 0 V tolerance) shall be applied at a rate of not less than 50 V/s for a test period of 60 (+ 10, - 0) seconds.

GDEL-675: For test purpose, all hot and return lines shall be externally short circuited.

GDEL-680: In addition, the primary power lines shall be transformer insulated from all secondary power.

GDEL-685: Insulation characteristics shall be better than 50 nF//1 MΩ.

6.7.10 Isolation

GDEL-700: For any LCL or electronic fuse+electronic switch in the PCPU which is commanded OFF, the isolation quality shall be such as to limit any "leakage" current on the power line output to a maximum of 1 mA.

6.7.11 DC/DC converter synchronisation

GDEL-705: DC/DC converters on the Herschel and Planck shall be free running.(TBC)

GDEL-710: DC/DC converters frequency shall be selected to be outside of the critical operating bandwidth of the instruments (the frequency range is TBC)

6.7.12 NED

Non Explosive Device command is required to command the opening of the Herschel cryostat cover. Their characteristics are:

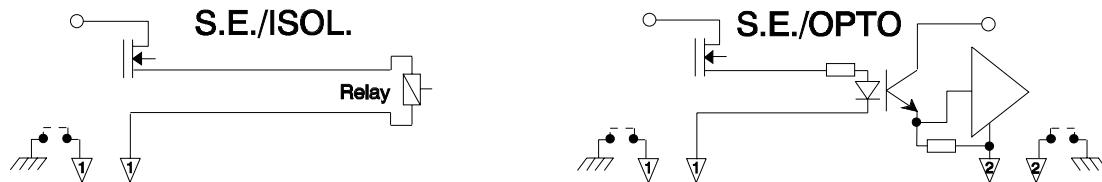
Voltage:	+28V
Source impedance :	0.625Ω including harness
Command pulse duration:	200ms
Firing current:	<10A
Non firing current:	300mA

6.8 DATA HANDLING INTERFACES

6.8.1 Commands Interfaces

6.8.1.1 High Priority (HP) or High Level Commands (HL)

The command signal is a single ended positive voltage pulse, distributed to the user on a dedicated line for Relay or Opto-coupler driving.



The interface characteristics are :

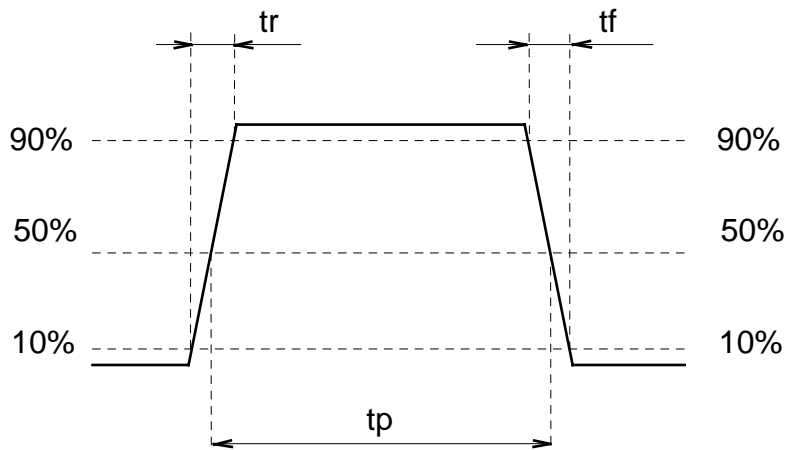
	SOURCE	LOAD
CIRCUIT TYPE	Single ended driver	Relay
VOLTAGE		
- Active voltage	$22\text{ V} < U < 29\text{ V}$ (when load $> 162\ \Omega$)	Max switching threshold: [a] $< 22\text{ V}$; [b] $< 16.6\text{ V}$
- Passive voltage	$0\text{ V} < U < 2\text{ V}$	Min switch. threshold $> 4\text{ V}$
CURRENT		
- Sinking current	$< 50\ \mu\text{A}$	[b] $R_{\text{min}} > 92\ \Omega$
- Driving capability	$\geq 180\text{ mA}$ (with $U > 16.6\text{ V}$) $\geq 135\text{ mA}$ (with $U > 22\text{ V}$)	[a] $R_{\text{min}} > 162\ \Omega$
- Leakage	$\leq 2.5\ \mu\text{A}$	
- Short circuit	$\leq 400\text{ mA}$ (during pulse)	
SIGNAL SHAPE		
- Pulse length (T_p)	$26\text{ ms} \pm 2\text{ ms}$	
- Rise time(10%-90%)	$50\ \mu\text{s} < T_r < 500\ \mu\text{s}$ (*)	
- Fall time(10%-90%)	$50\ \mu\text{s} < T_f < 500\ \mu\text{s}$ (*)	
CAPACITY	$< 50\text{ pF}$	$< 300\text{ pF}$
REPETITION RATE	Pulse rate $< 4\text{ Hz}$	
FAILURE CASE		
- Max. Emission	$0\text{ V} < U < 33\text{ V}$ (current limited to 400 mA)	⊕ & return short circuit $-5\text{ V} < U < 48\text{ V}$
- Tolerance	The interface shall withstand a permanent short circuit condition between ⊕ & return outputs with no resulting damage $-5\text{ V} < U < 48\text{ V}$	$0\text{ V} < U < 33\text{ V}$ (Fault source limited to 400 mA)
LINE CHARACTERISTICS		
Type		Twisted-AWG26
Differential Capacitance		$< 600\text{ pF}$
Voltage Drop		$< 240\text{ mV}$

* = when loaded by $270\ \Omega$ in parallel with 0.6 nF

	SOURCE	LOAD
CIRCUIT TYPE	Single ended driver	Opto-coupler
VOLTAGE - Active voltage - Passive voltage	22 V < U < 29 V (when load > 162 Ω) 0 V < U < 2 V	Max switching threshold: < 14 V Min switch. threshold: > 5 V
CURRENT - Sinking current - Driving capability - Leakage - Short circuit	< 50 μA ≥ 10 mA ≤ 2.5 μA ≤ 400 mA (during pulse)	Min. current > 2.5 mA
SIGNAL SHAPE - Pulse length - Rise time(10%-90%) - Fall time(10%-90%)	Tp = 26 ms ± 2 ms 50 μs < Tr < 500 μs (*) 50 μs < Tf < 500 μs (*)	<u>command validation:</u> time threshold ≥ 5 ms
CAPACITY	< 50 pF	< 300 pF
° REPETITION RATE	Pulse rate < 4Hz	
FAILURE CASE - Max. Emission - Tolerance	0 V < U < 33 V (Fault source imp. ≥ 1.5 kΩ) The interface shall withstand a permanent short circuit condition between + & return outputs with no resulting damage -5 V < U < 48 V	+ & return short circuit -5 V < U < 48 V » 0 V < U < 33 V (Fault source imp. ≥ 1.5 kΩ)
² LINE CHARACTERISTICS Type Differential Capacitance Voltage Drop		Twisted-AWG26 < 600 pF < 240mV

* = when loaded by 10kΩ in parallel with 0.6 nF

The HP & HL commands delivered by Data Handling to user Subsystems are only of one type and are able to drive 180 mA (relay command type).



