Title

DESIGN, INTERFACE, ENVIRONMENT and TEST REQUIREMENT SPECIFICATION for EQUIPMENTS (DIET)

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1 SCOPE

This specification defines :

- the general mechanical, electrical and thermal design and interface requirements

- the minimum environmental design and test conditions

which must be met by equipments to be used on EUROSTAR 3000 satellites.

Certain items are exempt from calling DIET as an applicable document under the condition that all relevant requirements issued from the DIET are include within a "self contained" specification for the item in question. Relevant requirement are to be agreed upon between the person responsible for the item and the system group. The items are ~~This specification is not applicable to~~: antennas ; solar arrays ; batteries ; harness ; structure ; propellant tanks ; wave guides, co-axial cables and support ; CPS and PPS piping. ~~*This means that the specifications of such items are self-content and includes all relevant requirement from the DIET.*~~ *For big electronics units (as payload processors) dedicated mechanical and thermal specifications have to be used.*

Equipment has to be understood as hardware and software when both are delivered by the Subcontractor. This specification is not applicable to the satellite central software (running in the SCU), which is under Prime Contractor responsibility.

This specification applies to the whole mission life, except for ground activities where the specification is to be met with respect to beginning of life parameters.

Equipment specifications are superseding the DIET specification. If an equipment specification clearly identifies a waiver against DIET requirements, this waiver will be internally handled by the Prime Contractor.

Three kind of items can be found in this document :

1. requirements **[R]** : any deviation of the equipment must be traced by a formal RFW (unless superseded by the equipment specification)
2. guidelines **[G]** : any deviation of the equipment must be traced and justified in the compliance matrix to DIET (unless superseded by the equipment specification)
3. clarification : comment in italics, only given for information, to clarify a particular specification.

All items which are neither in italics, nor labelled as "guideline", must be considered as "requirement", by default.

The test specification and the environmental data given in this document are consistent with the environmental conditions encountered within the EUROSTAR 3000 platform, launched either by ARIANE 4/5, PROTON, ATLAS 2A/2AS/2AR/2ARS, DELTA III, SEA LAUNCH, H2 and LONG MARCH 3B. Shock levels specified hereafter consider ARIANE 4/5 and ATLAS. Radiated EMC specification covers all the launchers, but specific compatibility analyses may be necessary for TCR-RF units according to frequency band and ON/OFF status at launch.

2 APPLICABLE AND REFERENCE DOCUMENTS

The applicable documents form a part of this specification to the extent specified herein. Any conflict between this specification and applicable documents referenced herein, shall be brought to the attention of the Prime Contractor. The Statement Of Work (SOW) applicable to the contract defines the applicable issues of these documents, and the precedence between these documents.

AD1	EUR-SPM-00002-MMT	Radiation Hardness Assurance

The reference documents are called to find additional informations on particular points :

RD1	EUR-SPM-00004-MMT	Product Assurance Requirements
RD2	EUR-SPM-00003-MMT	Parts Material Process Specification
RD3	CDSP.QG.034.PCE	CADM requirements for telecom satellites
RD4	MIL-STD-1553B + notice2	1553B data bus standard
RD5	EUR-NT-0009-MMT	EICD data base exchanges
RD6	EUR3-SP-05441-MMT	Specification of the high level interface between data handling and remote computers
RD7	EUR3-TN-06450-T-MMS	Shock levels for EUROSTAR 3000 equipments and appendages
RD8	EUR3-SP-05832-MMT	Synthesis of the main sizing conditions for the E3000 spacecraft (mechanical EV for appendages)

3 DEFINITIONS

3.1 GENERAL

3.1.1 Spacecraft or system

The complete spacecraft assembly, including all those hardware items present after separation of the spacecraft from the launch vehicle.

3.1.2 Subsystem

A functioning entity comprising two or more equipments within the system and described by a subsystem specification.

3.1.3 Equipment

A self-contained combination of parts and/or assemblies within a subsystem and described by an equipment specification.

3.1.4 Function

Any block appearing in the reliability diagram that is redundant and/or switchable.

3.1.5 Command

The classification of the commands is performed in three categories. This classification is under Prime Contractor responsibility.

Category 1 : Critical commands.

These are commands which, if executed at the wrong time, could cause the loss of, or significant degradation to the mission with irreversible state of the satellite or with a modification of functional performances (such as pyro orders, LAE fire commands).

Category 2 : Vital commands

These are commands, which do not belong to category 1, but which are essential to the success of the mission, and if sent at the wrong time could cause a momentary loss of the mission.

Category 3 : Configuration - dependant commands

These commands shall only be sent if a particular configuration of sub-system or payload is not established, or that shall be sent under a certain defined condition.

3.1.6 Glossary

ADCS, AOCS	Attitude Determination and Control subsystem
AIT	Assemble Integration and Test
BOL	Beginning Of Life
CDR	Critical Design Review
CPS	Combined Propulsion Subsystem
DRB	Delivery Review Board
EEE parts	Electrical, Electronics, Electromechanical parts
EGSE	Electrical Ground Support Equipment
EMC	Electromagnetic compatibility
EOL	End Of Life
EQSR	Equipment Qualification Review
ESD	Electrostatic discharge
EPS, PSS	Electrical Power Subsystem
EQSR	Equipment Qualification Status Review
EV	Environment, Environmental
FPC	Full Performance Check
GHC	Good Health Check
LAE	Liquid Apogee Engine
LPC	Limited Performance Check
MGSE	Mechanical Ground Support Equipment
MRR	Manufacturing Release Review
NC	Non Compliance
PDR	Preliminary Design Review
PMP	Parts Material and Processes
QR	Qualification Review
RIU	Remote Interface Unit
SPF	Single Point Failure
TCR, TTC	Telemetry Telecommand and Ranging subsystem
TC	Telecommand
TM	Telemetry
TML	Total Mass Loss
TRB	Test Review Board
TRR	Test Readiness Review
VCM	Volatile Condensable Mass
WC, wc	Worst Case
Prime Contractor	MMS/DSCC project team
Subcontractor, Supplier	Equipment manufacturer or supplier to the Prime Contractor

3.2 MECHANICAL FIELD

3.2.1 Limit loads

Maximum loads expected on an equipment or a system including storage, handling, flight. Acceptance test levels are the limit load levels.

3.2.2 Design loads

Design loads are the limit loads multiplied by the design coefficient. Any equipment or system shall be designed to withstand design loads with the required safety margin. Qualification test levels are the design load levels.

3.2.3 Notching

Equipment or spacecraft interface loads reduction related to specified levels during sinusoidal vibration test at resonance frequency. Any notching shall be subject to the Prime Contractor approval.

3.2.4 Mechanical tests

Any test comprising subjection of an equipment or system to purely mechanical loading (i.e. excluding thermal induced loading, but including for example static loading, constant acceleration, spin, spin acceleration, vibration, acoustic noise, high internal pressure or inertial loading for rotating mechanisms).

3.3 THERMAL FIELD

3.3.1 Operating Temperature : TFO

The operating temperature limits specify the temperature extremes at and between which the functioning equipment shall be designed to operate whilst meeting all the specification requirements.

3.3.2 Acceptance Temperature : TFA

The acceptance temperature limits specify the temperature extremes to which flight model equipment must be subjected during thermal testing, in operating conditions, whilst fully meeting their performance requirements.

3.3.3 Qualification Temperature : TFQ

The qualification temperature limits specify temperature extremes to which qualification and protoflight model equipment must be subjected during thermal testing, in operating conditions, whilst fully meeting their performance requirements.

3.3.4 Non functioning Temperature : TNF

The non functioning temperature limits specify the temperature extremes at and between which the equipment shall be designed to survive without functioning for any period of the mission and without performances degradation.

3.3.5 Start-up Temperature : TSU min

The start-up temperature specifies the minimum temperature for the equipment to have power applied, or to be activated.

The equipment design shall be such that upon such power application or activation with temperature moving into the operating range the equipment performance reaches specification requirements.

3.3.6 Ground storage Temperature : TGS

The ground storage temperature limits specify the temperature extremes at or between which the equipment shall be designed to survive in a not-powered state during manufacturing, storage, handling, transport and integration.

3.3.7 Mean dissipation

The mean dissipation is the integrated time-average of the dissipated powers. It is used to design the thermal control system so that the fluctuation in dissipated power around the mean dissipation does not make the temperature of the equipment vary by more than 0.5°K.

3.3.8 Peak of dissipation

A peak of dissipation is a significant fluctuation (either positive or negative) around the mean dissipation. This peak will have to be taken into account if it induces a variation in the temperature of the equipment of more than 0.5°K.

3.3.9 Radiatively controlled equipment

The equipment with power density on the total skin area less than $70W/m^2$ in all its operating modes, will be considered lightly dissipating.

The thermal control of this equipment will have to be by radiation only.

3.3.10 Conductively controlled equipment

The equipment that does not meet the previous criterion, shall be mounted so that the baseplate is conductively coupled with the satellite.

3.3.11 Isothermal equipment

Radiative equipment : for every operating mode with the test configuration (see equipment specification) the temperature gradient between all points of the equipment case must be less than 3°C.

Conductive equipment : for every operating mode with the test configuration (see equipment specification), the temperature difference between any point on the equipment baseplate must be less than 3°C.

3.3.12 Non isothermal equipment

For the equipment that does not meet the previous criteria, the equipment Supplier shall provide a temperature distribution whose elements are isothermal and meet the previous criteria. The equipment Supplier shall provide the associated thermal model as part of the thermal data sheets (model with several thermal nodes).

3.3.13 Stabilised temperature

For equipment or subsystem thermal cycling, a stabilised temperature has been achieved when the measured temperature of the equipment has not changed by more than 1°C during the previous one hour period.

3.3.14 Equilibrium temperature

For spacecraft or subsystem space simulation testing, equilibrium temperature is achieved when the rate of change of temperature at the pre-set points is less than 1°C in four hours.

3.3.15 Reference temperature

For radiative isothermal equipment, the reference temperature is the arithmetic average temperature of the skin in proportion to areas.

For conductive isothermal equipment, the reference temperature is the arithmetic average temperature of the contact area.

For non isothermal equipment, a reference temperature is defined for each thermal node as above.

For all cases, it is possible to change the definitions for a specific reference point on the equipment. This point shall be defined in agreement between the equipment Supplier and the Prime Contractor. This point shall be mentioned on interface plan and in the thermal data sheets and shall be instrumented during equipment level thermal testing.

A reference temperature definition is required for all units.

3.4 ELECTRICAL FIELD

3.4.1 Electrical Ground Reference Plane

The spacecraft structure is intended to provide an electrical ground plane reference (EGRP).

This EGRP will carry the primary power return currents (See § 6.1.1.2.1 for details).

For each equipment, the secondary voltage reference (0V) and the housing shall be connected to the EGRP via a bonding stud and a bonding strap with the minimum impedance (resistive and inductive). For exceptions see §6.1.1.2.2.

For information, electrical properties of the satellite structure are integrated in the "EUROSTAR Structure Specification" (EUR-SP-0290.MMT).

3.4.2 Bus Users

Bus users are equipments which are connected to the power bus. These equipments shall be considered as standard equipments for grounding, current monitoring, power bus interface and protection philosophy, unless superseded by the equipment specification as for EPS equipments that are upstream the power bus.

4 GENERAL DESIGN AND INTERFACE REQUIREMENTS

4.1 EQUIPMENT INTERFACE CONTROL

4.1.1 Introduction

[R10] Interfaces will be subjected to a formal inspection, using interface data sheets in respect of mechanical, thermal and electrical properties and any other detail which proves useful. These data sheets, will be completed by the equipment manufacturers and then brought together into ICD, administered by the Prime Contractor.

[R20] Those data sheets shall provide Prime Contractor with best estimate values and not specified values. Relevant documentation shall be delivered on electronic support (spread sheets) together with a paper copy. Exact format shall be agreed between Subcontractor and Prime Contractor (examples are given in Appendix A, B, C). Only international standard units shall be used.

4.1.2 Update of interface control data

[R] Management and delivery dates of interface data sheets is defined in RD3 and the Statement of Work. As a minimum, they will be updated at PDR, EQM/QM TRR, CDR, QR and MRR.

4.1.3 Thermal data sheet

[R] One thermal data sheet (see Appendix C) is to be provided for each equipment (some items of the second column, may not be filled by the equipment Supplier). The information required to be provided under each heading is as follows :

- unit solar absorptivity (for externally mounted equipments)
- unit emittance
- unit contact area (for "conductive" and "radiative" equipments)
- unit thermal capacitance
- functioning and non functioning temperature
- temperature reference point(s) exact location, on equipment drawing (temperatures to be measured or controlled)
- thermal model: the nodes description, coupling between nodes and dissipation per node shall be provided on a separate sheet
- thermal dissipation :
    - for each operating mode, the nominal dissipation and worst case dissipation shall be provided. (The worst case dissipation takes into account primary/secondary power fluctuation, component efficiency dispersion,...)
    - for short duration mode (< 24h), the duration of mode shall be provided
    - when one unit has a non-uniform dissipation profile, adequate information shall be provided in the comments block

For equipment designed for space viewing (e.g. : sensors...) details of exposed surface, aperture, lenses,... shall be provided (geometry, thermo-optical property definitions).

4.1.4 Electrical and functional Data Sheets

4.1.4.1 Main bus protection need

[R10] In order to size fuses (if fuse protection selected) protecting main power bus(es), bus users equipments shall fill-up the main bus protection need sheet detailed in §6.2.1.5.

[R20] The fuse rating is under equipment Supplier responsibility, and shall be submitted for Prime approval.

4.1.4.2 Electrical power data sheet

[R] Those data sheets shall provide power consumption data for all supplies obtained either from the Electrical Power Subsystem (power bus as described § 6.2.1) or from subsystem conditioning unit. Those data sheets shall include :

- identification of operational mode
- primary/secondary supply voltages
- power consumed by each equipment from each supply voltage (mean and peak with duration)
- conversion factor and quiescent consumption of the conditioning unit relative to each voltage output
- the power consumption shall be calculated or measured for a 50V bus voltage (conversion factor shall be given).

4.1.4.3 List of unit connectors

[R] The required content and format is described in RD5, connector's files. Those data sheets shall include for each equipment at least the following information :

- connector name
- connector type (manufacturer, pins number, pin/socket, keying)
- function of this connector

4.1.4.4 Electrical data sheet (pin function)

[R] One electrical data sheet (see Appendix A) is to be provided for each connector of each equipment. The required content and format is described in RD5, pin's files. A description of the circuit associated with each listed pin giving at least source/input impedance, input filters, inductance, continuity and termination of screening shall be provided, together with the complete equivalent interface schematics (for all interfaces including power input filter).

The information provided on this format is used as basic data in the design of the spacecraft electrical harness and in the compilation of circuit data for overall interface control.

4.1.4.5 TC list

[R] Telecommand data sheets are to be provided for each equipment/unit with all information under Supplier knowledge and control. The information required is as follows (when applicable) :

- Remote Interface Unit Address
- TC name (20 digits maximum)
- TC type
- Sub-address
- 1553B data
- Hardware path
- Hardware TM verification (including nominal values)
- Command category
- Execution conditions (satellite mode, environmental constraints, equipments needed configuration, validity conditions for category 3).
- Minimum delay (or maximum if applicable) between two telecommands reception or execution
- TC description (effect on satellite or mission, time constraints, effect if command is untimely sent for category 1, execution control)
- Comments.

4.1.4.6 TM list

[R] Telemetry data sheets are to be provided for each equipment/unit with all information under Supplier knowledge and control. The information required is as follows (when applicable) :

- Remote Interface Unit Address
- TM name (20 digits maximum)
- TM type
- Sub-address
- 1553B data
- Number of useful bits
- Hardware path
- TM description (location, needed sampling frequency, range, accuracy, scale factor, calibration)
- TM interpretation (nominal values, monitoring thresholds, failure cases interpretation)
- Validity condition
- Delay between telecommands reception and corresponding acknowledgement)
- Comments.

4.1.4.7 Electrical diagrams

[R10] Unit internal grounding diagram shall be provided.

[R20] Unit internal switching diagram shall be provided.

4.1.5 Mechanical data sheets

[R10] The Supplier shall provide the compliance status with respect to the mechanical DIET requirements with the support of the M.I.C.D. format in Appendix B.

[R20] The equipment axes shall have :

- as origin a fixation point at the interface plane level,
- as X axis a parallel to the longest in-plane dimension,
- as Z axis a parallel to the out-of-mounting-plane dimension and
- as Y-axis the axis which complete the right-handed orthogonal set axes.

[G30] The functional reference frame should be defined by the equipment Supplier according to the functionality of the unit (ex : rotation axis of a mechanism).

4.1.5.1 Mass Properties

[R] A set of Mass Properties Data Sheets shall be compiled for each unit. Details of unit mass, centre of gravity and inertia are contained in these sheets. Data entered shall include :

- identification of the unit
- mass change per unit
- current mass per unit
- unit size where L, B, H represent overall size of the unit including any protrusions from the normal rectangular shape, e.g. plugs/sockets, support feet. This data must be supported by a detailed interface drawing
- unit C of G where l, b, h are identified related to unit interface axes system and shown by an interfaces drawing
- unit inertia : local inertia about each axis through the unit C of G including any protrusions as defined here above
- data source (calculated, measured,...)
- accuracy of each data.

4.1.5.2 Alignment Data

[R10] This data sheet shall include the necessary data to perform alignment at satellite level :

- alignment requirements
- tolerance on this alignment
- position of alignment mirrors/cubes
- environmental stability of the mirrors/cubes and of its interfaces with the equipment under simulated spatial environment.
- tolerances between different faces of one mirror cube
- comments.

[R20] Alignment data must consist of the cosine directors of normalised vectors perpendicular to the mirror faces (i.e. not functional axes). All the alignment data shall be finally given in equipment axes and functional axes.

[G30] Drawing of reference frame and alignment vectors shall be provided with the equipment alignment measurements. Alignment vectors shall have co-ordinates defined with 6 digits after the decimal point, or shall have azimuth and elevation angles defined with 4 digits for degrees (or 6 digits for radians) after the decimal point.

4.1.5.3 Interface Control Drawings

[R10] These drawing shall be provided under the following forms :

- one reproducible copy (scale 1 skin - copy)
- one A3 printing
- one electronic tape/disk in CATIA format (version 4.22 or previous) preferably otherwise STEP and IGES formats are accepted.

[R20] They shall contain the following information (see Appendix B for example) :

- dimensioned views of the equipment, including footprint (diameter, thickness)
- clearance hole size diameter and tolerance with the position tolerance,
- the ICD must show, in dot lines, the Interface Requirement Drawing (IRD, with the maximum allowable volume)
- viewing aperture and field of view
- mass
- centre of mass location
- momentum of inertia
- thermal capacity
- thermal dissipation
- operating and functioning temperatures
- mounting surface and its material (flatness and surface finish)
- bolts and washers types and torque (for all fasteners fixed on the equipment)
- surface treatment
- identifier location
- connectors types, location and orientation
- necessity or not of a bonding strap
- grounding point(s) location
- position of the alignment mirrors / cubes.

[R30] When an equipment is mounted on a bracket provided with it, the interface control drawing shall take into account this bracket as a part of the equipment. If not, the bracket shall be considered as an equipment and have its own interface control drawing associated.

[R40] Each Interface Control Drawing shall be dedicated to a model. For Modular Equipments, one « generic » Interface Control Drawing could be dedicated to several configurations of the Modular equipment. Each configuration of the Modular Equipment will be clearly identify through an internal reference. The Subcontractor is bound to update simultaneously the interface control drawing and the interface data sheets.

4.1.6 Other data

Any other specific interface data necessary to insure normal operation of the unit shall be defined by the Supplier.

4.2 CONSTRUCTION REQUIREMENTS

4.2.1 Dismounting and Interchangeability

[R10] Each equipment must be interchangeable, with respect to its form, assembly and function, with any other equipment of the same part number.

[R20] The performance characteristics shall be such that an exchange of equipments is carried out with a minimum of adjustment and recalibration.

4.2.2 Testability

[R10] Equipment shall be designed so that it can be adequately tested (including active redundancy built in to preclude SPF, automatic software and systems), at equipment level and above (e.g. at subsystem or system level during integration). This requirement does not mean to include testing down to component level but the equipment design and its testing requirements shall be such that modules within an equipment can be tested at equipment level and above.

Example: when secondary voltages of power converters are cross-strapped in hot redundancy, a logical level (0-5 V) dedicated to each converter shall allow to inhibit the working of one of those in order to verify the other if this is not possible by other means. This test point shall obviously generate no converter failure.

[R20] Each equipment Supplier shall describe precisely the set of tests which are performed at board and equipment level, for each qualification and flight model. The list of functions or redundancies which are not covered by these tests for each level (board or equipment) shall be clearly identified and justified.

4.2.3 Identification of Product

[R10] Each equipment, excluding interconnecting cables and waveguides, shall be permanently labelled with an identification plate as defined in RD1. The identification shall be visible where at all possible when unit installed onto the platform and its location shall be noted on the ICD drawing for the equipment. Where the physical size of the equipment precludes an identification plate, a "bag and label" technique shall be used.

[R20] If metallic, the identification plate shall be grounded to the equipment housing.

4.3 DESIGN ASSURANCE REQUIREMENTS

4.3.1 Design rules and analyses

[R10] The design of subsystems and equipment shall be undertaken in accordance with the requirements set out in the technical specification and SOW of the concerned item. Due account must be taken of the general "fitness for purpose" and design standard for space flight use. All hardware and software must be qualified to meet the appropriate performance criteria, under the expected worst case conditions of the ground handling, storage, launch and mission environment.

[R20] Sufficient design margin shall be allowed to demonstrate that performance can be achieved in worst case conditions and for the required life time. Adequate verification testing shall be implemented accordingly.

[R30] Sufficient ground testing must be performed to demonstrate that the equipment has the specified performances in all modes of operation and can survive environmental exposure, and to verify the quality of workmanship and eliminate "infant mortality" defects.

[R40] Sufficient analyses shall be provided to demonstrate that all aspects of the design are capable of meeting the worst case operational and qualification requirements. The need of analysis can be split into three categories as follows :

a) where ground test is not feasible

b) where ground test is feasible, but early confidence is required to avoid programme risk

c) where qualification of the generic design has been performed on a previous programme, but requires to be demonstrated by similarity.

In the case of category (a) the analysis shall be fully traceable to the design standard. Any modelling techniques require Prime Contractor approval.

[R50] As a general design rule, all flight equipment shall be able to withstand on ground (e.g. in addition to launch environments) :

- 3 protoflight test sequences (in line with the random qualification duration of §10.1.2)
- or, 2 protoflight test sequences and 2 acceptance test sequences
- or, 5 acceptance test sequences

(this requirement assumes that a unit having seen qualification levels during a cumulated duration equal to those of the qualification model, is flightworthy)

4.3.2 Maintainability

[R10] Equipment shall be designed such that no special tools are required for mounting and dismounting at satellite level, except when special alignment is required or if the unit mass is above 20kg. In those cases, the specific tool will be delivered with the unit. A mounting and dismounting procedure shall be provided.

[R20] Equipment shall be designed such that no special calibration is required at satellite level.

[R30] All the PROMs which contain on board software shall be easily accessible by a trap door or external plug. The PROM replacement shall not require any equipment requalification. Specific tools for PROM installation shall be provided by the equipment Subcontractor.

[R40] All external programming/configuration devices (configuration selection, parameter set or adjust,...) shall be easily accessible for inspection, test and replacement without box opening that would require any equipment requalification.

4.3.3 Reliability and Safety

[R10] Equipment shall be designed to meet the numerical reliability specified in the technical specification. The reliability computation will be performed at the « reliability » temperature (Trel) provided by the Prime Contractor and for end of life thermal behaviour of the equipment. In addition assessment at Trel+10°C and Trel-10°C shall be performed, in order to evaluate the sensitivity to temperature.

The figures are allocated between equipment, in a way that permits successful operation of the system for its required period in the mission. Reliability computation temperature given by the Prime Contractor are the mean temperature computed for the last year in orbit : (Tmin + Tmax)/2.

[R20] Equipment internal redundancy shall be utilised as necessary to achieve the reliability specification and to prevent critical failures modes.

[R30] The design of equipment shall take into account the derating requirements for electronic components as defined in the PA requirements (RD1).

[R40] The procedures to be used for failure modes and criticality analyses (FMECA) are referenced in the PA requirements (RD1).

[R50] Failure mode effects and their criticality shall be taken into account when demonstrating the design fault tolerance. Special account shall be taken of electrical and thermal failure propagation from function to function (including outside the equipment), and from PCB to PCB.

[R60] For internally redundant units, single point failures are not acceptable.

[R70] Monitoring and telemetry shall be implemented to detect the source of any failure or anomaly either directly or by some other unambiguous means (see §4.4.2 for general observability requirements).

[R80] FMECA shall provide identification of : the telemetries or any other observable symptoms associated to each failure mode; the required reaction time (if applicable) for corrective actions at subsystem or system level to avoid any irreversible degradation or failure propagation.

[R90] The equipment shall be designed and manufactured in accordance with the safety requirements which are part of the PA requirements (RD1), in such a manner that all hazards associated with the equipment use are eliminated or minimised and controlled, and that launch authority safety regulations are satisfied.

[R100] Credible failure modes which could cause injury to personnel or damage to third party property, shall not be permitted.

4.3.4 Selection of parts, materials and processes

[R10] The selection of E.E.E. parts shall comply with the corresponding section of the Parts Materials and Processes specification (RD2) and AD1.

[R20] The selection of materials shall comply with the corresponding section of the Parts Materials and Processes specification (RD2). In addition the Supplier shall deliver a complete outgassing budget (TML and VCM) of its equipment.

[R30] The selection of mechanical parts shall comply with the corresponding section of the Parts Materials and Processes Specification (RD2).

[R40] The selection of processes shall comply with the corresponding section of the Parts Materials and Processes specification (RD2).

4.3.5 Lifetime Requirements

4.3.5.1 Items subject to "volume throughput"

[R] Items such as valves, filters, traps and orifices shall be capable of operating after a "volume throughput" equal to at least a factor of 1.5 times the maximum number of ground and post launch operation.

4.3.5.2 Items subject to degradation of performance due to environmental conditions

[R] Items such as optical surfaces, solar cells, thermal blankets shall be capable of meeting end of life requirements when subjected to degradation caused by in-orbit contamination or radiation, with a safety factor of 1.2.

4.3.5.3 Items subject to mechanical wear-out or sensitive to thermal cycles

[R10] Life demonstration requirements on items such as mechanisms are given in §5.1.4.

[R20] Life demonstration requirements on items subjected to high thermoelastic distortion is given in §10.8.3.

4.3.5.4 Storage (on-ground and in-orbit)

[R10] Unit shall be designed to allow for up to 5 years storage conditions before launch with a minimum maintenance activity, and still meet all requirements. Maintenance activities shall be identified by the Subcontractor.

[R20] For units used in cold redundancy, the in-orbit storage may be up to 15 years, with a minimum of maintenance activity. Maintenance activities shall be identified by the Subcontractor.

4.3.5.5 Operational life (on-ground and in-orbit)

[R10] The ground operation after delivery to the Prime Contractor will be limited to 1 year.

[R20] The in-orbit operational life is 15 years.

Applicable duty cycle, can be found in the equipment specification.

4.4 COMMANDABILITY AND OBSERVABILITY

Requirements for commands and monitoring, including any automatic function and reconfiguration logic are detailed hereafter.

[R] All the requirements apply to the whole mission life from the launcher separation until de-orbiting (graveyard orbit).

4.4.1 Commandability

[R10] The ground shall have the possibility to send any command necessary to activate, to put in operational state, or to define the performance of any on-board function or equipment.

[R20] There shall not be any function or equipment on which the ground has no direct access (commands directly sent to the function or to the equipment) or indirect access (through a function or equipment of higher level).

[R30] All telecommands shall be compliant with the following requirements :

a) It shall be possible to acknowledge by telemetry, all telecommands under ground control.

b) Telecommands controlling relays, switches or electronic circuits, shall be associated to a telemetry of the relay, switch state or the operation status of the electronic equipment.

c) Memory load commands controlling equipment(s) configuration shall be associated to a telemetry of the corresponding operational effect.

d) Critical memory load commands of category 1 (as defined in §3.1.5 and categorised by the Prime Contractor), shall have a separate execute command to permit verification of load data.

e) ON/OFF commands shall only operate one function. In case of equipment critical configuration (decided at Prime Contractor level), multiple ON/OFF command is authorised ; for instance if nominal and redundant equipment or function must not be ON simultaneously, it is recommended that the same ON/OFF command controls the execution.

f) All telecommands shall always have the same action during the mission.

g) Critical commands of category 1 (as defined in §3.1.5 and categorised by the Prime Contractor), shall require at least two separate operations and commands for execution : an arm/safe or enable/disable followed by an execute command, operating on different circuits.

h) No telecommand shall be dependant on any previous command history. *This is neither applicable to memory load + execute commands nor to arm + execute commands. This is mainly applicable to incremental commands (switch rotation, mechanism steps, ...), with no direct TM of the current status.*

i) Repetition of the same telecommand shall be possible, without any detrimental effect on the equipment.

j) Incorrect sending or receiving of a nominal set of telecommands shall be possible (ex : anyone of the set not executed ; abortion of the set at any location ; start of the set not at the beginning) without causing any stress or loss of functionality when nominal sequence resumes.

k) Non-valid/non-defined telecommands shall be rejected or at least shall have no action (including reinitialisation, stop, stop receiving, stop execution modes).

l) Each unit using power from the power bus shall be provided with ON and OFF commands. OFF commands shall operate correctly even under failure condition of the corresponding function leading to power consumption excess, so that after OFF command completion, no more power is drawn from the power bus.

m) It shall be possible, to override/inhibit partially or totally, any on-board autonomous function. This requirement is not applicable to electrical protections that require a reaction time not compatible with ground or on-board software reaction time, but in any case desirable. It shall be possible to replace any on-board autonomous function with ground control, unless not compatible with ground reaction time.

n) In case of an on-board automatism, using several criteria, the ground shall have access to each criteria. Particularly, the inhibition of an OR-ing configuration shall be performed independently at each criteria level, without affecting the functioning of the automatism for the remaining criteria. The same restrictions as for point (m) shall apply.

o) Each data used in the definition of an on-board automatism (bias, threshold, mask, temporisation, selection,...) shall be configurable by ground TC. Limitations to this requirement shall be identified and proposed to the Prime Contractor.

p) For payload computers managing their own time-tag, it shall be possible to terminate immediately an on-going on-board command execution (not yet executed command).

q) A reset telecommand, or equivalently a read-reset, shall be associated to any memorisation of transient events.

r) The definition of data or address shall be always considered MSW first and then LSW.

[R40] TC list shall be provided according to §4.1.4.5.

4.4.2 Observability

[R10] The satellite functioning shall be observable in any mode and shall be compliant with the following requirements :

a) Monitoring shall be unambiguous and provided by direct measurement rather than secondary effects or combination.

b) Monitoring shall not be dependant on previous command knowledge.

c) Redundant elements shall be monitored through failure independent telemetry channels (the loss or failure of one channel shall not prevent access to telemetry of other channels).

d) Monitoring shall be able to detect failures of automatic reconfiguration functions.

e) For hot active redundancy functions, telemetry of both functions shall be provided at the same time with unambiguous status determination.

f) The status of inhibit functions and of internal switches (relay or electronic switch) shall be monitored and telemetered even if equipment is not powered.

g) For all bus users active units which have a primary consumption greater than 3W (TBC), a primary current measurement shall be provided for external ANA SE acquisition.

h) Content of all registers or memories that determine an operational state shall be monitored (including autonomous on-board functions and internal diagnostic).

i) For thermostatically controlled devices : each independently controlled heater shall have a temperature sensor for regulation and a temperature sensor for telemetry, both of them being transmitted to ground via telemetry.

j) Bus users power converters shall provide the following telemetry signals in addition to the primary current telemetry (ANA SE) :

- temperature (TEMA)

- secondary voltages (ANA SE) necessary to provide adequate observability of unit proper operation and critical parameters drift trend.

k) Concerning bilevel telemetry : the logical level "1" shall correspond as far as possible to the following labels : ON, enabled, authorised, armed, powered, opened, ...; the logical level "0" shall correspond as far as possible to the following labels : OFF, inhibited, disarmed, closed, ...

l) The state of protection devices (authorised/inhibited) as well as the action of the protection (triggered, not triggered) shall be monitored.

m) All telemetry corresponding to a transient event shall remain in the same logical state and cleared upon reading or dedicated reset TC.

n) The telemetry range of an operational parameter shall include margins in order to monitor degraded modes or failures. The telemetry accuracy shall allow to detect unambiguously any abnormal behaviour, without saturation.

o) For units where a test connector has to be replaced by a flight connector before launch, a status indication verifying the installation of the appropriate flight connector shall be provided.

p) Mechanisms :

- Telemetry shall be provided to determine directly or not, but unambiguously, the absolute position of all mechanisms and deployable devices in all phases of the mission.
- As a minimum, the following TM shall be provided : pointing of steerable antennas; position of all electromechanical devices; positive latch-up indication of all deployment mechanisms; voltage or current of reference supplies used in conjunction with the position indicating devices; solar array position; temperature of electrical motors; commanded current (image of the control torque).

q) Payload : as a goal, the Communications Subsystem shall provide sufficient data to unambiguously determine the configuration and performance of all repeater hardware at any time. To achieve this, the following information shall be provided :

- Actual position of all RF switches which provide a static connection (for configuration, connectivity or redundancy selection purposes).
- Status of all gain frequency states, where adjustable.
- Critical performances parameters of all travelling wave tubes. Where applicable, this shall include helix current, cathode current, or control anode voltage and status for filament, filament boost and high voltage on-off.
- Individual load current for all RF power amplifiers and replacement heaters. In order to cope with current sensing TM allocation, grouping of load current measurements shall be reviewed with the Prime.

r) Units which have a functional sensitivity to temperature levels shall be provided with a temperature telemetry .

[R20] TM list shall be provided according to § 4.1.4.6.

5 MECHANICAL DESIGN AND INTERFACE REQUIREMENTS

5.1 MECHANICAL DESIGN REQUIREMENT

5.1.1 Stiffness requirement

Minimum natural frequency requirements are imposed upon the spacecraft and its units for the following reasons :

- *to avoid excessive dynamic interaction between the spacecraft and its launch vehicle*
- *to avoid coupling between appendages and the main modes of the structure during launch and the spacecraft control system while in orbit*
- *to ensure predictable dynamic responses for the design of the structure*
- *to avoid excessive loads and deflections.*

[R] equipments shall be designed to have its first resonant frequency above 140 Hz. These frequencies are required for equipments, or equipment assemblies, fixed at their interface points to a rigid jig.

5.1.2 Design factors and safety margin for equipments

[R10] all equipment shall be designed to withstand the design loads, i.e. equal to :

- flight limit loads multiplied by design factors of 1.5, and
- grounding (handling, transportation and storage) loads multiplied by design factors of 2.0.

[R20] all equipment shall demonstrate margin of safety greater than :

- 0% for yield stress of metallic parts
- 25% for ultimate stress of parts (except for composite parts)
- 25% for first ply failure of composite parts
- 10% for elastic buckling.

[R30] Loads are defined in §8, §9 and §10.

Note : Acceptance test levels are the limit loads levels ; qualification test levels are the design loads levels.

5.1.3 Notching philosophy (sine and random test)

[R] The notching is a waiver so it shall be justified by detailed analysis and agreed by the Prime Contractor.

5.1.4 Design rules for equipment subject to life time degradation

Equipment subject to life time degradation shall be divided in five classes :

a) Deployment mechanisms that are used once during the mission. They are solar array deployment mechanism, antenna deployment mechanisms, pyrotechnic release mechanisms and pyrotechnic valves.

b) Pointing or switching mechanisms, which are used several times during the mission. They are antenna pointing mechanisms, antenna trimming mechanisms, RF switches, or any other pointing mechanisms.

c) Rotating mechanisms. They are low rate rotating mechanisms like solar array drive mechanisms and high rate rotating devices like gyro and momentum wheel.

~~b)~~ d) Linear devices (e.g. electromagnetic valves, ...)

~~c)~~ e) Equipments subject to gas or liquid throughput : such equipments include valves, thrusters, filters, propellant management devices and bubble traps, pressure regulators, orifices, ...

5.1.4.1 Redundancy

[R] Redundancy concepts shall be selected to minimise single points of failure and to optimise reliability for the mission and life requirements. Where a single point failure mode is identified and cannot be made redundant, the required reliability shall be demonstrated. Active elements of mechanisms such as sensors, motors, actuators, switches and electronics shall be redundant. Failure of one element shall not prevent the others from performing its intended function, nor the equipment from meeting its performance requirements.

5.1.4.2 Actuation factor

[R10] The actuation factor is defined as the ratio of the actuation force or torque applied to cause specified operation, to the striction, friction or other forces which resist such operation.

[R20] Mechanism actuators torque / force margins shall be analysed. Actuators (electromechanical, mechanical, thermal and others) shall be sized to provide throughout the operational life-time of the mechanisms a Margin of Safety (Ms) >2 of worst case (minimum) actuator force / torque (Fa) against worst case (maximum) resistance forces / torque's (Fr). For calculation of Ms, the following equation shall be applied :

$$Ms = Fa / Fr$$

[G30] Fa is the sum of all participating actuating forces/torque's divided by their respective factor. Fr is the sum of all participating resistive forces / torque's multiplied by their respective factor.

Element	Impact	Fa	Fr
Friction	Resistive	---	Multiply
Spring	Resistive	---	Multiply
	Actuating	Divide	---
Inertia	Resistive	---	Multiply
	Actuating	Divide	---
Hysteresis	Resistive	---	Multiply
Surface Contact	Resistive	---	Multiply
Adhesion	Actuating	Divide	---

[G40] At Design Stage

At design stage, the definition of the worst case resistance torques / forces shall be by means of multiplication factors applied to the worst predicted components of resistance :

Ff : Resistive force / torque due to friction	mf = 3 *
Fs : Resistive force / torque due to spring	ms = 1.2
Fi : Resistive force / torque due to inertia	mi = 1.1
Fh : Resistive force / torque due to hysteresis	mh = 3 *
Fc : Resistive force / torque due to surface contact adhesion	mc = 3
Others	mo = TBD

The factors marked by * can be reduced to 1.5 provided that torque / force resistance components are worst case figures measured during tests on similar mechanisms or mechanism components in similar conditions.

[R50] At Qualification Stage

At qualification stage, the figures of components of resistance torque shall be based on measurements (including temperature effects see § 10.7.2.1). The derivation of the worst case resistance components shall be by means of multiplication factors applied to the worst measured components of resistance :

Ff : Resistive force / torque due to friction	mf = 1.5
Fs : Resistive force / torque due to spring	ms = 1.1
Fi : Resistive force / torque due to inertia	mi = 1.05
Fh : Resistive force / torque due to hysteresis	mh = 1.5
Fc : Resistive force / torque due to surface contact adhesion	mc = 3
Others	mo = TBD

[R60] Deployment mechanisms and one shot devices shall be demonstrated to provide the specified torque / force margin in static conditions throughout the motion range. This implies that :

- The kinetic energy should not be considered as an actuator nor to provide any driving force / torque (to be negotiated case by case),
- Static friction coefficient shall be considered.