Signal waveform for the HLC pulses

6.8.1.2 Extended High Level Commands (EHL)

The command signal is a single ended positive voltage pulse, distributed by the Data Handling to the user. The interface characteristics are the same than HL and HP ones except:

	SOURCE	LOAD
CIRCUIT TYPE	Single ended driver	Relay-Switch I/F
SIGNAL SHAPE Pulse length	500 ms \pm 5 ms	

6.8.1.3 Low level command

The LLC are of SBDL type as described in section 6.8.1.4. The pulse duration shall be >10mS.

6.8.1.4 The Standard Balanced Digital Link (SBDL)

The Standard Balanced Digital Link (SBDL) is a fully differential interface, with a "true line" and a "complementary line" (see Figure 6.8-1). The status of the signal is defined as high when the true line has a positive voltage "1" level with reference to the ground and the complementary line has a "0" level with reference to the ground. The signal is defined as low when the true line is at "0" and the complementary line is at "1".

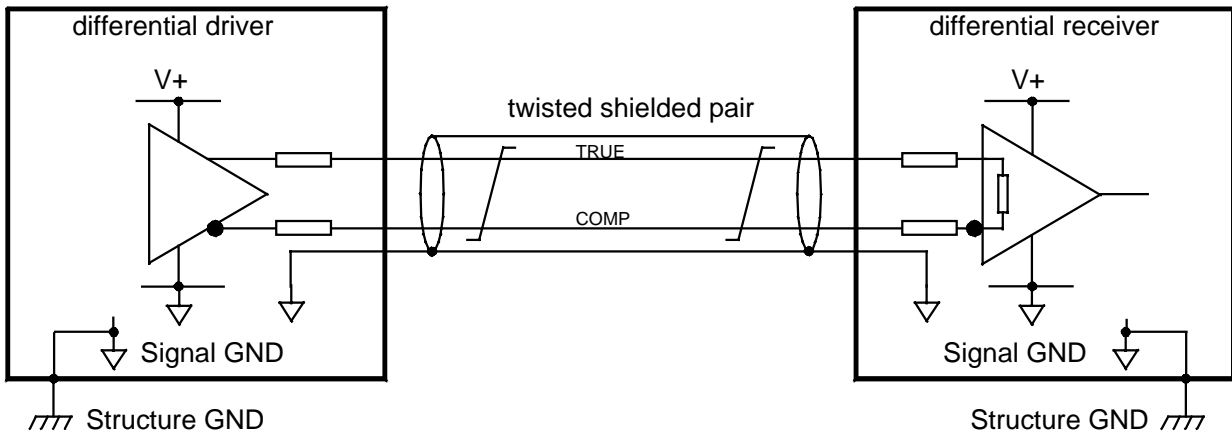


Figure 6.8-1 Schematic Electrical interface for the SBDL

GDEL-730: To ensure the maximum of compatibility and the minimum of risk, the SBDL interface shall be implemented using the components as shown in Figure 6.8-2. Additional protection components (to provide protection during on-ground operations) may be added as deemed necessary by the circuit designer.

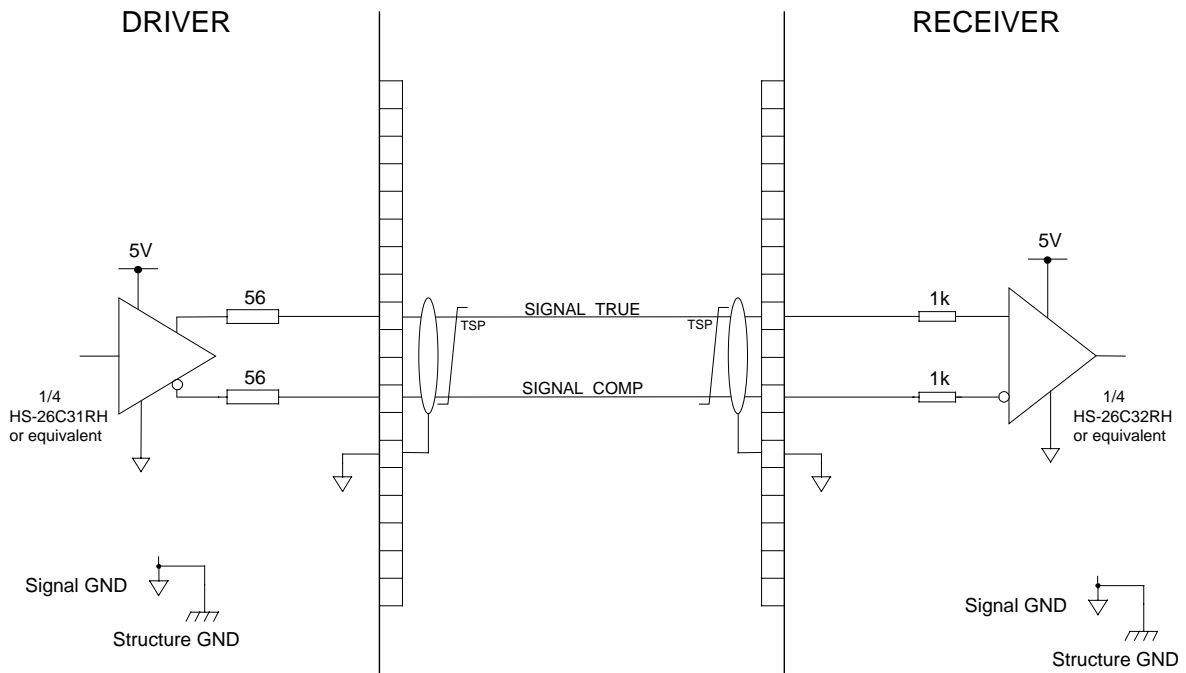


Figure 6.8-2 SBDL Interface Details

Driver Characteristics

DRIVER	
CIRCUIT TYPE	Complementary CMOS Driver
Zero Reference	signal ground
Low Level Output Voltage	$0\text{ V} \leq V_{OL} \leq 0.5\text{ V}$ (1)
High Level Output Voltage	$2.5\text{ V} \leq V_{OH} \leq 5.5\text{ V}$ (1)
Differential Output Voltage	$2.0\text{ V} \leq V_{OD} \leq 5.5\text{ V}$
Rise and Fall Times	$0.1\ \mu\text{s} \leq t_r \leq 0.80\ \mu\text{s}$ (2) $0.1\ \mu\text{s} \leq t_f \leq 0.30\ \mu\text{s}$
Differential Output Impedance	$115\ \Omega < Z_d < 125\ \Omega$
Current Drive and Sink Capability	sufficient to comply with specified t_r & t_f (2)
Short Circuit	short circuit proof; current limited to <150 mA
Max. Fault Voltage	Tolerance: -12 V to +12 V (3) Emission: 0V to +5V
NOTES: 1. non-inverting (true) & inverting (comp) output with ref. to signal ground; 2. when loaded with differential 1.2 nF (harness & user input capacitance) 3. with an overvoltage source impedance of 1.5 kOhm	

Line Characteristics

LINE CHARACTERISTICS	
Type of cable	125 Ohm TwinAx Cable to be used: Gore GSC 6509, Rev. 6

Receiver Characteristics

RECEIVER	
CIRCUIT TYPE	Complementary CMOS Driver
Differential Input Voltage	Low : $V_{ID} \leq -1V$ High $V_{ID} \geq +1V$
Common Mode Voltage	$-2.5 V \leq V_{CM} \leq +2.5 V$
Diff. Input Impedance	DC: $\geq 5 \text{ k}\Omega$
Max. Fault Voltage	Tolerance: -0.5 V to +7 V Emission: 0 V to +5V (1)
NOTES: 1. with an overvoltage source impedance of 1.5 k Ω	

6.8.1.5 Memory Load Command (ML16)

The purpose of the Memory Load Command (or 16 bits serial load command) link is to transfer a 16 bits data word in serial form.

Any undefined ML16 bit pattern (bit pattern having no predefined interpretation or decoding sense at user level) shall be ignored by the addressed user.

The interface consists of the following 3 signals :

Sample (or address)

The user will be provided with a dedicated address line for each ML16.

Clock :

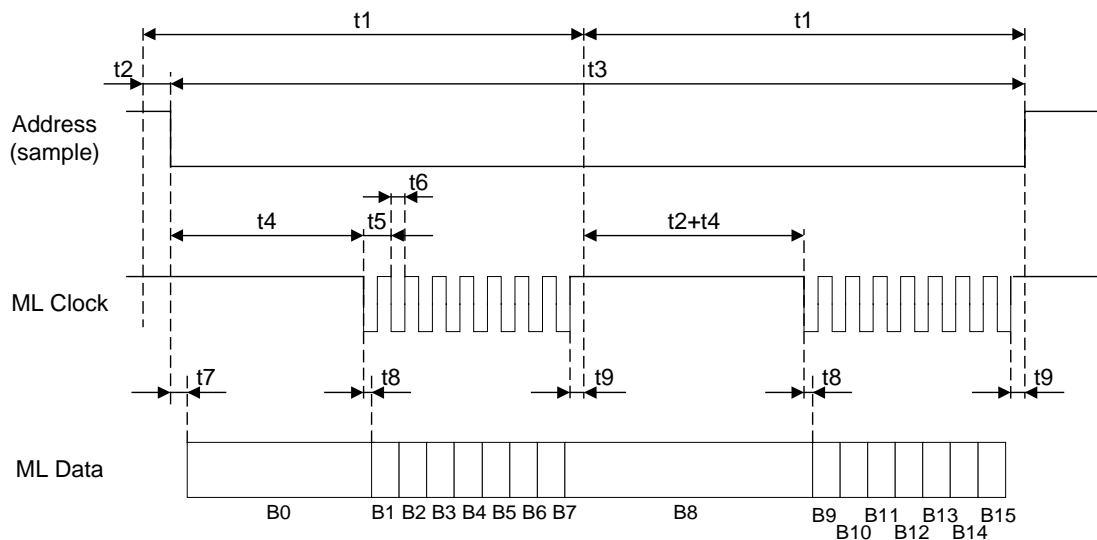
One Clock line is provided to each user. Clocks pulses are provided simultaneously to all users. 16 of these Clocks pulses are gated during the Address (Sample) signal interval, together with 16 bits Data, thus enabling the user to read the Data after detection of one of its addresses. The Clock pulses have a known and reliable phase relationship with the NRZ-L Data transitions, thus ensuring reliable Data read-in by the user.

Data :

One Data line (16 bits serial NRZ-L) is provided to each user.

ML16 command protocol and signal wave form

The Serial command timing is according to the figure below.



Memory Command timing (B0 is MSB)

Timing requirements :

t1	$64 t \pm t$
t2	$4 t \pm t$
t3	$124 t \pm t$
t4	$28 t \pm t$
t5	$4 t \pm 0.1 t$
t6	$2 t \pm 0.6 t$
t7	$< 4 t$
t8	$0.5 t \text{ to } 2 t$
t9	$> 1.5 t$

where $t = 2^{-20} \text{ s} \approx 0.95 \mu\text{s}$

Rise and fall times are valid for all three signal types: address, clock, and data.

The electrical characteristics of address, clock and data lines are as given for the SBDL (see paragraph 6.8.1.4)

6.8.2 Telemetry Interfaces

6.8.2.1 Analogue telemetry

	SOURCE	RECEIVER
CIRCUIT TYPE	Single ended (or differential)	Differential Receiver
VOLTAGE - Differential - Common mode (return w.r.t receiver ground) - C.M.R.R	0 V < U < 5.12 V -2.5 V < U < 2.5 V	0 V < U < 5.12 V 60 dB up to 10 kHz falling 20dB/dec. up to 1MHz
IMPEDANCE - Differential (power ON) - Com. mode (powerON) - Com. mode (power OFF)	≤ 10 kΩ ≤ 100 kΩ	> 15 MΩ // < 1μF > 10 MΩ > 1kΩ // < 1μF
CAPACITANCE (differential)	50 nF ≤ C ≤ 1μF	< 1 μF (at input) < 100 pF (after MUX)
LEAKAGE CURRENT	to deal with a permanent load of 1 kΩ	< 500 nA (power ON) < 0.5 mA (power OFF)
FAULT VOLTAGE - Emission - Tolerance	-3 V < U < +14 V -16 V < U < +16 V (in series with ≥ 1.5 kΩ)	-16 V < U < +16 V (in series with ≥ 1.5 kΩ) -3 V < U < +14 V (1) (I < 16 mA when power OFF)
LINE CHARACTERISTICS Type Core to core Capacitance Core to shield Capacitance Voltage Drop	Twisted shielded 5 cores - AWG26 < 900 pF < 1.8 nF < 2 mV	

(1) shall not cause any damage, nor shall affect the performance of any other part than the concerned input.

The A/D coding shall be achieved by using 12 bits.

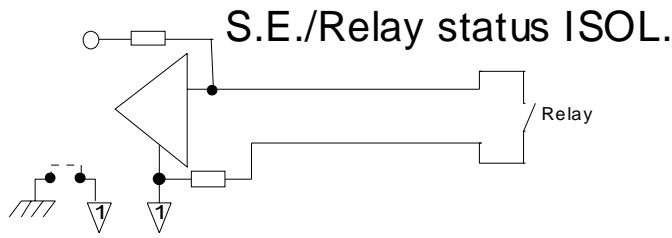
6.8.2.2 Thermistor acquisition

The Thermistor types and measurement ranges are TBD once the ranges of temperature to be acquired are consolidated.