5.1.4.3 Number of cycles

Deployment mechanisms

[R10] These items shall be designed to be capable of being operated the greater of 50 times or twice the maximum number of ground operations (to be agreed between the Prime Contractor and the Supplier) without degradation.

Pointing or trimming mechanisms

[R20] These items shall be designed to be capable of being operated 1.5 times, the number of cycles experienced during ground testing and post launch life. This number of cycles shall be at least 50.

Rotating mechanisms

[R30] These items shall be designed to withstand 1.5 time the number of ON/OFF if not continuously rotating and to withstand 1.5 time the cumulated operating time. These items shall be capable to operate in a clean room (atmospheric pressure), without any degradation. This number of cycles shall be at least 50.

Linear Devices

[R40] These items shall be designed to be capable of being operated 1.5 times the number experienced during ground testing and post launch life.

Equipments subject to gas or liquid throughput.

[R50] These items shall be designed such that the total test volume throughput is at least 1.5 times the maximum expected during ground testing and subsequent spacecraft life.

[R60] These items must be designed to operate with the following conditions :

a) when the inlet pressure is 1.5 times the maximum expected in flight, and when the inlet pressure is 2/3 the minimum expected in flight. This latter requirement need not to be met for pressure reducing or pressure relief valves which are not required to operate at such low inlet pressures.

b) In the case of pressure reducing, or relief valves, the rate of volume throughput shall be such that the number of operations of the internal regulating mechanism is equal to or greater than 1.5 times the maximum expected during ground testing and subsequent spacecraft life.

c) In the case of thrusters, each duty cycle expected during spacecraft life shall be designed such that the accumulated number for each duty cycle exceeds the maximum expected flight number by at least 1.5. Where the number of cycles expected in spacecraft life is less than 10, then the design number shall be the greater of 10 or twice the maximum expected number.

5.1.4.4 Lubrication system

[G] The required number of cycles for the design of the lubrication system is covered by paragraph §5.1.4.3. in term of design number of cycles.

5.1.4.5 End stops

[R] mechanical stops shall be provided on commendable mechanisms to limit the motion and travel extremes to the maximum position for proper functioning of the actuated item and to prevent interference with interfacing equipment. The mechanical stops shall be designed to absorb impacts resulting from actuating forces and inertia at the travel extremes. Engaging of a stop shall not result in a non-recoverable situation. The status of the stops shall be independently telemetered.

5.1.4.6 Latching/Locking

[R10] Latching mechanisms used to assure positive locking shall be designed to avoid inadvertent opening by vibration or shock under operating conditions. Locking of latching mechanisms shall be designed to be operable by a single control and shall provide a clear indication of whether the latch/lock is open or closed. Latches must be simple and self-locking and must be easily resettable for ground testing. Off load mechanisms shall be capable of being operated manually for protection during handling and transportation.

[R20] Switches, latches, locks, shall always have a motorization effect.

5.1.4.7 Release devices

[R] All pyrotechnic or other release devices shall be fully redundant (fully redundant means that the cutting, release function must be redundant up to the final function : hold down points equipped of two cutters).

5.1.4.8 Pre-loaded ball bearings

[R] if pre-loaded ball bearings are used, pre-loading shall be applied by solid pre-load or produced by compliant loading technique. Sliding surfaces shall be avoided as far as possible. Where they can not be avoided, lubricated hard surface coatings shall be applied to prevent fretting.

5.1.4.9 Flushing

[R] parts of mechanisms that are sensitive to operation in air due to the presence of moisture, particles or other deleterious contamination, shall be provided with a means for flushing with an inert gas.

5.1.5 Mechanical Analysis Report

[R10] The purpose of this document is to demonstrate the compliance of the equipment design with regards to the DIET requirements and guidelines ; it also insures integrity of electronic components and demonstrate positive margins on the structural parts with regards to the Qualification Mechanical Environments.

[G20] The table of contents of this document may be :

1. Introduction (heritage,if any ;...)
2. Applicable Documents
3. Mechanical Specifications (interface requirements, stiffness, environment, margin of safety,...)
4. Mechanical Description of the equipment
5. Description of the Finite Element Model (axis, f.e. types, boundary conditions, material properties, damping factors, mass,...)
6. Analysis results (showing predicted compliance's, margins of safety, some significant modal shapes,...)
7. Conclusion.

5.2 MECHANICAL INTERFACES REQUIREMENTS

[R] The equipment layout and methods of attachment shall be shown on drawings which will form part of the Mechanical Interface Control Document (see §4.1.5 for standard data sheets).

5.2.1 Interfaces definition and tolerances

5.2.1.1 Insert and bolt

[R10] except in special circumstances, all equipment mounted on sandwich structure shall be through bolted into threaded inserts using type M4 Titanium bolts.

[R20] embedded central bolt is prohibited.

5.2.1.2 Mounting feet

Hole size

[R10] the clearance hole size for M4 bolts shall be 4.4mm ± 0.1mm with a position tolerance of 0.15mm. A hole size of 4.3 mm +0.1 -0.05 mm with a position tolerance of 0.1 mm shall be agreed on existing equipments.

Feet size

[R20] All feet of one unit must have a 17.0 mm-minimum-diametre-disc footprint on the sandwich structure wall around each bolt axes. A foot square footprint of 12 mm minimum is acceptable.

Thickness

[R30] All feet of one unit shall have the same thickness.

[R40] The thickness of the mounting feet on each unit shall be preferably 3 mm ± 0.2 mm. Thickness' of 6 mm +/- 0.2 mm or 1.5 mm +/- 0.5 mm may be acceptable (with Prime Contractor agreement).

Configuration

[R50] Provision shall be made under the bolt head for a flat washer of 8 mm diameter and 0.5 mm or 1 mm thickness.

[R60] Minimum distance between two bolt axes shall be 25 mm.

[R70]

[R80] No protrusion shall prevent a direct bolts access all along the equipment height.

Remark : for passive equipments, the §5.2.4 Grounding Provisions paragraph allows the grounding through the feet of the equipment.

[R85] Electrically conductive area is requested on the mouting feet.

Loads

[R90] the load in a 1 g environment in any direction acting through the centre of gravity, shall not exceed 20 N per M4 bolt along the bolt axis. If it exceeds, additional bolts shall be added.

[R100] for all boxes (equipment or stacked equipments) mounted on sandwich structure, a minimum of 4 fixing bolts are required. Feet shall not be aligned and the footprint size shall be at least 25*25 mm²

Feet design for equipment requiring alignment

[R110] equipment requiring critical alignment shall preferably be mounted in a statically determinate manner. Several bolts per foot can be necessary for load constraint.

5.2.1.3 Mounting plane

[R10] The plane of the attachment feet and any other interface surface nominally lying in the plane of those feet, for each equipment, shall have a surface finish of 3.2 micros centre-line average or better and shall be flat to within : 0.1 mm over any 100 mm length for all the equipments. The flatness requirement shall be demonstrated applying a light hand pressure on to the unit.

[R20] Mounting faces shall be paint free and any protective coating applied to mounting faces shall be electrically conducting, and shall not compromise the equipment interface bonding resistance.

5.2.1.4 Damping support

[G10] the use of damping support internal and external to the equipment shall be minimised.

[R20] the use of damping support internal and external to the equipment shall be defined in the proposal.

5.2.1.5 Interface fillers (when defined by subcontractor)

[R10] Unless justified and agreed beforehand with the Prime Contractor, any thermally conducting interface filler, used between an equipment and the surface on which it is mounted, shall be of non-curing gasket type. The Prime Contractor can on request provide the thermal performance characteristics for specific applications

[R20] For equipments relying on structure electrical return, the gasket used shall be electrically conductive type.

5.2.2 Alignment

5.2.2.1 Interface definition and adjustment

[R10] When the equipment alignment is achieved by the use of screw adjusters or/and non standard shims, these shall be designed and supplied by the unit manufacturer. The structure subsystem supplies the standard shims.

[R20] Screw and nut shall be of self locking class.

5.2.2.2 Alignment reference

[R10] Equipment which require accuracy's of alignment of ± 0.25° or better shall be provided with optical reference cubes or mirrors by the equipment Supplier. The location of the mirror shall be clearly visible at total spacecraft integration and identified in top assembly drawings, which shall form a part of the Mechanical Interface Control Document. This location shall be defined before the preliminary design review and shall be agreed by the Prime Contractor.

[R20] In case of dismountable mirror, demonstration shall be made of the repeatability of the mirror location and orientation accuracy (each axis).

[R30] The accuracy of the mirror alignment shall form a part of the Mechanical Interface Control Document.

[R40] The following points shall be observed in designing equipment optical references. These requirements are standard requirements, which may be superseded in equipment specification, for units requiring more severe alignment needs.

a) components requiring alignment about two axes shall carry a reflecting mirror parallel to the plane containing those two axes or two reflecting mirrors orthogonal to that plane

b) components requiring alignment about three axes shall carry two orthogonal reflecting mirrors

c) the direction of the equipment sensitive axes shall be known relative to the direction of the axes of the optical reference to an accuracy better than ± 0.0056° = ± 20".

d) each mirror face shall be perpendicular to an accuracy better than ±10" = ±0.00278° of angle.

e) the reflecting surfaces be optically polished and flat to within lambda/4 (sodium yellow)

f) the optical references shall have a minimum size of 15 mm and a minimum thickness of 6 mm

g) if mounted optical references are part of the equipment, they shall be required to withstand all the environments to which the equipment is subjected. Stability of the optical reference position shall remain within ± 0.0056° = ± 20" during the equipment life on ground.

h) if the mirror is fixed on a specific support, this support shall be attached to the equipment by 3 points.

~~b)~~ i) the mirror shall be fixed on a rigid part dependent of the equipment functional part. The mirror shall have a non-flight protection cover fixed by non-flight specific screws (not structural screws).

5.2.3 Connectors location

[R10] Unless otherwise agreed with the Prime Contractor, connectors shall be located on one lateral face of the equipment ; connectors, including their fixation screws, shall be more than 50 mm above the mounting interface.

[R20] Where connectors are located more than 100 mm above the mounting interface, the equipment supplier shall design and define the mounting zones of tie-wrap supports for the harness on the unit walls. The mechanical ICDs shall clearly identify those mounting zones.

5.2.4 Grounding Provisions

[R10] It is required to ground the equipment to the structure. The equipment chassis material shall be electrically conductive and the compatibility of the chassis material with the structure material shall be verified. An additional electrical path to ground is required with stud provision being provided on the equipment for bonding straps. These straps shall be mechanically fixed on the structure such that the DC resistance between equipment and structure meets the requirement of §6.1.1.3.

An M4 diameter threaded bonding stud shall be fitted at an accessible position on one side of the equipment, preferably located in the vicinity of the power input connector.

For internally redundant units, a second such stud shall be provided.

Passive equipments do not require bonding studs if grounded (e.g. to the structure via the mounting feet); grounding method shall be submitted to prime approval. If the bonding stud is not used to carry d.c. currents, whatever the options of §6.1.2.1, an M3 diameter threaded stud can be used.

[R20] The stud shall provide (8 mm - 0, +2 mm) of useable thread for attachment of a strap.

5.2.5 Physical characteristics requirements / measurements

5.2.5.1 Mass

[R10] The mass of the items must be measured to an accuracy of :

- up to 20 kg ± 0.010 kg
- 20 - 200 kg ± 0.05 kg

[R20] The mass variance for qualification, flight and flight spare equipment shall not exceed 0.2 kg or 3% which ever is the smaller.

5.2.5.2 Centre of gravity

[R] The centre of gravity of the equipment shall be recorded. The centre of gravity of the equipment must be measured to an accuracy of 1.0 mm radius sphere on the first model, assuming no hardware modification on the following models. For equipment having moments of inertia less than 0.2 kg*m², calculated values of centre of gravity may be supplied.

5.2.5.3 Inertia

[R10] The moments of inertia of equipment must be given through its centre of gravity.

[G20] The moments of inertia of equipment must be measured to an accuracy of 5% on the first model, assuming no hardware modification on the following models.

[G30] Computed inertia's can be accepted, given a model well correlated with regards to measurement of mass and centre of gravity (differences less than 3%).

5.2.6 Summary of the Mechanical Interfaces Requirements

[G] This drawing is attached in Appendix B.

6 ELECTRICAL DESIGN AND INTERFACES REQUIREMENTS

6.1 ELECTRICAL DESIGN REQUIREMENTS

6.1.1 Electrical Grounding

6.1.1.1 General

Electrical grounding and bonding is requested for all mechanical structure elements, equipment housing, thermal blanket devices :

- *to prevent hazard from high potentials*
- *to prevent build up of static charges*
- *to reduce electromagnetic interference*
- *to protect from high voltage arcing*
- *to establish an Electrical Ground Reference Plane (EGRP)*
- *to potentially use the structure to carry primary power returns*
- *The spacecraft structure will constitute a low impedance voltage reference plane named EGRP.*
- *The power supply regulator will be the primary power reference point where the electrical power subsystem common return is connected to the structure.*

6.1.1.2 Return Grounding and Screening Requirements

6.1.1.2.1 Main Bus grounding

The negative side of the main bus shall be grounded at the electrical power subsystem distribution points, at the power supply regulator side.

Intensive use of structure return is used at system level.

All platform equipments (power bus users) shall be compliant with option A only.

Payload equipments (power bus users) shall be compliant either with Option A or Option B. Option A is the preferred configuration. Option selection (A or B) shall be brought to Prime approval .

For both option A and B, the low impedance grounding reference (defined in fig. 6.1/1) shall comply with the § 6.1.1.2.2. requirements.

Each unit shall provide the detailed input filters electrical diagrams together with the equipment grounding diagram.

Option A :

For each equipment power input, an insulation (galvanic insulation for power converters, i.e. primary to secundary insulation by means of transformers with insulated primary and secundary windings) shall be provided between primary return and structure (see Figure 6.1/1) with impedance such that R> 10 kΩ in parallel with C< 50 nF ; in case of NC with this requirement, the supplier shall justify the use of a capacitor exceeding 50 nF.

Power lines maximum conducted emission is defined in § 10.3.3.1.1

The common mode filter (balun if any or harness inductance plus common mode capacitor) is a resonant device; therefore its quality factor shall be limited by an appropriate damping network.

No single failure shall lead to the violation of the galvanic insulation requirements.

When option A is selected, the equipment will be used either with structure return or with wire return philosophy. The structure return will be achieved by connecting together in the harness the power bus return and the housing pins of the power connector(s) (see note 2 of fig. 6.1/1). Additional housing pins shall be considered in order to meet the pin current derating.

Option B :

Primary return is grounded to the low impedance grounding reference inside unit (Primary structure return).

Power line maximum conducted emission is defined in § 10.3.3.1.

As there might be no primary to secondary galvanic insulation, it shall be demonstrated than any single failure does not propagate to other units nor to the corresponding redundant unit (no thermal failure propagation, no overvoltage exceeding specified values on all the unit interfaces, no propagation through cross-strapping).

6.1.1.2.2 Secondary supply grounding

These requirements aim at ensuring performance of the unit internal grounding, in order to master the common mode voltage internally and at interface level.

All secondary supplies, when only used inside the equipment, shall have their return grounded through a low inductance path to a low impedance grounding reference, inside the unit (see Figure 6.1/1).

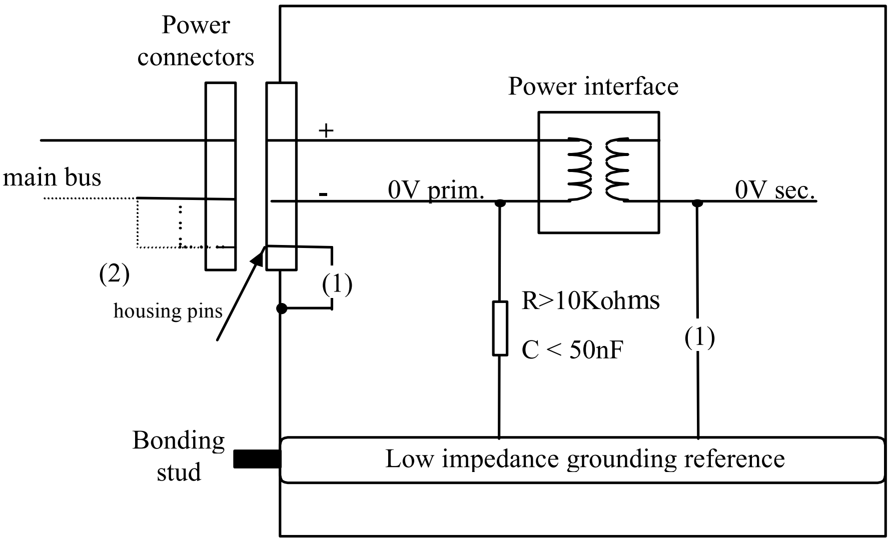
The bonds used to ground the secondary supplies returns shall have a length not exceeding 5 cm, the type and number of wires being defined according to unit power consumption.

[G] The impedance of the low impedance grounding reference shall be less than 2.5 mΩ DC between the bonding stud and any point of the low impedance grounding reference.

[R] The internal grounding shall be designed such that the voltage drop between the bonding stud and the internal secondary 0V, does not exceed 100 mV peak-to-peak d.c. to 30 MHz, when the equipment is operated with representative interfaces. This requirement shall be demonstrated by test.

When secondary supplies are not used only inside the equipment, the same philosophy shall apply, except when the application requires insulation ; in that case the unit shall provide dedicated insulated windings used with balun transformers in order to ground the supply return at load unit level, inside the unit.

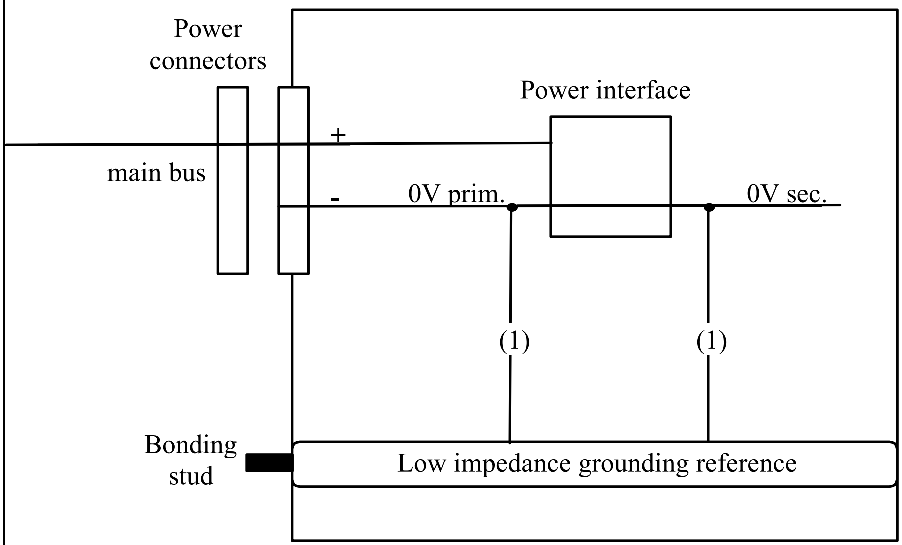
Option A



(1) Low impedance bond, length less than 5cm, type and number of wires defined according to unit power consumption, as close as possible to the power transformer.

(2) structure or wire return configuration : it shall be possible to configure either wire return or structure return at connector level. Unit shall be compliant to both, and the choice of wire return shall be brought to prime approval.

Option B



(1) Low impedance bond, length less than 5cm, type and number of wires defined according to unit power consumption.

FIGURE 6.1/1 : MAIN BUS GROUNDING

6.1.1.2.3 Signal grounding

Unless otherwise specified in this document or in the equipment specification, all analogue and digital logic signals shall use structure return.

In any case, signals interface design shall be compatible with a common mode specification of 0.5 Vrms from 10 kHz to 30 MHz and ± 300 mVdc. This requirement shall be demonstrated by analysis in the WCA.

Where above requirement cannot be met or when specific design/performance requirements (such as noise immunity or cable-to-cable coupling risks) exist, dedicated return wires can be used.

For all equipments, a general grounding diagram shall be provided to system level showing :

- all main bus(es) grounding paths
- all secondary supplies grounding paths
- all circuit diagram at equipment interfaces with detail of electrical reference.

6.1.1.2.4 RF Signals

RF signals shall be carried by waveguides, by semi-rigid coaxial cables or by flexible coaxial cables optimised for use over the operating frequency range, or any other transmission line appropriate to the Payload operational and performance requirements.

- selection of waveguide and waveguide connections and selection of coaxial cable and connectors shall take account of the Product Assurance requirements
- any venting aperture for waveguide, cables and connectors shall take account of the Product Assurance requirements and also the radiated interference requirements in section 10.3 herein
- for venting analysis/test, refer to §8.3.3 and §10.6
- all RF components shall be designed to prohibit the occurrence of multipactor discharge when ambient pressures below 10-4 Torr have applied for times greater than 10 minutes, for instantaneous RF powers of up to 200% of the maximum operating instantaneous RF power
- RF components which carry power during launch and ascent shall be designed to preclude corona discharges at any pressure below 1 atmosphere
- flexible coaxial cables shall be tied down to the satellite structure in such a way that the cable, inner to outer conductor dimensions will not be permanently altered if the cable experiences launch acceleration and vibrations and at intervals to be determined by the Prime Contractor
- bends in coaxial cable shall be smooth and at no time shall the bend radius be less than the minimum bend radius stated by the cable manufacturer
- semi-rigid cables shall, where possible, have inner and outer conductors formed of the same type of material. Where this is not practicable, the maximum differential expansion over the operational temperature range, between the inner and outer conductor of any cable, shall not exceed 0.2 mm
- the maximum strains imposed by connectors and connecting equipments by differential expansion between semi-rigid cable and waveguide and the spacecraft structure shall be reduced to tolerable levels by incorporating strains reducing devices e.g. bends in semi-rigid cables and bends or flexible waveguide where appropriate in waveguide runs.

6.1.1.3 Electrical bonding

The bonding and grounding resistances shall be measured with a 4-point method, with a d.c. current of 1A.

6.1.1.3.1 Equipment housing bonding

All active equipments shall be provided with a bonding stud.

The DC resistance measured in either direction between any metallic part of the equipment housing and the bonding stud shall be less than 5 mΩ (see fig. 6.1/2). This shall be demonstrated by test at equipment level.

The DC resistance between bonding stud and power connectors housing pins (See fig. 6.1/2) shall be lower than 30 mΩ but sized in accordance with primary current return (current derating shall be applied). This shall be demonstrated by test at equipment level.

This connection, from housing pins to the bonding stud, shall withstand without stress a DC current of at least 4 times the maximum user current.

The performance impacts of the primary power lines grounding through the housing pins (additional voltage drop w.r.t §6.2.1.1, power dissipation, EMC through common impedance) shall be considered at unit level.

If the bonding stud is only used for potential reference (when the unit structure is not used as an internal low impedance grounding reference, but only concerned by ESD grounding or cable shields grounding), other bonding methods (e.g. mounting feet) could be submitted to Prime approval.

For information :

The DC resistance, between the equipment bonding stud and the spacecraft structure at a point adjacent to the spacecraft structure bonding stud with the bonding strap installed will be less than 2.5mΩ.

6.1.1.3.2 Shielding Connection to the EGRP

Multi-point grounding to the Electrical Ground Reference Plane (EGRP) shall be provided if necessary.

Bus users primary power connectors, shall have at least 2 pins connected to the equipment housing (housing pins). Those housing pins shall only be used for primary power return connection to the structure, the connection being performed in the harness, when option A of §6.1.1.2.1 is selected.

For other connectors, screen/shield pins (if any) will not be used. The connection of the harness shields to the EGRP shall be performed at both ends through the connector body/screws, so that the shields currents do not flow inside the equipment. Each equipment connector body shall provide contact to the bonding stud with an impedance less than 20 mΩ (see fig. 6.1 /2).

6.1.1.3.3 Bonding of Thermal Insulation Blankets

All thermal insulation blankets shall be grounded to the equipment or to the spacecraft structure by an impedance of less than 100 Ω between any of the conductive layers and the equipment or spacecraft structure. The provisions for ESD protection shall also apply.

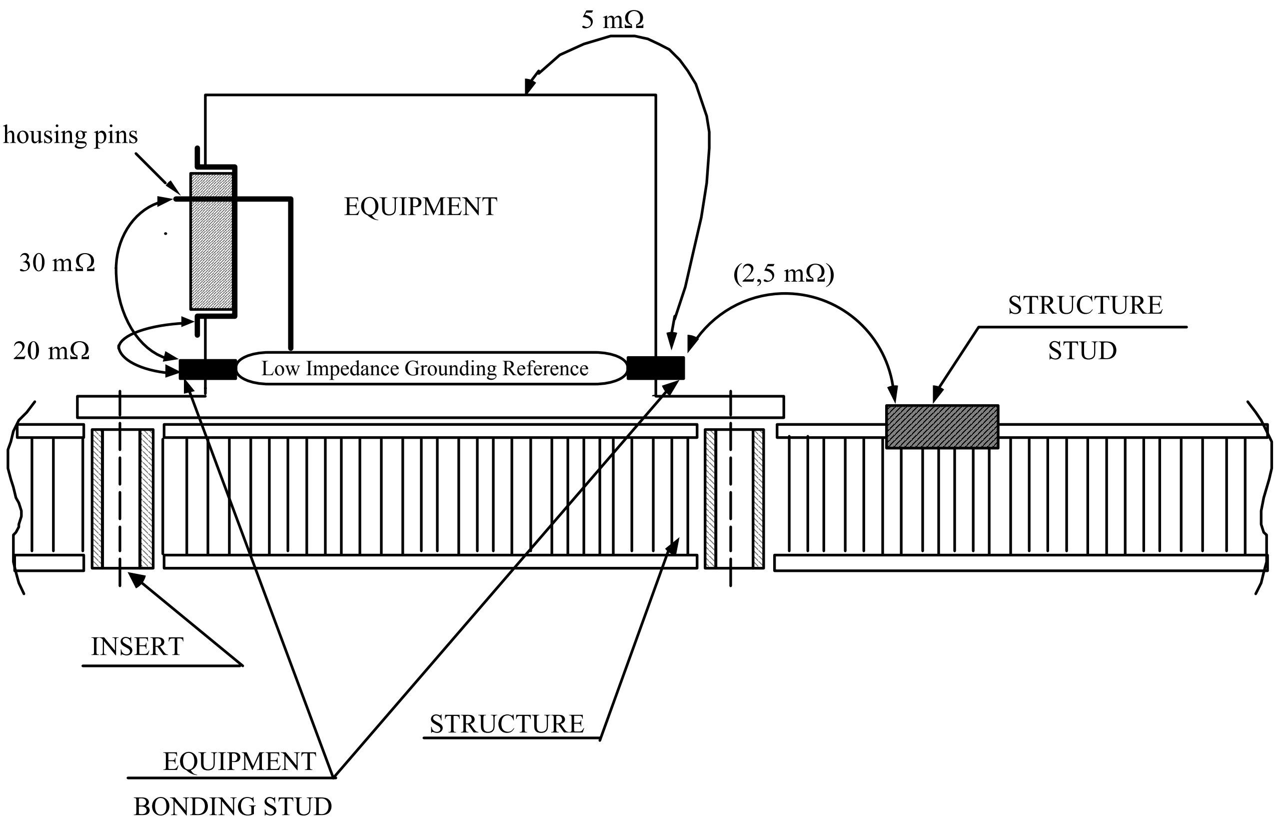


FIGURE 6.1/2 : ELECTRICAL BONDING

6.1.1.3.4 Electrostatic Cleanliness

6.1.1.3.4.1 Reduction of ESD occurrence risk

During and after launch, the spacecraft will be surrounded by a low density plasma of high energy electrons and protons. On any spacecraft insulated surfaces the electrons will build up a charge which will discharge when the voltage breakdown of the insulating materials is reached.

In order to minimise the effects of ESD, the general design principle is that all space facing surface (for externally mounted equipments) shall be electrically conductive and reliably connected to spacecraft structure. Specific design requirements to satisfy the principles are as follows :

- all external (outside the spacecraft) surface above 5cm² shall be electrostatically conductive and grounded to the structure ; the surface resistance shall be less than 1E+9 Ω.□ and the bulk resistance shall be less than 1E+13 Ω.m.
- Otherwise, the use of dielectric material shall be submitted to ESD Prime Contractor authority approval.
- All external/internal metallic parts (even very small ones such as metallic labels, connector brackets, the EPC and heaters baseplates (or doublers), the heatpipes, the tyraps) and intrinsically conductive parts (like carbon) shall be grounded to the main spacecraft by a resistance much lower than 1MΩ and typically 100kΩ. Floating metallic parts are strictly prohibited without any area consideration.
- Blankets shall be grounded to the structure with at least 2 bonding straps and any point on a blanket shall be within 1 m of a bonding strap. *The bonding strap shall be grounded to the structure by a proven technique such as a wire that is as short as possible (not longer than 15 cm as far as possible). All external (on walls, Antennas, Battery, Fluid loop...) and internal (IMUX, OMUX, TWT, CPS, Battery...) Multi-layers Insulation shall be grounded to the structure. The area of individual thermal blankets shall not exceed 2 square meters. Adjacent blankets shall be separately grounded to structure.*
- *Blanket bonding strap shall be routed from the blanket attachment point to the structure bonding stud below the surface of the blanket, wherever possible, to avoid external exposure to downlink RF power.*
- Optical Solar Reflectors are to be bonded using an electrical conductive adhesive.
- *White PCBZ & PSG120FD, black ELECTRODAG 501 and conductive BLACK AEROGLAZE Z306 paints have demonstrated good performance in order to dissipate the electrostatic charges.*

6.1.1.3.4.2 External materials submitted to Prime approval

ESD occurrence risks will be encountered in the situation here below :

- use of Perforated Aluminised Teflon (SSM) and the use of standard Teflon (FEP, PTFE, FLPO, TEFZEL)
- uncoated Kapton is generally unacceptable due to high resistivity. *However, tests have demonstrated the good performance of 25 µm Aluminised Kapton in order to dissipate the electrostatic charges. In continuous sunlight application, if less than 130 µm thick, Kapton is sufficiently photoconductive for use. Moreover, 50µm Kapton at solar array inter-cells level is authorised due to the very low exposed surface.*
- use of epoxy glass,
- silica cloth,
- metallic floating parts (wire, connector, strap, metallic part on non-conductive Velcro...).

The use of non-conductive materials shall be submitted to Prime EMC/ESD authority for approval.

If compliance with the above ESD requirements cannot be achieved due to conflicting design requirements then tests shall be performed on a representative sample of the concerned surface material. Details of the procedure and the test results shall be submitted to Prime Contractor EMC authority for approval.

6.1.1.3.4.3 Reduction of ESD effects

The following general principles should be applied in addition to any specific circuitry techniques :

- the equipment and interconnecting cable harnesses shall be designed so that they will not be susceptible to the effects of ESD,
- electronic interfaces are controlled : use of galvanic insulation, input filter,
- circuit bandwidths should be restricted to the necessary minimum,
- high input and output impedance should be avoided,
- loop areas of circuits using structure return should be minimised by routing the wires of these circuits close to the structure,
- « pigtail » loop areas should be minimised,
- bonding impedance should be as low as possible to minimise common impedance coupling,
- all sensitive harness use twisted shielded pairs or coaxial cables,
- all external harness not routed through filter connector is shielded. Moreover, the access inside the spacecraft is mainly made through filter-connectors,
- *external Top-floor harness and units protected by an RF/ESD Screen as far as possible.*

6.1.1.3.5 Assembly Bonding

All metallic subchassis, chassis and enclosures of each unit, including all connector shells and other fittings, shall be considered electrically as extensions of the EGRP. The bonding requirements are such that all satellite equipment primary and secondary structure 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 two 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 of length to width ratio not exceeding 5/1. This method shall only be used with the consent of the Prime Contractor.

6.1.1.3.6 Application of Bonds

In order to achieve a low and stable impedance bond from DC to RF, the following requirements are to be fulfilled at system level :

- *bonds shall be adequate in cross-sectional areas to carry 20 A DC and fault currents of 600 A during 10 ms, without fusing, burning or arcing*
- *length $\leq$ 10 cm (in any case as short as possible)*
- *length/width $\leq$ 5 (as close as possible to 1)*
- *DC resistance (including contacts) $\leq 2.5\ m\ \Omega$*
- *bond straps should be spaced no more than about every 50 cm along any two panels being bonded*
- *bond straps shall be fabricated from the same type of metal as the structure itself. They shall be protected from moisture and other corrosion causes*
- *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 interface 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*
- *where dissimilar metals are to be bonded, the elements of the bonding connections shall be selected to minimise the possibility of corrosion, and to ensure that if corrosion occurred, it would be in replaceable elements, such as washers, jumpers or separators, rather than in the system basic structure*
- *the use of two or more bonding straps or jumpers in series is not permitted. The MLI pieces shall not use chain grounding system.*
- *outer and inner metallised layers of thermal insulation shall both be bonded to the structure and provision of redundant bond straps shall be considered*

6.1.2 Electrical Connectors

Electrical connectors shall provide a low-impedance path for all internal wires and a low-impedance bond via the outer shell.

6.1.2.1 Connector Types

Connectors located at interface assemblies shall be selected in accordance with the Product Assurance Requirements.

The type of connectors shall be defined separately for equipment connectors, RF connectors, skin connectors and pyrotechnic connectors if applicable. The same types of connector shall be used for all equipment models.

Unit mounted micro subminiature connectors (MDM) are forbidden for flight connectors, unless their use has been expressly agreed with Prime.

Connectors pin count shall be limited to 78 ways, unless their use has been expressly agreed with Prime.

6.1.2.2 Characteristics

Connectors on the exterior of units shall be clearly and uniquely identified.

Pyrotechnic connectors shall be separated from other circuit connectors.

Separate coaxial connectors shall be used (as required).

The housing of connectors shall be electrically connected to the unit structure.

Connectors supplying or distributing power shall be female.

Other unit mounted connectors type (male or female) shall be selected in order to avoid mismating.

Male and female connectors shall be mechanically locked together to prevent inadvertent disconnection.

The backs of connectors susceptible to the entry of moisture, fumes, contaminants and foreign objects shall be potted or otherwise sealed.

Mechanical methods in conjunction with identification markings shall be employed as far as possible to prevent incorrect mating of connectors (cannon connectors can be used).

Number of assembly and disassembly operations on flight connectors, including test connectors, will not exceed 50. Savers shall be used, if necessary, during integration phase.

The Supplier will identify the connector numbers on the interface drawing.

Unless expressly specified (e.g. § 6.1.2.3.1), connectors shall not carry both prime and redundant signals of a given functionality. Any deviation to this requirement shall be brought to prime approval, while providing the exhaustive list of connectors and signals concerned.

On the equipment Sub-D connectors a torque of 4.5 cm kg shall be applied on each screw lock. When the harness connector is connected to the equipment, the applied torque is 3.5 cm kg. For other connectors types, the Prime shall be consulted concerning torque to be applied on screw lock.

In order to guarantee good mechanical characteristics for the bundle on the connector, it is suggested that the connected contacts shall never be inferior to two third of the maximum capacity.

[G] Flame labels shall clearly identify equipment connectors that present a risk of permanent damage or failure propagation, when shorted to ground or when any two pins of that connector are shorted.

6.1.2.3 Connector Pin Assignment

To establish the electrical configuration of interfaces, the Detailed Interface Handbook shall include the electrical and interface data sheets as described in §4.1.4.4.

Screen pins can be implemented but will not be used ; bus user primary power connectors shall be provided with housing pins (refer to §6.1.1.3.2).

The position and orientation of each connector shall be shown on an interface control drawing.

The number of connectors shall be kept to a minimum but using the following assignment :

- pyrotechnic connector (specific)
- RF connector (specific)
- data bus connector(s)
- primary power bus connector(s)
- signal connector(s)
- test connector(s)

6.1.2.3.1 1553B Data bus connector

Unless otherwise agreed with the Prime Contractor, the connection between a remote terminal equipment and the MIL-STD-1553 B bus stubs shall be performed via a Cannon 9 P equipment connector, according to the following pin function :

pin 1	1553 B bus prime
pin 2	not connected
pin 3	not connected
pin 4	not connected
pin 5	1553 B bus redundant
pin 6	1553 B bus prime return
pin 7	not connected
pin 8	not connected
pin 9	1553 B bus redundant return

Unless otherwise agreed with the Prime Contractor, the remote terminal address definition shall be performed on a dedicated Cannon 9 S equipment connector, according to the following pin function :

pin 1	remote terminal address bit n° 4 (MSB)
pin 2	remote terminal address bit n° 3
pin 3	remote terminal address bit n° 2
pin 4	remote terminal address bit n° 1
pin 5	remote terminal address bit n° 0 (LSB)
pin 6	remote terminal address parity bit
pin 7	secondary OV
pin 8	secondary OV
pin 9	not connected

Concerning remote terminal address definition pins (bits 4 to 0 and parity), a logical « 1 » level shall be obtained by floating the corresponding pin (no connection at harness connector level) ; adequate filtering shall be provided inside the unit on those signals. A logical « 0 » level shall be obtained by connecting the corresponding pin to the secondary OV pin at harness level ; the current in each remote terminal address definition pin shall not exceed 10 mA when programmed to logical level « 0 ».

This connector definition shall apply to all remote terminal equipments that are not internally redundant.

For internally redundant equipments, two sets of data bus connectors shall be implemented, one for the prime Remote Interface Unit (RIU), and the other one for the redundant RIU.

6.1.2.3.2 Primary power bus connector

The primary power bus input lines for DC/DC converters shall be assigned on a dedicated connector type.

Unless otherwise agreed with the Prime Contractor, a Cannon 15 P way connector, with the following pin allocation shall be implemented :

pin 1	Main bus CV
pin 2	Main bus CV
pin 3	spare
pin 4	spare
pin 5	spare
pin 6	spare
pin 7	spare
pin 8	spare
pin 9	OV Main bus
pin 10	OV Main bus
pin 11	spare
pin 12	Housing
pin 13	spare
pin 14	spare
pin 15	Housing

Otherwise, power pin allocation remains under Prime approval.

For internally redundant equipment, at least two power bus connectors shall be implemented (one for nominal functions and another one for redundant functions).

Additional pins (for main bus CV, 0V main bus and housing) shall be used in order to meet pin current derating rules.

In case of power bus protection inside the unit (i.e. when fuse protection outside the unit is not chosen), double insulation requirements impose a different pin allocation with sufficient spacing between power pins and power return / housing pins.

6.1.2.4 Test Connectors

6.1.2.4.1 Definitions

Test point return : test points shall be referenced to their ground reference inside unit ; in the case where floating is required (at unit or EGSE level), the test point return shall be considered as a test point.

For information :

- *Test point : point used either to get information used in the satellite without affecting its operation, or to inject a stimulus affecting its operation.*
- *Occasional AIT test points : test points used during integration and complementary satellite test ; they are not necessarily connected to EGSE but shall be accessible without breaking the functional harness.*
- *Functional permanent AIT test points : test points used during all satellite on ground tests, and included in umbilical links toward EGSE. These are then vital functional signals used to start and basically operate the satellite.*
- *Recurrent permanent AIT test points : test points used during satellite recurrent tests, and connected to EGSE. These non vital links are used to characterise the satellite operation.*
- *Restricted equipment test points : test points used at equipment test level, which use is forbidden or strongly not recommended for AIT (safety, unprotected). Restricted use during the first integration.*
- *Standard equipment test points : test points used at equipment test level, which use is authorised for AIT.*
- *Signal test point : test point with current less than 0.1A in nominal, failure or short cases.*
- *Power test point : test point with current greater than 0.1A in nominal case towards EGSE (source or load).*
- *Voltage test point : signal test point with low source impedance with regards to the receiver impedance.*
- *Current test point : signal test point with high source impedance with regards to the receiver impedance.*

6.1.2.4.2 Test connectors classification

As far as possible, functional and test connectors shall be segregated.