	SOURCE	RECEIVER
CIRCUIT TYPE	Thermistor (Ex: Type Fenwall - GB 42)	Single ended Receiver
VOLTAGE AFTER THERMISTOR CONDITIONING (after resistor bridge)		$0\text{ V} < U < 5.12\text{ V}$ (cod. range) -->LSB = 20 mV
IMPEDANCE Min, Max	TBD (Typical: 15 kΩ at 25°C)	depends on bridge resistances values
CAPACITANCE (differential)		< 1μF (at input) < 100 pF (after MUX)
THERMISTOR SELF POWER DISSIPATION < 0.05 W	Th. current $< \sqrt{\frac{0.05\text{ W}}{R_{\min}}}$ Rmin = thermistor min. resist.	Voltage applied to thermistor $< \sqrt{0.05\text{ W} * R_{\min}}$
FAULT VOLTAGE - Emission Tolerance	short circuit to mechanical ground $-16\text{ V} < U < +16\text{ V}$ (in series with $\geq 1.5\text{ k}\Omega$)	$-16\text{ V} < U < +16\text{ V}$ (in series with $\geq 1.5\text{ k}\Omega$) short circuit to mechanical ground (1)
LINE CHARACTERISTICS Type Core to core Capacitance Core to shield Capacitance	Twisted shielded pair - AWG26 < 900 pF < 1.8 nF	

(1) shall not cause any damage, nor shall affect the performance of any other part than the concerned input.

6.8.2.3 Digital relay status acquisition



The digital status information is presented by the user in the form of a contact resistance that can assume only two distinct values, a closed contact (logical "1" level) represented by a low resistance and an open contact (logical "0" level) represented by a high resistance, between the 2 digital status lines. Each digital status acquisition corresponds to one bit of the housekeeping telemetry format

	SOURCE	RECEIVER
CIRCUIT TYPE	Switch / Relay contact	Single ended Receiver with pull-up resistor
RESISTANCE / VOLTAGE - "0" level (open) - "1" level (closed)	$R_s \geq 1 \text{ M}\Omega$ $R_s \leq 10 \Omega$	$V_{out} \leq 2.5 \text{ V}$ (max. threshold) $V_{out} \geq 1.5 \text{ V}$ (min. threshold)
CURRENT	< 10 mA	0.1 mA < I < 10 mA
VOLTAGE	contact capability > 5.5 V	$V_{out} < 5.5 \text{ V}$
FAULT VOLTAGE - Emission - Tolerance	$-3 \text{ V} < U < +14 \text{ V}$ $-16 \text{ V} < U < +16 \text{ V}$ (in series with $\geq 1.5 \text{ k}\Omega$)	$-16 \text{ V} < U < +16 \text{ V}$ (in series with $\geq 1.5 \text{ k}\Omega$) $-3 \text{ V} < U < +14 \text{ V}$ (1)
LINE CHARACTERISTICS Type Core to core Capacitance Core to shield Capacitance	Twisted (shielded) pair- AWG26 < 900 pF < 1.8 nF (if shielded)	

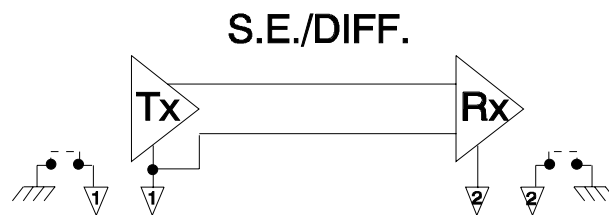
(1) shall not cause any damage, nor shall affect the performance of any other part than the concerned input.

6.8.2.4 Digital bi-level acquisition

Each bi-level digital channel is used to acquire one of a number of discrete status bits.
 A digital bi-level channel consists of 2 lines..

The digital bi-level information is presented by the user in the form of a voltage that can assume only two distinct values, an "ON" level (logical "1" level) represented by a positive voltage and an "OFF" level (logical "0" level) represented by a zero voltage between the high bi-level source line and the low bi-level source line with the low bi-level source line as reference. Each digital bi-level acquisition corresponds to one bit of the housekeeping telemetry format.

At user level a single ended transmitter is allowed.



	SOURCE	RECEIVER
CIRCUIT TYPE	Single ended	Differential Receiver
VOLTAGE	- "0" level (differential) $0\text{ V} < U < 0.5\text{ V}$ - "1" level (differential) $3.5\text{ V} < U < 5.5\text{ V}$	$U < 2.5\text{ V}$ (max. threshold) $U > 1.5\text{ V}$ (min. threshold)
IMPEDANCE	- Differential (power ON) $\leq 10\text{ k}\Omega$ - Com. mode (power ON) $\leq 100\text{ k}\Omega$ - Com. mode (power OFF)	$> 15\text{ M}\Omega // < 1\mu\text{F}$ $> 10\text{ M}\Omega$ $> 1\text{k}\Omega // < 1\mu\text{F}$
CAPACITANCE (differential)	$50\text{ nF} \leq C \leq 1\mu\text{F}$	$< 1\mu\text{F}$ (at input) $< 100\text{ pF}$ (after MUX)
LEAKAGE CURRENT	to deal with a permanent load of $1\text{ k}\Omega$	$< 500\text{ nA}$ (power ON) $< 0.5\text{ mA}$ (power OFF)
FAULT VOLTAGE	- Emission $-3\text{ V} < U < +14\text{ V}$ - Tolerance $-16\text{ V} < U < +16\text{ V}$ (in series with $\geq 1.5\text{ k}\Omega$)	$-16\text{ V} < U < +16\text{ V}$ (in series with $\geq 1.5\text{ k}\Omega$) $-3\text{ V} < U < +14\text{ V}$ (1) ($I < 16\text{ mA}$ when power OFF)
LINE CHARACTERISTICS	Type Core to core Capacitance Core to shield Capacitance Voltage Drop	Twisted (shielded) 5 cores - AWG26 $< 900\text{ pF}$ $< 1.8\text{ nF}$ (if shielded) $< 2\text{ mV}$

(1) shall not cause any damage, nor shall affect the performance of any other part than the concerned input.

6.8.2.5 Status Lines

Status lines may be used instead of the digital bi-level acquisition lines to provide digital telemetry.

The electrical interfaces shall be as defined for the SBDL see paragraph 6.8.1.4.

The duration of a status signal shall be $>10\text{mS}$.

6.8.2.6 Digital Serial Acquisition (DS16)

The purpose of the Serial Digital Acquisition link is to transfer a 8 or 16 bit data word, in serial form, from a particular user location on-board the satellite to a command distribution unit.