Nevertheless, « functional permanent AIT test points » and « restricted equipment test points » must be available on functional connectors, except if the test point is susceptible to EMC/ESD perturbations that could generate unit performance degradation ; in that case, those test points shall be implemented on separate test connectors and protected with metallic covers.

To test the performance of the system or subsystems when completely integrated onto the satellite, dedicated points shall be available on specific equipment AIT connector(s) (if equipment is concerned) ; the AIT connectors concern the « occasional AIT test points » and the « recurrent permanent AIT test points » that must not be implemented on functional connectors.

The test points necessary to test the unit by itself shall be available on specific equipment test connector(s) ; this concerns the « standard equipment test points ».

AIT and Test specific connectors shall be easily accessible and uniquely designated.

6.1.2.5 Test Points

6.1.2.5.1 AIT test point need identification

For information :

« Satellite function » is understood as a hardware or software functional subset that can be isolated upstream and downstream, in order to replace it by an equivalent subset (this is the case of cold redundancies), or to be passivated without altering the subset operation (this is the case of hot active redundancies). A function can encompass several equipments, or concern down to equipment parts.

Tests will generate stimulus and monitor the effects in return ; stimulus and effects are mostly electrical.

These AIT test points shall be provided when a « satellite function » is identified by common consent between AIT and the Prime Contractor, and shall provide the adequate commandability and observability of the function.

A hardware test point (stimuli) shall be provided each time a software information in the control loop cannot be modified.

These test points shall cover as a minimum :

- *the emulation of attitude sensors, temperatures, currents, voltages, according to the nominal operation of the satellite,*
- *the active hardware or software protections according to the abnormal operations of the satellite.*

These functions are generally included in the on-board controls, that cannot be activated during tests (e.g. satellite rotation, satellite attitude for a given sensor, extreme temperature,...).

The corresponding test points shall then allow to stimulate the on-board control and measure the effects, with a maximum use of on-board hardware and software.

All tests, recurrent or not, performed to demonstrate the correct operation and the integrity of the satellite functions (including safety, hot active redundancies check-out) shall be possible without breaking flight harness, except when duly justified.

The effect of a simuli test point shall be observable in unit telemetry.

6.1.2.5.2 Test points design requirements

The goal of the following requirements is to protect the satellite equipments against the ground test operation most frequent errors, and to define the EGSE failure domain. Failure is allowed but shall remain fail safe with respect to the satellite.

[G] If there is no cost/mass impact, a good way to limit the damage risk between EGSE and unit is to encourage stimuli generation or built-in self-test, inside the unit itself.

[R] These requirements are applicable to specific AIT and Test connectors only (commonly named test connectors hereafter).

a) The test interfaces shall be compatible and meet performance specifications with EGSE to spacecraft distance over 60m for specific signals as addressed in the equipment specification.

b) A test point shall be either of « signal » type or of « power » type and identified as such in the ICD.

c) A signal test point shall be either of « current » type or of « voltage » type and identified as such in the ICD.

d) As far as possible, equipment test connectors shall be female ; this requirement remains valid in case of bi-directional power test points. Nevertheless, priority shall be given to avoid mismating.

e) Mix of « signal » and « power » test points shall be avoided as far as possible on the same connector. Nevertheless, in case of power injection on a power test point, the signal test points allowing the control of the injected voltage shall be provided on the same connector.

f) Equipments shall not exhibit any part at a voltage higher than 50 V, that can be in direct contact with AIT people.

g) Where test connectors are provided, these should be protected by metallic covers to provide protection against mechanical damage when not in use (particle tightness). The test connectors shall be shielded from EMI prior to launch. Protections covers of all test connectors shall be part of equipment delivery.

h) Test points on multi-pin connectors shall be designed to withstand without causing damage, permanent voltages up to 10 % or 2 Volts (whichever is the greater) above the highest voltage on that connector, under zero impedance. As far as possible this voltage limit shall be extended to 50V. This voltage may be the output voltage from that unit (short of any two pins on that connector) or the expected maximum test input voltage. Permanent short of these points to ground shall not cause damage. The equipment operation, including test points, shall resume when the short is removed.

i) Test points shall not generate, under any failure case, voltages up to 30 % above the highest nominal voltage on that connector.

j) Test points shall be designed to withstand without causing damage, permanent currents up to twice the nominal current. Test points wiring shall withstand up to four times the maximum current on that connector.

k) Test points shall not generate, under any failure case or short condition, currents up to twice the nominal current.

l) The equipment design shall allow without equipment damage, the supplies switching off (EGSE and internal to spacecraft) without any sequential order constraint.

m) The wiring of test points used for safety purpose shall be redundant.

n) If fuses are used to protect test points (if current requirements cannot be met), the equipment shall withstand without causing damage the fuse clearing time under any short impedance.

o) For points g) through n), transient currents and voltages shall remain in the equipment parts safe operating area.

p) RF test ports shall be accessible without dismounting RF shield or thermal blankets.

q) Exclusive use of test points shall be identified in the unit User Manual, in the case when critical test points should not be used simultaneously.

6.1.2.6 Connector Savers

Connector savers are not required to be delivered with the unit, except for payload units.

Connector savers shall be provided for all functional and test port. Connector savers shall be compatible with flight hardware, e.g. gold-plated.

The savers shall remain in position for all electrical and environmental tests but removed for mass property measurements. Connector savers shall be shielded or removed for specific radiated interference tests, when these are likely to compromise the test.

Saver connectors removal shall be carried out under P.A. control.

Connector savers shall be screw-locked in position during mechanical testing.

6.1.3 Magnetic Requirements

The magnetic momentum of any fully operational equipment, electronic or others, shall not exceed 0.5 Am2 in any direction. Analysis will normally be acceptable for demonstration of compliance except for equipments which are specifically magnetic.

For high power consumption units (above 100W), the magnetic momentum shall not exceed 1 Am2.

6.1.4 Double Insulation requirements

The double insulation requirements depends on the accurate identification of :

- the way insulation is performed (thickness, gap, materials) between two electrically conductive elements at different potentials

- the conceivable variations of the thickness / gap

- the possibility of insulation loss due to external pollution (metallic particles, ...)

Terminology :

Invariable gap : when the physical distance between two electrically conductive elements is not subject to significant variations or changes, whatever the constraints applied to the unit or part of the unit.

Variable gap : when the physical distance between two electrically conductive elements can be subject to variations or changes, according to the constraints applied to the unit or part of the unit (environmental tests, AIT operations, changes with time, use of insulation materials, ...).

Rigid insulating material : strong, resistant, non porous, etc.

Non Rigid insulating material : flexible, thinness (kapton, choterm, glue, varnish, etc.)

Case A : Invariable gap, and gap > 1mm

The double insulation requirements ask for at least one insulating material (rigid or not) ; the selection of a non rigid insulating material is authorised if it is resistant whatever the constraints undergone during lifetime (manufacturing processes, AIT operations, environmental tests, launch and in-orbit environment operation). In this case of invariable gap, the minimum physical distance between two electrically conductive elements shall be greater than 1mm.

Case B : Variable gap, or gap < 1mm

In case of Variable gap, or when the physical distance between two electrically conductive elements is less than 1mm, the double insulation requirements ask for two insulating materials including one rigid insulating material. The non rigid insulating material shall be resistant whatever the constraints undergone during lifetime (manufacturing processes, AIT operations, environmental tests, launch and in-orbit environment operation).

[R] The supplier shall provide a document that presents the solutions retained to comply and that demonstrates the compliance to the double insulation requirements; this document shall be submitted to Prime approval.

Examples of double insulation implementation (as guidelines) :

- Pins inside connectors : case A
  - double insulation requested between pins for example
  - invariable gap due to ceramic
  - insulating material due also to ceramic
- Connector connections : case B
  - double insulation requested between pins and wires for example
  - variable gap due to flexibles wires
  - two insulating materials due to jackets on connections, and wire outer covering
- PCB connections < 1mm : case B
  - double insulation requested between solder joints and/or solder joints and metallic cover for example
  - two insulating materials due to varnish on each solder joint
  - two insulating materials due to kapton sheet and varnish for solder joints
- PCB tracks < 1mm : case B
  - double insulation requested between tracks for example
  - two insulating materials due to epoxy and varnish
- Relay fixed on PCB : case A
  - Double insulation requested between relay case and PCB metallic chassis for example
- insulating materials due to epoxy and screw insulation and mechanical spacing (chassis + bleeding resistor)
- Board to board : case A
  - Double insulation requested between boards components and/or boards tracks
  - Invariable gap due to metallic chassis
  - Insulation performed by a dielectric cover

Application of double insulation requirements :

The double insulation requirements concern the following elements :

- power conductors up to, and including, the power bus protection.
- All cross-strapped signals from source to load (e.g. TC matrices, TM matrices, external supplies, etc.)
- Any element where insulation loss would result in electrical failure propagation (e.g. primary to secondary insulation loss)
- Any element where insulation loss would result in mission loss or degradation (e.g. majority voting)

6.2 ELECTRICAL INTERFACE REQUIREMENTS

6.2.1 Power interface

6.2.1.1 Main bus voltage

The main bus voltage is controlled by the power supply regulator in sunlight from the solar arrays, and in eclipse from the battery.

DC voltage at user primary power connector input is 50 V ± 1% + 1Vrms ripple superimposed (sine wave signal 50 Hz to 10 MHz) +0/-350mV (harness voltage drop).

All users shall meet full performance under these conditions.

6.2.1.2 Current and Voltage ripple

Equipments shall not inject on the power main bus, current ripple exceeding requirements of figure 10.3/2.

Equipments are required to meet full performance when the power main bus presents the voltage ripple defined in §10.3.3.2.1.

6.2.1.3 Transients

6.2.1.3.1 Transient due to load switching

Units switch-on induce load current variations, resulting in transient power bus voltage transients.

Units shall be switched On in a sequential way only : multiple unit simultaneous switch-on is forbidden.

For a step load, the bus voltage disturbance will not exceed ± **6**% with a leading or a falling edge rate of 50V/ms, followed by an exponential recovery time of less than 5 ms. The repetition rate of the transient due to load switching will not exceed 10Hz.

6.2.1.3.2 Transients due to fuse clearing event

During such events, the bus voltage will be within hatched areas - 100% to ± 10% according to figure 6.2/1.

Platform equipments shall remain fully operational in case of a 1 ms power drop from 50V with 50V/ms minimum primary voltage slope at recovery, according to figure 6.2/1.

For power drops of up to 45 ms, all users are not required to meet performance parameters under these conditions, but must ensure that they survive the event and that no overstressing of the system occurs during or recovering from it, so that proper operations can resume (autonomously or not) after the power bus transient, with nominal performance.

Applicable to all Spacecraft units, all software and configuration data (e.g. RAM, registers) integrity shall be guaranteed during at least 100 ms with 0V power bus voltage, in order to be insensitive to the specified transients.

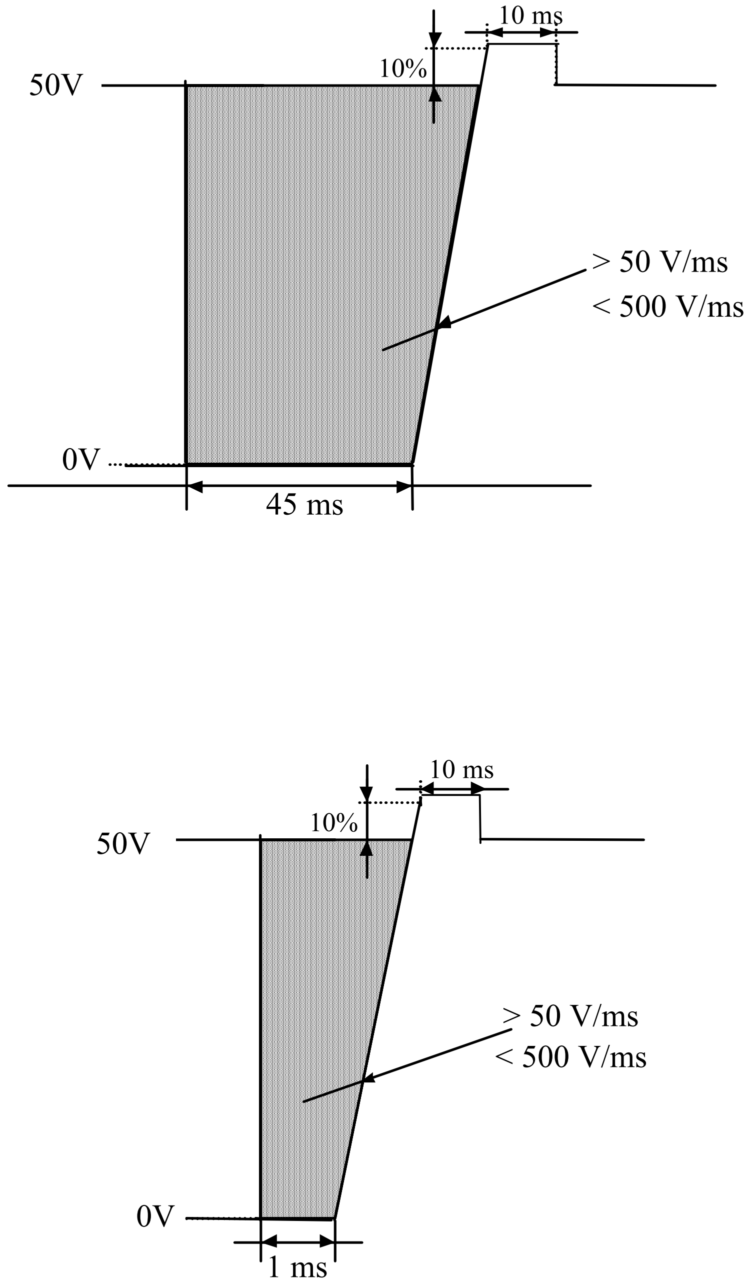


FIGURE 6.2/1 : Transient due to fuse clearing

6.2.1.4 Abnormal Modes

6.2.1.4.1 General

All equipments shall not be stressed when power bus voltage is between 0V and 50V ± 1% whatever duration and settling rate, or with overvoltage (up to 55 V during 10 ms). Fuse deratings shall be met under these conditions.

An Under/Over Voltage Detection should be implemented.

There shall be no turn-off mode for the command subsystem.

Any conceivable bus voltage or environmental conditions shall not result in spurious command generation or execution.

Requirements shall be demonstrated by test or analysis.

6.2.1.4.2 Platform units

The platform equipments shall continue to operate functionally when the power bus voltage goes down to a voltage of 35 Vdc, in the same conditions as under normal bus voltage, with the exception that the telemetry transmitter performance may be degraded by no more than 3 dB in output power and ± 10% modulation index.

Some critical platform units may have more stringent low voltage specified value in their equipment specification.

6.2.1.4.3 Payload units

For payload equipments, an automatic switch-off shall be implemented ; low voltage thresholds shall be set to 45 +0/-1V for a duration greater than 5 ms (filtering at detection), response time not exceeding 5 ms (from detection to complete switch-off). Restart shall be performed by external command only.

6.2.1.5 Main bus protection

The general principle for the main power bus is that it is generated in such a manner that it is single point failure free at the distribution point (i.e. no failure of a part or insulation can cause the loss of the power bus) to ensure the bus remains reliable when users are connected to it ; the users of the main bus shall protect the bus from overload caused by equipment failure.

Protection shall be either by current limiting or by fuses, combined with double insulation between the power distribution point and the limiting device.

The integrity of the double insulation shall be verifiable following integration of the equipment on the spacecraft.

If compliance with this requirement is implemented by any automatic means other than fusing or current limiting, a provision for ground override shall be made.

Current limitation - If current limitation is chosen, the following requirements shall apply :

- After any equipment failure, the user shall limit the current consumption to 1.5 time the maximum steady state current within 1 ms.
- For loads above 30 Watts, the current limiter shall initiate an automatic turn-off within 5 seconds.

Fuses - When fuses are used to protect the bus :

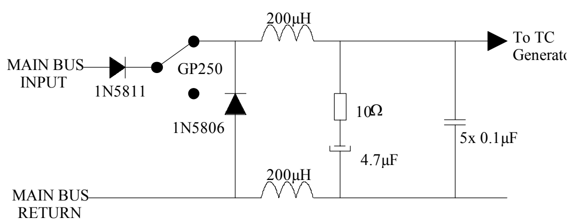
- The input relay of the unit shall be sized to switch twice the manufacturer's fuse rating current. Input relay means relay that can be used to switch the primary current consumed by the unit.
- Fuses shall not be implemented inside equipments, unless with the prior consent of the Prime Contractor.
- Fuses shall be placed such that required fuse blowing current is available to the fuse.
- The fuse temperature shall be considered in the range [-40°C ; +85 °C].
- Fuses in vacuum shall have a current derating according to RD1 specifications, for DC current.
- For surge currents, a margin ratio of at least 4 shall be considered with respect to the fuse manufacturer data.
- The fuse sizing shall include unit power off, all operational modes of the unit (e.g. including EHT switching on and off for TWTA payload units), and abnormal modes (§6.2.1.4) and all surge current situations (e.g. non exhaustive list : inrush current at switch on, with or without precharged filter ; surge currents induced by §6.2.1.3. transients with maximum voltage rate of 500 V/ms and whatever the transient duration from 0ms to 45ms ; surge currents induced by abnormal modes of §6.2.1.4.).
- The fuse rating current shall not exceed 15 A, unless with the prior consent of the Prime Contractor.
- Redundant fuses may be used only with the prior consent of the Prime Contractor.
- Fuses which are used to protect any primary bus from primary power user failure, shall comply with the following requirement : any fuse shall blow in vacuum when energised for 45 ms with 4 times the fuse current rating, under all qualification environmental conditions.
- As far as possible, the fuses type shall be MEPCOPAL P600L ; any other type choice shall be justified.
- When current is subjected to significant variations (such as internally thermally regulated equipments, or as resistive loads) with respect to those conditions, the details of current variation shall be given (such as levels and duration, dissipation versus skin temperature, or consumption versus voltage).

The Supplier shall be responsible for the fuse rating sizing, that shall be submitted to Prime for approval.

In order, - to assess internal fuse sizing,

- to define spacecraft centralised protection,
- to size external switching elements if any,
- to ensure compatibility of internal switching w.r.t. centralised protection,

[R] the following table 6.2.1.5 shall be fulfilled by the equipment designer each time a protection is needed (power bus, transformer output, telecommands, telemetries, internal functions ...).

OVERALL FUNCTION	Name of the function or set board e.g. :CVA or heater group 8
REF	Reference in the board part list for internal fuses e.g. :F10
IF(A)	Fuse rating e.g. : 2A
VF(v)	Fuse Max voltage e.g. : 72V
MANUFACTURER	Manufacturer's name and fuse type e.g. : MEPCOPAL P600L 72-2
FUSE FUNCTION	Describe the function of the fuse e.g. : Bus input protection or Capacitor S.C. failure protection
STATUS	I (internal to the unit) or O (outside the unit : centralised protection)
TYPE OF LOAD	R (resistive like heaters) with value R/L (coil) with characteristics @ 25°C P=cte (converter) with value (W) and inductor characteristics
Inom(A) / V(v)	Maximum steady state current w.r.t. nominal voltage and low voltage if applicable e.g. :0.5A/50V 0.57A/45V 0.6A/35V 0.7A/20V
Imax(A) / t (ms)	Max worst case current w.r.t. voltage including pulsed load like telecommand, motor drive during the corresponding duration t. e.g. : 0.45A / 50ms @ 50V
INRUSH	Measured profile of primary (first connection), secondary (start up) and bus transient recovery inrush current if applicable I=f(t) at extreme voltage (20V, 35V,45V and 50V). (simulated profile acceptable at the beginning)
SWITCHING	To identify when existing if a mechanical switching at unit level or an electronic switching is compliant with the selected fuse according to the present document requirements e.g. :GP250 (2A/50V) or Electronic ON/OFF ...
Nber OF SWITCHINGS	Number of switching expected at unit level if applicable e.g. :1/week or none or N/A ....
OTHER PROTECTIONS	To identify all other protections in series (upstream or downstream) with thresholds and timings Under Voltage UV OVercurrent OVI OVerVoltage OVV This shall be indicated even if no fuse is concerned e.g. : Main bus UV 20V/20ms 15V OVI 1A/<1ms
ELECTRICAL SCHEMATIC	Electrical schematic of parts around the fuse (e.g. input filter) with their value e.g. : 
COMMENTS / REMARKS	selectivity constraints with upstream or downstream fuses ....

[G] When fuse sizing is driven by transient margin and leads to a static sizing derating factor lower than 20%, the equipment design shall be modified to lower inrush current.

[R] For units with power consumption above 300 Watts on a given power line, the Prime Contractor should be consulted on the manner in which the load shall protect the power bus. For those units, the failure modes leading to EMC perturbations on the power bus shall be clearly identified and provided with quantitative current effects, and submitted for Prime approval. In any case of failure, the unit current ripple shall not exceed the unit conducted emissions specification +6 dB.

No single failure in the spacecraft including failures of wiring, connectors, etc., shall open or short the main power bus or affect definitely the normal operation of the spacecraft (Single Point of Failure), other than the possible loss of the load path where the failure occurred, provided that the corresponding function is redunded (and not affected by the failure).

6.2.1.6 Interfaces common mode requirements

All functions with primary or secondary referenced interfaces shall withstand without stress (ratings can be reached) a dc common mode voltage from -50V to +50 V, of whatever duration, with respect to their local electrical ground reference (mechanical structure, chassis, secondary 0V). This requirement is applicable whatever on or off state of the unit.

6.2.2 Data Handling Interfaces

This part defines the requirements for all signals between data bus subscribers and users : High Level Command (HLCD and HLCP), Very High Level Command (VHLC), High Power Command (HPC), 16-bit Memory Load Command (ML), Direct Telecommand (DTC), Direct Telemetry (DTM), Analogue acquisition (ANA), temperature/resistor acquisition (TEMA/RESA), Bi-level acquisition (TM BL N), switch closure relay status acquisition (TM BL D/S), and Low Speed Serial Bus Interface (LSSB).

Emitted signals concern source equipments and received signals concern load equipments in this part.

The telecommands and switch closure acquisitions matrix allocation (implementation inside the matrix) shall be flexible ; any hypothesis of row or column grouping shall be agreed with Prime.

The command interface circuit design shall be such as to ensure that no single failure of its components, when all possible failure modes are considered, shall allow a short circuit condition to be 'seen' across the telecommand input connection and the return, or between either of the pins and chassis.

6.2.2.1 General Requirements and conventions

a) timing :

signal duration : time between crossing points of fall and rise time to 50% of the measured full amplitude.

signal rise, fall time : maximum time between 10% and 90% of the nominal voltage swing.

delay between 2 signals : time between the voltage crossing point 50 % of the full amplitude level.

b) driver characteristics shall be considered at the level of the source equipment output connector ; harness voltage drop will be specified for each case.

c) for serial transmission, MSB is transmitted first.

d) care should be taken to ensure that input levels do not exceed manufacturer's rating even when units are unpowered.

e) the receiver interface design shall permit the power-on of unit without damage when the electrical interface are not terminated or driver unit is off.

For HLCD, VHLC, HPC, DTC, HLCP :

- The command lines (rows and columns) shall be double insulated inside equipment ; the user shall not impose any potential or grounding reference on any row or column with an impedance lower than 500 kΩ. The capacitance between any row and EGRP, and between any column and EGRP, at load side, shall not exceed 50 pF.
- All telecommands, except ML commands, are matrix telecommands. All telecommand users shall provide two diodes in series with the commanded device at any matrix node, and shall not implement quenching diodes at user side. If the command user is not redunded (e.g. non redundant payload switch), the 2 diodes shall be replaced by a diode network allowing the diode function whatever any single failure.

For TMBLD and DTM :

- The user shall not impose any potential or grounding reference on any row or column with an impedance lower than 500 kΩ. The capacitance between any row and EGRP, and between any column and EGRP, at load side, shall not exceed 500 pF. The capacitance between row and column, at load side, shall not exceed 50 pF.
- The matrix switch closure acquisition are generated through a matrix organisation. Two diodes shall be provided in series with each switch.

6.2.2.2 High-level command (HLCD or HLCP)

HLCP commands are dedicated to payload equipments and payload thermal control.

The command signal is a differential single positive voltage pulse (one row is pulled up to a positive voltage and one column is pulled down the secondary 0V so that only the device at the node of the activated row and column is commanded) distributed to the user for relay driving or general logic control application.

The HLCD and HLCP duration is 48 ms $\pm$ 5 ms.

6.2.2.2.1 Signal source characteristics

a) Type of source matrix power drivers

b) Output voltage measured at the source equipment output connector between a row and a column when loaded by the load defined in § 6.2.2.2.2 a)

* True state « 1 » : $+12$ V < U_1 < $+17$ V during the command

* False state during inductive load energy restitution (100ms max.), the row and column voltages with respect to EGRP, will be :

- 2 V < Row voltage < +17V (+30.8V in case of failure)

0V < Column voltage < +47 V

These voltages are seen by all the matrix users connected on the same row or the same column.

After inductive load energy restitution, the driver false state sink current shall not exceed 100µA

At any time, the differential voltage between row and column is thus in the range - 49V to +17V (+30.8V in case of failure).

c) Signal shape see figure 6.2 / 2

d) harness voltage drop $\leq$ 1.0 V

e) Failure cases :

the load shall withstand a true state voltage of +30.8V with nominal HPC telecommand duration.

the load shall withstand a telecommand duration of up to 10 seconds.

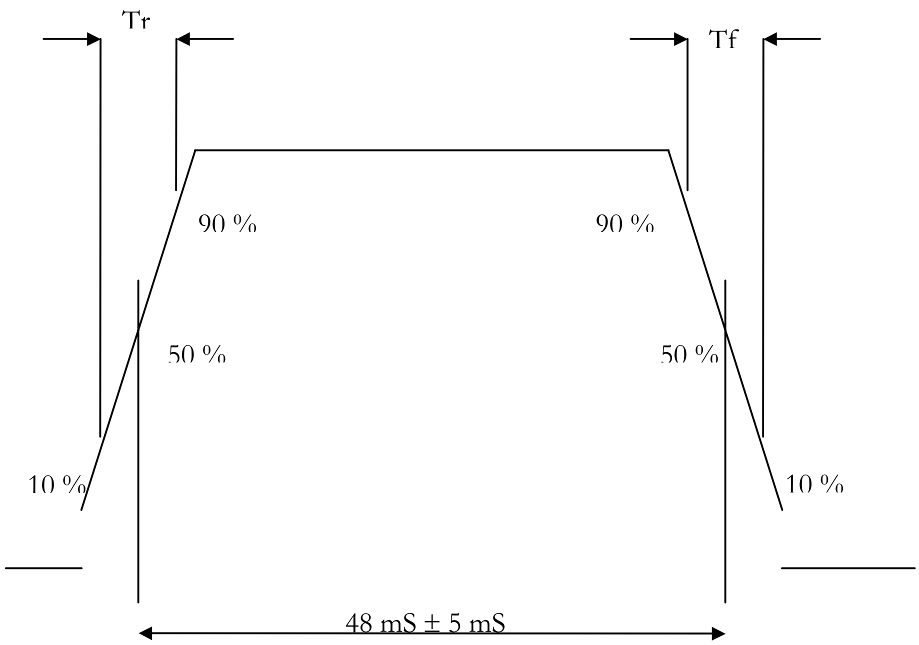
6.2.2.2.2 Signal load characteristics (user side)

a) Load impedance 60 Ω min. , 5 kΩ max. ; in parallel with 1 nF max ; plus 2 diodes in series.

b) The command shall not be executed (user load not susceptible) when a +40 V row voltage is applied while the column is connected to secondary 0V through an uncharged 10 nF capacitor. The compliance shall be demonstrated by analysis or test showing that this transient energy does not lead to command execution.

c) ON/OFF commands of a given equipment or function shall not share the same return (column) unless authorised by the FMECA analysis results.

FIGURE 6.2/2 : HIGH-LEVEL COMMAND : SIGNAL WAVEFORM AND TIMING DIAGRAM



HLCD : 10 µs $< t_r , t_f <$ 3 ms

HLCP : 300 µs $< t_r , t_f <$ 3 ms

6.2.2.3 Very-high-level command (VHLC)

The command signal is a differential single positive voltage pulse (one row is pulled up to a positive voltage and one column is pulled down to the secondary 0V so that only the device at the node of the activated row and column is commanded) distributed to the user for power relay driving or coaxial switches of the payload (matrix organisation).

The VHLC duration is 100 ms ± 10ms.

6.2.2.3.1 Signal source characteristics

a) Type of source matrix power drivers

b) Output voltage measured at the source equipment output connector between a row and a column when loaded by the load defined in § 6.2.2.3.2 a).

* True state « 1 » : +25.2 V < U1 < +30.8 V during the command

* False state during inductive load energy restitution (100ms max.), the row and column voltages, with respect to EGRP, will be :

- 2 V < row voltage < +30.8 V

0V < column voltage < +47 V

These voltages are seen by all the matrix users connected on the same row or the same column

After inductive load energy restitution, the driver false state sink current shall not exceed 100µA

At any time, the differential voltage between row and column is thus in the range -49V to +30.8V

c) Signal shape see figure 6.2/3

d) harness voltage drop $\leq$ 1.5V

e) Failure cases :

the load shall withstand a true state voltage of +40V with nominal telecommand duration.

the equipment shall not enter any invalid state when commanded with HLCD or HLCP telecommand

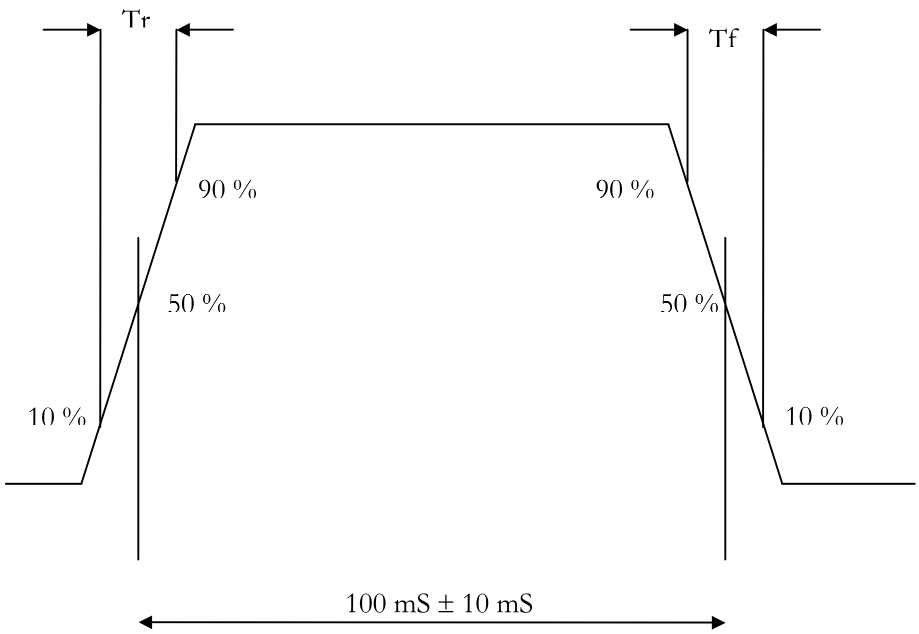
6.2.2.3.2 Signal load characteristics (user side)

a) Load impedance 56 Ω min. , 5 kΩ max. ; in parallel with 1 nF max ; plus 2 diodes in series.

b) The command shall not be executed (user load not susceptible) when a +40V row voltage is applied while the column is connected to secondary 0V through an uncharged 10 nF. The compliance shall be demonstrated by analysis or test showing that this transient energy does not lead to command execution.

c) ON/OFF commands of a given equipment or function shall not share the same return (column) unless authorised by the FMECA analysis results.

FIGURE 6.2/3 : VERYHIGH-LEVEL COMMAND : SIGNAL WAVEFORM ,TIMING DIAGRAM



t_r , t_f = 300µs to 3 ms

6.2.2.4 High power command (HPC)

The command signal is a differential positive voltage single pulse (one row is pulled up to a positive voltage and one column is pulled down to the secondary 0V so that only the device at the node of the activated row and column is commanded) distributed to the T coaxial and wave-guide switches of the payload (matrix organisation).

6.2.2.4.1 Signal source characteristics

a) Type of source matrix power drivers

b) Output voltage measured at the source equipment output connector between a row and a column when loaded by the load defined in § 6.2.2.4.2 a)

* True state « 1 » $+25.2\text{ V} < U_1 < +30.8\text{ V}$ during the command

* False state during inductive load energy restitution (100ms max.), the row and column voltages, with respect to EGRP, will be:

- 2 V < row voltage < +30.8V

0V < column voltage < +47 V

These voltages are seen by all the matrix users connected on the same row or the same column

After inductive load energy restitution, the driver false state sink current shall not exceed 100µA

At any time, the differential voltage between row and column is thus in the range -49V to +30.8V

c) Signal shape see figure 6.2/4

~~f)~~d)harness voltage drop ≤ 1.5V

e) Failure cases :

the load shall withstand a true state voltage of +40V with nominal telecommand duration.

the equipment shall not enter any invalid state when commanded with HLCD or HLCP telecommand

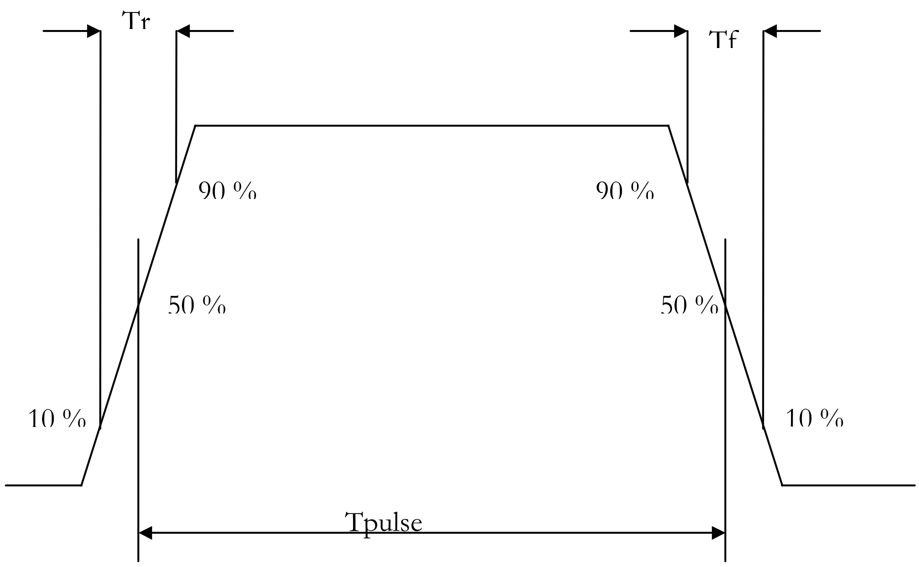
6.2.2.4.2 Signal load characteristics (user side)

a) Load impedance 56 Ω min , 5 kΩ max. ; in parallel with 1 nF max ; plus 2 diodes in series.

b) The command shall not be executed (user load not susceptible) when a +40V row voltage is applied while the column is connected to secondary 0V through an uncharged 10 nF. The compliance shall be demonstrated by analysis or test showing that this transient energy does not lead to command execution

c) ON/OFF commands of a given equipment or function shall not share the same return (column) unless authorised by the FMECA analysis results.

FIGURE 6.2/4 : HIGH-POWER and MEDIUM POWER COMMAND : SIGNAL WAVEFORM AND TIMING DIAGRAM



1 - t_r , t_f = 300 µs to 3 ms

2 - HPC : T pulse = 750 ms ± 10 ms

6.2.2.5 16-bit serial memory load command (ML)

Refer to §6.2.2.10. of this document for the Low Speed Serial Bus (LSSB) requirements.

6.2.2.6 Single Ended Analogue Acquisition (ANA SE)

The analogue acquisition signal appears in the form of a voltage varying within two defined limits.

The voltage to be acquired is periodically sampled and will be numerically coded on 12 bits over the full scale range, with a full performance of 8 bits.

6.2.2.6.1 Signal source characteristics (at generation side)

a) type voltage source

b) Voltage range 0 to + 5 V

c) Output impedance $R_S \leq 1$ kΩ

d) Protections : Short circuit : a permanent short circuit to ground shall not cause any damage, nor shall it affect the performance of any part than the output concerned.

Overvoltage : the application of a ±16 V overvoltage (through a 4kΩ resistor) on the output line of the analogue source shall not damage the source.

In any case of source single failure, the source output voltage shall remain in the ±16V range.

e) **[G]** Emission noise shall be less than 20mVpp (20 MHz bandwidth measurement) .

f) **[G]** The output shall not be susceptible (no offset no stress) when a signal 40 mVpp square wave 1 MHz is injected.

g) Signal reference : the analogue acquisition reference shall be connected at generation level, to the chassis of the equipment (EGRP). Single-ended analogue acquisitions shall use structure return.

6.2.2.6.2 Signal load characteristics (at acquisition side)

a) The receiver input impedance shall be greater than 100 kΩ.

b) Each analogue signal acquisition interface shall include a first order low pass filter, with a cut-off frequency in the range from 10Hz to 2kHz.

c) The interface shall withstand input voltages in the range from -16V to +16V.

d) When the input voltage is between -16V and 0V, or between +5V and +16V, the analogue to digital conversion chain shall provide a full scale saturation corresponding respectively to 0V and +5V.

6.2.2.7 Temperature (TEMA) and Resistance Switch Position (RESA) Acquisition

- This signal is obtained from a thermistor or a resistor located in the equipment which temperature or resistance is to be monitored.
- The thermistor or resistor shall be isolated within the equipment with respect to its chassis by at least 10MΩ.
- The thermistor or resistor shall not be conditioned (polarisation) inside the equipment.
- The thermistor or resistor shall be in the range 900Ω to 400kΩ.
- For temperature acquisition, the sensor accuracy shall be better than 1°C in the range -20°C to +85°C.
- The preferred thermistor part is FENWALL 526-31-BS09-153 (variant 32 part number MMS) corresponding to TEMA1E 15kΩ @ 25°C negative temperature coefficient. Other thermistor types shall be submitted to the Prime approval.
- Sets of resistors may be connected by auxiliary telemetry switches to generate a resistance signal indicating the set position of RF switches. The Resistance Acquisition (RESA) signal shall be handled exactly as for the thermistor signals. A maximum of 16 levels on a given RESA shall not be exceeded.

6.2.2.8 Bi-level acquisition (TMBL NE)

6.2.2.8.1 General

Each bi-level digital channel is used to acquire a status bit. The bi-level digital information is presented in the form of a voltage signal which can take the following two distinct values :

- the logical level « 1 », corresponding to positive voltage
- the logical level « 0 », corresponding to zero voltage.