The interface consists of the following 3 signals :

Sample

The user will be provided with a dedicated address line

Clock :

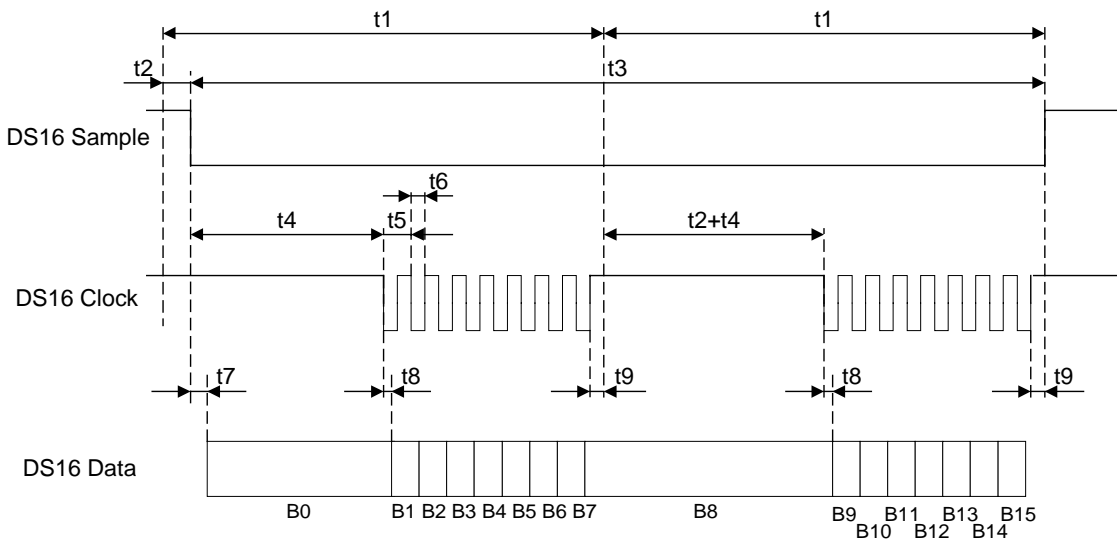
One Clock line is provided to each user. Clocks pulses are provided simultaneously to all users. 8 or 16 of these Clocks pulses are gated by the user with the Sample signal interval and used to control the shifting out of the 8 or 16 bits serial Data from the user. The Clock pulses have a known and reliable phase relationship with the NRZ-L Data transitions, thus ensuring reliable Data clocked out by the user and Data read-in by the command distribution unit.

Data :

One Data line is provided to each user. Selection of the user location is performed by means of the sample lines.

The Digital Serial Acquisition (DS/16) signals (Sample, Data, and Clock) shall comply with the interface requirements of the SBDL differential driver/receiver interface.

The DS16 acquisition timing shall be according to the figures below. The values specified are valid at the SBDL output when it is loaded with $1.2\text{ nF} \parallel 10\text{ k}\Omega$.



Digital Serial Acquisition (16 bit) timing (B0 is MSB)

	DS16
t1	64 t ± t
t2	4 t ± t
t3	124 t ± t
t4	28 t ± t
t5	4 t ± 0.1 t
t6	2 t ± 0.6 t
t7	< 16 t
t8	< 1.2 t
t9	> 1.5 t

where $t = 2^{-20} \text{ s} \approx 0.95 \mu\text{s}$

Digital Serial Acquisition timing

6.8.3 MIL-STD-1553B bus

- GDEL 712: The reference standard is MIL-STD-1553B Notice 2.
- GDEL-715: The bus users shall use the long stub configuration (transformer-coupled to the bus).
- GDEL-720: The MIL-STD-1553B bus connectors shall be dedicated (no sharing of connectors with any other signal) and segregated (one connector for nominal bus and one for redundant bus) on each unit using this bus.
- GDEL-730: Connectors shall preferably be 9 DBAS 70 3 0 S N 1A and 9 DBAS 70 3 0 S X 1A (for nominal and redundant MIL-STD-1553B bus lines).

If different, they shall be submitted to Satellite Contractor approval.

- GDEL-740: MIL-STD-1153B users shall conform to the bus protocol specified in AD- 41 Appendix 9.

6.8.4 Timing and synchronisation

GDEL-740: All timing and synchronisation signals shall use the SBDL interface as defined in paragraph 6.8.1.4.

GDEL-750: A synchronisation signal derived from the on board master clock will be made available. It shall have the following characteristics:

Frequency	131071 Hz \pm 1ppm (TBC)
Long Term Stability (1 month)	\pm 20mS over 30 days
Short Term Stability (1 Hour)	TBD
Duty Cycle	50% \pm TBD %
Jitter	TBD

APPENDIX 1

IDS STANDARD

EQUIPMENT INTERFACE CHARACTERISTICS

UNIT DESIGNATION :		
TOTAL NUMBER :	...	IN OPERATION :
	...	IN REDUNDANCY :
	...	

MECHANICAL CHARACTERISTICS PER UNIT

<u>DIMENSIONS</u> ⁽¹⁾ (Baseplate=Length x Width)			
Length :mm	Width :mm
Diameter :mm	Height :mm
<u>MASS</u> :kg +/- kg			
<u>CoG. LOCATION</u> ⁽¹⁾ (mm) (wrt reference hole R) :			
X : +/-	Y : +/-
	Z : +/-
<u>INERTIA</u> (m ² .kg) (wrt CoG)			
Ixx :	+/-	Iyy :	+/-
	+/-	Izz :	+/-
<u>MATERIAL OF HOUSING AND SURFACE FINISH</u> ⁽⁵⁾ :			
<u>TOTAL CONTACT AREA</u> :		cm ² =	% of baseplate area
<u>ROUGHNESS OF CONTACT AREA</u> :		MICRONS RMS	
<u>EIGENFREQUENCY</u> :	Hz	vs	Hz
		<u>TIGHTENING THICKNESS</u> :	mm

THERMAL CHARACTERISTICS PER UNIT

<u>BASEPLATE MATERIAL AND THICKNESS</u> (mm):	
<u>SURFACE PROPERTIES</u> :	
EMISSIONITY :	ABSORPTIVITY ⁽²⁾ :
<u>SPECIFIC AREAS</u> ⁽¹⁾ :	
<u>SPECIFIC HEAT</u> (J/kg/°K) :	

QUALIFICATION TEMPERATURE LIMITS (°C)