6.2.2.8.2 Source characteristics (generation side)

a) « 0 » logical level V0 (loaded through the encoder input) $0\ V \leq V0 \leq +0.5\ V$

b) « 1 » logical level V1 (loaded through the encoder input) $+3.5\ V < V1 < +5.5\ V$

c) Output impedance $R_S < 10\ k\Omega$

d) Protections : Short circuit : a permanent short circuit to ground shall not cause any damage, nor shall shall it affect the performance of any part than the output concerned.

Overvoltage : the application of a ± 16 V overvoltage (through a 4kΩ resistor) on the output line of the analogue source shall not damage the source.

In any case of source single failure, the source output voltage shall remain in the ±16V range.

e) **[G10]** Emission noise shall be less than 200mVpp (20 MHz bandwidth measurement).

f) **[G20]** The output shall not be susceptible (no logical state change or stress) when a signal 400 mVpp square wave 1 MHz is injected.

g) Signal reference : The bi-level acquisition reference shall be connected at generation level, to the chassis of the equipment (EGRP). Structure return shall be used.

6.2.2.9 Switch closure acquisition (TMBL D/S)

6.2.2.9.1 Matrix switch closure acquisition (TM BL D)

Matrix switch closure acquisition (differential contact) will be performed via a matrix acquisition structure.

Typical acquisition pulse duration = 40 µs corresponding to matrix row voltage pulse, at the end of which the acquisition is sampled.

The contact measure furnished by the indicator allows to check the corresponding commands.

The switch closure matrix organisation is not compatible with active (0-5V) bi-level TM.

Contact characteristics :

- the user shall provide two diodes in series with the switch
- continuous current capability $\geq$ 4 mA
- leakage current (OFF state) < 10 µA
- the voltage drop (when status is ON) generated by a 4 mA current shall not exceed 2.4V (including the voltage drop of the 2 serial diodes) at user side
- maximum transient current $\leq$ 20 mA
- maximum polarisation voltage : + 20V
- signal reference : the status and status return lines shall be isolated from equipment chassis or any potential reference as per §6.2.2.1 requirements
- The use of optocouplers is strongly not recommended, and shall be brought to Prime knowledge for analysis and approval .

6.2.2.9.2 Single ended switch closure acquisition (TM BL S)

Direct switch closure acquisition will not be performed via a matrix acquisition structure, but with dedicated circuits referenced to the secondary 0V.

The contact characteristics shall be the same than for § 6.2.2.9.1. except for the following requirements :

- the direct switch closure acquisition return shall be connected at switch side, to the chassis of the equipment
- the switch shall not provide two diodes in series with the switch contact, but only the switch contact.
- continuous current capability $\geq$ 1mA
- contact resistance : ON state < 200 Ω
  OFF state > 1MΩ

6.2.2.10 Low Speed Serial Bus (LSSB)

6.2.2.10.1 General Description

The purpose of the serial bus is to allow serial data transfer between one bus controller (BC) or source equipment (master) to several user terminals (UT) or slave equipments.

Two different data transfers can be identified :

Serial command : a 16 bit word is sent by the bus controller to the terminals

Serial Telemetry (Acquisition) : two 16 bit words are sent repeatedly by one terminal to the bus controller

The bus consists of five differential lines :

SAMPLE_CMD	Validates the shift clock during serial commands	Source : Controller	Destination : All terminals
SAMPLE_ACQ	Validates the shift clock during serial telemetry acquisitions	Source : Controller	Destination : All terminals
CK	Shared clock sent during serial commands and serial telemetry acquisitions to synchronise the data transfer	Source : Controller	Destination : All terminals
DATA OUT	Mono-directional data bus passing serial command data towards all the terminals under the control of the bus controller	Source : Controller	Destination : All terminals
DATA IN	Mono-directional data bus passing telemetry data to the controller under the control of one terminal, controlled by one terminal during telemetry data acquisition	Source : One terminal	Destination : Bus controller

Each of the four differential lines from the bus controller to the terminals has the architecture shown in Figure 6.2.2.10/a.

The single differential line from each terminal to the bus controller has the architecture shown in Figure 6.2.2.10/b.

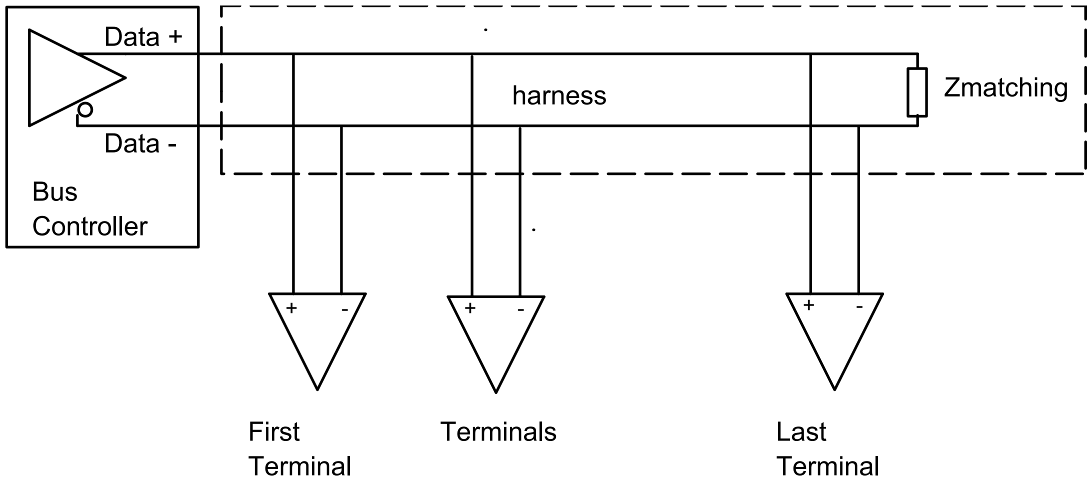


Figure 6.2.2.10/a - Architecture of CK, SAMPLE-CMD, SAMPLE-ACQ and DATA OUT lines

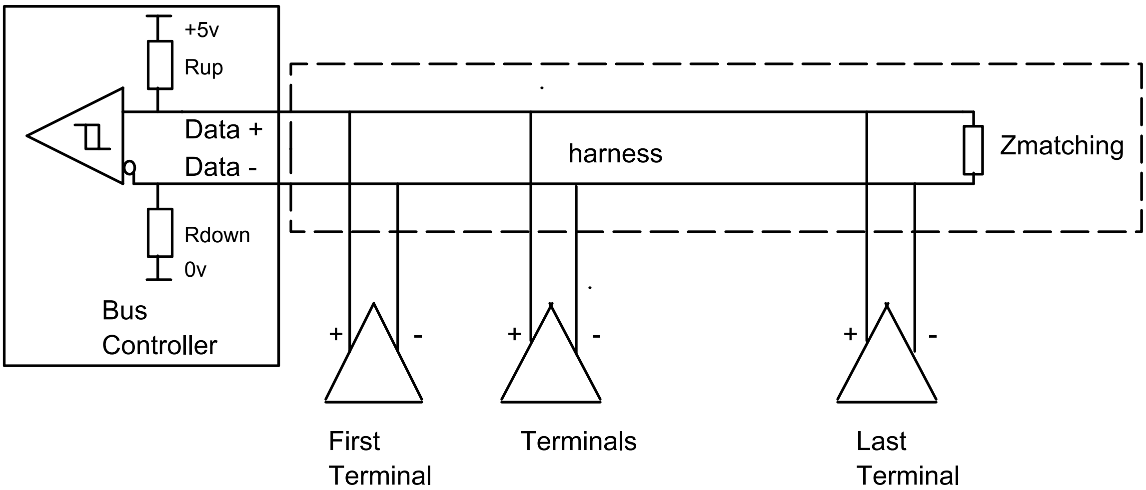


Figure 6.2.2.10/b - Architecture of DATA IN line

6.2.2.10.1.1 CK, SAMPLE-CMD, SAMPLE-ACQ and DATA OUT lines

Each of the four differential lines from the bus controller to the terminals, at its source, can have 3 functional states as defined in Figure 6.2.2.10/c (Bus controller powered) :

- High state (logic level 1)
- Low state (logic level 0)
- Undefined state
- When unpowered, the bus controller functional state will be defined as the so-called OFF state. Each terminal destination can be in 3 different states as defined in Figure 6.2.2.10/c :
- High state detected (logic level 1)
- Low state detected (logic level 0)
- Transient state (hysteresis zone)

In all these cases, the receiving terminal voltage is determined by the single source when the source is active, and lies in the inactive Hysteresis Zone when the source is inactive.

6.2.2.10.1.2 DATA IN Line

The single differential line from each terminal to the bus controller, at its source, can have two functional states as defined in Figure 6.2.2.10/c :

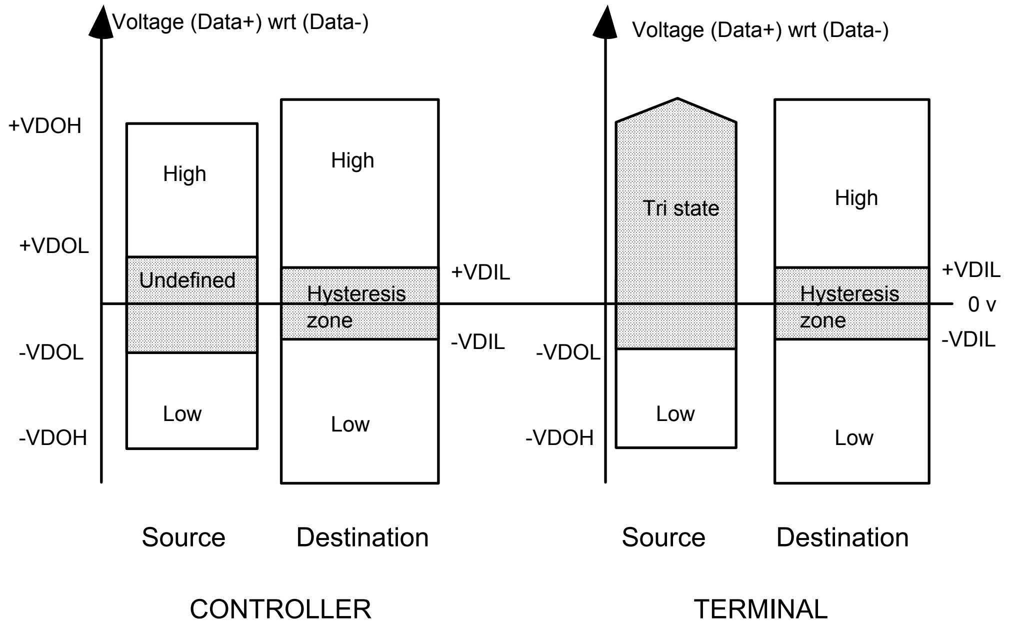
- Low state (logic level0)
- Tri-state or OFF state (inactive state)
- When unpowered, the terminal functional state will be defined as the so-called OFF state.
- The bus controller destination can be in 3 different states as defined in Figure 6.2.2.10/c :
- High state detected (logic level 1)
- Low state detected (logic level 0)
- Transient state (hysteresis zone)

In this case, the receiving bus controller voltage is determined by any one terminal source when the source is actively in the low state, and by its own internal configuration when an active terminal source is in the high state, or when all terminal sources are inactive. In proper operation, only one source will be active, and the architecture shown allows the parallel connection of all the terminals to the one DATA IN bus.

The bus signals shall be compliant with the following functional definition :

- The SAMPLE -CMD, the SAMPLE-ACQ and the CK signals shall be driven by the bus controller in the high state when active, and in the low state when inactive.
- The DATA-OUT signal shall be a logic « 1 » when driven in the high state by the bus controller or a logic « 0 » when in the low state.
- The DATA-IN signal shall be a logic « 1 » when in the tri-state from any terminal and a logic « 0 » when driven in the low state by a terminal.

For future growth, the bus controller shall be able to change the SAMPLE-CMD and SAMPLE-ACQ level convention.



VDOH = High Output Differential Voltage (Source)

VDOL = Low Output Differential Voltage (Source)

VDIH = High Input Differential Voltage (Source)

VDIL = Low Input Differential Voltage (Source)

Figure 6.2.2.10/c - Bus Voltage Definition

6.2.2.10.2 Electrical Signals Characteristics

6.2.2.10.2.1 Source transmitter

Each transmitter shall meet the following specification.

6.2.2.10.2.1.1 Common characteristics

Max differential output voltage : |VDOH| 5.5 V

Min differential output voltage : |VDOL| 1.5 V

Fault voltage emission : +/- 8V max.

Overvoltage susceptibility : An application on any bus line of an overvoltage +/- 16V via an impedance of 1 kΩ in the range DC to 1 MHz shall not damage the transmitter (whatever the ON or OFF state) or cause any failure propagation on source equipment or towards the destination users.

6.2.2.10.2.1.2 Specific bus controller characteristics

Transmitter type : Differential driver

Output load : Up to 32 terminal receivers

Level « 1 » : (Data + voltage) - (Data - voltage) > +VDOL for all load conditions (32 terminal receivers and matching impedances)

Level « 0 » : (Data + voltage) - (Data - voltage) < -VDOL for all load conditions (32 terminal receivers and matching impedances)

OFF state differential : SAMPLE-CMD line : - 0.3 V to + 0.3 V
output voltage level : Other lines : -VDOL to + VDOL

No emission level : Once equipment has been initialised, the transmitter output level shall be level « 0 » in the case of no data emission

Transmitter short circuit : A permanent short circuit due to harness or output protection failure circuit between each output line and the source equipment ground or between output differential lines shall not damage the transmitter or cause any failure propagation on source equipment.

6.2.2.10.2.1.3 Specific terminal characteristics

Transmitter type : Differential driver

Level « 1 » : Transmitter in tri-state or OFF state

Level « 0 » : (Data + voltage) - (Data - voltage) < -VDOL for all load conditions (Bus controller receiver, matching load and others terminal emitters)

Output leakage current : +/- 10µA transmitter in tri-state or OFF

Output capacitance : Cout < 20 pF

Single failure : No failure propagation towards the redundant terminal bus shall occur in the event of a transmitter single failure. Failure propagation probability on the bus shall be lower than 1 fit over the mission

Transmitter short circuit : A permanent short circuit between each output line and the source equipment ground and between output differential lines shall not damage the transmitter or cause any failure propagation on source equipment or towards the redundant terminal bus.

Bus contention : The emitter shall withstand an abnormal simultaneous terminal emission on the DATA IN bus

No emission level : Once equipment initialised, the transmitter output level shall be the tri-state.

6.2.2.10.2.2 Receiver characteristics

6.2.2.10.2.2.1 Common characteristics

Receiver type : Differential

Threshold voltage : |VDIL| = 1 V max

Input impedance : Rin > 50 kΩ on each input line (excluding bus controller pull-up and pull down resistors)

Input capacitance : Cin < 20 pF

Noise immunity : A minimum input hysteresis of 0,6 V (+/- 0.3V) shall be guaranteed

Common mode voltage : All the receiver performances shall be maintained with a maximum common mode voltage of +/- 5 V in the range DC to 1 MHz. (rectangular signal, maximum rise time 50 nsec).

6.2.2.10.2.2.2 Specific bus controller characteristics

Receiver type : Differential

Pull up resistor : A pull up resistor of 150 Ω +/- 5 % shall be connected between the Data in + input line and the bus controller internal 5V. This resistor shall withstand a continuous short circuit between the Data In + line and the ground.

Pull down resistor : A pull down resistor of 150 Ω +/- 5 % shall be connected between the Data in - Input line and the bus controller internal ground. This resistor shall withstand a continuous short circuit between the Data In - line and a +5v supply.

Pull up/down config. : These resistors shall be configurable at board level.

Single failure : No failure propagation on source terminal equipment shall occur in the event of a receiver interface single failure (input serial impedance case)

Input voltage range : The receiver, without pull-up and pull-down resistors, shall withstand an input voltage in the range - 16V to + 16V.

6.2.2.10.2.2.3 Specific terminal characteristics

Single failure : No failure propagation towards the redundant terminal bus shall occur in the event of a transmitter single failure. Failure propagation probability on the bus shall be lower than 1 fit over the mission.

Noise immunity : When the receiver is in its hysteresis range, its output shall not change if no input differential voltage is applied.

Input impedance : The input resistors shall be matched to 1 %

Input current : The input offset current shall be in the range [-75µA, +75µA] for either one of the inputs when submitted to a voltage in the range [-5V, +10V]

Input offset current : The input offset current shall be in the range [-1µA, +1µA] (Input Connected to ground)

Input voltage range : The receiver shall withstand an input voltage in the range -16V to +16V.

6.2.2.10.2.3 Terminal Equipment Bus Selection

Every terminal bus user shall be connected to prime and redundant (A and B) serial buses. The connection to each bus shall be made via an independent hardware interface.

The terminal user shall only process commands and respond to telemetry acquisition requests received via one bus at a time. Selection of bus A or bus B by the terminal equipment shall be performed by one of the two methods, either as a result of external configuration control or by an autonomous selection process.

Any failure occurring on one bus or on one command or telemetry bus interface shall not propagate to the redundant bus, or to the selection mechanism, so as to prevent its use.

6.2.2.10.2.3.1 External Configuration Control

In the case of external configuration control, switches within each terminal equipment shall be used to perform the selection between operation with A or B serial buses. The switches shall be controlled by external pulse commands.

6.2.2.10.2.3.2 Autonomous Bus Selection

In the case of autonomous bus selection, the terminal equipment shall select operation with either bus A or bus B.

The terminal user equipment shall select the bus that is currently, or most recently, active.

In the event of any single point failure occurring on one bus, the selection process shall ensure that the user terminal is maintained via the remaining operational bus.

Bus selection shall be performed on the rising edge of the SAMPLE-CMD signal.

Once the bus has been selected, the terminal bus user shall use the A (respectively B) signals for CK, DATA OUT, DATA IN, SAMPLE-ACQ, SAMPLE -CMD.

6.2.2.10.2.4 Bus Harness

The equipment shall be connected to the bus controller via a harness with the characteristics defined below. All command and telemetry interfaces shall operate within specification under these conditions.

Harness type	:	1 twisted shielded pair bifilar AWG 26 for each differential CLK, SAMPLE-CMD, SAMPLE-ACQ, DATA OUT and DATA IN line.
Max length	:	< 8 m
Shielding	:	The harness shielding shall be connected to the structure at grounding brackets level (both sides) externally of the equipment
User number	:	1 to 32 terminals may be connected on the bus in daisy chain

Terminal or bus controller :

stub length : < 0.3 m (from bus connection to input circuits)

Matching stub length : < 0.5 m (from bus connection to matching impedances)

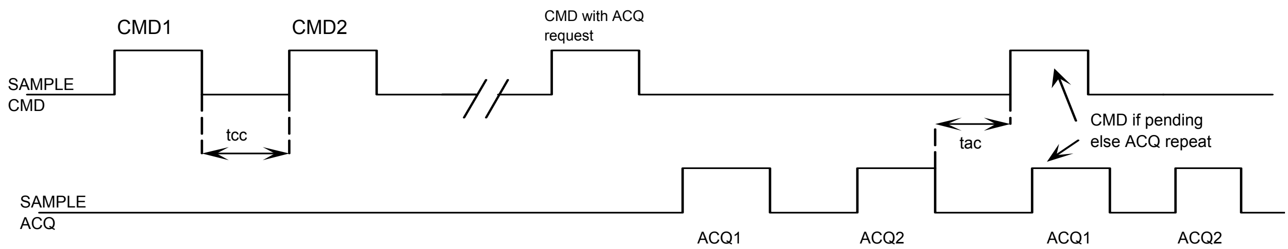
Matching impedance : These impedances are connected at the extremity of the cables away from the bus controller (the other extremity is the bus controller).
For all the lines except the DATA IN, the impedance is a capacitance of 10 nF in series with a 57Ω +/- 5% resistor. For the DATA IN line the impedance is a 300Ω +/- 5% resistor. This resistor shall withstand a continuous dissipation of 0.5 W.

6.2.2.10.3 Timing Requirements

The figures specify the timings at Transmitter output level (Tr) and at Receiver input level (R).

6.2.2.10.3.1 General Sequence

The timing between two data transfer blocks (signal on the same bus), at terminal input level, is shown in figure 6.2.2.10/d.



	Min	Max
Command to command delay t_{cc}	2.00 ms	-
Acquisition to command time t_{ac} if a command is	300 µs	2300 µs

Figure 6.2.2.10/d - DATA TRANSFER BLOCK TIMING

6.2.2.10.3.2 Serial Commands

The timing of the 16-bit serial command signals shall be as shown in Figure 6.2.2.10/e and Table 6.2.2.10/f.

The serial interface shall operate over the whole range of the time T shown in Table 6.2.2.10/f.

Bit B0 is sent first and is the MSB of the received command data.

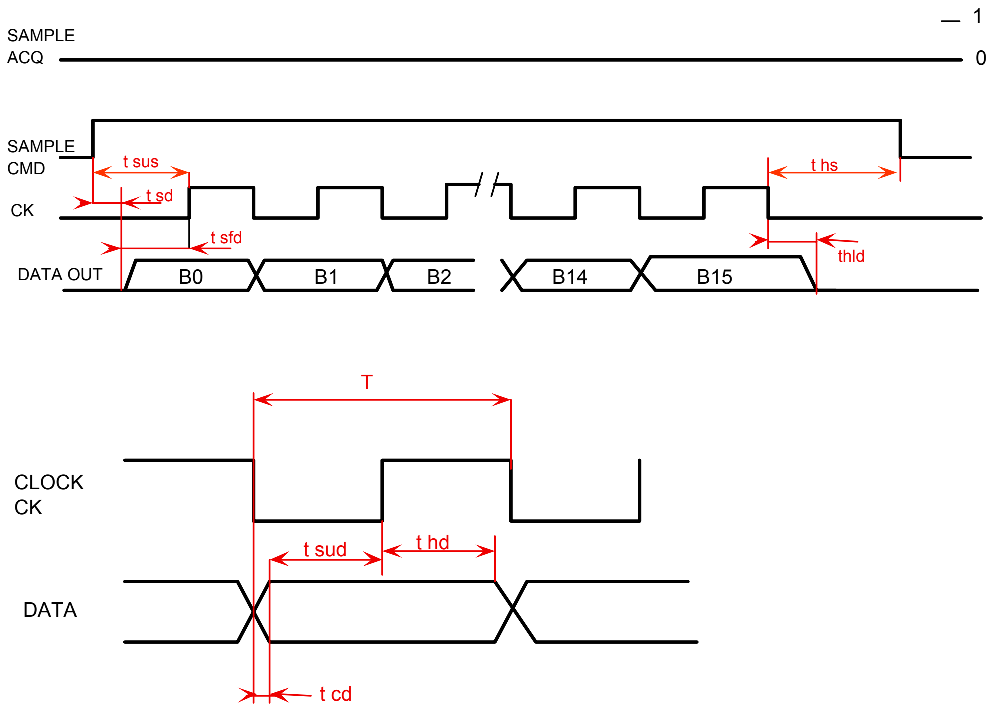


Figure 6.2.2.10/e - SERIAL COMMAND BIT TIMING

		Bus Controller			Terminal		
		Min µs	Max µs	Type	Min µs	Max µs	Type
Transfer clock period	T	60	1000	Tr			
Sampling signal set up time	tsus	420	2500	Tr	400	2520	R
Sampling signal hold time	ths	45	240	Tr	30	260	R
Data signal set up time	tsud	NA	NA	Tr	10	1.05*T/2	R
First data set up time	tsfd	NA	NA	Tr	10	1000	R
Data signal hold time	thd	25	NA	Tr	20	1.05*T/2	R
Last data signal hold time	thld	- 5	40	Tr	- 10	60	R
Clock to data time	tcd	- 5	10	Tr	NA	NA	R
Sampling signal to first data	tsd	0	100	Tr	NA	NA	R
Clock duty cycle	DC	45%min	55%max	Tr	NA	NA	R

Table 6.2.2.10/f - TIMING DEFINITIONS FOR SERIAL COMMAND DATA TRANSFER

6.2.2.10.3.3 Serial Telemetry Acquisition

The timing of the serial telemetry acquisition signals shall be as shown in Figure 6.2.2.10/g and Table 6.2.2.10/h.

After a controller request a 32 bit word is transferred from the terminal to the controller, although the 32 bits may be regarded as two separate telemetry words of 16 bits for operational purposes.

The serial interface shall operate over the whole range of the time T shown in Table 6.2.2.10/g.

The SAMPLE-ACQ signal will be available for optional use by the terminal.

Bit B0 shall be sent first and shall be the MSB of the first 16 bit word and of the second 16 bit word.

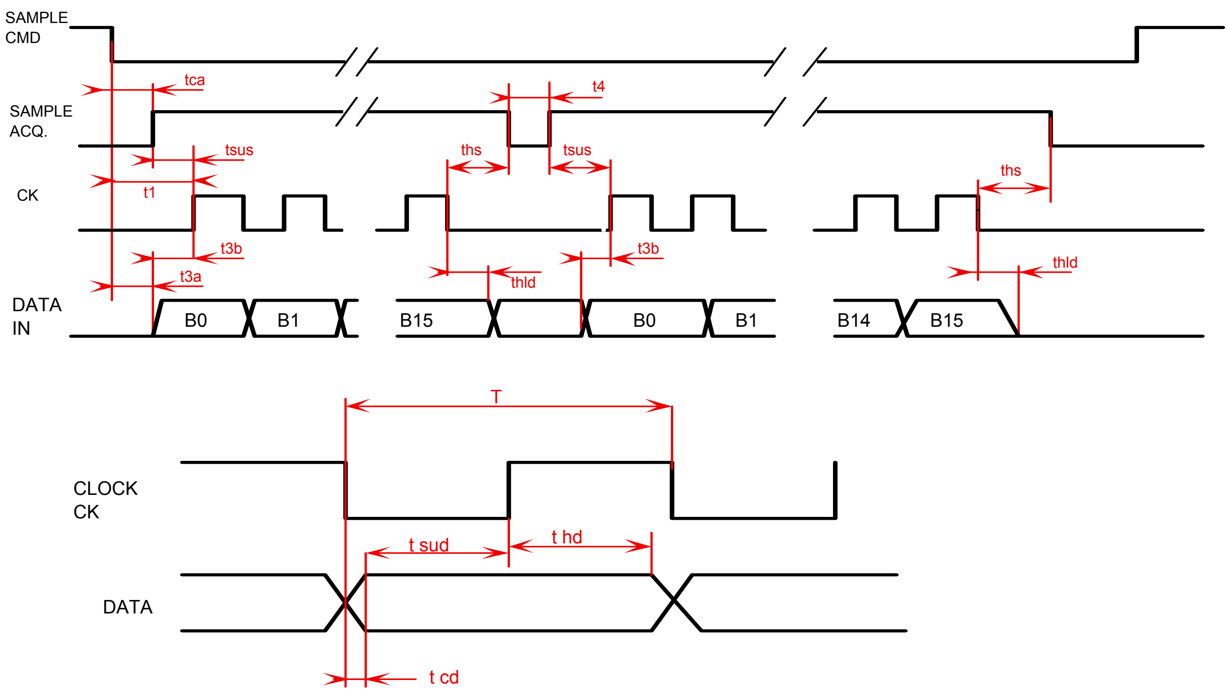


Figure 6.2.2.10/g - SERIAL TELEMETRY ACQUISITION BIT TIMING

		Bus Controller			Terminal		
		Min us	Max us	Type	Min us	Max us	Type
Transfer clock period	T	60	1000	Tr			
	t1	2000	3500	Tr	2000	3510	R
	tsus	420	2500	Tr	400	2520	R
t1-t3b	t3a	NA	NA	R	0	2300	Tr
	t3b	10	2000	R	NA	NA	Tr
Duration between acquisitions	t4	1950	2300	Tr	2000	2350	R
	thld	- 5	+40	R	0	T/2	Tr
	ths	45	240	Tr	30	260	R
	tsud	10	-	R	20	NA	Tr
	thd	10	-	R	20	NA	Tr
	tcd	NA	NA	R	0	5	Tr
tca=t1-tsus	tca	300	2500	R	NA	NA	Tr
Clock duty cycle	DC	45%min	55%max	Tr	NA	NA	R

Table 6.2.2.10/h - TIMING DEFINITIONS FOR SERIAL TELEMETRY DATA TRANSFER

6.2.2.10.4 Protocol

This section considers that selection of prime or redundant bus has been performed as described in § 6.2.2.10.2.3.

On reception of all 16 bits of a command word, and prior to performing the address check, the user terminal equipment shall compute an even parity bit value from bits 0 to 14. It shall compare the computed parity with the received value of bit 15. The received command word shall be considered validated on equality.

If the computed and received parity are not equal, the invalid command shall be ignored. The parity error shall be memorised and a Parity Error Flag (PEF) inserted into telemetry for command verification purposes.

If a parity error occurs then the PEF shall remain set to indicate the parity error event until it has been transmitted in telemetry. Once it has been transmitted then the PEF shall be reset.

After the parity validation has been successfully completed, the user terminal equipment shall then proceed to check the embedded address (as described in section 6.2.2.10.5.2.). If the received command address is equal to its hard-wired address then the user terminal equipment shall proceed to decode the user data. If the addresses are not identical then the command shall be ignored.

As the parity check is performed prior to determining the address validity, all user terminal interfaces on the bus shall set their PEF if they detect a parity error. If the parity error is within the received command then the error will be common to all user terminals on the bus. If only one interface sets its PEF then the parity error is within that interface.

The structure of each command is defined in paragraph 6.2.2.10.5. The contents of the 10 bit user data field shall be defined by the user and as such may differ between different bus user applications.

The bus user shall define the contents of the command data field so as to reserve some bus commands as user telemetry acquisition requests, from the bus controller. As a minimum the bus shall interpret one command data field code as a bus controller request for telemetry verification of the command data received by the user.

Following the reception of a validated command containing a telemetry request and until the reception of the next command, the user terminal shall enable the continuous transmission of the requested telemetry data to the bus controller via the DATA IN bus line.

Throughout the continuous and repetitive transmissions of the requested telemetry, the telemetry data contents shall be constantly refreshed to provide a real time monitoring function of the telemetered parameters.

Telemetry transmission following the occurrence of the telemetry acquisition request shall commence with the next clock pulse following the end of the telemetry acquisition request command.

The acquisition of telemetry consists of the bus controller acquiring 32 bits of telemetry data from a single user terminal which the user terminal transmits as two 16 bits data words. The contents of these data words are defined by the user.

The contents of the two data words may be identical to each other or their contents may be different. The contents of the two data words may be fixed or they may be selectable by a user defined decoding of the telemetry acquisition request commands.

Whilst the Telemetry Clock signal is active on the bus, and in the presence of the Telemetry Strobe signal, the two word telemetry transmission sequence (ACQ1 & ACQ2), shall be repetitively transmitted onto the DATA IN bus.

On the next reception of any command, and prior to parity check or address validation, the transmission of telemetry shall be disabled on the DATA IN bus line, and control of the bus shall be relinquished to the Command Interface.

In the case of memory dump need, the prime shall be contacted.

6.2.2.10.5 Command Structure

6.2.2.10.5.1 Bit Allocation

The allocation of the 16 bits in the command word will be as defined in the next table.

BIT POSITION	FUNCTION
0 to 4	Embedded Address
5 to 14	User Data
15	Parity Bit

Table 6.2.2.10/i : Command Word Bit Allocation

6.2.2.10.5.2 Embedded Address

The five bits of the Embedded Address shall be termed EB 0 to 4 taking Bit 0 as the first received bit (MSB).

Bit 0 = Embedded Address Bit EB0

Bit 1 = Embedded Address Bit EB1

Bit 2 = Embedded Address Bit EB2

Bit 3 = Embedded Address Bit EB3

Bit 4 = Embedded Address Bit EB4

The terminal equipment interface shall compare each bit of the embedded address, EA 0 to EA 4, with a corresponding hardwired local address, HWA 0 to HWA 4, available at unit connector level, and process the user data information contained in bits 8 to 14 when all 5 bits match.

Bit 0	EA 0	compared with hardwired bit	HWA 0
Bit 1	EA 1	compared with hardwired bit	HWA 1
Bit 2	EA 2	compared with hardwired bit	HWA 2
Bit 3	EA 3	compared with hardwired bit	HWA 3
Bit 4	EA 4	compared with hardwired bit	HWA 4

Concerning the remote terminal address pins definition (HWA0 to HWA4), this definition shall be performed at harness level according to the following rule :

- a logical « 1 » level shall be obtained by floating the corresponding pin (no connection at harness connector level) ; adequate filtering shall be provided inside the unit on those signals,
- a logical « 0 » level shall be obtained by connecting the corresponding pin to the secondary 0V pins at harness level.

In applications where less than the maximum number of user terminals are employed, the all zero and all ones embedded command address codes should be avoided as they correspond to a bus failure case.

6.2.2.10.5.3 User data

Bit 5 to bit 14 are to be defined by the terminal equipment.

The user shall nevertheless manage at least one binary code to provide a Telemetry Acquisition Request to provide verification of received bus commands.

6.2.2.10.5.4 Parity Bit

Bit 15 shall be used as a parity bit (Even Parity), as defined in Protocol section.

6.2.2.10.6 Telemetry Structure

The user terminal equipment shall provide 32 bits of telemetry data in the form of two 16 bits telemetry data words in response to telemetry acquisition request commands from the bus controller. The contents of the two telemetry data words shall be defined by the user.

The contents of these telemetry data words may be fixed or may be selectable by the user decoding of the data field contents of the telemetry acquisition request commands from the bus controller. This decoding shall be defined by the user.

Following the reception of a validated command containing a telemetry request and until the reception of the next command, the user terminal shall enable the continuous transmission of the requested telemetry data. The telemetry data contents shall be regularly refreshed to provide a real time monitoring function of the telemetered parameters. On the next reception of any command, and prior to parity check or address validation, the transmission of telemetry shall be relinquished to the Command interface.

6.2.2.10.6.1 Command Verification Telemetry

The equipment connected on the serial bus shall provide verification of received commands via telemetry.

The command verification telemetry shall include the Embedded Address of the terminal equipment and a Parity Error Flag.

The Embedded Address shall be assigned to bits 0 to 4 of the command verification telemetry word.

The Parity Error Flag shall be assigned to bit 15 of the command verification telemetry word.

6.2.2.10.6.2 Functional Telemetry

The equipment connected on the serial bus shall provide sufficient telemetry data to allow the verification and monitoring of all equipment internal functions.

The content of the functional telemetry data words shall be defined by the user.

6.2.2.11 Direct telecommands (DTC)

The command signal mainly concerns the on/off commands of all MIL-STD-1553B system bus subscriber equipments, that shall be generated by the SCU.

The characteristics shall be the same as the HLCD, except the following modifications :

6.2.2.11.1 Signal source characteristics

- True state voltage: +13 V < U1 < +17 V (differential)
- False state column voltage < +32V
- At any time, the differential voltage between row and column is thus in the range -34V to +17V.
- Harness voltage drop ≤ 1.0 V
- 300µs < tr,tf < 3ms.

6.2.2.11.2 Signal load characteristics

- Load impedance : 45Ω min. , 5 kΩ max. in parallel with 1 nF max. ; plus 2 diodes in series.

6.2.2.12 Direct Telemetry (DTM)

The status signal mainly concerns the on/off status of all MIL-STD-1553B system bus subscriber equipments, that shall be acquired by the SCU.

The DTM's shall be compliant with §6.2.2.9.1.

Typical acquisition pulse duration = 32 µs corresponding to matrix row voltage pulse.

6.2.2.13 1553B Data Bus

The following requirements are related to the MIL-STD-1553 B system bus protocol at subscriber equipments levels, in terms of addressing capability, exchange type, dwell interruptibility, providing a protocol as standard as possible, which complies with the various constraints linked to each subscriber type. The following requirements only concern dumb slave subscribers (i.e. apart from slave computer).

Interface requirements concerning slave computers (« intelligent » subscribers) are presented in RD6.

- Each system bus subscriber equipment shall comply will the MIL-STD-1553B + Notice 2 standard (RD4).
- Each subscriber shall be connected to both prime and redundant system buses.
- In normal operation, only one system bus is active at a time, and each powered subscriber shall answer to or accept the messages corresponding to its Remote Terminal (RT) address only.

In shadow mode operation, both prime and redundant system buses are active, but messages for a given RT address will be generated on one system bus only : each powered subscriber shall answer to or accept the messages corresponding to its RT address either on the prime or on the redundant bus which issued the message. A consequence of the shadow mode, is that broadcast commands shall not be used (RT address = « 31 »(11111)) by any subscriber.

- Each powered subscriber shall be in Remote Terminal configuration only ; therefore, the dynamic bus control mode command shall not be used and be ignored by all the subscribers.

  Other mode commands can be used.

- Each subscriber shall be compatible with transformer coupling (long stub).

  Each 1553B remote terminal shall provide, for each system bus (prime and redundant), a long stub DC reference to the equipment chassis ground (EGRP), in order to avoid stub charging and arcing due to space environment. This reference shall be performed at the centre tap of the coupling transformer inside the equipment, at stub side, with a DC impedance greater than 100 kΩ, but less than 1GΩ.

  No single failure shall lead to an unreferenced stub potential : impedance shall be less than 1GΩ even in case of any single failure (e.g. redundancy can be obtained by 2 resistors in parallel).

- The implementation of the option to analyse illegal commands is not required, but the design must be able to withstand the existence of these undefined commands without causing the remote terminal internal errors or data bus system problems. The general philosophy is to « respond in form », in other words, according to the protocol as if it was legal.

6.2.2.13.1 1553B message format -Addressing capability

Transfers on the 1553B bus will be performed in a single controller environment (the SCU is the single data bus master). All transfers are therefore initialised under the central computer control. Most transfers of command type, will be thus performed with the « Controller-to-RT (Remote Terminal) transfer » format ; the other class of transfers of command type refers to « mode command » transfers (specific commands as the self-test, the status word transmission, coupler configuration,...) : see RD4.

The structure of the « Controller-to-RT » transfer format is as follows :

3	5	1	5	5	1
Synchro	RT address	T/R	Sub-address / mode	Data count / mode code	P

- The RT addressing capability (number of potential subscribers) amounts to 31 subscribers : the RT address « 31 »(11111) is reserved by the standard for broadcast commands.
- The RT address allocation to each equipment will be made by the Prime Contractor.
- The RT address shall be programmable at data bus connector level, as defined in § 6.1.2.3.1.

- The direct sub-addressing capability (number of possible sub-addresses) is 29 (29 in command and 29 in acquisition) ; the sub-addresses « 31 » (11111) and « 32 » (00000) are reserved by the standard for mode commands, and the sub-address « 30 » (11110) is reserved by the standard (notice 2) for coupler self-testing (data wrap-around). But the dwell requirements (leading to the sub-address MSB use for the distinction between normal and dwell acquisitions) bring this number down to 14 available sub-addresses.
- The block transfer capability is given by the following field of 5 bits (Data count/mode code), indicating the number of data words included in the transfer ; the block transfer capability is therefore brought up to 32 words.

This field is also used for mode commands decoding when the sub-address is « 31 » or « 32 ».

This field does not allow to extend the sub-address field since the EUROSTAR 3000 application requires a direct access to each command / acquisition point, this requirement being imposed by the dwell.

6.2.2.13.2 Sub-addressing capability needs

According to the equipment type, the sub-addressing need may be very different and may be compatible or not with the direct sub-addressing capability of the MIL-STD-1553B standard. In case of incompatibility, the transfers related to acquisitions shall be managed by double transfers.

A first transfer of « Controller to-RT » type with a single data word will allow to define the end-address level that is required and to start up acquisition sequencing, and a second transfer of « RT-to-controller » type will allow to retrieve the acquisition result, as indicated by the diagram below :

1st transfer	Receive Command	Data 1	**	Status	#
2nd transfer	Transmit Command	**	Status	Data 2	#

Data 1 : data word associated to the Receive command, defining the end-address and starting acquisition

Data 2 : data word associated to the Transmit command, acquisition result

** response time : > 4µs and < 12µs

inter-message gap (IMG) ≥ 30µs

The minimum time between the end of the first transfer status and the beginning of the second transfer is then 30µs. More generally, the delay between the end of any transfer and the beginning of the following one can be 30µs minimum.

6.2.2.13.3 Interruption by the Dwell

The two transfers defined here above constitute a complete message for a given acquisition, and any other transfer shall not alter the acquisition result.

In particular, one dwell acquisition occurrence (asynchronous in relation to the normal acquisition managed cyclically by the SCU) taking place between the 1st transfer (receive command) and the 2nd transfer (transmit command), shall not alter the information retrieved by the 2nd transfer and this, regardless of the dwell acquisition which, in most cases, could also be an acquisition in two transfers. It is therefore necessary to store the acquisition result in different registers for a normal acquisition and a dwell acquisition.

The multiplexing and the ADC conversion or the acquisition of register content (status, AS8, AS16) shall be performed on this 1st transfer (« receive command »), while the 2nd transfer (« transmit command ») shall be a simple reading of a register ; therefore the result shall be stored in separate registers (normal acquisition and dwell acquisition register(s)) during the first transfer.

The distinction between a normal acquisition and a dwell acquisition, at the register storage level, shall take place during the 1st transfer (« receive command »), by means of different sub-addresses.

The distinction at the level of the result register reading shall take place in the 2nd transfer (« transmit command ») therefore at different sub-addresses.

The first transfer being always in writing mode and the second transfer in reading mode, the same sub-address shall be selected for the two transfers of a given acquisition, the distinction between the storage in the result register and its reading being achieved by the T/R bit ; the distinction between a normal acquisition and a dwell acquisition shall be made on one bit (MSB) of the sub-address.

This mechanism is depicted in figure 6.2/6.

To sum up, the first transfer of a normal acquisition shall define the multiplexing level (« end address »), start the acquisition and store the result in the « normal acquisition » register.

The second transfer of this acquisition shall read the result in this register.

If a dwell acquisition takes place between these two transfers, the first transfer of the dwell acquisition shall define the multiplexing level (« end address »), start the acquisition and store the result in the « dwell acquisition » register.

The second transfer of the dwell acquisition shall read the result in the « dwell acquisition » register and the « normal acquisition » register content shall not be affected ; the second transfer of the normal acquisition shall then read its result in this register.

- Normal and dwell acquisitions are managed asynchronously, so that there shall be no restriction at any subscriber level, with respect to the dwell acquisition occurrence (except that the IMG requirement is met).
- The first and the second dwell acquisition transfers are always contiguous (the insertion of another transfer not possible).
- The maximum dwell interrogation rate is 300 Hz.

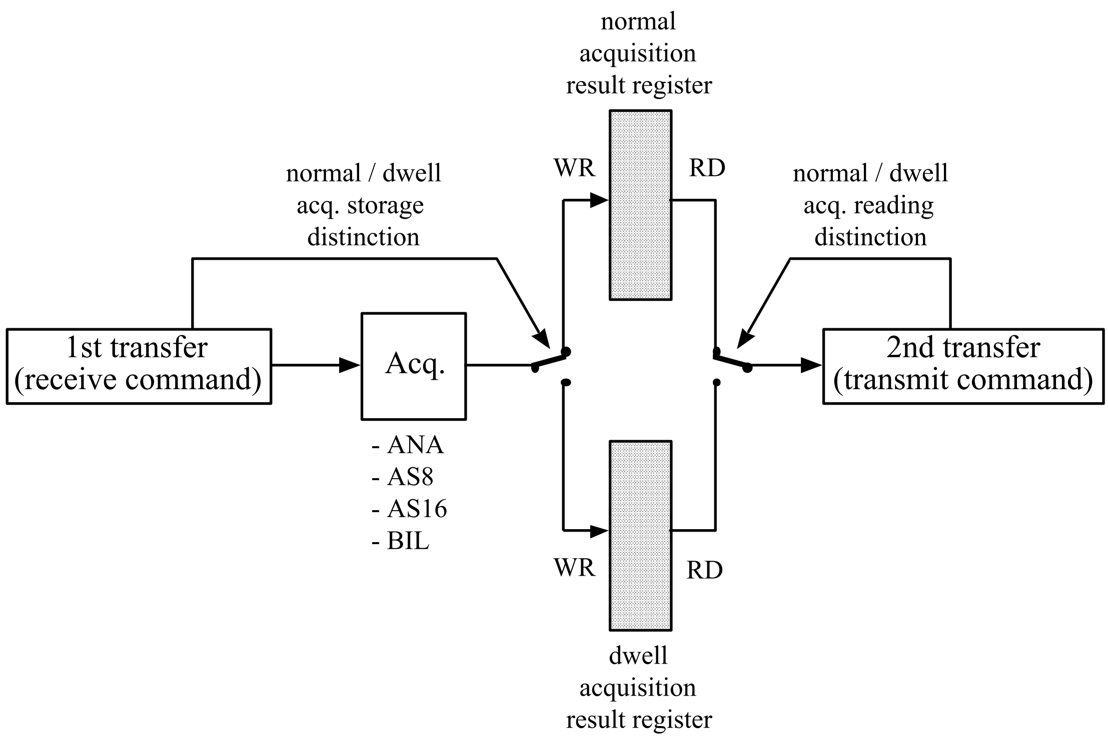


FIGURE6.2/6 : Interruption by the Dwell - Normal and Dwell registers

6.2.2.13.4 1553B Subscriber Protocol

The aim of this section is to define the protocol in terms of messages structure on the 1553B bus towards the subscriber equipments of the avionics.

There are 3 kinds of subscribers :

- Simple subscribers : concerns subscribers needing less (or equal) than 14 telecommands and 14 acquisitions. Such subscribers will advantageously use the direct sub-addressing with commands and acquisitions performed with a single transfer.
- Complex subscribers : concerns subscribers needing more than 14 telecommands or more than 14 acquisitions. Such subscribers shall use the indirect sub-addressing, with acquisitions performed with double transfer.
- « Intelligent » subscribers : such as remote slave computers with memory upload and dump needs. Intelligent subscribers protocol is defined in RD6.

6.2.2.13.4.1 1553B Protocol for the complex subscribers

The structure of each message is described here below for commands and acquisitions :

Commands : LSC and HLCD

Receive Command	Data 1	**	Status	#

Commands : ML, HLCP, VHLC, HPC

Receive Command	Data 1	Data 2	**	Status	#

Acquisitions : BIL, AS8, AS16, ANA

1st transfer	Receive Command	Data 1	**	Status		#
2nd transfer	Transmit Command	**	Status	Data 3		#

The structure of a command word (receive command or transmit command) is recalled here :

3	5	1	5	5	1
Synchro	RT address	T/R	Sub-address / mode	Data count / mode code	P

The « RT address » field has been defined in the § 6.2.2.13.1.

The T/R bit is set to '0' in the case of a receive command and to '1' in the case of a transmit command.

The sub-address field is defined as follows :

MSB	SA4	SA3	SA2	SA1	SA0	LSB

The SA4 bit (MSB) of the sub-address field (SA4 to SA0) is, as seen above, reserved for normal/dwell distinction. (D=0, dwell acquisition ; D=1, normal acquisition). As this bit is useful for acquisitions only, the transfers related to commands shall not decode it (X means that the SCU can set this bit indifferently to '0' or '1').

The SA3 to SA0 bits will be used for coding the different types of commands as described in the following table.

SA4	SA3	SA2	SA1	SA0	Command		
0	0	0	0	0	Forbidden		
X	0	0	0	1	Memory Load command	(ML)	
X	0	0	1	0	Long Switch closure on/off	(LSC)	48 ms
X	0	0	1	1	High-level on/off command	(HLCD)	48 ms
D	0	1	0	0	Digital Bi-level data acquisition	(BIL)	
D	0	1	0	1	16-bit serial digital data acquisition	(AS16)	
D	0	1	1	0	8-bit serial digital data acquisition	(AS8)	
D	0	1	1	1	Analogue data acquisition	(ANA)	
X	1	0	0	0	Very high level command	(VHLC)	100 ms
X	1	0	1	0	High power command	(HPC)	750 ms
X	1	0	1	1	HLC payload command	(HLCP)	48 ms

Recall : - the sub-addresses '00000' and '11111' are reserved for mode command

- the sub-address '11110' is reserved for data-wrap-around test

X : can be indifferently '0' or '1' ; D = '0' : Dwell acquisition ; D = '1' : Normal acquisition

The Data count / Mode code field, associated to ML, LSC, HLCD, HLCP, VHLC, HPC, BIL, AS16, AS8, and ANA transfers allows to determine the number of data words associated to the transfer.

The value of this field is defined in the following table for each transfer :

Command	Data count
ML (Receive command)	0 0010
LSC and HLCD (Receive command)	0 0001
HLCP, VHLC, HPC (receive command)	0 0010
BIL, AS8, AS16, ANA (Receive command)	0 0001
BIL, AS8, AS16, ANA (Transmit command)	0 0001

The structure of a data word is defined here below :

3	16	1
Synchro	Data	P

For all « Receive command » transfers defined at the beginning of the section 6.2.2.13.4.1., the Data 1 word will include the end-address corresponding to this command/acquisition.

A theoretical addressing capability of 65536 channels is therefore available.

Practically, it could be interesting, in order to simplify the decoding at the subscriber level, to partition this 16-bit Data 1 word according to the different applications.

For Memory Load Commands, the Data 1 word corresponds to the ML channel address as defined above, and the Data 2 word corresponds to the actual information of the ML command.

For the 2nd transfer of acquisitions (transmit command), the Data 3 word (result of acquisition) will be sent back in response by the subscriber (single 16-bit word).

SUMMARY (for complex subscribers)

LSC commands

Receive Command	Data 1 (end address)	**	Status	#

⇓

	XXXXX	0	X0010	00001	
Synchro	RT address	T/R	Sub-address / mode	Data count / mode code	P

HLCD commands

Receive Command	Data 1 (end address)	**	Status	#

⇓

	XXXXX	0	X0011	00001	
Synchro	RT address	T/R	Sub-address / mode	Data count / mode code	P

ML command, HLCP, VHLC, HPC

Receive Command	Data 1 (end address)*	Data 2 (ML data or end address*)	**	Status	#

⇓

	XXXXX	0	YYYYY	00010	
Synchro	RT address	T/R	Sub-address / mode	Data count / mode code	P

with YYYYY=X0001 for ML

YYYYY=X1000 for VHLC

YYYYY=X1010 for HPC

YYYYY=X1011 for HLCP

* For HLCP, VHLC, and HPC, the receive command is constituted by two data words, in order to have the possibility to send 4 commands simultaneously. The 32 bits of end address correspond then to 4x8 bits, witheach « 8 bits » defined as follows :

$\underbrace{\text{MSB}}_{\text{Xboard selection}}\ \underbrace{\text{X X X}}_{\text{Column selection}}\ \underbrace{\text{X X X LSB}}_{\text{Row selection}}$

All « 8 bits » are set to « 0 » in case of « no command »

BIL acquisitions

1st transfer

Receive Command	Data 1 (end address)	**	Status	#

⇓

	XXXXX	0	D0100	00001	
Synchro	RT address	T/R	Sub-address / mode	Data count / mode code	P

2nd transfer

Transmit Command	**	Status	Data 3 (result)	#

⇓

	XXXXX	1	D0100	00001	
Synchro	RT address	T/R	Sub-address / mode	Data count / mode code	P

AS16 acquisitions

Same as BIL acquisition but with a sub-address 'D0101'

AS8 acquisitions

Same as BIL acquisition but with a sub-address 'D0110'

ANA acquisitions

Same as BIL acquisition but with a sub-address 'D0111'

For ANA acquisitions, the Data3 word (result) shall be as follows :

MSB	X X X X	ADC results (12 bits)	LSB

Notations :

XXXXX = RT Address

X : indifferently '0' or '1'

D bit of sub-address field : D='1' normal acquisition

D='0' dwell acquisition

6.2.2.13.4.2 1553B Protocol for the simple subscribers

The protocol defined in this section is applicable to simple subscribers which do not require double transfers to comply with the sub-addressing capability requirements.

For these equipments, the application of the protocol defined for the complex subscribers may increase unnecessarily the complexity of their subscriber coupler and of the associated transfers.

The commands will be sent with the following format :

Receive Command	Data 1 (data)	**	Status	#

⇓

	XXXXX	0	1YYYY	00001	
Synchro	RT address	T/R	Sub-address / mode	Data count / mode code	P

Transmit Command	**	Status	Data (result)	#

⇓

	XXXXX	1	1YYYY	00001	
Synchro	RT address	T/R	Sub-address / mode	Data count / mode code	P

- XXXXX = RT Address of the equipment (refer to § 6.2.2.13.1 of this section).
- The MSB of Sub-address / mode field is forced to '1'
- YYYY = equipment sub-addresses (according to equipment definition).

As double exchanges are no longer required, the normal/Dwell distinction is no longer needed, and the « interruptibility by the Dwell » requirements are not applicable.

When an analogue-to-Digital converter (ADC) is used, the channel multiplexing plus the conversion time might not be compatible with a single transfer command ; in that case the subscriber shall use the double transfer philosophy and becomes a complex subscriber, and subsequently the « interruptibility by the Dwell » requirements shall apply.

6.2.2.13.5 Timing constraints

For a given subscriber, all command types can be sent with only the intermessage gap (IMG) (> 30 µs) between two commands.

The time gap between the single commands is defined below (in ms) :

2nd command ☞ 1st command ☟	ML	HLCD /LSC	HLCP	VHLC	HPC
ML	IMG	IMG	IMG	IMG	IMG
HLCD/LSC	IMG	100	100	100	100
HLCP	IMG	100	100	100	100
VHLC	IMG	200	200	200	200
HPC	IMG	1000	1000	1000	1000

Concerning the acquisitions (transmit command transfer) performed on a simple subscriber, the result shall be immediately ready for transmission in the given transfer (data word following the status word).

7 THERMAL DESIGN AND INTERFACES REQUIREMENTS

7.1 THERMAL DESIGN REQUIREMENTS

7.1.1 Temperature, heat flux and daily variation

Required values for non functioning, start-up operational temperature limits (average on the baseplate except if specific requirements are identified in the equipment specification) and daily variation are given in table 7.1/1, together with allowable values for base heat flux. Daily variation is defined without any margin and for a stabilised payload configuration.

The baseplate heat flux is defined as the ratio of the thermal dissipation versus effective contact area when the equipment is in the test configuration described in §10.8.

Local heat flux shall not be greater than 1.5 x specified baseplate average heat flux. (Baseplate heat flux is not applicable to radiatively controlled equipment).

7.1.2 Temperature stability

Any special requirements for temperature stability on particular equipment shall be brought to the attention of the Prime Contractor as early as possible. Equipment thermostatically controlled requires specific care and shall be brought to the attention of the Prime Contractor.

7.1.3 Component temperature limits

The requirements for case or junction temperature for all solid state devices (or other components with similar requirements) on or inside the equipment are as follows :

- Component temperature to be at or inside the appropriate maximum life derated value for the component as given by RD2, when the equipment is at its maximum operating temperature.
- Component temperature to be at or inside the appropriate maximum rated value as given by manufacturer's data, when the equipment is at its maximum qualification temperature limits.

7.1.4 Equipment thermal analysis requirements

An equipment thermal analysis is required for all equipment carried on-board, covering the most thermally critical operating modes and including transient cases where relevant.

The objective of the analysis is to demonstrate that internal components have acceptable temperatures (refer to § 7.1.3) when the equipment itself (i.e. case or baseplate) is at its functioning temperature limits (TFOmin,max and TFOmin,max) and to verify that the heat flux density (skin or baseplate) is inside the specified range. The detail of the model shall be such that peak fluxes can be predicted to within +/-5% accuracy.

The analysis can be simple for radiatively controlled equipment, but the level of local detail shall be sufficient to give valid temperature predictions for the most thermally critical internal components and to show any hot and cold spots on the case and on the baseplate of equipment.

For conductively controlled equipment, a preliminary thermal analysis shall be carried out early in the design stages to highlight potential problem areas.

A simplified thermal model shall be provided to the Prime Contractor. This thermal model will be representative of the internal equipment conductance and will be composed of typically 1 or 2 nodes for simple radiative equipment, up to 6 or 8 nodes for highly dissipative equipment like OMUX or TWTA. Thermal analysis validity shall be proved by the equipment Supplier and accepted by the Prime Contractor. This validity shall be proved by a test with correlations.

Equipment acceptance temperatures are :

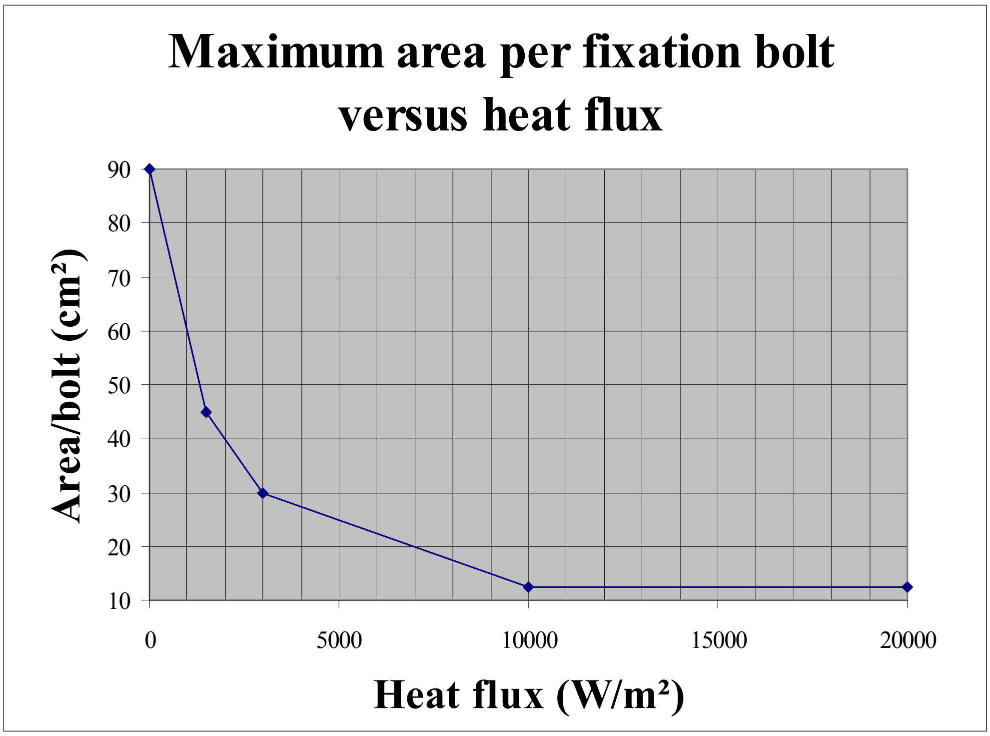
- $TFA_{min} = TFO_{min} - 5°C$
- $TFA_{max} = TFO_{max} + 5°C$

Equipment qualification temperature are :

- $TFQ_{min} = TFO_{min} - 10°C$
- $TFQ_{max} = TFO_{max} + 10°C$

7.1.5 Number of fixation bolts per equipment

[R] The number of fixation bolts on each equipment depends of the unit internal dissipation. The minimum surface by fixation bolts depending of the local unit baseplate thermal flux shall satisfy the condition given on the following figure.



	TEMPERATURE LIMITS °C					
EQUIPMENT	**Non functioning TNF**	**Start-up TSU min**	**Functioning operating TFO**	**Temp limits definition**	**Daily variation**	**Flux W/m² (if conductive)**
Payload						
TWT	-35 / +95	-35	-5 / +80	Baseplate	15°C	<16000 for TWT
EPC	-35 / +75	-35	-10 / +60	Baseplate	15°C	
OMUX	-40 / +90	-40	+10 / +75 (*)	Baseplate	15°C	<3500 if S<100cm2
IMUX	-40 / +75	-40	+10 / +60 (*)	Case	15°C	<1500 if S>100cm2
CAMP/DLA	-40 / +75	-40	-10 / +60	Baseplate	15°C	for other payload units
SSPA	-40 / +80	-40	0 / +65	Baseplate	15°C	
RECEIVER	-40 / +75	-40	-10 / +60	Baseplate	15°C	
LNA	-40 / +75	-40	-10 / +60	Baseplate	15°C	
Input FILTER	-40 / +75	-40	-10 / +60	Baseplate	15°C	
Output FILTER	-40 / +90	-40	0 / +75	Baseplate	15°C	
Input SWITCH	-40 / +90	-40	-10 / +75	Baseplate	15°C	
Output SWITCH	-40 / +90	-40	0 / +75	Baseplate	15°C	
DIPLEXER	-40 / +90	-40	0 / +75	Baseplate	15°C	
APME	-40 / +75	-40	-10 / +60	Baseplate	15°C	
PROCESSOR	-40 / +75	-40	0 / +60	Baseplate	15°C	
High Power Load	-40 / +135	-40	-10 / +120	Baseplate	15°C	
Isolator	-40 / +90	-40	+10 / +75	Baseplate	15°C	
Circulator	-40 / +90	-40	+10 / +75	Baseplate	15°C	
Test Coupler	-40 / +90	-40	-10 / +75	Baseplate	15°C	
External W/Guide	-160 / +150	NA	-145 / +135	NA	NA	
Internal W/Guide	-40 / +150	NA	-25 / +135	NA	NA	
Other ONET unit	-40 / +90	-40	-10 / +75	TBD	15°C	
Other unit	-40 / +75	-40	-10 / +60	TBD	15°C	
Platform						
MPIU	-40 / +75	-40	-25 / +60	Baseplate	15°C	<1500 if S>100cm2
SCU	-40 / +75	-30	-20 / +60	Baseplate	15°C	<2500 if S<100cm2
ADE4	-40 / +75	-40	-25 / +60	Baseplate	15°C	for all platform units
GEU	-40 / +75	-40	-25 / +60	Baseplate	15°C	
GMU	-25 / +70	-10	0 / +45	Baseplate	15°C	
Momentum Wheel	-40 / +75	-10	-10 / +60	Case/Env	15°C	
WDE	-40 / +75	-25	-15 / +60	Baseplate	15°C	
Reaction Wheel	-40 / +75	-10	-10 / +60	Baseplate	15°C	
PRU	-40 / +75	-40	-25 / +60	Baseplate	15°C	
PSR Day CM	-40 / +75	-40	-25 / +60	Baseplate	15°C	
PSR Night CM	-40 / +75	-40	-25/55	Baseplate	15°C	
PPU	-45 / +75	-30	-15 / +60	Baseplate	15°C	
IRES	-40 / +65	-40	-15 / +50	Foot	40°C	
BASS	-80 / +95	NA	-30 / +80	Baseplate	NA	
LiASS	-90 / +100	NA	-10 / +80	Baseplate	NA	
TTC TRSP	-40 / +75	-40	-10 / +60	Baseplate	15°C	
TTC Beacon	-40 / +75	-40	-10 / +60	Baseplate	15°C	
Relay bracket	-40 / +85	-40	-30 / +70	Baseplate	15°C	

(*) actual flight range is given in equipment specification

TABLE 7.1/1 : EQUIPMENT TEMPERATURE LIMITS

7.1.6 Equipment thermal analysis approach

Analysis configuration and qualification test configuration must be as similar as possible and representative of flight configuration. These configurations are described in equipment environmental test requirements.

7.1.6.1 Internally mounted radiative equipment

For every operational modes, the nominal dissipation versus the total external area of the equipment is less than 70W/m2.

The thermal environment for analysis will be :

- No conductive coupling
- Radiative environments*:
- TFO_{max} - 10°C for hot cases but not lower than 40°C (*unless TFO_{max} explicitly refers to Environment)
- TFO_{min} - 15°C for cold cases but not lower than - 40°C

* For some equipment the temperature reference point TFO_{max} may be defined explicitly as the radiative environment (e.g. momentum wheel).

7.1.6.2 Internally mounted conductive equipment

Hot case : baseplate temperature is TFO_{max} and the radiative environment seen by the five other faces is TFO_{max}

Cold case : baseplate temperature is TFO_{min} and the radiative environment seen by the five other faces is TFO_{min} - 15°C (but not less than - 40°C).

7.1.6.3 Externally mounted equipment

Equipment level thermal analysis for externally mounted equipment shall take into account :

- the relevant external environments given in §8.4.
- any special interface requirements given elsewhere in this specification or in the Detailed Interface Handbook.
- Equipment with view factors to space : the analysis shall simulate the output/input of solar flux and the view factors with space.

Potential problems in this area should be brought to the attention of the Prime Contractor. Where necessary, the Prime Contractor will provide definition of the satellite geometry, thermo-optical properties and boundary temperatures.

7.1.7 Thermal Finishes for internal Equipment

All internal equipment shall be provided with a high emittance surface > 0.8. The only exceptions to this requirement could be for small non-dissipative equipment, and shall be agreed by the Prime.

7.1.8 Design requirements under dissipative failure conditions

For equipment being not internally redundant, it is required that under all failure mode conditions causing an equipment overdissipation, the failure does not affect the capability of the equipment to be switched off.

For equipment being internally redundant, the same applies. Moreover, for the channels without failure, it is requested that component temperature remain inside the appropriate life derated range.

7.2 THERMAL INTERFACE REQUIREMENTS

7.2.1 Reference point

See definitions in §3.3.

7.2.2 Mounting provision

7.2.2.1 Interface filler

Certain very dissipating equipments shall be mounted with an interface filler (DC93500, SIGRAFLEX). The choice between one and the other is dependent on the following criteria :

- Thermal performance (DC93500 is better than SIGRAFLEX)
- Dismountability (SIGRAFLEX is better than DC93500)
- Electro/Chemical compatibility (e.g. SIGRAFLEX contains carbon and reacts with Gold)

Generally, SIGRAFLEX shall be used for the equipments that have a large contact area and/or are mounted directly to the panel face-skin and DC93500 for the others when mounted directly to surface heatpipes.

7.2.2.2 Thermal washers

Certain equipments shall be able to be mounted with isolating washers. (e.g. batteries, BASS, DEMUX...)

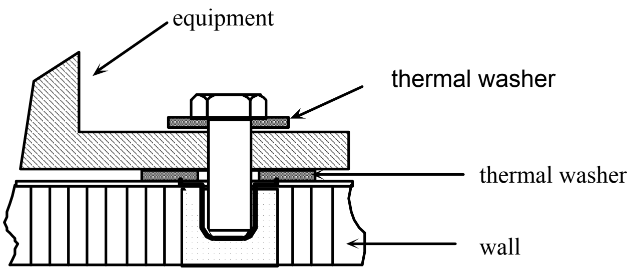


FIGURE 7.2/1 : Mounting with thermal washers

7.2.2.3 Spacers

Certain equipment shall be able to be mounted with spacers (e.g. TWT, OMUX, PPU).

7.2.2.4 I/F with heat pipes

Certain equipment shall be mounted over heat pipes (e.g. EPC, TWT, SSPA, OMUX, PPU, SSPA, ...). For equipment mounted to directly 'surface mounted' heat pipes, spacers shall be used, as far as possible (without accessibility problem) so that the heat pipe flanges should not endure stress during launch and strains from tightening. Without spacers the heat pipe and its interface filler risk a damage.

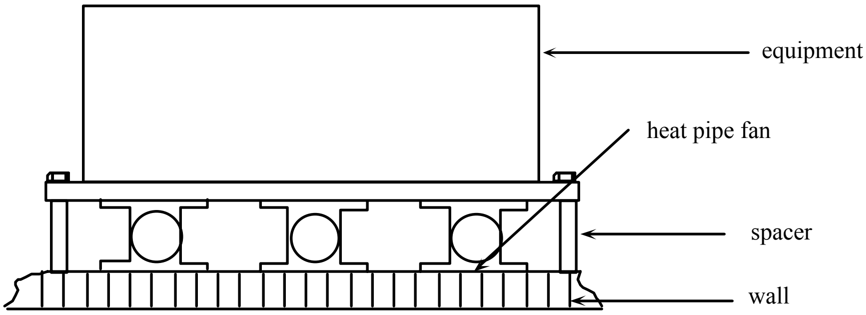


FIGURE 7.2/2 : INTERFACE WITH HEAT PIPE
(principle drawing : spacers are generally put between heat pipes)

7.2.2.5 Contact thermal conductance

The contact thermal conductance at equipment to satellite structure interface level is provided on Figure 7.2/3, for local heat flux calculation and thermal reference point selection purpose.

EQUIPMENT	Contact thermal conductance (W/m2.K)	COMMENTS
Payload :		
TWT	2000	DC93500
EPC	1000	DC93500
OMUX	800	SIGRAFLEX
IMUX	NA	Radiative equipment
CAMP/DLA	1000	DC93500
SSPA	2000	DC93500
RECEIVER	800	SIGRAFLEX
LNA	800	SIGRAFLEX
FILTER	300	Dry contact
SWITCH	300	Dry contact
DIPLEXER	800	SIGRAFLEX
APME	800	SIGRAFLEX
PROCESSOR	800	SIGRAFLEX
High Power Load	2000	DC93500
Other ONET units	TBD	TBD
Platform :		
MPIU	200	SIGRAFLEX
SCU	1000	DC93500
ADE4	200	SIGRAFLEX
GEU	300	Dry contact
GMU	800	SIGRAFLEX
Momentum wheel	300	Dry contact (Radiative equipment)
WDE	200	SIGRAFLEX
Reaction wheel	800	SIGRAFLEX
PRU	20	Dry contact
PSR	800	SIGRAFLEX
PPU	1000	DC93500
IRES	300	Dry contact
LiASS	300	Dry contact
BASS	300	Dry contact
TTC TRSP	200	SIGRAFLEX
TTC Beacon	200	SIGRAFLEX
Relay bracket	300	Dry contact

FIGURE 7.2/3 : CONTACT THERMAL CONDUCTANCE

8 GROUND AND FLIGHT ENVIRONMENTS

8.1 GENERAL

[R10] The requirements in this section refer to the transportation, handling, storage, pre-launch, launch/ascent, transfer orbit, and on station environments. Where specific levels are not stated in this section, then the environmental design requirement is that specified in the test section for equipments qualification levels.

[R20] Equipments shall be designed to achieve their specified performance requirements during and/or after exposure to the specified environments. The demonstration can be done by test or analysis, after Prime Contractor approval.

[G30] If handling, transportation and storage environments drive the design of an equipment, then the Prime Contractor shall be advised.

8.2 HANDLING, TRANSPORTATION AND STORAGE

[R] The normal modes of transportation to be considered shall include air, sea and overland. The environments experienced during the fabrication, delivery, storage and installation phases shall be controlled so as to be significantly less severe than launch and ascent conditions.

8.2.1 Handling

[R10] The equipments shall be designed to withstand the ground handling limit loads as defined in Table 8.2/1. In each case, vertical and horizontal loads can apply simultaneously. Values for the vertical condition include normal gravity (1 "g").

[R20] This loads have to be considered for any equipment orientation.

	CONDITION	EQUIPEMENTS
HOISTING either at unit and spacecraft levels	VERTICAL HORIZONTAL	2.0 g 0.1 g
ON. INTEG. FIXTURE	VERTICAL HORIZONTAL	1.5 g 1.5 g

TABLE 8.2/1 - GROUND HANDLING LIMIT LOADS

8.2.2 Transportation

a) Steady state acceleration

[R10] Equipment transportation containers and their method of transportation shall be such as to ensure that levels experienced by the equipments are less severe than those specified in Table 8.2/2. Values for the vertical condition include normal gravity (1.0 "g").

[R20] This loads have to be considered for any equipment orientation.

	CONDITION	EQUIPEMENTS
AIR TRANSPORTATION	VERTICAL	2.5 g
	HORIZONTAL	3.5 g
GROUND TRANSPORTATION	VERTICAL	3.0 g
	HORIZONTAL	2.0 g

TABLE 8.2/2 - TRANSPORTATION STEADY STATE LIMIT LOADS

b) Sine and random vibration

[R30] Transportation containers shall be designed to ensure that the load levels passed on to the flight equipment are limited to the constant acceleration levels defined in Section a) above and table 8.2/2.

c) Shock

[R40] For containers, the shock requirement is a drop of 100 mm onto concrete of one corner of the container, an other corner lying on the concrete floor.

[R50] The transportation containers shall be designed to ensure that the flight equipment contained within is protected from and shall be undamaged by shocks.

d) Temperature

[R60] Equipments may suffer extremes of temperatures during transportation and they shall be designed to withstand the environments and tests specified in § 10.

[R70] Containers shall be marked external with temperature limits which are equal to or within the non-operating temperature limits for the equipment(s) inside. Containers, in transit or in storage under extreme temperatures from -40 °C to +65 °C during 8 hours, shall be given protection or environmental conditioning as necessary to ensure that the marked temperature limits are not exceeded by the equipments inside.

8.2.3 Storage

[R] By appropriate environmental control and maintenance to be defined by supplier, it shall be possible to store all elements of the spacecraft for the storage period duration given in §4.3.5.4. Separate storing of critical items requiring periodic checking and/or storage in a particular orientation, storing of piece parts rather than integrated units or assemblies, and the replacement of items demonstrated to be subject to excessive deterioration, will be allowed during the storage period. These requirements have to be clearly defined by the Subcontractor in the equipment user's manual.

It is also recalled that all specified performance requirements have to be met through the in-orbit storage period duration given in §4.3.5.4.

8.3 PRE-LAUNCH AND LAUNCH/ASCENT ENVIRONMENT

8.3.1 General

[R] The environments of pre-launch and launch/ascent phases are covered by test specifications of chapter 10. These tests cover transient, sine, random and acoustic environment of launch phase. They also cover the thermal environments during parking orbit (when applicable).

8.3.2 Shock (separation and deployment)

[R] Shocks will be experienced at fairing separation, at satellite separation and when appendage deployments devices are activated. Resultant structural response characteristics resemble the form of complex decaying sinusoid which can excite resonant responses in equipment. The equipments have to withstand the Shock Response Spectrum (SRS) of chapter 10, which depend on their location on the satellite.

8.3.3 Depressurization

[R10] For the design of the equipments, the following assumptions have to be used :

- maximum pressure decay rate of 70 mbars / sec.
- pressure decay of 0.8 bar in 27 sec

(these values are more stringent than the envelope of the worst launcher conditions : 20mbar/sec over 20sec; peak at 69mbar/sec of very short duration on some launchers; 0.8 bar in 75 sec min)

[R20] A demonstration by test (see §10.6) is required. Alternately, a venting analysis showing a margin factor of 1.5 with the here above hypotheses, could be accepted after Prime approval.

8.3.4 Corona

[R] Units ON during launch will be submitted to all pressure values between 1 bar and 0 bar. They have to be designed to operate in such an environment without any arcing (see §10.4).

8.3.5 Aero-thermal flux

[R] Externally mounted units, shall be able to withstand a nominal aero-thermal flux of 1135W/m2. In addition, for some particular launch configuration, they shall be able to withstand 1500W/m2 during 70sec.

8.4 IN ORBIT ENVIRONMENT

8.4.1 Microvibrations

[R10] Sinusoidal vibration can be induced by the operation of the spacecraft actuators. The in-orbit flight excitations induced by all units at baseplate level, shall be equal or lower than the following spectrum :

5 - 200 Hz	10^{-2}g
200 - 450 Hz	decrease based on $1/f^2$
450 - 2000 Hz	2 x 10^{-3}g

The method used to compute or measure the microvibrations generated at equipment level shall be approved at Prime Contractor level.

[R20] All equipment shall meet their performance requirements when submitted to this environment.

(qualification levels are 1.5 times the above level)

8.4.2 Vacuum

[R] Exposure to a hard vacuum commensurate with orbital altitude will occur at synchronous orbit, this will be 10^{-10} torr in free space, but may be as high as 0.1 torr within the spacecraft interior. Equipments shall be designed to operate in these environments, in particular without any arcing (see §10.4).

8.4.3 Sun and Earth Radiation

8.4.3.1 Solar radiation

[R10] Externally exposed equipment will be subjected to solar electromagnetic radiation and solar particle radiation. Values of total solar radiance to be used for thermal design of external equipments are :

DATE	SOLAR IRRADIANCE (W/m2)
Hot case Winter solstice	1422
Hot case Summer solstice	1332
Cold case Equinox (autumnal)	1357

[R20] The spectrum applicable to one solar constant at 1AU is as follows (Flux level in ergs cm-2 sec-1 /m-1):

SPECTRAL REGION	WAVELENGTH BAND	FLUX LEVEL ACROSS BAND	VARIABILITY IN CYCLE
Radio	λ > 1 mm	10^{-8} to 10^{-14}	100 X
Far infrared	1 mm $\geq \lambda$ > 10 µm	10^{-2}	Unknown
Infrared	10 µm$\geq \lambda$ > 0.75 µm	10 to 10^{-5}	Unknown
Visible	0.75 µm$\geq \lambda$ > 0.3 µm	10^{6}	< 1 percent
Ultraviolet	0.3 µm$\geq \lambda$ > 0.12 µm	10^{2} to 10^{5}	1 percent to 2 X
Extreme UV	0.12 µm$\geq \lambda$ >0.01µm	10^{2}	10 X
Soft X-ray	0.01 µm$\geq \lambda$ > 1 A	10^{2} to 10^{4}	100 X
Hard X-ray & Gamma ray	1 A $\geq\lambda$	10^{-4} to 10^{-5}	10 to 100 X

8.4.3.2 Albedo radiation (Earth and Moon)

[R10] The solar radiation reflected from the Earth is obtained with an average albedo value of 0.30 $\pm$ 0.02.

[R20] The solar radiation reflected from the Moon is obtained with an average albedo value of 0.15 (TBC).

8.4.3.3 Earth radiation

[R] The average value of infra-red Earth emission is 237 $\pm$ 7 W/m2 (Earth emitted value, not incident at the spacecraft).

8.4.4 Single Event Phenomena

Galactic Cosmic Ray (GCR) and solar flare radiation result in charge deposition inside EEE components, which can induce different kind of Single Event Phenomena (SEP), such as Single Event Upset (SEU), Single Event Latch-up (SEL), Burn-Out (BO) Single Event Gate Rupture (SEGR), Single Hard Error (SHE), Single Event Functional Interrupt (SEFI), Single Event Snapback (SES) and others.

[R10] Subsystems and equipment shall be designed to ensure that nominal performance is maintained in the presence of SEP (logical and analogue SEP).

[R20] The equipment Supplier shall compute the SEP occurrence probability and effects. SEP rate calculations and SEP characterisation are based on Linear Energy Transfer (LET) integral spectra for galactic cosmic ray and anomalous large solar flare conditions. Applicable integral spectra for both conditions are given on figure 8.4/2. The analysis rules are given in AD1.

The weather index M=3 defines an environment for GCR that will not be exceeded for more than 10% of the mission life. M=8 defines the environment during anomalous large solar flare conditions. At least 4 anomalous large solar flares of 4 days each, will be considered over a 15 years life, for upset occurrence probability computation.