GROUND STORAGE & TRANSPORT		OPERATING MODE		NON OPERATING MODE		START UP
MIN	MAX	MIN	MAX	MIN	MAX	MIN

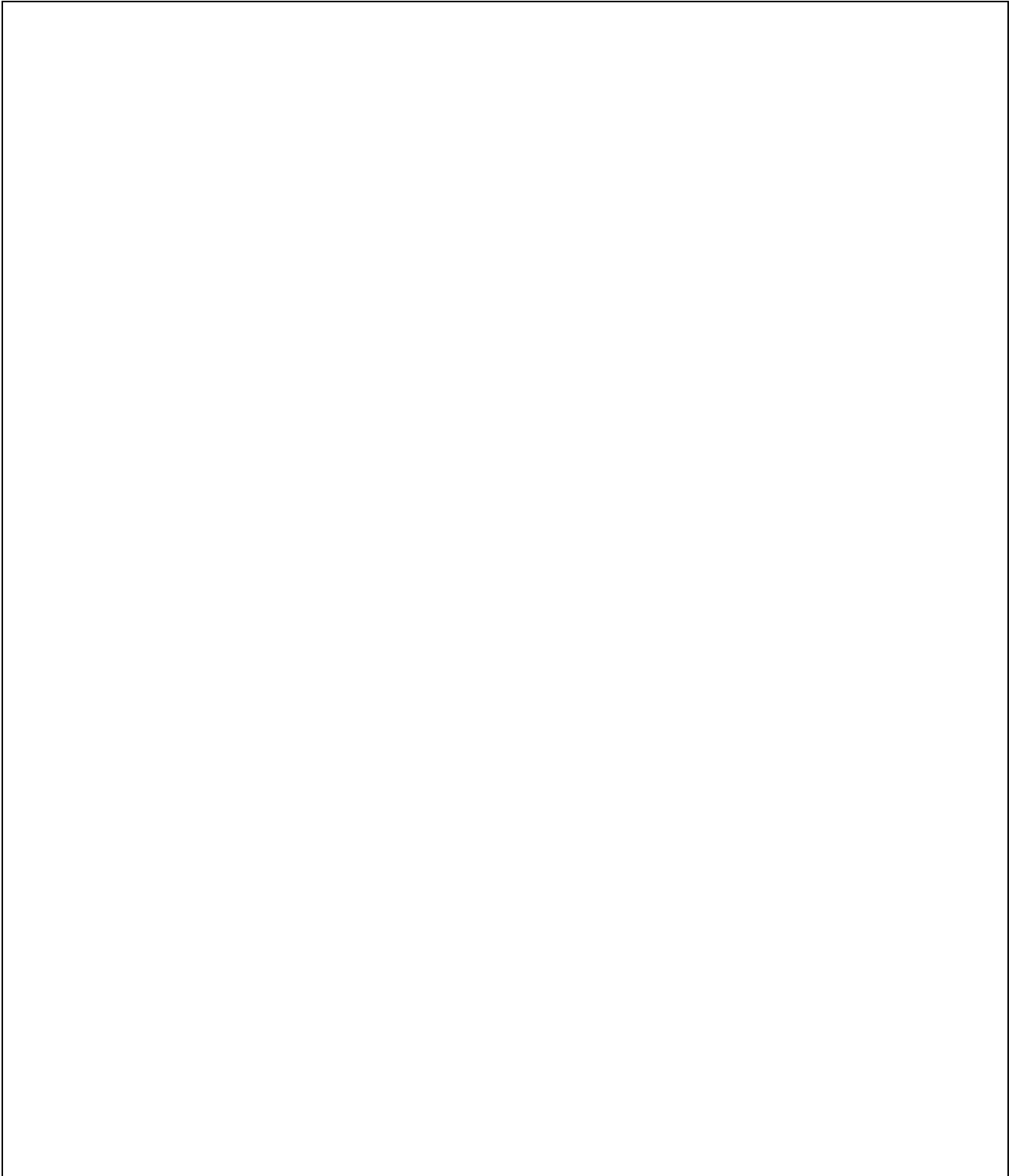
HEAT DISSIPATION (W) (give % of incertitude)

MODE ⁽⁴⁾	AVERAGE	MINI ⁽³⁾	MAXI ⁽³⁾

OBSERVATIONS

- (1) Precise with a drawing on separated sheet (Page 2) specific areas in case of various thermal coating (if any)
- (2) Solar Absorptance only for locations outside of the satellite (which could be seen by the sun)
- (3) Give diagram on separated sheet W = f(t) for each typical phase
- (4) Complete with special modes if any : state precisely relevant events
- (5) Including baseplate characteristics

DRAWING (mechanical)



On this drawing, indicate dimensions, inertia axes OX, OY, OZ, footprint, location of CG, mounting points, diametric tolerance, centre to centre distance, position tolerance (guide pins or holes), location type orientation, location and reference of connectors, necessary access after integration for calibration or test, bonding stud location and length and so on

If additional pages are necessary, add the number after 2

ELECTRICAL POWER DEMAND (Average)

MAXIMUM AVERAGE DEMAND (W)
 (maximum of the integrated average power demand in any period of 5 minutes excluding peak power)
 (detail Total Power, and Power per LCL)

PHASE (1)	MODE ⁽²⁾	POWER REQUESTED PER UNIT	NUMBER OF WORKING UNITS	TOTAL POWER DEMAND

REMARKS :

(1) Operation Phase (Launch, ...)
 (2) Instrument Operation mode Complete with mode details for phase, if necessary, and with special modes if any, stating precisely when they occur

ELECTRICAL POWER DEMAND (peak)

MAXIMUM PEAK DEMAND (W) :
 (detail Total Power, and Power per LCL)

PHASE (1)	MODE(2)	PEAK TYPE(3)	PEAK DEMAND	DURATION	REPETITION RATE(p/s)	OCCURENCE (4)

REMARKS :

- (1) Operation Phase (Launch, ...)
- (2) Instrument Operation mode .Complete with mode details for phase, if necessary and with special modes if any, stating precisely when they occur
- (3) Peak type : L - long peak, max. duration 5 min, maximum of the integrated mean demand in any period of 100 min.
 S - short peak, max. duration 100 ms, maximum of the integrated mean demand in any period of 1 min.
- (4) Describe when peak demand occurs.

PIN ALLOCATION

(use one sheet per connector as connector)