[R25] Equipment improper operation resulting from Single Event Upset (logical and analogue SEU) over the orbital design life shall be at least a factor 10 less than the probability of improper operation from component failure (improper operation does not include telemetry transient anomaly).

[R30] The Subcontractors having access to CREME based codes can use the CREME parameters given in the table 8.4/1. If not, tabulated values are given in AD1.

CREME parameter	*Solar flare*	*GCR*
Geomagnetic cut-off	*Yes*	*Yes*
Earth Shadow	*Yes*	*Yes*
Magnetosphere	*Quiet*	*Quiet*
Heavy ion atomic number range	*1 to 92*	*1 to 92*
Weather index M	*M=8*	*M=3 (90 % Adams worst case)*
Shielding thickness	*1g/cm2*	*1g/cm2*

TABLE 8.4/1 - CREME PARAMETERS FOR GCR and SOLAR FLARES

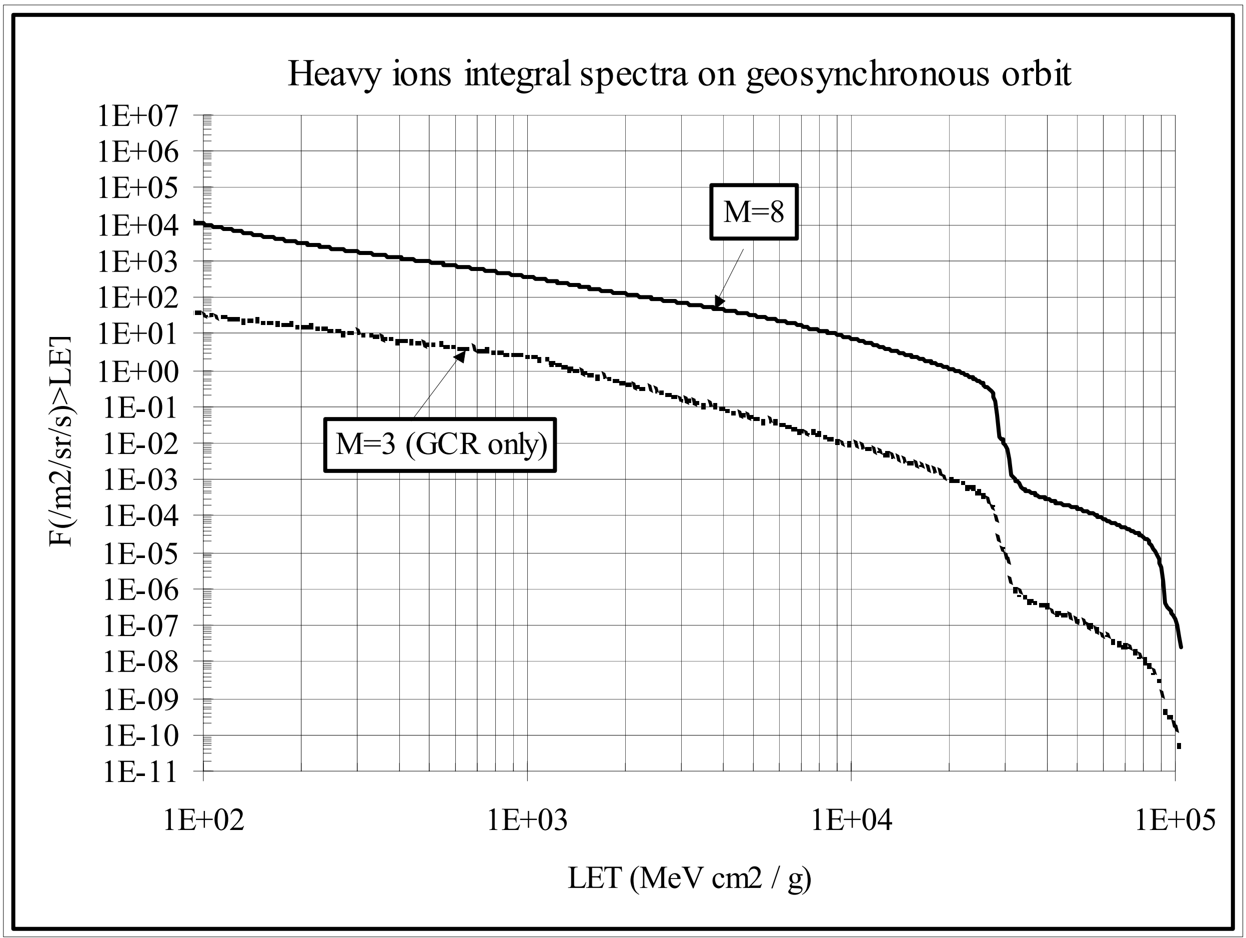


FIGURE 8.4/2 - LET SPECTRA

8.4.5 Mission Dose Depth Curve

The space radiation environment (electrons and protons) as seen by the satellite over the orbital design life (see figure 8.4/3) shows that the radiation dose seen by the units and components can be reduced by adequate shielding.

[R10] Units used in the spacecraft shall be designed to ensure that any radiation sensitive components have sufficient shielding such that any change in a component parameter resulting from the radiation environment does not degrade the unit performance below the specified limits (as detailed in the Worst Case Analysis of the equipment). Refer to AD1 concerning required margins wrt unit radiation analysis.

[R20] For the preliminary analysis, it shall be assumed that the satellite structure and its major components offers a shielding of at least : 0.5mm omni-directional for an equipment mounted inside the satellite; 0.5mm on the baseplate for an equipment outside the satellite. For equipment which cannot meet the above requirement, the Supplier shall ask for Prime Contractor to perform an analysis to define more accurately the shielding offered by the spacecraft. Analysis methods are specified in AD1.

[R30] Suppliers wishing to perform a more accurate analysis shall require to Prime Contractor the flux spectrum of particles as applicable to the mission.

[R40] The total dose curve given in figure 8.4/3, corresponds to a 160°W geostationary position, 15 years of lifetime, 4 anomalous large flares (King's model), 1D shell sphere calculation and over 4π steradian. This dose curve has to be used in conjunction with the method "NORM" for equivalent aluminium shielding computation at unit level (see AD1). This is the preferred method leading to the most accurate analysis.

[R50] Subcontractors having only sector analysis code using the "SLANT" method (see AD1), shall use it in conjunction with the solid sphere dose depth curve given in figure 8.4/5 and table 8.4/6.

[R60] The subcontractor shall inform the Prime Contractor of the method used since it may affect the satellite aluminium equivalent shielding.

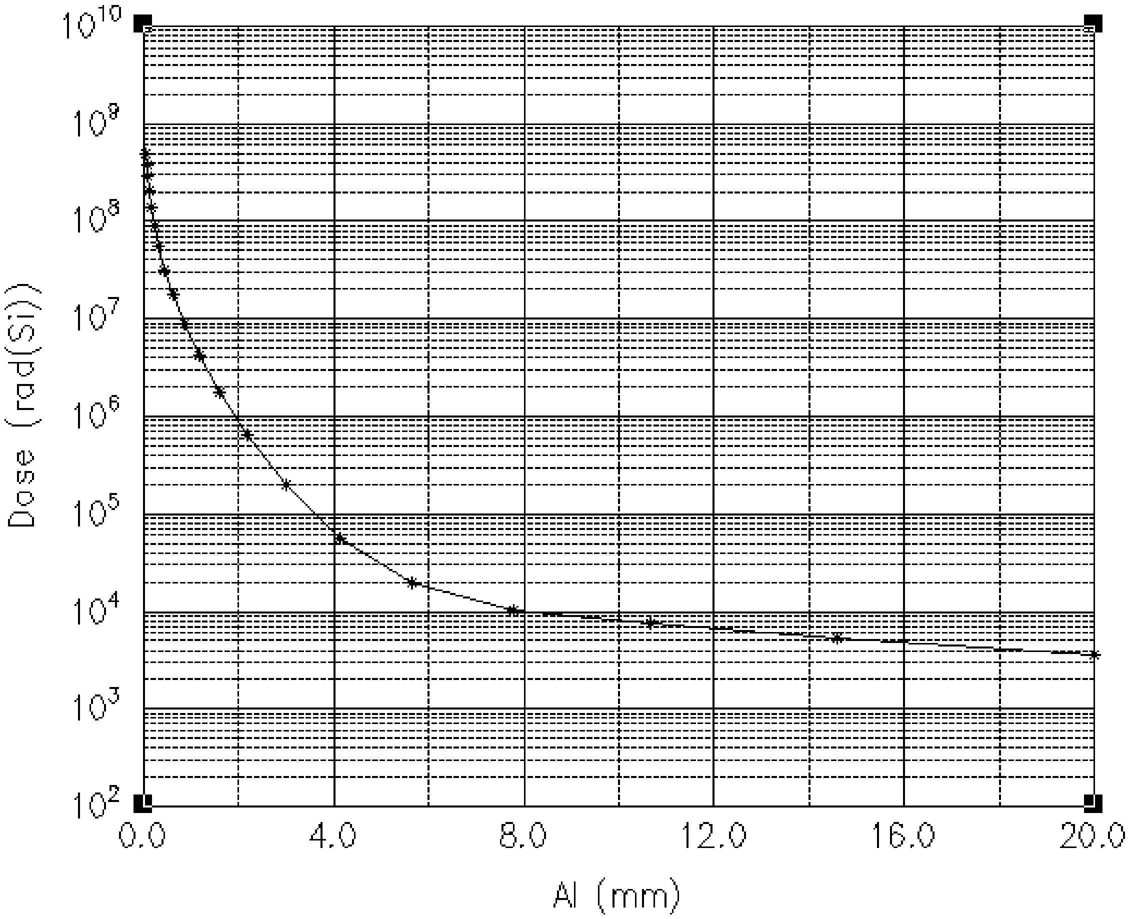


FIGURE 8.4/3 : GEOSTATIONARY ORBIT DOSE VERSUS ALUMINIUM SHIELDING THICKNESS
(15 years; shell sphere dose; 160°W; 4π steradian; 4 AL solar fares)

Al (mm)	Shell sphere dose (rad)	Al (mm)	Shell sphere dose (rad)	Al (mm)	Shell sphere dose (rad)
0.050	0.495E+09	0.473	0.297E+08	3.484	0.111E+06
0.064	0.406E+09	0.607	0.184E+08	4.472	0.409E+05
0.082	0.325E+09	0.779	0.110E+08	5.740	0.185E+05
0.106	0.254E+09	1.000	0.617E+07	7.368	0.110E+05
0.136	0.193E+09	1.284	0.325E+07	9.457	0.815E+04
0.174	0.142E+09	1.648	0.160E+07	12.139	0.626E+04
0.224	0.101E+09	2.115	0.729E+06	15.582	0.473E+04
0.287	0.695E+08	2.714	0.302E+06	20.000	0.343E+04
0.368	0.461E+08				

TABLE 8.4/4 : Dose depth values corresponding to Figure 8.4/3

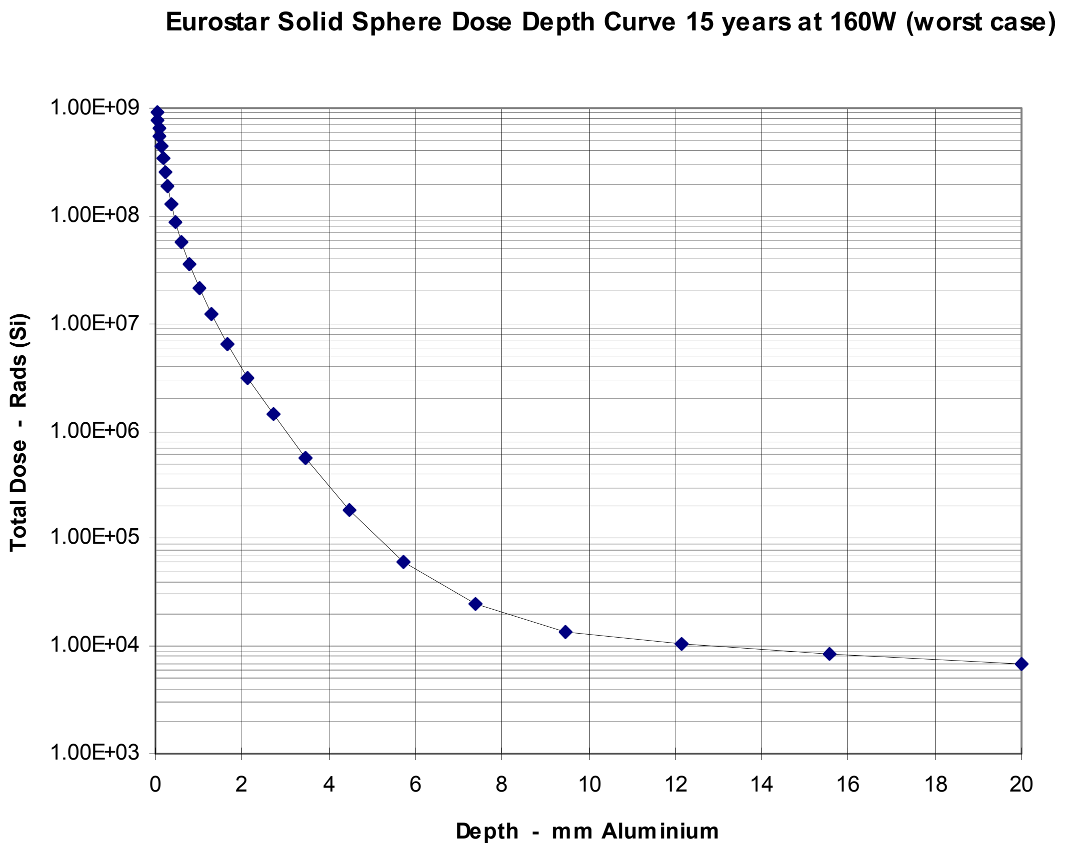


FIGURE 8.4/5 : GEOSTATIONARY ORBIT DOSE VERSUS ALUMINIUM SHIELDING THICKNESS
(15 years; solid sphere dose; 160°W; 4π steradian; 4 AL solar fares)

Al (mm)	Solid sphere dose (rad)	Al (mm)	Solid sphere dose (rad)	Al (mm)	Solid sphere dose (rad)
0.050	9.15E+08	0.473	8.65E+07	3.484	5.61E+05
0.064	7.89E+08	0.607	5.62E+07	4.472	1.86E+05
0.082	6.64E+08	0.779	3.55E+07	5.740	6.12E+04
0.106	5.47E+08	1.000	2.15E+07	7.368	2.44E+04
0.136	4.38E+08	1.284	1.21E+07	9.457	1.35E+04
0.174	3.41E+08	1.648	6.37E+06	12.139	1.07E+04
0.224	2.56E+08	2.115	3.13E+06	15.582	8.58E+03
0.287	1.86E+08	2.714	1.43E+06	20.000	6.80E+03
0.368	1.29E+08				

TABLE 8.4/6 : Dose depth values corresponding to Figure 8.4/5

8.4.6 Mission Displacement Damage Equivalent Fluence (DDEF)

The Space radiation environment can induce permanent damage by displacement in the active material bulk (Silicon, GaAs, or other). Estimation of displacement effects is based on the equivalent proton or neutron Displacement Damage Equivalent Fluence (DDEF) curve. DDEF is estimated considering relevant particle energy spectrum (trapped and flare protons, electrons) for solid sphere aluminum shielding.

[R10] Units used in the spacecraft shall be designed to ensure that any radiation sensitive components have sufficient shielding such that any change in a non-MOS active component parameter resulting from the radiation environment does not degrade the unit performance below the specified limits (as detailed in the Worst Case Analysis of the equipment). The analysis shall comply with requirements presented in [AD1].

[R20] For the preliminary analysis, it shall be assumed that the satellite structure and its major components offers a shielding of at least 0.5mm omni-directional for an equipment mounted inside the satellite and 0.5mm on the baseplate for an equipment outside the satellite. For equipment which cannot meet the above requirement, the Supplier shall ask for Prime Contractor to perform an analysis to define more accurately the shielding offered by the spacecraft. The agreed analysis methods are specified in [AD1].

[R30] DDEF curves given in figure i, corresponds to a 160°W geosynchronous position, 15 years of lifetime, 4 anomalous large flares (King's model), 1D solid sphere calculation and over 4π steradian. The DDEF curve is presented on figure 8.4/7 for Silicon target and figure 8.4/9 for GaAs target.

[R40] Suppliers wishing to perform a more accurate analysis shall require to Prime Contractor the flux spectrum of particles as applicable to the mission.

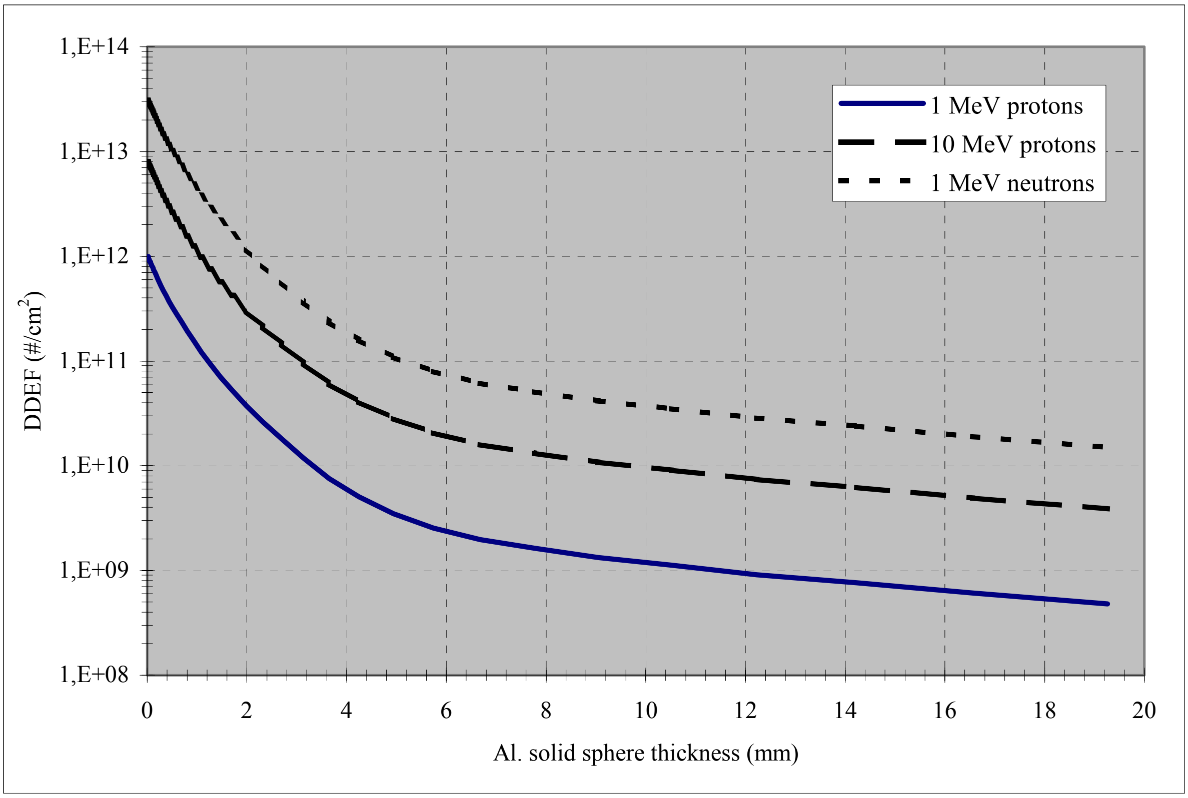


Figure 8.4/7 : DDEF on Geosynchronous orbit, 15 years mission (4AL solar flares), 160°W, 4π steradian, for** Silicon target**, solid sphere aluminum shielding

Shielding thickness (mm)	DDEF (#/cm²)			Shielding thickness (mm)	DDEF (#/cm²)		
	1 MeV protons	10 MeV protons	1 MeV neutrons		1 MeV protons	10 MeV protons	1 MeV neutrons
0,01	9,91E+11	8,02E+12	3,10E+13	5,74	2,54E+09	2,06E+10	7,95E+10
0,05	8,95E+11	7,24E+12	2,80E+13	6,68	1,97E+09	1,59E+10	6,15E+10
0,11	7,76E+11	6,28E+12	2,43E+13	7,77	1,63E+09	1,32E+10	5,09E+10
0,51	3,25E+11	2,63E+12	1,02E+13	9,04	1,33E+09	1,08E+10	4,17E+10
1,09	1,21E+11	9,81E+11	3,79E+12	10,52	1,12E+09	9,07E+09	3,51E+10
1,99	3,73E+10	3,01E+11	1,17E+12	12,23	9,12E+08	7,38E+09	2,85E+10
3,14	1,18E+10	9,56E+10	3,69E+11	14,23	7,65E+08	6,19E+09	2,39E+10
3,65	7,55E+09	6,11E+10	2,36E+11	16,56	6,08E+08	4,92E+09	1,90E+10
4,24	5,05E+09	4,09E+10	1,58E+11	19,26	4,78E+08	3,87E+09	1,50E+10
4,94	3,49E+09	2,83E+10	1,09E+11				

Table 8.4/7 : tabulated values corresponding to figure 8.4/7

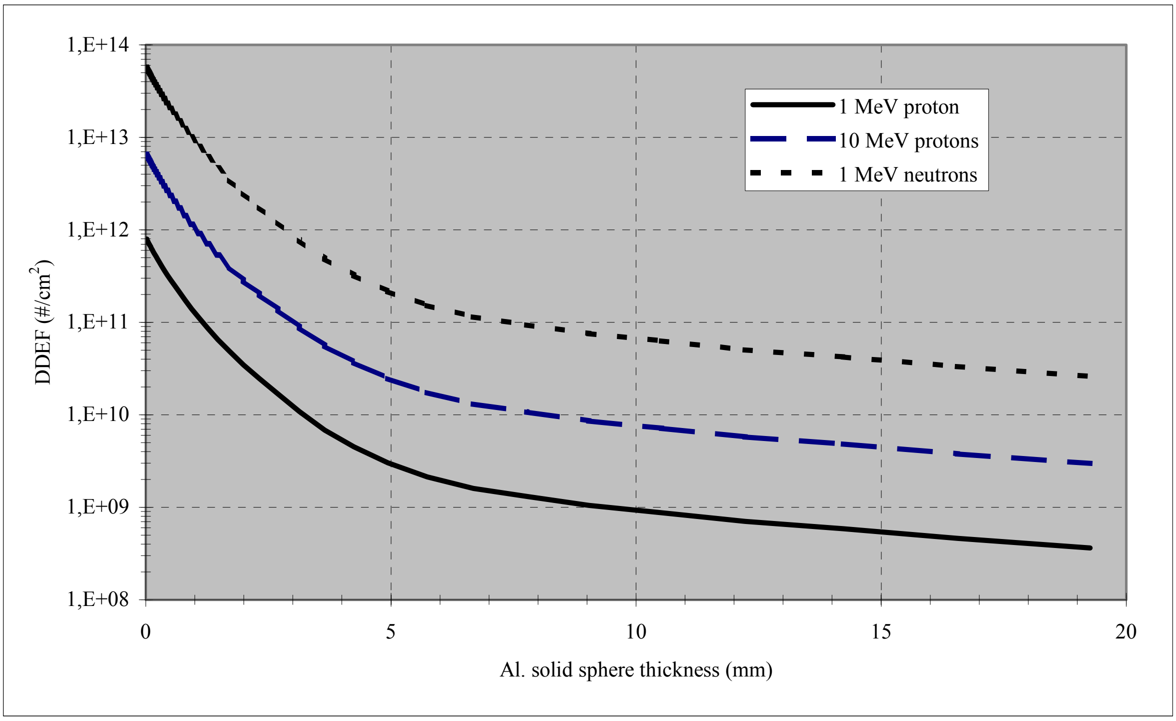


Figure 8.4/8 : DDEF on Geosynchronous orbit, 15 years mission (4AL solar flares), 160°W, 4π steradian, for* GaAs target*, solid sphere aluminum shielding

Shielding thickness (mm)	DDEF (#/cm²)			Shielding thickness (mm)	DDEF (#/cm²)		
	1 MeV protons	10 MeV protons	1 MeV neutrons		1 MeV protons	10 MeV protons	1 MeV neutrons
0,01	7,96E+11	6,53E+12	5,71E+13	5,74	2,13E+09	1,75E+10	1,53E+11
0,05	7,26E+11	5,96E+12	5,21E+13	6,68	1,60E+09	1,31E+10	1,14E+11
0,11	6,35E+11	5,20E+12	4,55E+13	7,77	1,31E+09	1,07E+10	9,39E+10
0,51	2,86E+11	2,35E+12	2,05E+13	9,04	1,05E+09	8,63E+09	7,55E+10
1,09	1,11E+11	9,08E+11	7,95E+12	10,52	8,76E+08	7,18E+09	6,28E+10
1,99	3,47E+10	2,85E+11	2,49E+12	12,23	7,02E+08	5,75E+09	5,03E+10
3,14	1,08E+10	8,89E+10	7,77E+11	14,23	5,89E+08	4,83E+09	4,22E+10
3,65	6,83E+09	5,60E+10	4,90E+11	16,56	4,63E+08	3,79E+09	3,32E+10
4,24	4,51E+09	3,70E+10	3,23E+11	19,26	3,63E+08	2,98E+09	2,60E+10
4,94	3,03E+09	2,48E+10	2,17E+11				

Table 8.4/8 : tabulated values corresponding to figure 8.4/8

8.4.7 Deep Dielectric Discharge (DDD)

Electrostatic discharge can result from charging of dielectric and floating conductors within a spacecraft by energetic electrons (E>2MeV).

[R10] The Subcontractor shall identify in its equipment, all the metallic surfaces which are not always referenced to a fixed potential (track of PCB floating in particular equipment configuration, ...).

[R20] For equipment outside the satellite structure, the DDD analyses have to be performed by the Subcontractor. The energetic electrons shall be shielded such that electric fields at boundaries or between components shall not exceed a breakdown level of 20MV/m. Where shielding is inappropriate, the analysis shall show that discharges, that may take place shall not affect the performance or degrade the integrity of the equipment, its components and materials.

[G30] For equipments inside the satellite structure, the DDD analyses will be conducted at satellite level, taking into account the satellite shielding and Subcontractor data (dielectric or floating conductors inside the unit).

8.4.8 Micrometeoroids

The analysis of micrometeoroid collisions (damage and probability) is performed by the Prime Contractor.

[R] However the subcontractor has to provide the characteristics of the external surfaces of its unit : material, thickness, surface. On a case by case basis, the Subcontractor may have to answer to questions about the possible damage due to a penetrating particle.

8.5 SPECIFIC TEST CONDITIONS AT SUBSYSTEM/ SATELLITE LEVEL

[R] All units shall be able to be operated during spacecraft or subsystem thermal vacuum tests at pressure lower or equal to 10^{-3} mbar. *(1 torr = 133 Pa = 1.33 mbar).*

This is normally covered by the requirement of §8.4.

9 ENVIRONMENTAL TESTS CONDITIONS AND SEQUENCE

9.1 MODEL DEFINITION AND QUALIFICATION PHILOSOPHY

Equipments can gain qualification status in one of three ways :

a) Qualification testing

At least one equipment of a set of identical flight standard equipments must satisfactorily survive a set of tests at least as severe as the qualification tests specified in §10.

b) Protoflight qualification testing

An engineering model shall be subjected and shall survive the qualification tests specified in §10. Thereafter one equipment of a set of identical flight standard equipments must satisfactorily survive the protoflight qualification tests specified in §10.

c) Similarity

If the equipment is identical to that used on another project, and if an identical equipment was qualification tested by the other project, to a set of tests at least as severe as the qualification tests specified in §10, qualification by similarity can be accepted, pending the Prime Contractor approval at EQSR.

If the equipment is similar, but not identical, and the degree of similarity has been approved by Prime Contractor, the same requirements apply.

Conditions for use of an equipment on a flight spacecraft are defined in Product Assurance Requirement (see RD1).

Particular case of modular units : when the number of modules of an equipment depends on the mission, the qualification of the generic equipment shall take into account the worst configuration for each of the environmental conditions (mechanical, thermal, electrical) and for each of the analyses (radiation, reliability, ...). The necessity of a delta qualification for each particular configuration will be decided by Prime Contractor at EQSR.

9.2 GENERAL TEST CONDITIONS

9.2.1 Ambient Conditions

Unless otherwise specified, all measurements and tests shall be made within the following ambient conditions :

- temperature : 23° ± 5°C
- relative humidity : 60 % maximum
- pressure : 760 ± 25 mm mercury

Whenever these conditions must be closely controlled in order to obtain reproducible results, a reference temperature of 23 °C, a relative humidity of 50 % and an atmospheric pressure of 760 mm of mercury respectively shall be used, together with whatever tolerances are required to obtain the desired precision of measurement.

Actual ambient test conditions shall be recorded periodically during the test period.

Should the limits on ambient conditions of temperature and pressure be exceeded the decision not to test or to stop any test in progress shall be vested in the test conductor, who must ensure that there will be no adverse influences on equipment performance. However, the temperature of the equipment shall not be allowed to exceed the relevant range. Decisions made by the test conductor must subsequently be ratified by the next Material Review Board (MRB).

9.2.2 Tolerance of Test Conditions (Excluding Ambient)

The maximum allowable tolerances of test conditions (exclusive of accuracy of instruments) shall be as follows unless otherwise stated in this specification or in the equipment specifications.

a) Temperature : maximal temperature -0 °C + 3 °C ; minimal temperature +0 °C - 3 °C.

b) Pressure : ± 5 % or 1.5 mm of mercury whichever provides the greatest accuracy. When devices are used such as ion gauges, whose accuracy depends on location and type of gauge and which, therefore, can only be specified in test procedures, the actual achieved pressure must be equal to or lower than that specified.

c) Relative humidity : ± 5 %.

d) Acceleration : + 10 % /- 0% (linear), ± 0.5 rad/sec^2 (angular).

e) Vibration level :

- sinusoidal + 10 %/- 0 % "g" peak. At low frequencies, the electrodynamic exciter may have an amplitude limitation which prevents achievement of 12.5 mm, zero to peak, and the subsequent "g" level. Such limitations are acceptable down to a minimum amplitude of 5 mm zero to peak for equipment having resonant frequencies greater than 30 Hz.
- (Random) power spectral density (± 3 dB).
- (Random) overall acceleration (rms) (+ 10 %/-0 %).

f) Frequencies : ± 2 %, ± 0.5 Hz below 20 Hz.

g) Time : + 5 %; -0%.

h) Shock test tolerances : Shock test tolerances are defined with regard to the specified SRS. They are :

- From 100 Hz up to 1 kHz : +0 / +3 dB
- From 1 kHz up to 10 kHz : +0 / +6 dB

9.2.3 Measurements

The accuracy of all instruments and test equipments used to control or monitor the test parameters, shall be verified periodically.

All instruments and test equipments used to conduct the specified tests shall have an accuracy of better than one third of the tolerance for the variable to be measured.

Calibration and maintenance of test equipment shall be in accordance with RD1.

9.2.4 Rejection and Retest

If a failure, malfunction or out-of-tolerance performance occurs during or after a test, the test shall be stopped and, the deficiency addressed in a dedicated Material Review Board (MRB), as part of the general non conformance system (see RD1 for more details).

A complete record shall be made of any such failures and the corrective actions taken.

9.2.5 Substitution of Equipment

Any change on an equipment under a formal test sequence (qualification or acceptance) shall be submitted to a dedicated Material Review Board (MRB) and formally approved by the Prime Contractor (see MRB procedure in RD1).

9.3 PERFORMANCE CHECK BETWEEN AND DURING TESTS

Performance checks and inspections shall be performed in alternance or simultaneously with the environment tests. Three levels of performance check are defined :

- "Full Performance Check" (FPC) which includes measurement of all the parameters which are necessary to demonstrate compliance of the equipment with required performance.
- "Limited Performance Check" (LPC) which includes a slightly reduced number of tests. When parameters are not sensitive to temperature or when the margins measured at ambient temperature are sufficient, it may be accepted to reduce the content of the performance checks made during thermal vacuum test.
- "Good Health Check" (GHC) is a rapid check of some critical parameters which is performed to demonstrate with a good probability that no failure occurred and that the equipment status was not modified during the environment test.

The list of measurements to be performed during each of these performance check is provided in the relevant equipment specification. The alternance of performance checks and environmental test is specified §9.4.

The only exceptions are those items which cannot be realistically tested in ambient conditions. In such cases, initial testing shall be designed to prove compliance as far as possible without causing damage to the tested item. The exceptions allowed are all the items associated with fluid propellants, for which a substitute may be used to ensure operation (open/close) of the unit. For thruster performance, operation using the correct propellant in vacuum is necessary.

[G] In addition to the performance checks during the test which are specified in the relevant environmental test section, a GHC and a visual inspection shall be performed after each installation on the test facility and prior to removal of the item from the test facility.

9.4 TEST SEQUENCE

All qualification testing shall be completed prior to the first flight. Environmental acceptance testing shall be completed prior to installation on a flight spacecraft and prior to qualification/ protoqualification testing at spacecraft level.

The nominal test sequence for all equipments is shown table 9.4/1. Suppliers wishing to modify the order of the sequence for qualification, proto-qualification and acceptance testing shall ask for prior approval to Prime Contractor.

For units which have a sensitivity to thermal cycles (mechanical degradation), thermal test may have to be performed before mechanical test (agreement between Supplier and Prime).

	QUALIFICATION SEQUENCE	PROTOFLIGHT SEQUENCE	ACCEPTANCE SEQUENCE
Full performance check	X	X	X
Sinus vibration	X	X	
[G] Good health check	X	X	
Random	X	X	X
[G] Good health check	X	X	
Constant acceleration (5)	X	X	
Limited performance check	X	X	X
Depressurisation	X	X	
Corona & Arcing	X	X	If applicable
Thermal Vacuum	X	X	X (6)
Mechanical measurement	X	X	X
Shock test (2)	X	X (3)	X (3)
EMC	X	X (4)	(1)
ESD	X		
Full performance check	X	X	X
Life test	X		

(1) Limited EMC test as required in the equipment specification. In particular each RF flight unit must be EMC tested (radiated emission and susceptibility), to detect any workmanship defect.

(2) §10.5 applies for all units. Analytical justification has to be approved by Prime Contractor, and in any case a demonstration by test (on QM only) is recommended. Shock test may be performed right after constant acceleration test pending Prime Contractor approval.

(3) §10.5.1 for units including pyrotechnically operated devices.

(4) According to the test results on the QM, additional tests might be performed.

(5) May be grouped with sine vibration as explained in §10.2.

(6) Cf § 10.8.2

TABLE 9.4/1 - NOMINAL TEST SEQUENCE

10 EQUIPMENT ENVIRONMENTAL TESTS

[R10] The tested equipment shall be installed in the test facility at room temperature in a manner which will simulate service usage. Plugs, covers and inspection plates used in service shall remain in place. When mechanical or electrical connections are not used, the connections normally protected in service shall be adequately covered.

[R20] Equipment shall be attached to the test fixture by M4 molykoted titanium bolts and the bolts tightened to a torque of 2.5 Nm (plus running torque).

[R30] The interface thermal filler, if any, is not requested for mechanical tests.

[R40] The electrical circuit interface used in the test bench shall be representative of the worst case of input/output load or parameter as specified by the equipment specification or in §6.

[R50] The grounding of equipment under test and of the circuit interfaces in the test bench shall be submitted to the Prime Contractor for approval, in order to check the representativity with respect to the equipment grounding within the satellite.

[R60] For equipments which are ON during launch : at all times during any vibration, acoustic and constant acceleration tests, the equipment under test shall be energised, power supply voltages, currents and selected performance parameters shall be continuously monitored and recorded with adequate bandwidth.

[R70] For equipments which are ON during shock (clampband, solar array and deployable reflectors shocks) : at all times during shock tests, the equipment under test shall be energised, power supply voltages, currents and selected performance parameters are not requested to be continuously monitored and recorded.

[R80] A vibration survey 0.5 g, 10 to 2000 Hz shall be conducted prior and after performing each various mechanical tests specified. For the best correlation of model, the low level signature can be done without harness.

[G90] For equipments which are not mechanically tested with a flight configuration with respect to the Connector and Harness configuration, the connectors assemblies will be validated mechanically by a dedicated test, by similarity, or by local test.

[R95] See § 6.1.2.6 concerning saver connectors requirements.

Mechanical Test Report

[R100] The purpose of this document is to demonstrate the compliance of the equipment w.r.t. the DIET requirements and guidelines. It also insures a good correlation between the analysis and test results.

[G110] The table of contents of this document may be :

1._ Introduction

2._ Applicable and Reference Documents (test specification)

3._ Description Model description (equipment model, mass, reference, axes, ...)
Test facilities (short description, date of the tests, ...)
Instrumentation plan (attached in annex, with the axis of each captors)

4._ Test Sequence included aborts, actual schedule, problems,...

5._ Test Results Frequencies, Damping factors,
Finite Element Models comparison and explanations of the differences, if any
Quasistatic ; Sine & Shock tests :
levels measured for the equipment, axis per axis ;
parallel between tested and expected/qualified levels for each parts ;
parallel between low levels before/ after qualification test ;
final visual or other inspections.
Random tests :
same explanations as Quasistatic and Sine tests,
additional parallel with previously tested levels for some parts ;

6._ Electrical and/or Alignment and/or dismounting « Good Health Checks »

7._ Points of attention (if any)

8._ Conclusion

9._ Recommendations for Spacecraft test : notching criterion and test instrumentation sensors, if any ;
test instrumentation sensors to be checked, ...

ANNEX : picture of the equipment on the test fixture ; qualification levels at the basis for each axis ;
important captors curves, ...

10.1 VIBRATIONS

10.1.1 General

The following conditions shall apply to vibration tests :

[R10] The input levels defined in this section are applicable at the test fixture/equipment interface.

[R20] To avoid significant amplification of inputs to the equipments during sinusoidal and random vibration test the test fixture shall be designed taking account the following rules :

- The first frequency of the test fixture loaded by the equipment (or by equivalent masses and inertia) shall be at least 1.5 time the first frequency of the equipment alone.
- The main frequencies of the test fixture loaded by the equipment (or by an equivalent mass) shall not be coupled with the main equipment frequencies.

[R30] Successful completion of the vibration survey shall be a requirement for qualification. The transmissibility frequency behaviour, and cross-talk of the test fixture loaded by the equipment shall be determined by a swept sinusoid or a low level random vibration applied in each of the three mutually perpendicular axes. The shift in frequency, if any, between the 2 low level tests before/after each mechanical test should be less than 5%.

[R40] These values shall be measured with a sufficient number of accelerometer mounted at the equipment/test fixture interface.

[R50] For equipments sensitive to the in-orbit micro-vibrations levels specified in §8.4.1 a low level run (as low as possible) shall be performed from 10 to 2000 Hz, the equipment being operating and the sensitive parameters recorded. The levels to be used for demonstration of compliance are 1.5 times those of §8.4.1 for qualification and equal to those of §8.4.1 for acceptance.

10.1.2 Random vibrations

[R10] Qualification levels and proto-qualification (PQ) levels are identical .

[R20] Test duration's are :

- 180 s for qualification test ;
- 60 s for proto-qualification;
- 60 s for acceptance tests.