CONNECTOR REF (1) :	CONNECTOR TYPE 1 :
---------------------	--------------------

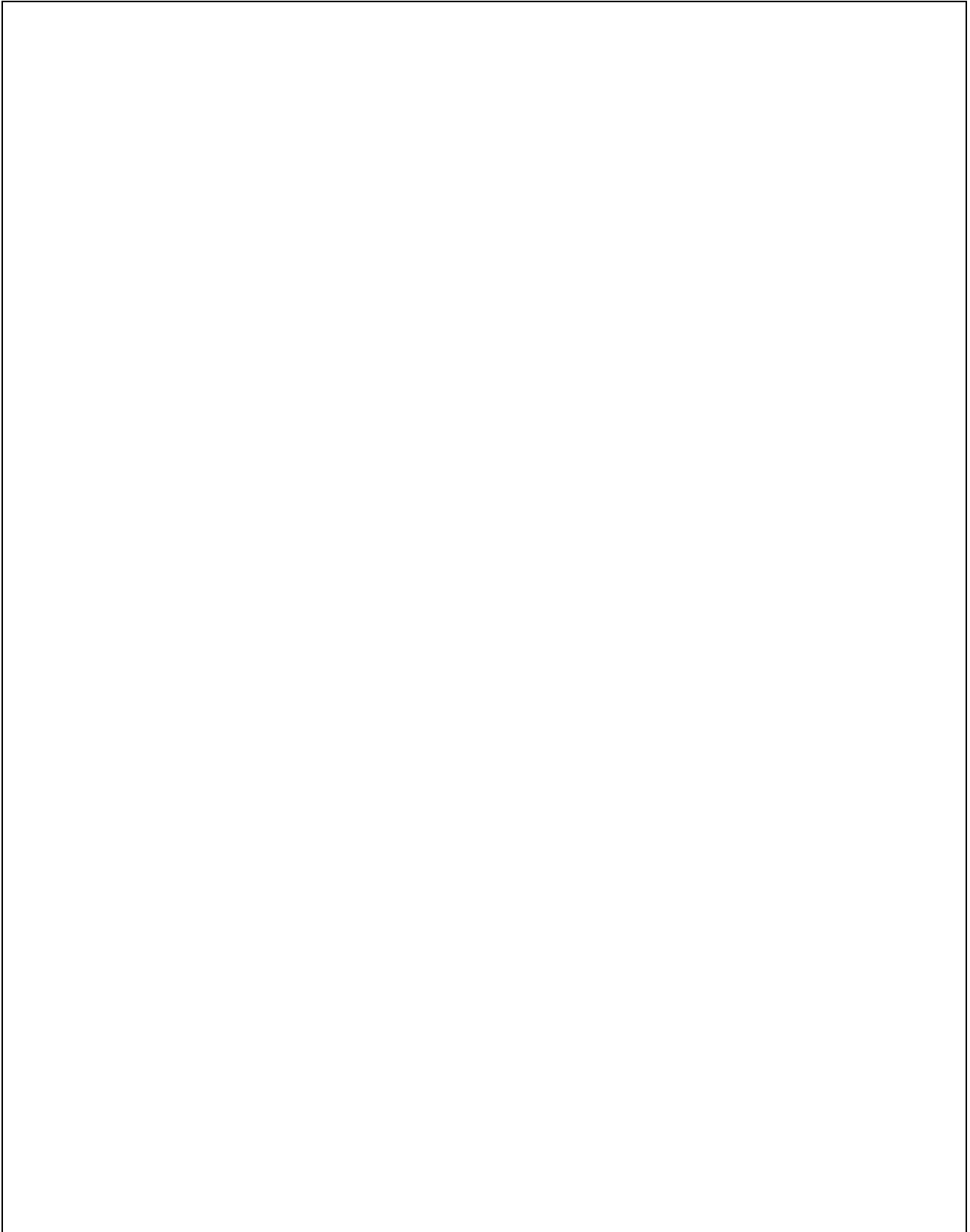
PIN REF	FUNCTION	TYPE OF LINE	INTERFACE CABLING REQ. ²	REMARKS