[R30] The equipment shall be subjected to the following random vibration input separately along each orthogonal axis. For a given equipment, the applicable spectrum is given in its equipment specification.

a) Equipment except those specified hereafter

[R40] i) Perpendicular to equipment interface plane (equipment longitudinal axis)

	QUALIF/PQ	ACCEPTANCE
10 Hz - 60 Hz	+ 9 dB/oct	+ 9 dB/oct
60 Hz - 400 Hz	0.5 g2/Hz	0.22 g2/Hz
400 Hz - 2000 Hz	- 6 dB/oct	- 6 dB/oct
Overall level	18.4 g_{RMS}	12.3 g_{RMS}

[R50] ii) In equipment interface plane (equipment lateral axis)

	QUALIF/PQ	ACCEPTANCE
20 Hz - 80 Hz	+ 4 dB/oct	+ 4 dB/oct
80 Hz - 1000 Hz	0.1 g2/Hz	0.044 g2/Hz
1000 Hz - 2000 Hz	- 3 dB/oct	- 3 dB/oct
Overall level	12.8 g_{RMS}	8.6 g_{RMS}

b) Equipments mounted

on the satellite CM top floor panel,

on the satellite +Z extensions on Y walls with low mass distribution (TBC)

on the satellite SM Floor panel, for heavy equipments,

on the satellite SM X walls.

[R60] i) perpendicular to equipment interface plane

	QUALIF/PQ	ACCEPTANCE
20 Hz - 100 Hz	+ 12 dB/oct	+ 12 dB/oct
100 Hz - 300 Hz	1.5 g2/Hz	0.67 g2/Hz
300 Hz - 650 Hz	- 15 dB/oct	- 15 dB/oct
650 Hz - 850 Hz	0.03 g2/Hz	0.013 g2/Hz
850 Hz - 2000 Hz	- 6 dB/oct	- 6 dB/oct
Overall level	21.4 g_{RMS}	14.3 g_{RMS}

[R70] ii) in equipment interface plane

	QUALIF/PQ	ACCEPTANCE
20Hz - 80 Hz 80Hz - 1000 Hz 1000Hz - 2000 Hz	+ 4 dB/oct 0.1 g2/Hz - 3 dB/oct	+ 4 dB/oct 0.044 g2/Hz - 3 dB/oct
Overall level	12.8 g_{RMS}	8.6 g_{RMS}

c) Equipments mounted **on the satellite SM floor panel, for small equipments (CPS, relay bracket,...)**

on the satellite Shear Walls.

[R80] i) perpendicular to equipment interface plane

	QUALIF/PQ	ACCEPTANCE
20 Hz - 100 Hz 100 Hz - 300 Hz 300 Hz - 2000 Hz	+ 12 dB/oct 1.5 g2/Hz - 8 dB/oct	+ 12 dB/oct 0.67 g2/Hz - 8 dB/oct
Overall level	24.3 grms	16.2 grms

[R90] ii) in equipment interface plane

	QUALIF/PQ	ACCEPTANCE
20Hz - 80 Hz 80Hz - 1000 Hz 1000Hz - 2000 Hz	+ 4 dB/oct 0.1 g2/Hz - 3 dB/oct	+ 4 dB/oct 0.044 g2/Hz - 3 dB/oct
Overall level	12.8 g_{RMS}	8.6 g_{RMS}

d) Liquid Apogee Engine

[R100]

All three axes	QUALIF/PQ	ACCEPTANCE
20 Hz - 80 Hz	+ 18 dB/oct	+ 18 dB/oct
80 Hz - 117 Hz	0.03 g2/Hz	0.013 g2/Hz
117 Hz - 190 Hz	+ 24 dB/oct	+ 24 dB/oct
190 Hz - 230 Hz	1.5 g2/Hz	0.67 g2/Hz
230 Hz - 375 Hz	- 24 dB/oct	- 24 dB/oct
375 Hz - 500 Hz	0.03 g2/Hz	0.013 g2/Hz
500 Hz - 2000 Hz	- 6 dB/oct	- 6 dB/oct
Overall level	12.5 g_{RMS}	8.3 g_{RMS}

e) Equipments installed on brackets (IRES, SADM,...)

[R110]

All three axes	QUALIF/PQ	ACCEPTANCE
20 Hz - 60 Hz	+ 9 dB/oct	+ 9 dB/oct
60 Hz - 400 Hz	0.5 g2/Hz	0.22 g2/Hz
400 Hz - 2000 Hz	- 6 dB/oct	- 6 dB/oct
Overall level	18.4 g_{RMS}	12.3 g_{RMS}

f) Linear Analogue Sun Sensor (LiASS), Bi-Axis Sun Sensor (BASS)

Qualification spectrum can be achieved in several parts if deemed necessary due to shaker limitations.

[R120]	All three axes	QUALIF/PQ	ACCEPTANCE
Common spectrum	20 Hz - 80 Hz	+ 15 dB/oct	+ 15 dB/oct
	80 Hz - 450 Hz	10 g2/Hz	3.5 g2/Hz
	450 Hz - 2000 Hz	- 12 dB/oct	- 12 dB/oct
	Overall level	73.1 g_{RMS}	43.2 g_{RMS}
BASS additional spectrum	700 Hz - 1600 Hz	1.5 g2/Hz	N/A
	1600 Hz - 2000 Hz	- 22 dB/oct	
	Overall level	40.5 g_{RMS}	
LiASS additional spectrum	800 Hz - 1140 Hz	1 g2/Hz	N/A
	1140 Hz - 2000 Hz	- 25 dB/oct	
	Overall level	23.2 g_{RMS}	

g) Chemical thruster modules

Thruster levels are specified in the Equipment specification.

h) Plasma thruster module

Specified in the Equipment specification (in accordance with RD8).

10.1.3 Sinusoidal vibrations

[R10] The intent of this test is to verify that minimum design stiffness requirements are met (see equipment specifications) and to verify that the design can survive later spacecraft level sinusoidal vibration testing. The following levels will be applied separately along the three orthogonal axes.

[R20] Qualification levels and proto-qualification levels are identical.

[R30] Test sweep rates are :

- 2 octaves/minute for qualification test.
- 4 octaves/minute for proto-qualification test.

a) Equipment except those specified hereafter

[R40] Qualification levels, all three axes :

FREQUENCY (Hz)	ACCELERATION (g 0-peak)
5 - 20	11 mm 0-peak (or max. shaker limit)
20 - 100	20 g

b) Linear Analogue Sun Sensor (LiASS) and Bi-Axis Sun Sensor (BASS)

[R50] Qualification levels, all three axes :

AXIS	FREQUENCY (Hz)	INPUT ACCELERATION (g)
3	5 to 20	11 mm
orthogonal axes	20 - 30	20
	30 to 70	20 to 80 (slope)
	70 to 100	80

10.2 STEADY STATE ACCELERATIONS

Any equipment shall withstand a constant acceleration.

[R10] For all equipments, this shall be demonstrated by test.

[R20] Qualification levels and proto-qualification levels are identical and equal to 20g. The test duration shall be 60 sec for each axis.

[G30] Sustained acceleration qualification may be achieved by sinusoidal vibration testing at a frequency well separated from equipment resonance's. In this case, a constant frequency sine input (typical value : 35Hz) shall be held for one minute after the steady sine level (20g) has been established.

10.3 EMC/ESD TESTS

10.3.1 General

An EMC test matrix is given in Table 9.4/1, with the EMC test requirements applicable to each type of equipment.

Compliance with these requirements for each equipment design must be demonstrated by submitting one sample to a test programme to be agreed upon with the Prime Contractor. The sample to be tested shall be in general the protoflight model. The use of an engineering model may be accepted provided that it is electrically and mechanically identical to the flight standard design. In addition, Subcontractor supplying equipment of a new design are reminded that it is necessary to check the EMC performance (at least for conducted parameters) at the "breadboard" stage of development to avoid the need for costly, late modifications.

In any case, every RF flight unit must be tested in R.E (radiated emission) and/or R.S (radiated susceptibility), in order to detect any workmanship defect. Limited radiated tests to be performed for acceptance testing are described in the equipment specification.

For existing equipment or equipments derived from a previous design with modifications which do not affect the EMC behaviour, the use of tests performed for a previous programme may be accepted to demonstrate compliance with EMC requirements, after Prime Contractor approval at EQSR. Applications for exemption from EMC testing shall be submitted by Subcontractors in their bids.

The following Test matrix summarises the EMC-ESD requirements tests detailed in §10.3 :

Tests performed	Measured / Injected value	Frequency range
Conducted Emission (CE)	Voltage/Current ripples	50Hz - 10MHz
	Inrush Current	(Time Domain)
	Common Mode Current (Only in Wire Return case)	10 kHz - 30 MHz
Conducted Susceptibility (CS)	Sine wave signal (1V rms)	50Hz - 10MHz
	Voltage/Current Transients	(Time Domain)
	Common mode for signal interfaces	Cf.§6.1.1.2.2 & §6.1.1.2.3
Radiated Emission (RE)	Electric field	1MHz - 47 GHz
Radiated Susceptibility (RS)	Electric field	1MHz - 30 GHz
Electrostatic Discharge (ESD)	Triangular shape Current	(Time Domain)

10.3.2 Test conditions

10.3.2.1 Test sample loading and stimulus

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

The simulation shall consist of reactive and resistive elements as necessary to maximise the value of the interference. However, all power supplies shall use Line Impedance Stabilisation Network (LISN), given in figure 10.3/1.

If the quantity being measured is current, the test sample load impedance shall be designed so as to exhibit the nominal or worst case equipment design currents appropriate to the flight installation. When the quantity being measured is voltage, the load impedance shall be made larger so as to increase the interference voltage on that particular wire.

The choice of components to be used for impedance simulation shall be listed in the test plan with the justification.

Typical devices for the impedance simulation of loads current measurements could be for example, bypass capacitors whose reactance value is lower than the value seen in the flight installation. Similarly for voltage measurements, the impedance increasing device could consist of a series inductance whose reactance value is larger than flight loads.

10.3.2.2 General conditions

The test sample shall be set up with harness that simulates flight harness in shielding, twisting, ground and wiring properties. The EMC test plan shall include a test harness description and shall be submitted to Prime approval.

The tests shall be performed in an ambient electromagnetic environment which is at least 6 dB below the lowest level to be measured. Emissions from the attendant test equipment and harnesses are included in the ambient levels.

The tests shall be performed with the test sample, appropriate unit test equipment (UTE) and flight representative harness elements, on an electrically conductive ground plane. This ground plane shall have a length of a least 2.5 metres and a width greater than 0.5 metres. If a shielded room is used, the ground plane shall be bonded to the room by bonds whose resistance is less than 2.5 mOhm and separated by no more than 2.5 metres. This connection of the ground plane is very important when the UTE has to be located outside the shielded room because of emission in excess of, or susceptibility below, the specified limits.

Interconnecting cable assemblies, in the vicinity of the ground plane test area, shall be flight representative in construction and content. Shielded wires shall not be used in the test set-ups unless that have been specified in the intended installation. No overall cable shields shall be used in the vicinity of the ground plane test area unless these are representative of the flight design.

10.3.2.2.1 Measuring equipment grounding

The grounding of the EMC measuring equipment shall be implemented in accordance with the details of this section in order to avoid false data introduced by ground loops and minimise the likelihood of shock hazards.

a) The antenna shall be remote from the measuring instruments.

b) The measuring instruments shall be physically grounded by only one connection to the ground plane.

c) The measuring instruments shall be connected to their power supply through an isolation transformer.

10.3.2.2.2 Receiving equipment

Any receiving equipment used shall be capable of measuring sine wave signals with an accuracy of $\pm$ 2 dB and broadband (impulse) signals with an accuracy of $\pm$ 3 dB. Its frequency accuracy shall be better than $\pm$ 2 %.

10.3.2.2.3 Signals sources

Any signal source such as signal generator, pulse generator, or power amplifier, may be used provided that it is capable of supplying the necessary modulated and unmodulated power required to develop the susceptibility levels over the frequency range specified and it meets the following requirements, where applicable :

a) Absolute frequency measurement accuracy $\pm$ 0.01 %

b) Harmonic content a minimum of 30 dB below fundamental signal level.

10.3.2.2.4 E-Fields, Tests antennas

The following antennas are recommended for E field test, although different antennas may be used provided that calibration curves are available.

10 kHz to 30 MHz	1 metre matched rod
30 MHz to 200 MHz	Biconical antenna
200 MHz to 1 GHz	Log spiral antenna
1 GHz to 10 GHz	Aperture type horns, log spiral etc.
10 GHz to 47 Ghz	Horns, ridged guide etc.

The emission level shall be measured at a distance of one metre from the equipment.

10.3.2.3 Power bus user

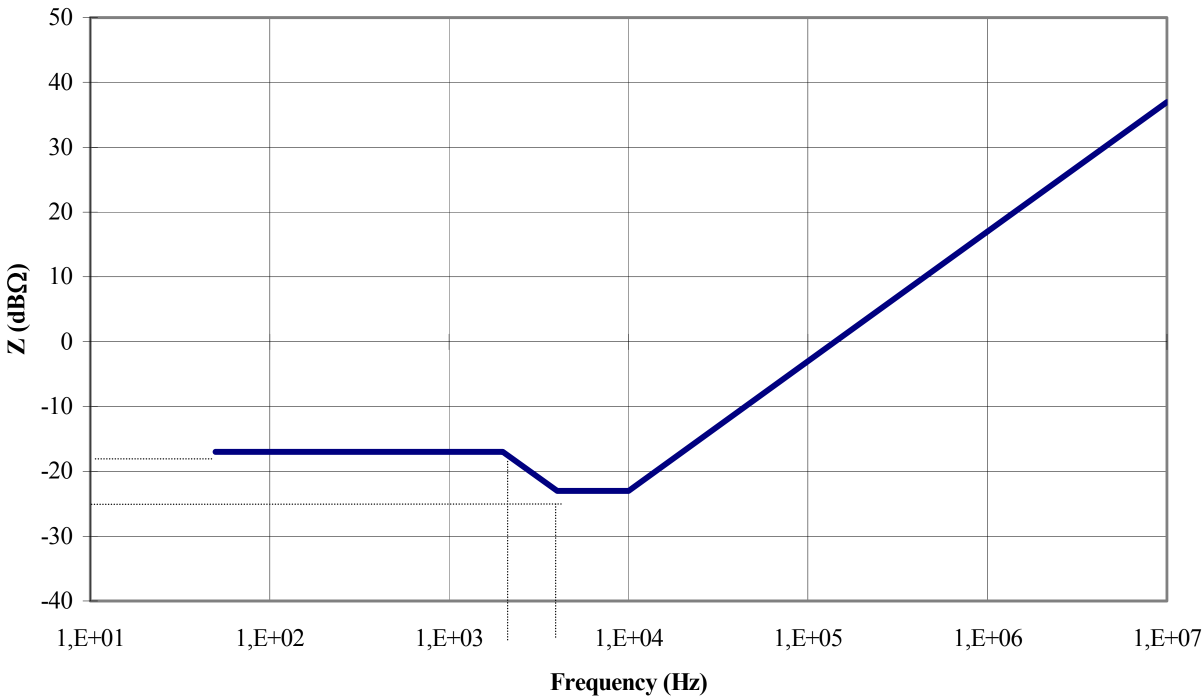
The user shall be powered from simulated power supplies routed via the LISN specified in figure 10.3/1. The user shall be loaded with representative loads simulating ripple current demand.

10.3.2.4 Sweeping rate for susceptibility tests

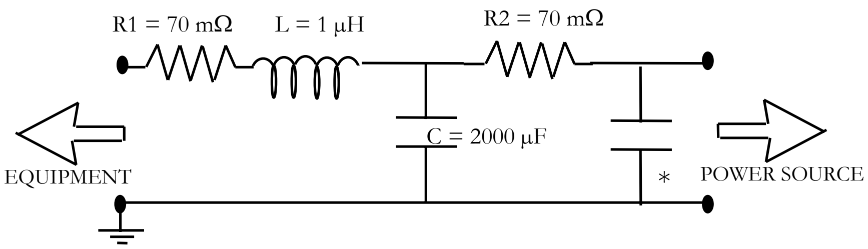
During conducted (1Vrms) and radiated susceptibility tests, the stimuli sweeping shall be defined as follows:

The dwell time at each frequency shall not be less than the time necessary for the equipment to be exercised and to be able to respond. However, the dwell time shall not exceed, as far as possible, 5 seconds at each frequencies during the scan.

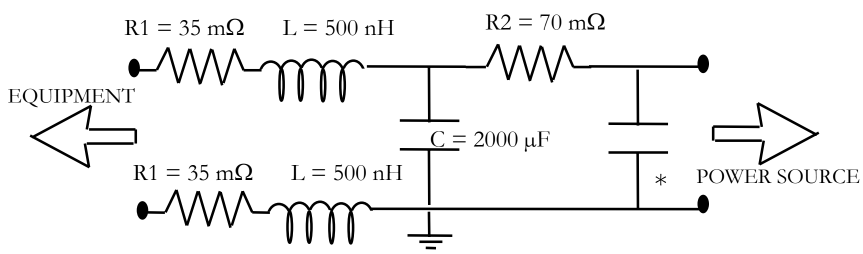
The frequency step size of the signal source shall not exceed 1% of the frequency of the injected signal.



Case B : Structure Primary Return



Case A : Wire Primary Return



(*) only if the power source has no output capacitance (10000µF)

For the 2000µF capacitance : ESR ≤ 10 mΩ and ESL ≤ 100 nH

For equipment power ≤ 125 W : case A or B is applicable

For equipment power > 125 W : LISN to be defined with Prime Contractor agreement.

FIGURE 10.3/1- LINE IMPEDANCE STABILIZATION NETWORK

10.3.3 EMC tests

Generally, all the tests shall be performed at the equipment level. Nevertheless the EMC tests could be performed at the level of group equipments if all the equipments of the group are manufactured by the same Subcontractor or under his responsibility. The decision to conduct the EMC tests at such level shall be agreed by the Prime Contractor.

EMC tests shall be performed with representative protection on primary power bus (including external fuse).

10.3.3.1 Conducted emission

10.3.3.1.1 Primary user

10.3.3.1.1.1 Differential mode

Conducted current emissions shall be measured into the impedance defined in figure 10.3/1 and in the frequency range 50 Hz - 10 MHz. Depending on the configuration (wire return and structure return), a different LISN is used.

Under these conditions, the current reinjected on the main bus shall be less than the limits given in figure 10.3/2. The requirement is applicable on each line, including neutral when existing.

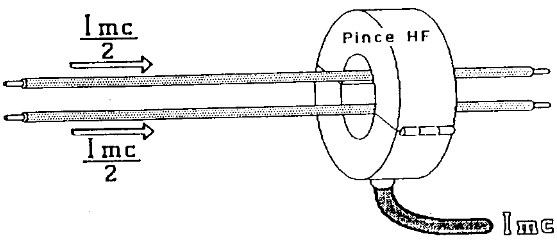
These limits apply directly to users demanding up to 30 W. For other power demands, the limits shall be scaled proportionally to demanded power (Increase in dB given by 20 log P/30). The relaxation factor, when relevant, shall not be used for the TDMA case (part of the curve under 10kHz).

The voltage and current ripples shall be measured in the time domain with a measuring bandwidth of at least 50 MHz.

10.3.3.1.1.2 Common mode

For the primary wire return set-up configuration (units compliant with option A of §6.1.1.2.1), the common mode current shall be less than 100 dBµA rms at 10 kHz, decreasing with frequency with a - 20 dB/decade slope up to 30 MHz.

The measurement shall be performed with both the positive and negative wires inside a current probe, as illustrated below :



The voltage and current ripples shall be measured in the time domain with a measuring bandwidth of at least 50 MHz.

The equipment shall be configured in primary wire return, operating with representative interfaces, and shall be representative of a flight configuration.

10.3.3.1.1.3 Inrush current

The inrush current transient into the impedance defined in figure 10.3/1 shall not exceed the limit defined in figure10.3/3.

The limits on the current integral ("X") are valid assuming that the load switching ON, are separated in time by at least 5ms (nominal case if the SCU is the only unit able to switch ON equipments). A dedicated approval by the Prime Contractor is necessary, for units having the capability to switch ON other equipments or functions, asynchronously with respect to the SCU.

10.3.3.1.2 Secondary user

The ripple current generated, in the range 50 Hz to 10 MHz, by an equipment connected to a secondary bus shall not cause current ripples on the secondary bus which shall be greater than those defined previously in §10.3.3.1.1.

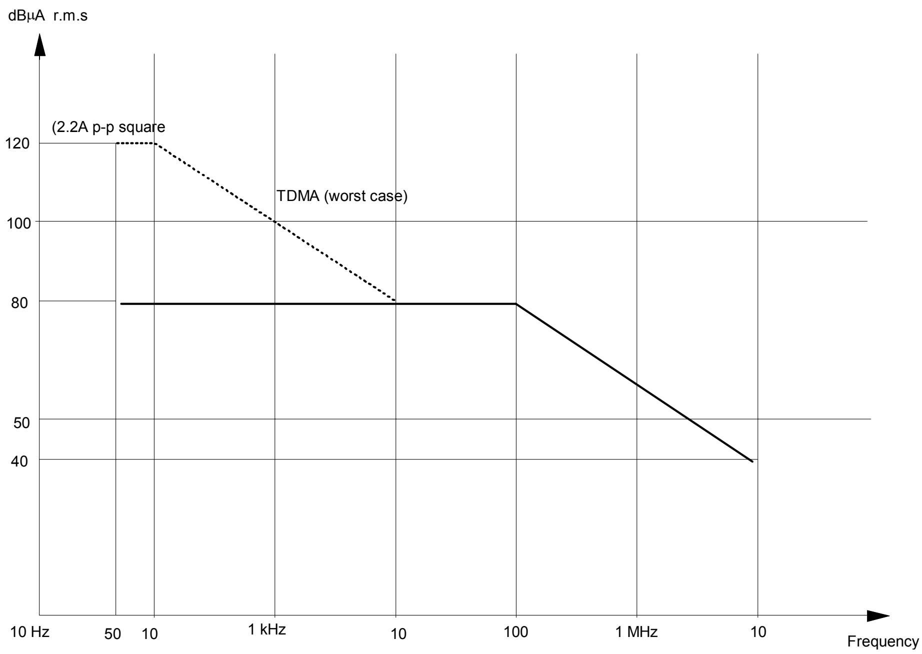
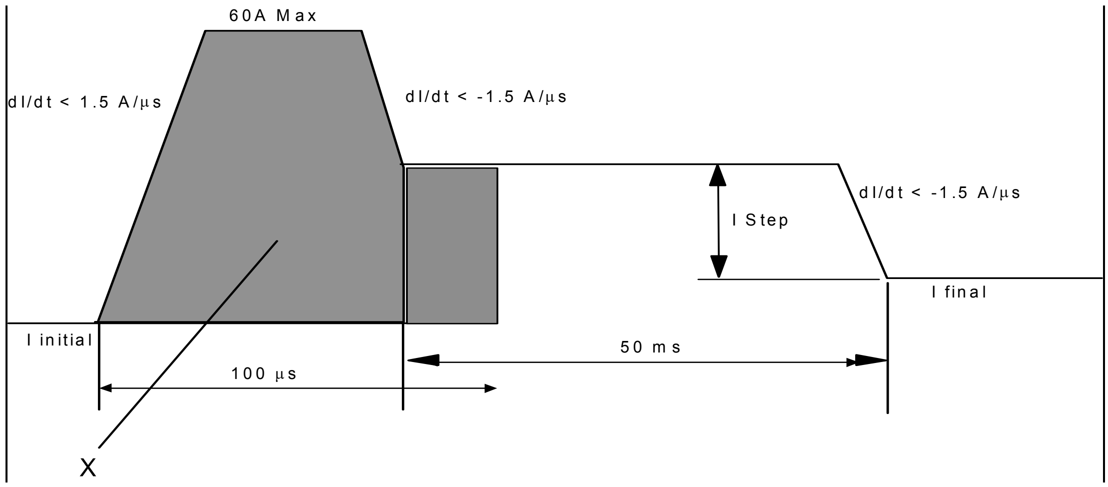


FIGURE 10.3/2 : CONDUCTED EMISSIONS - PRIMARY BUS EQUIPMENT NARROW-BAND



- X is the current integral over the first 100µsec

- At fuse clearing recovery (§6.2.1.3.2 transients due to fuse clearing event figure 6.2/1) with possibly uncharged input filter capacitors and when the bus voltage starts from 0V to nominal voltage with dV/dt up to 500V/ms : X<2500µC .

- In normal operation, at equipment level switch-on with the power bus steady at its nominal voltage 50V, the switch on shall not exceed X $\leq$ 2500 µC.

- The I step mean value during the plateau of 50ms maximum shall not exceed 15A. The worst case inrush current on any unit power line shall be taken into account in the fuse sizing or protection sizing (Cf §6.2.1.5).

FIGURE 10.3/3 - PRIMARY BUS - INRUSH CURRENT

10.3.3.2 Conducted susceptibility

10.3.3.2.1 Primary users

The equipment shall continue to operate in accordance with the relevant equipment performance specification when the interferences defined here after are applied to the power supply.

SINE WAVE SIGNAL : 1 V RMS for frequencies between 50 Hz and 10 MHz, the associated current shall be measured. Any notching shall be approved by prime.

TRANSIENTS : The signal defined in figure 10.3/4 shall be applied with a positive and a negative polarity, the DC level being within the 50V range. The transient level is increased until one of the following limits is reached:

- Transient voltage = 100 % of the DC supply voltage
- Transient current = 100 % of the DC supply current.

This transient shall be applied with frequency of 1 Hz and the total duration of the test shall not exceed 5 minutes.

10.3.3.2.2 Secondary users

The equipments using one or more secondary power supply shall continue to operate in accordance with their relevant equipment performances when the voltage ripples, in the range 50 Hz to 10 MHz, on these supplies are twice those emitted by the generator equipment (converter, ...).

The ripple voltage will be determined by the Subcontractor to represent the ripple arising from :

- The ripple voltage created during susceptibility test on the main bus of the generator equipment (Primary user).
- The ripple voltage created inside the generator equipment.
- The ripple voltage created by the secondary bus user.

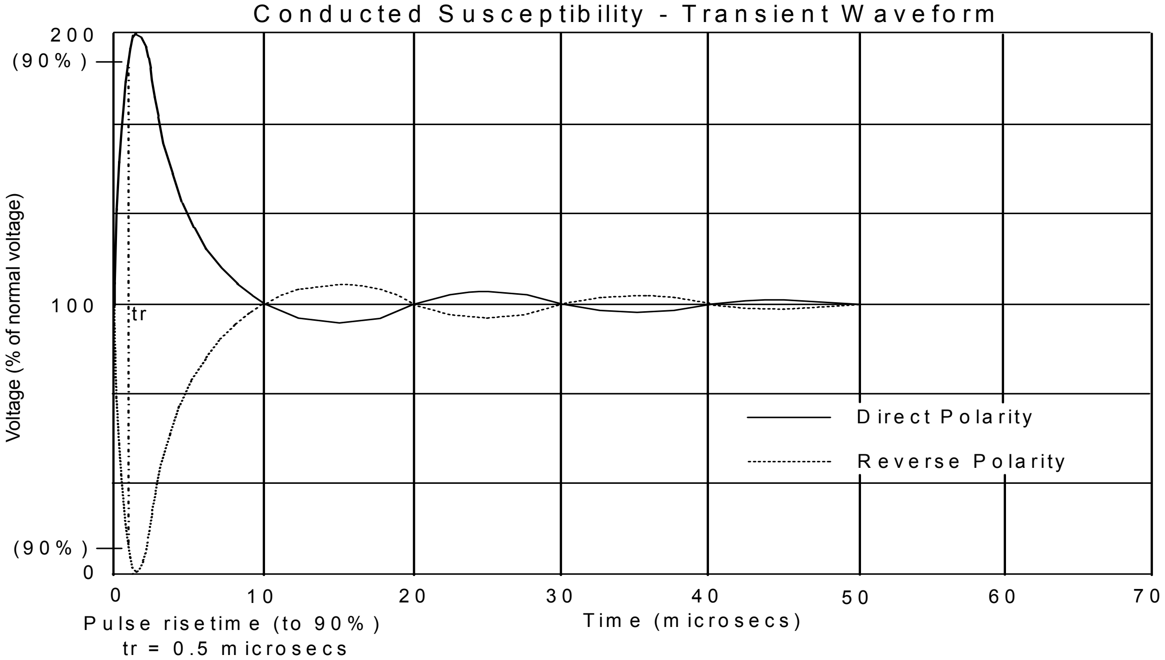


FIGURE 10.3/4 EQUIPMENT - SUSCEPTIBILITY TO TRANSIENTS PRIMARY POWER LINES

10.3.3.3 Radiated emission

The electric field, measured at 1m, radiated by the equipments in the range 1 MHz - 47 GHz shall not be greater than the limits defined on figure 10.3/5.

For what regards non RF equipments, the radiated emissions shall be imperatively measured up to 1 GHz. The measurements up to 47 GHz shall be only performed, if the levels measured between 500 MHz and 1 GHz are at 10 dB, or less, below the limits specified in the same range of frequency.

The emission from the RF equipments outside their operating bandwidth (for which no limitation is required) shall be measured up to 47 GHz.

As shown on the figure 10.3/5, the radiated levels are limited to :

- 20dBµV/m in the following frequency ranges : 400MHz to 500MHz *(A4/A5 launchers receiving frequency band);* 1575MHz to 1660.5MHz *(GPS and L-band TCR&Repeater receiving frequency band)*; 1930MHz to *2690MHz (S-band TCR&Repeater receiving frequency band);* 5450MHz to 7075MHz *(C/X-band TCR&Repeater receiving frequency band);*
- 30dBµV/m in the following frequency ranges : 12.75GHz to 14.5GHz - 17.3GHz to 18.1GHz *(Ku-band TCR&Repeater receiving frequency band);*
- 40dBµV/m in the following frequency ranges : 27GHz to 31 GHz - 42.5GHz to 47GHz *(Ka-band TCR&Repeater receiving frequency band).*

The radiated emission test shall be performed under the following conditions :

- the measurement shall be done in a worst case localisation (by detecting the most emissive face) and a worst case polarisation of the antenna
- distance between the antenna and the equipment : 1m
- the worst case radiated emissions shall be recorded.

Before beginning of this test, a leakage detection of the RF connections, cables and test set-up inside the EMC chamber shall be performed to ensure that the Equipment Radiated Emissions measurement will not be affected by the test set-up. A background measurement shall be performed. This measurement shall be at least 6dB below the test limit given in Figure 10.3/5.

10.3.3.4 Radiated susceptibility

The equipment shall continue to operate without degradation of its performances when the electric field defined in figure 10.3/6 shall be applied on it. This figure can be summarised as :

From 1 MHz to 1 GHz : E(V/m) = 1V/m (rms) = 0dBV/m (rms) , for all units.

From 1GHz to 30GHz :

E(V/m) = 25V/m (rms) = 28dBV/m (rms) , for all internal units (*) (in the structure or under RF shield).

E(V/m) = 89V/m (rms) = 39dBV/m (rms) , for all external units (sensors).

(*) except for receivers at Rx frequency where dedicated level shall be determined and submitted to EMC Prime authority.

The Radiated Susceptibility test shall be performed on the most sensitive face of the equipment (harness, connectors).

If a susceptibility occurs, the injected electric field at susceptibility frequency shall be reduced until the requirement is met. The new injected level shall be noted.

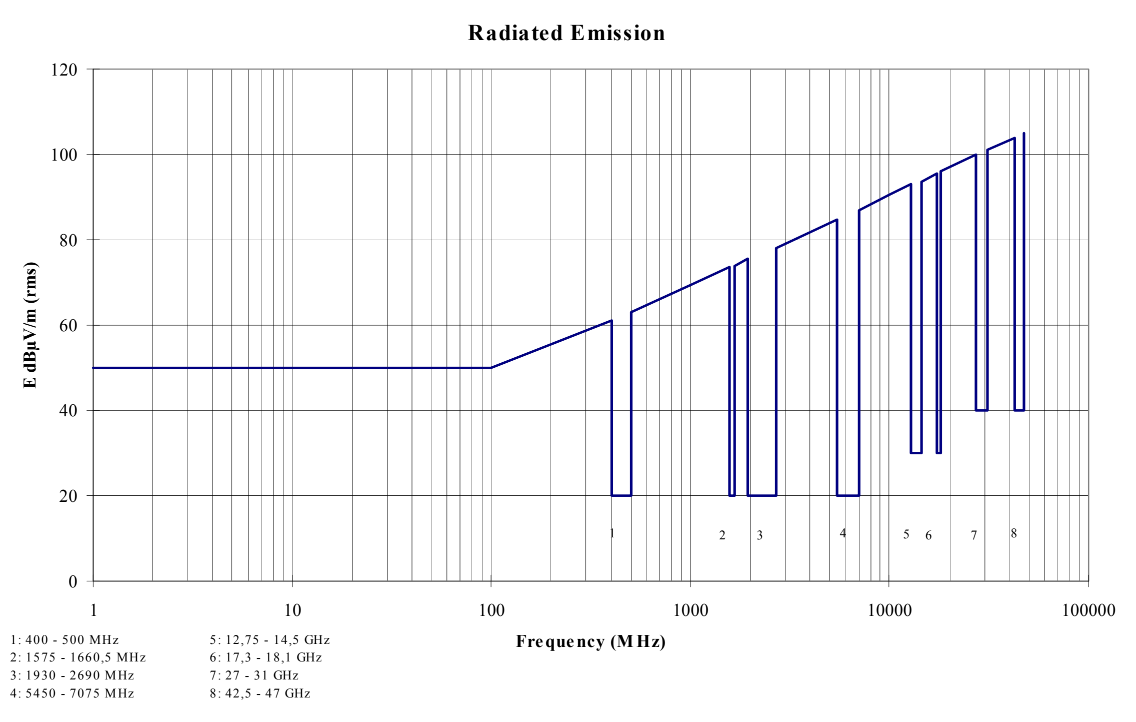


FIGURE 10.3 /5 : RADIATED EMISSIONS

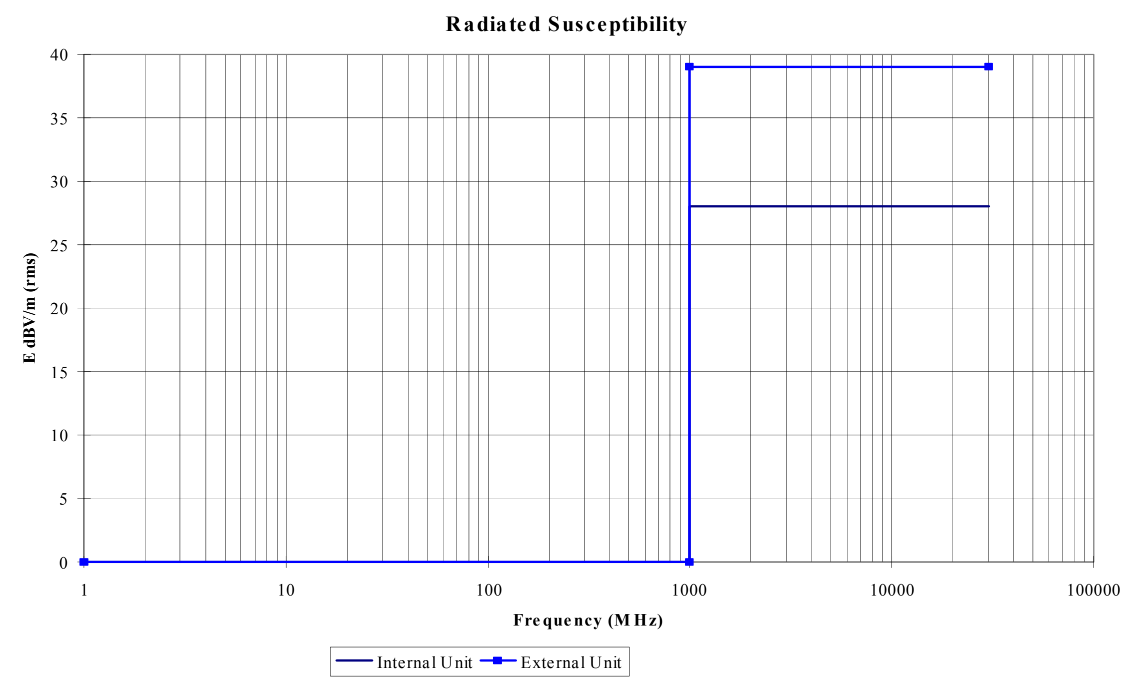


FIGURE 10.3 /6 : RADIATED SUSCEPTIBILITY

10.3.4 ESD tests

The equipment shall continue to operate in accordance with its performance specification when it is submitted to the following conditions :

- equipment mounted on a plane structure of the same nature of that used in the spacecraft
- bonding and grounding representative of the flight conditions.
- same harness than in the spacecraft (nature - technology - height above structure= 1cm - separate bundle...). The EMC test plan shall include a test harness description and shall be submitted to ASTRIUM approval ~~to MMS~~.
- Injected current in the plane structure of test (cf. figure 10.3.4/ 1) :
  - triangular shape of 20ns min to 50 ns max mid-height duration, 50A-peak in amplitude and dI/dt > 3.10^9 A/s for the front edge.
  - triangular shape of 300ns min to 500 ns max mid height duration, 100A-peak in amplitude and 10^9 A/s < di/dt < 2.10^9 A/s for the front edge.
- Each shape of injected current shall not be applied more than 10 times.
- Current transient coupled on the victim cables shall be monitored for information only.

Test set-up dimensions (figure 10.3.4/1) shall be respected in order to achieve specified current shapes within the structure (accuracy of +/- 1cm). RC components are typical values given for information, which can be adjusted to achieve specified levels. In case where distances/current shapes can not be achieved, cable coupling method (figure 10.3.4/2) can be used on each specified victim bundle.

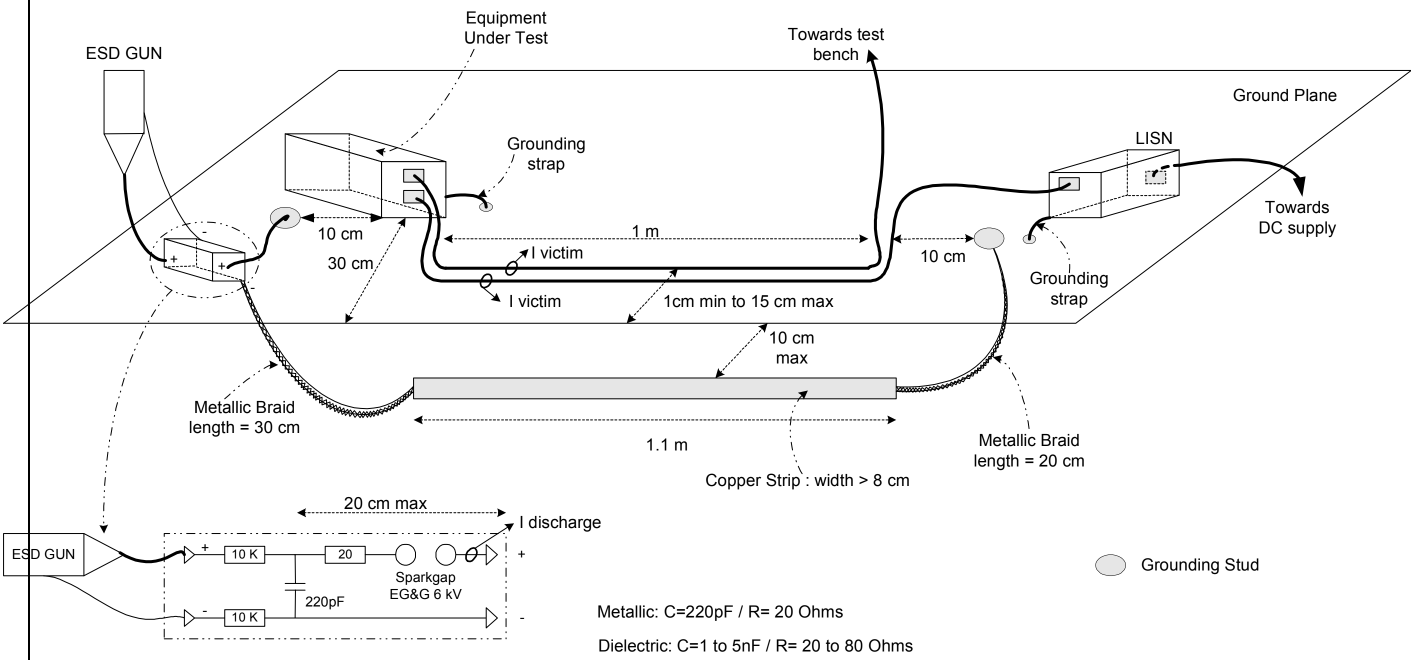


Figure 10.3.4/ 1 : ESD injection in the structure plane

In case of susceptibility during injection into the structure, ESD cable coupling test (cf. figure 10.3.4/ 2) shall be performed (with metallic discharge waveform of 20A min to 30A max amplitude ~~with the same injection waveform~~), for investigation, to discriminate the coupling path.