(1) Complete connector manufacturer designation

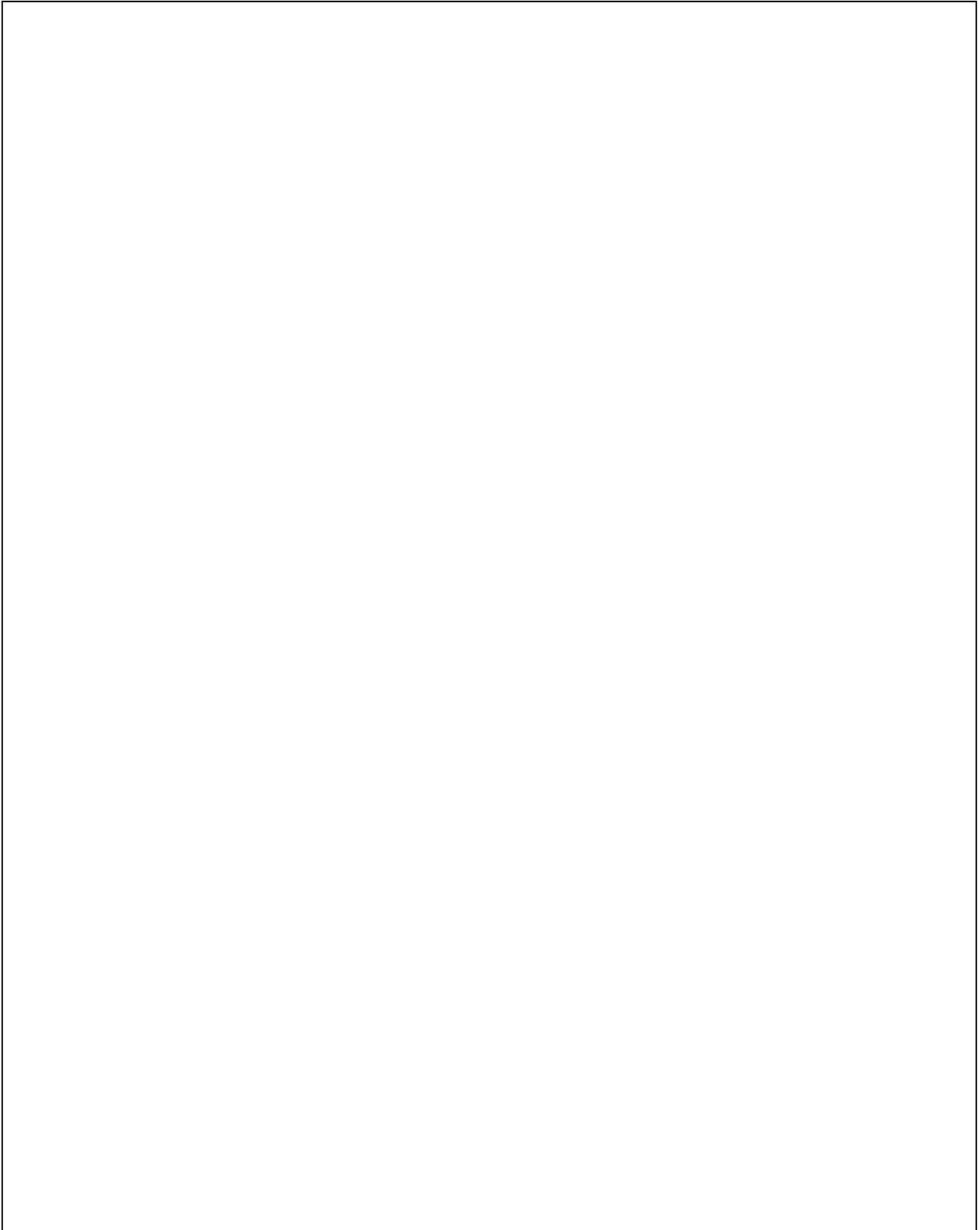
(2) If there is S/S requirement enter

TW	: Twisted
BL	: Bundled
SH	: Shielded

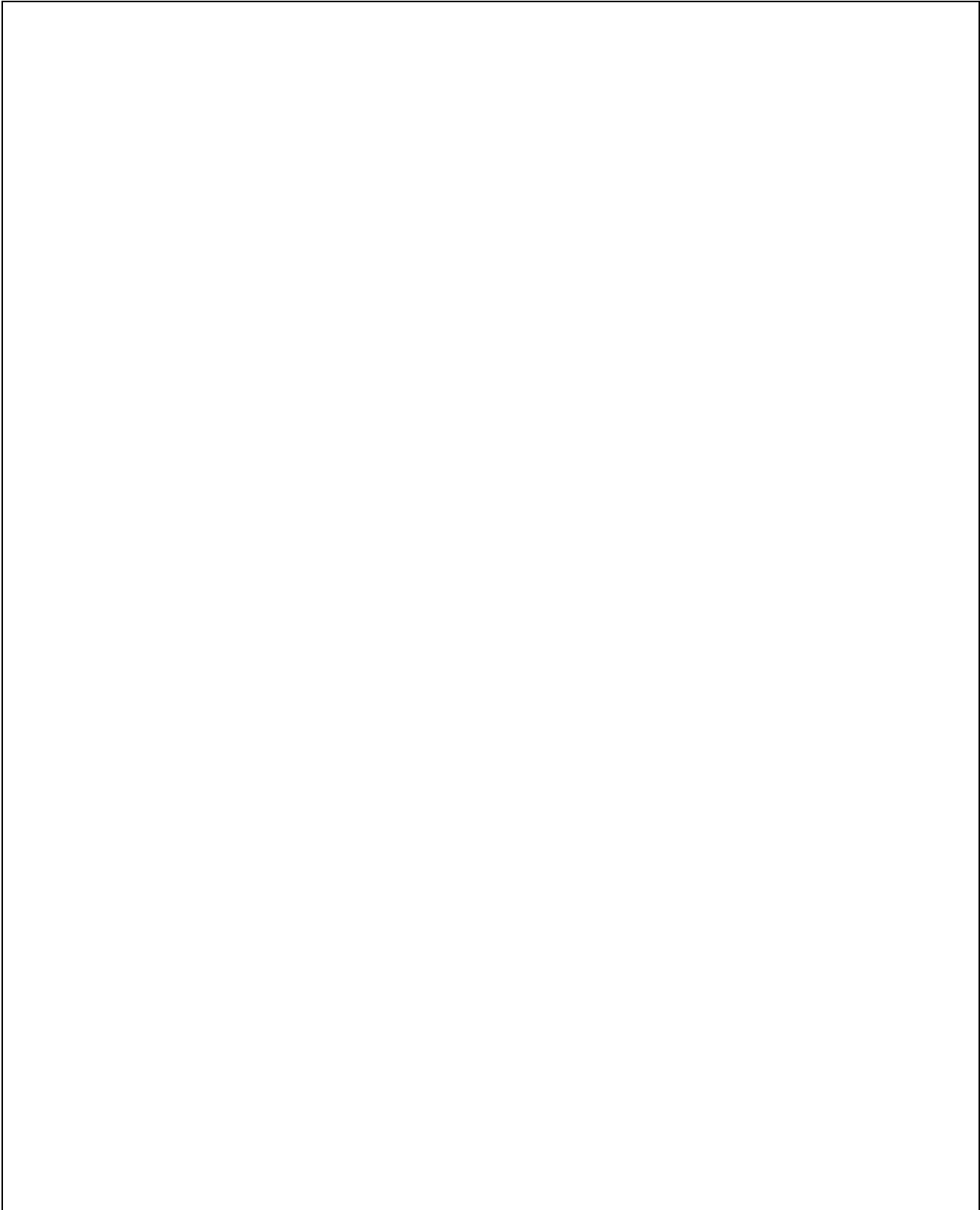
TM INTERFACE (CIRCUITRY DIAGRAM)



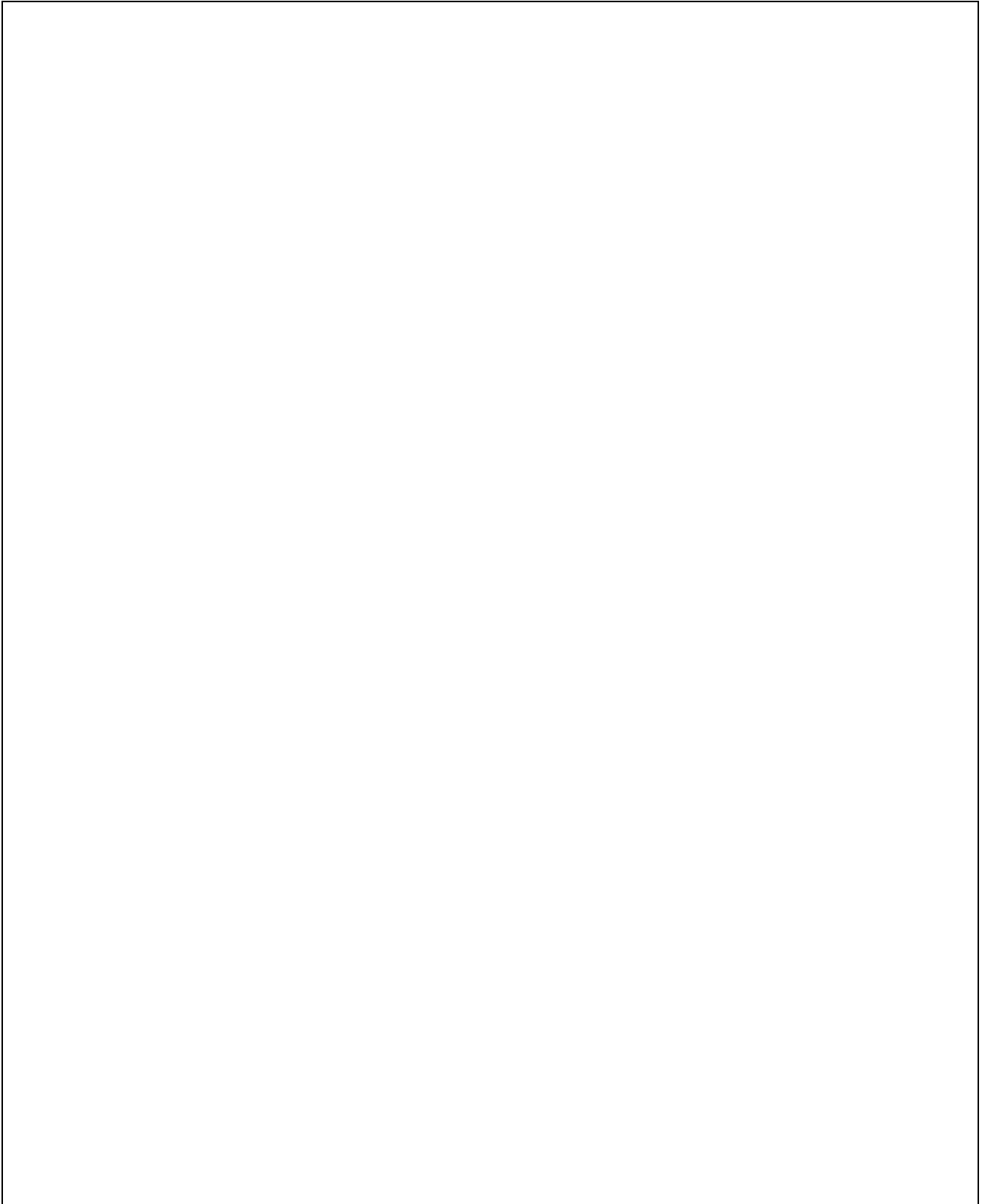
TC INTERFACE (CIRCUITRY DIAGRAM)



POWER INTERFACE



GROUNDING SCHEME



TM/TC DEMAND SUMMARY

Format TBD