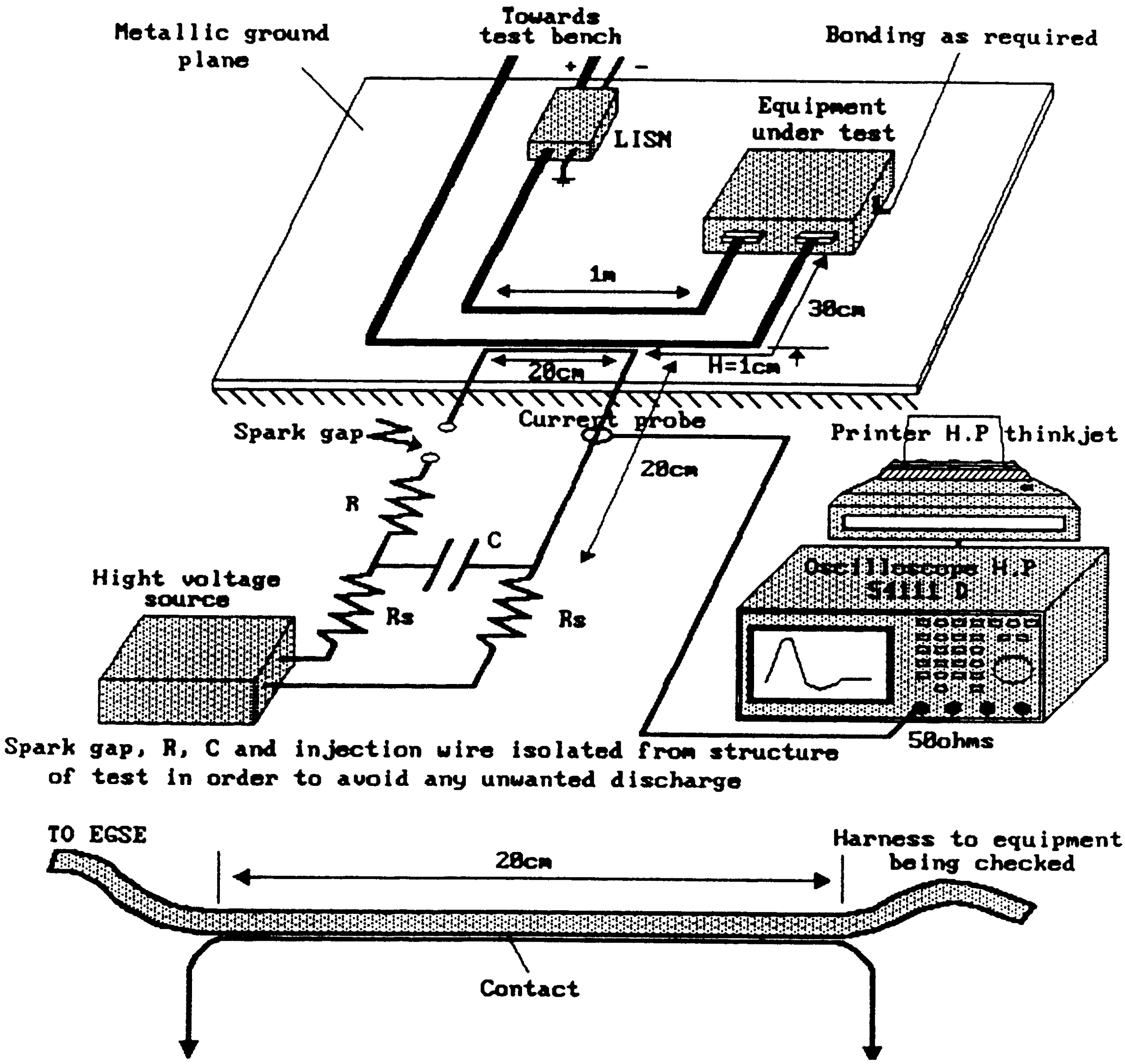


Figure 10.3.4/ 2 : ESD injection by cable coupling

10.4 CORONA - ARCING TEST

The aim of this test is to demonstrate the capability of the equipment to correctly operate (without arcing) in a low pressure environment, and therefore that no critical pressure exists :

- *during ascent phase (§8.3.4)*
- *on-station e.g during the initial outgassing phase or at any time during the operational life (§8.4.2)*

[R10] A corona test is mandatory for qualification models (EQM, QM, PFM) of units ON during launch. The presence of corona and arcing shall be determined during reduction of pressure for thermal vacuum test of §10.8. The pressure profile shall be such as to stay at least 1 hour between 10 torr and 10^{-4} torr. Corona and arcing shall not occur with the unit operating.

[R20] For flight models of units ON during launch, either a test or an analysis (showing that corona is not sensitive to workmanship) has to be performed.

[R30] For all units, either a test or an analysis, has to be performed to demonstrate the non sensitivity to satellite residual internal pressure specified in §8.4.2.

[G40] As far as a thermal vacuum test is performed, a corona test is recommended.

10.5 PYROTECHNIC SHOCKS

10.5.1 Specific tests for units including pyro-devices

[R10] All equipments which include in their design a pyrotechnically operated device shall be subjected to shocks resulting from firing the device. A minimum of 10 such firings shall be performed. At least 2 of these firings shall use flight standard pyrotechnic devices, the remainder may use pyrotechnic devices of the same design, but of lower quality. One firing shall occur at the maximum specified operating temperature, and one firing at the minimum specified temperature.

[R20] For equipments which could generate shocks, it is requested that these levels are lower than an equivalent SRS (Q=10) ½ sine wave 400g-2500Hz (measured at 10 cm from shock source on a representative panel).

10.5.2 Shock levels for all units

[R10] The equipments have to cope with flight events which generate shock inputs. These events are :

- Spacecraft separation (clampband release)
- Antenna release (deployable, steerable antennae)
- solar array release

(others events generating shocks -mechanism release, fairing separation, ...- are covered by these 3 events)

[R20] Any equipment shall be designed to withstand, without degradation, the shocks levels given hereafter. They are defined through areas since the shock inputs are attenuated mainly in function of the distance from the shock origin.

[R25] Any equipment shall be designed not to generate higher shocks levels than the one given hereafter.

[R30] The levels to consider are given by SRS (Shock Response Spectrum – Q=10). They have to be applied along the three axis.

[R40] If two (or more) SRS have to be considered for an equipment, the following requirements have to be taken into account :

- If one of the SRS covers the other one's, it has to be only considered,
- If the SRS's have different maximum (that is to say that the maximum SRS's occur at different frequencies), the SRS's envelope has to be considered.

[R50] The shock demonstration shall be done by tests on qualification models.

For non sensitive shock units (units which did not integrate mechanisms, sensitive parts (quartz, relay…)), a demonstration by analysis could be done This demonstration being a waiver with regard to general mechanical rules, it must be approved by prime. The analytical demonstration can be done by comparing the SRS to the qualification random equivalent acceleration (computed for 2 standard deviations : $\gamma = 2 \times (\pi/2 * 10 * f * \text{random input})^{1/2}$) from 20 up to 800 Hz, and 0.8 x frequency law from 800 Hz up to 10000 Hz. This law is not applicable to sensitive units such as mechanisms, relays…. Any other justifications rules can be presented.

For sensitive units, it is mandatory to perform a shock test. It is also possible to demonstrate the shock qualification by heritage or similarity. In that case, sufficient justification files must be provided to prime for approval.

[R60] These levels are qualification levels. No shock test is required for acceptance.

[R70] Since the equipment locations are dependent of the spacecraft mission, the Prime Contractor will define the areas to consider in the equipment specification. For the equipments where the area is not defined in the following chapter, they shall be specified to a half sine wave pulse [400g - 2500 Hz] or its equivalent SRS. Whatever the unit is, the specified levels shall be agreed by prime system team.

[R80] The main goal of a shock test being to check the equipment robustness, the equipment sensitive to the fatigue (vibration cycling, thermal cycling,....), have to be shock tested after being tested under conditions which could have affected its functional behaviour (see test sequence of §9.4). Mechanisms (gyro, wheels,...) have to be shock tested before the life tests (see test sequence of §9.4).

[G90] The possible facilities to test an equipment are :

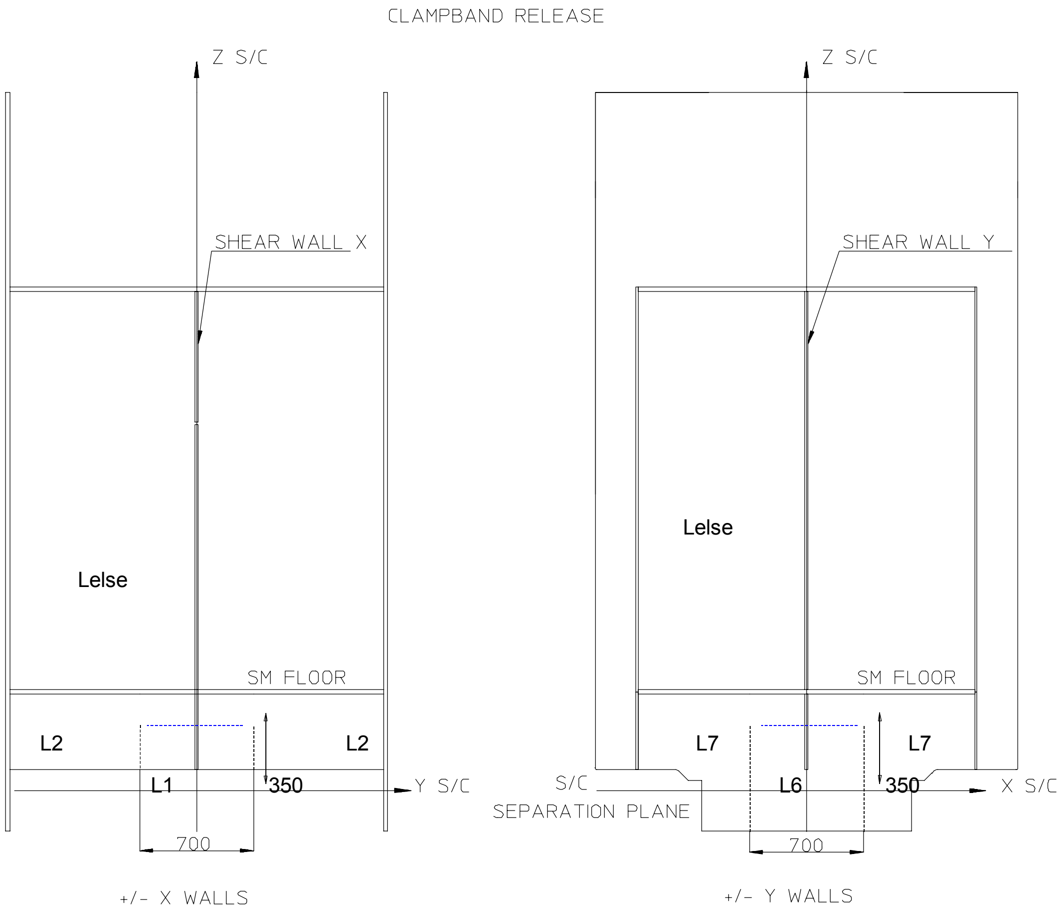
- Pyro shock table
- Standard shaker. In that case, the supplier will submit for approval the temporal input foreseen prior to tests. This input is dependent of the supplier shaker capabilities, but a shock duration of 30 ms is a correct basis of work.

10.5.2.1 Deployable antenna (with attenuator devices)

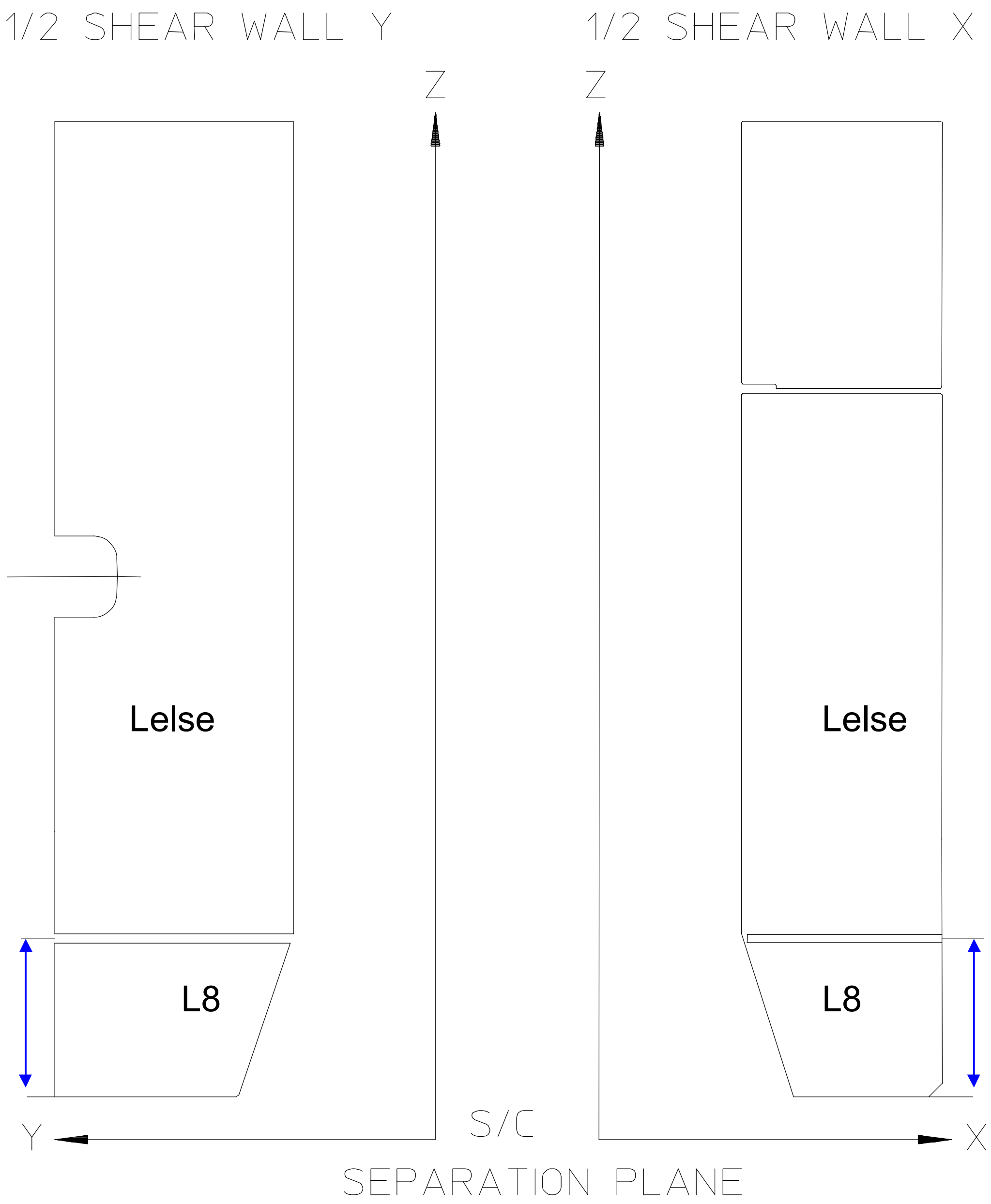
[R] The shock levels for all units due to Deployable Antenna Release with attenuator devices is equivalent to a sine wave input of 500 g amplitude, 2500 Hz frequency, lasting one half cycle (i.e. 2.10^{-4} second, 0-peak-0). This specification has to be considered in the vicinity of the antenna holdown point (max distance from shock source = 350 mm).

10.5.2.2 Spacecraft clampband release

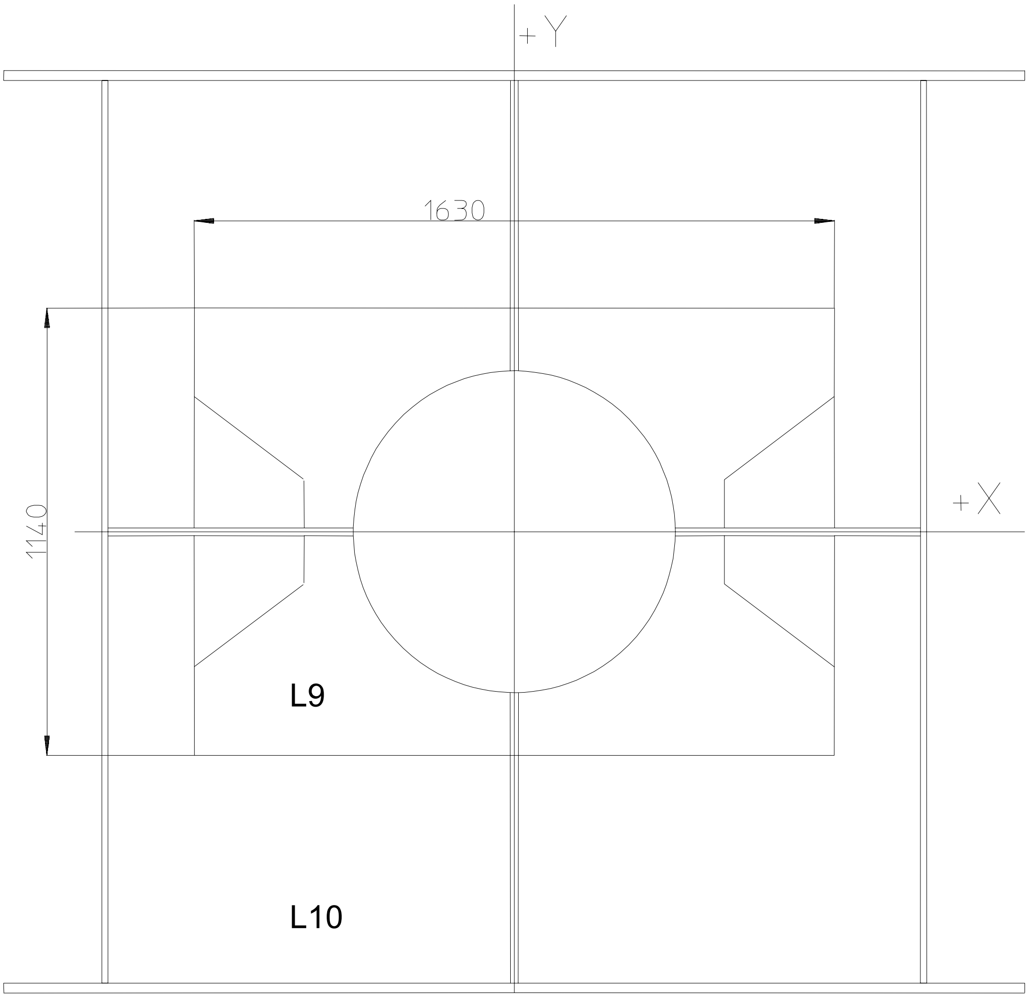
[R] The SRS to take into account are defined hereafter .



CLAMPBAND
RELEASE



CLAMPBAND
RELEASE



SM FLOOR

=

TANK LOWER FLOOR

10.5.2.2.1 Y WALL

L 6 Area (on Y walls)							
Units **not** fitted on external heat-pipes				Units **fitted** on external heat-pipes			
f (Hz)	in plane	f (Hz)	out of plane	f(Hz)	in plane	f(Hz)	out of plane
100	40	100	20	100	30	100	20
1000	800	400	400	1000	600	400	300
3000	800	1300	1200	3000	600	1300	900
10000	600	4000	1200	10000	450	4000	900
		10000	800			10000	600

L 7 Area (on Y walls)							
Units **not** fitted on external heat-pipes				Units **fitted** on external heat-pipes			
f (Hz)	in plane	f (Hz)	out of plane	f(Hz)	in plane	f(Hz)	out of plane
100	10	100	10	100	10	100	10
500	40	600	100	500	40	800	100
1300	100	2500	800	1300	100	2000	600
2000	700	10000	800	2000	600	10000	600
10000	700			10000	600		

10.5.2.2.2 X WALLS

L 1 Area (on X walls)			
f (Hz)	in plane	f (Hz)	out of plane
100	10	200	30
1500	700	1000	900
10000	700	2000	1500
		10000	1500

L 2 Area (on X walls)			
f(Hz)	in plane	f(Hz)	out of plane
100	10	100	10
500	40	600	100
1300	100	2500	800
2000	700	10000	800
10000	700		

10.5.2.2.3 SHEAR WALLS

L 8 Area (on shear walls)							
Units **not** fitted on external heat-pipes				Units **fitted** on external heat-pipes			
f (Hz)	in plane	f (Hz)	out of plane	f(Hz)	in plane	f(Hz)	out of plane
200	10	200	10	100	10	100	10
500	100	500	100	600	100	600	100
1000	600	1000	600	1000	400	1000	400
2000	1100	2000	1100	2000	800	2000	800
10000	1100	10000	1100	10000	800	10000	800

10.5.2.2.4 SM FLOOR

L 9 Area (on SM floor)			
f (Hz)	in plane	f (Hz)	out of plane
100	10	100	10
400	300	400	400
1000	700	1000	900
2000	2000	1500	1300
10000	2000	10000	1300

L 10 Area (on SM floor)			
f(Hz)	in plane	f(Hz)	out of plane
100	20	200	10
2000	700	500	100
10000	700	1000	400
		2000	1100
		10000	1100

10.5.2.2.5 Other areas than Battery, Tank, LAE, Pressurant Tank

L else in plane	
f(Hz)	in plane
100	10
500	40
1300	100
2000	700
10000	700

L else out of plane	
f(Hz)	out of plane
100	10
500	100
1000	300
3000	700
10000	700

10.5.2.2.6 LAE, PRESSURANT TANK, THRUSTER MODULE

- LAE

f (Hz)	Levels out of plane	f (Hz)	Levels in plane
200	30	200	30
1000	900	1000	900
2000	1500	2000	1500
10000	1500	10000	1500

- PRESSURANT TANK

f (Hz)	Levels out of plane	f (Hz)	Levels in plane
200	30	200	30
1000	700	1000	700
2000	700	2000	700
10000	700	10000	700

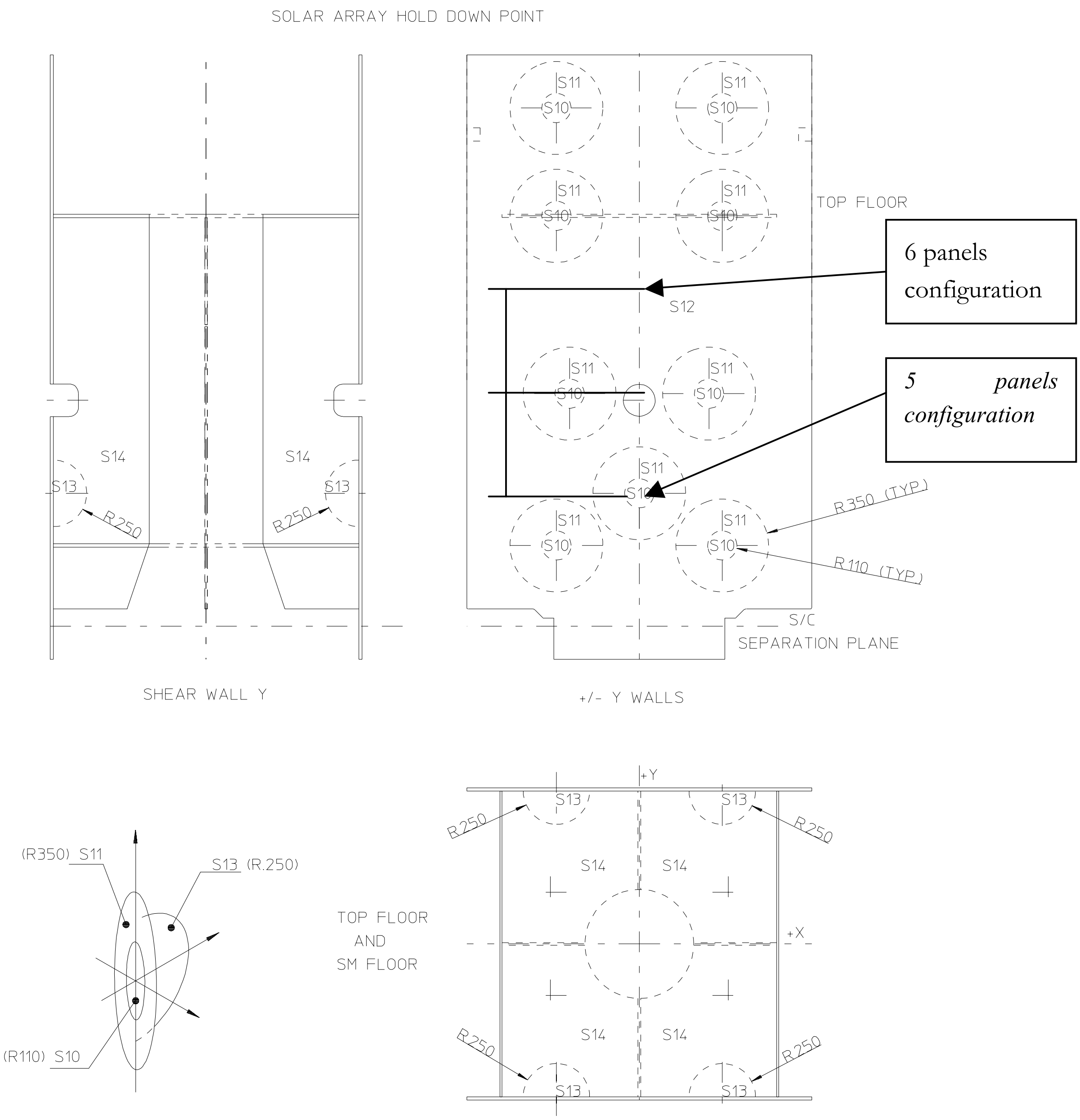
- THRUSTER MODULE

f (Hz)	Levels out of plane	f (Hz)	Levels in plane
100	30	100	20
1000	600	400	300
3000	600	1300	900
10000	450	4000	900
		10000	600

10.5.2.3 Solar array release

The levels specified in this chapter are only applicable if a DASA solar array is used. The position of this Hold Down points depends on the spacecraft configuration.

[R] The SRS to take into account are defined hereafter.



f (Hz)	Area S10	f (Hz)	Area S11	f (Hz)	Area S12
100	20	100	20	100	40
1000	80	1000	80	500	40
3000	1300	3000	800	2000	400
5000	1300	5000	800	10000	400
10000	400	10000	300		

SHOCK LEVELS FOR UNITS – PARALLEL TO MOUNTING PLANE

f (Hz)	Area S10	f (Hz)	Area S11	f (Hz)	Area S12
100	20	100	30	100	20
1000	80	200	30	2000	300
3000	1300	3000	700	10000	300
5000	1300	10000	700		
10000	400				

SHOCK LEVELS FOR UNITS – PERPENDICULAR TO MOUNTING PLANE

f (Hz)	Area S13	f (Hz)	Area S14
100	20	100	40
1000	80	500	40
3000	900	2000	400
5000	900	10000	400
10000	400		

SHOCK LEVELS FOR UNITS – PANELS PERPENDICULAR YO Y WALLS – ALL AXIS

10.5.2.4 Synthesis of applicable shock response spectrum

This table summarises for platform units the applicable spectrum. Antenna shocks are applicable to the IRES. The document RD7 gives the exact applicable SRS for each of those equipment.

For payload units and TCR-RF units the envelope of the applicable SRS of §10.5.2, has to be used (antennas, launcher, solar array).

	Equipments	LOCATION on E3000	Clampband	Solar array	Synthesis Spec to apply
A	IRES	support plate on Y wall	Lelse	S12	**Specific**
D	GEU	SM floor	L10	S14	**L10**
C	RSI	SM floor, Y s/ wall,(Y wall)	L10 HP	S14	**L10 HP**
S	RDR	X shear walls	L8	NA	**L8**
	GMU	X walls	L2	NA	**L2**
	WDE	X wall	L1	NA	**L1**
	LiASS 2A	on Solar Arrays	NA	S12	**S12**
	LiASS 2B	Y walls, deploy. refl., batt.	L7/Lelse	S12	**Enveloppe L7/Lelse**
	BASS	battery, deploy. Refl.	L7/Lelse	S12	**Enveloppe L7/Lelse**
E	PRU	SM floor	L10	S14	**L10**
P	SADM	Y walls, Y shear walls	L7	S12	**L7**
S	PSR	Y walls	L6 HP/L7 HP	S11/S12	**L6 HP**
D	SCU	Y walls	L6	S11/S12	**L6**
H	ADE 4	Y wall	L6	S11/S12	**L6**
S	MPIU	Y wall	Lelse	S12	**Lelse**
	Relay Box	SM floor, Y walls,(Y s/walls)	L6/L9	S12	**L9**
P	XRFS	SM floor	L10	S14	**L10**
P	PPU	Y walls	L7	S11/S12	**L7**
S	IPTM	Y walls	L6 HP/L7 HP	S12	**L6 HP**
C	He/Xe tank	Cone/cylinder	Specific	Specific	**See § 10.5.2.2.6**
P	LAE	Cone/cylinder	Specific	Specific	**See § 10.5.2.2.6**
S	Thruster	X,Y wall, shear wall	L6 HP	S12	**L6 HP**
	Miscell.	CPS SM floor	L10	NA	**L10**

10.6 RAPID DEPRESSURISATION

The unit shall be subjected to a rapid decrease in external pressure. The external pressure shall be reduced by 0.8 bar (8 X 10^4 N/m^2) within a time not exceeding 27 seconds. The pressure at the start of the test may exceed atmospheric by 0.8 bar.

Note 1 : The above test need not be applied if the ability of the equipment case (and internal compartments, if applicable) to withstand rapid depressurisation during launch is demonstrated by analysis (see §8.3.3). In establishing reserve factors, such analyses shall take into account the additional loads resulting from the launch acceleration/vibration environment.

Note 2 : The above test does not apply to sealed containers. However, sealed containers shall be analysed to establish hazard potential. Containers with hazardous potential shall be proof tested to 1.5 times the nominal pressure difference. Tests are identical for qualification and for protoqualification.

10.7 SPECIFIC TEST FOR EQUIPMENT SUBJECT TO LIFE TIME DEGRADATION

10.7.1 General

[R10] This chapter describes the tests which shall be performed at mechanism level (and not at subassembly level). It is recommended to measure and control the friction torques at different stages in mechanism building.

[R20] The following rules apply :

- Qualification of the mechanism will be obtained by the **addition** of qualification test sequence **and a life test**. Qualification shall be pronounced **after** the life test.
- Qualification **cannot** be obtained by proto-qualification (qualification shall be obtained by life test, and in consequence the qualification model cannot fly after the life test).
- When qualification is obtained, flight acceptance test sequence purpose is to verify workmanship and performances of the flight models.

[R30] All mechanism type shall be qualified on at least one unit. Qualification by similarity to a previous programme can be obtained only if the following conditions apply together :

- Loads and worst case conditions are lower than previous mission on which the mechanism has been qualified.
- Mechanism is used with the same cycle (type, number, duration)
- There is no modification on the hardware (and software if any).

10.7.2 Standard tests

10.7.2.1 Qualification tests

[R] At least one mechanism assembly of each type shall be subjected to the following tests, with the assembly mounted in a representative manner, and the worst case loads applied (flight loads can arise due to pulley tension, hinge misalignments, differential expansions within panel, thermo-elastic distortion loads, etc), and the worst case alignment.

i) The assembly shall be operated at ambient, and the performance measured (e.g. time to operate, resistance torque, minimum torque to operate, etc...). The test results will be used to validate performances before and after environmental tests.

ii) In thermal vacuum conditions, the assembly shall be cooled to be at least 10 °C lower than the minimum expected for flight operation, and the performance measured.

iii) The assembly shall be heated in thermal vacuum to be at least 10 °C hotter than the maximum expected for flight operation, and the performance measured.

iv) Worst temperature gradient within the mechanism which could hamper the motion by increasing friction torque's shall be represented at the maximum extent by the use of test heaters.

The torque margin shall be measured in ambient temperature (before and after EV tests), in hot and in cold environment for qualification.

10.7.2.2 Acceptance tests

[R10] The logic of tests to be performed at mechanisms level is identical to these defined for qualification tests. However the Subcontractor can submit a proposal of re-adjusted test plan to be approved by Prime Contractor.

[R20] During all tests the functional performances shall be measured and compared to the qualification performances to verify that not significant changes have occurred.

The torque margin shall be measured in ambient temperature (before and after EV tests), for acceptance.

10.7.3 Life tests

[R10] The following applicable tests shall be performed on any equipment which experiences mechanical "wear-out" in operation.

[R20] The usual rule is to use the operating temperature range (for life test on thermal cycles) ; or the worst case temperature in the operating range (for mechanical life test) ; or a typical cycle in operating range representative of daily variation, all along the life test.

[R30] Before life test, the (QM or EQM) unit must have been submitted to qualification vibration levels. In any case, the life test conditions have to be approved by the Prime Contractor.

[R40] For Deployment Mechanisms, the subassembly which experiences the wear may be tested on its own, as a subassembly. The subassembly shall be loaded in a representative manner and operated the same number of times as designed (see the appropriate number in §5.1.4.3.).

[R50] For Pointing or trimming mechanisms, these items shall be tested as designed (see the appropriate number in §5.1.4.3.).

[R60] For Rotating Mechanisms, the subassembly which experiences the wear may be tested on its own, where this is possible (e.g. a single gyro from an equipment containing other components). The equipment or subassembly shall be loaded in a representative manner and operated under vacuum at temperature extremes, such that the total number of accumulated operations or cycles is as designed (see the appropriate number in §5.1.4.3.).

[R70] For linear devices (e.g. electromagnetic valves,...). The subassembly which experiences wear may be tested on its own as a subassembly where this is possible, or as part of an assembly (e.g. thruster) or as an equipment. The subassembly, equipment or assembly shall be loaded in a representative manner and operated under vacuum at temperature extremes such that the total number of accumulated operations or cycles is as designed (see the appropriate number in §5.1.4.3.).

[R80] Equipments subject to gas or liquid throughput. Any equipment or subassembly subject to such throughput shall be tested under vacuum at temperature extremes such that the total test volume throughput is as designed (see the appropriate number in §5.1.4.3.). During such tests, the following conditions shall also be imposed :

a) For all such devices, the pressure (s) shall be generally representative of those expected in flight, but shall include a period equivalent to 10 % of volume throughput where the inlet pressure is higher than the maximum expected in flight (see the appropriate number in §5.1.4.3.), and a second period equivalent to 10 % of volume throughput, where the inlet pressure is lower than the minimum expected in flight (see the appropriate number in §5.1.4.3.). This latter requirement need not to be met for pressure reducing or pressure relief valves which are not required to operate at such low inlet pressures.

b) In the case of pressure reducing, or relief valves, the rate of volume throughput shall be such that the number of operations of the internal regulating mechanism is as designed (see the appropriate number in §5.1.4.3.).

c) In the case of thrusters, each duty cycle expected during spacecraft life shall be tested such that the accumulated number for each duty cycle is as designed (see the appropriate number in §5.1.4.3.).

10.8 EQUIPMENT THERMAL TESTS

QM or PFM equipment shall be tested over the qualification functioning temperature range (TFQ).

The number of cycles and the duration of a PFM equipment test shall be equal to the acceptance test number of cycles and duration.

FM equipment shall be tested over the acceptance functioning temperature range (TFA).

Equipment performance shall be met at qualification functioning temperature limits.

10.8.1 Thermal vacuum qualification

10.8.1.1 General

At least one unit representing a series of equipment shall be qualified in thermal vacuum to the requirements.

It is required that all equipment be qualified i.e. demonstrates full compliance with the requirement inside the qualification temperature range.

Temperature shall be controlled, measured and selected such that it can be guaranteed that the test item experiences actual temperature equal to or beyond the minimum and maximum qualification temperatures. Refer to §9.2.2 and §9.2.3 for tolerances and measurement accuracy.

Throughout the thermal testing, the performance shall be monitored to an extent necessary to detect any anomalous or transient behaviour which could be prejudicial to proper functioning of the associated subsystems or of the equipment. In addition, limited performance tests shall be performed at least 4 times during this sequence i.e. initial ambient, hot, cold and final ambient.

The following minimum test requirements shall be satisfied.

10.8.1.2 Pressure Requirement

Equipment shall be tested in a thermal vacuum environment having a pressure of 10^{-5} torr or less. *(1 torr = 133 Pa = 1.33 mbar).*

The test (temperature cycling) may be commenced when the pressure falls below 10^{-4}torr and a pressure of 10^{-5} torr or less shall be achieved prior to switch ON the unit.

Pressure conditions for tests at subsystem or satellite level are given in §8.5.

10.8.1.3 Test arrangement for internally mounted "radiative" equipment

i) The test arrangement required for equipment having temperature limits referred to as either

a) The average case temperature **(T_{skin})** as shown schematically in figure 10.8/1.

or

b) The average environment temperature **(T_{env})** as shown schematically in figure 10.8/1

ii) The equipment shall be suspended in a thermal vacuum chamber (conductively isolated). The assembly shall radiate to a thermally controlled isothermal black painted uniform environment. The environment shall be provided by either the chamber shroud or an arrangement of thermal control panels. Sufficient instrumentation shall be provided to allow accurate temperature control of the thermal control panel(s) and/or shroud by using a fluid loop and/or electrical resistance heaters.

iii) During test, the shroud or other thermal control panels (radiative environment) shall be controlled to either

a) Give the required temperature level on the equipment reference temperature (see spec. equipment.)

or

b) Give directly the required temperature level on the radiative environment (see spec. equipment.)

iv) For non-isothermal equipments the temperature of the environment shall be monitored by the hottest reference point during hot phases and by the coldest reference point during cold phases.

v) In any case (isothermal or non isothermal radiative equipment), the maximum temperature gap between the shroud and the equipment reference shall be less than 10°C for hot phases.

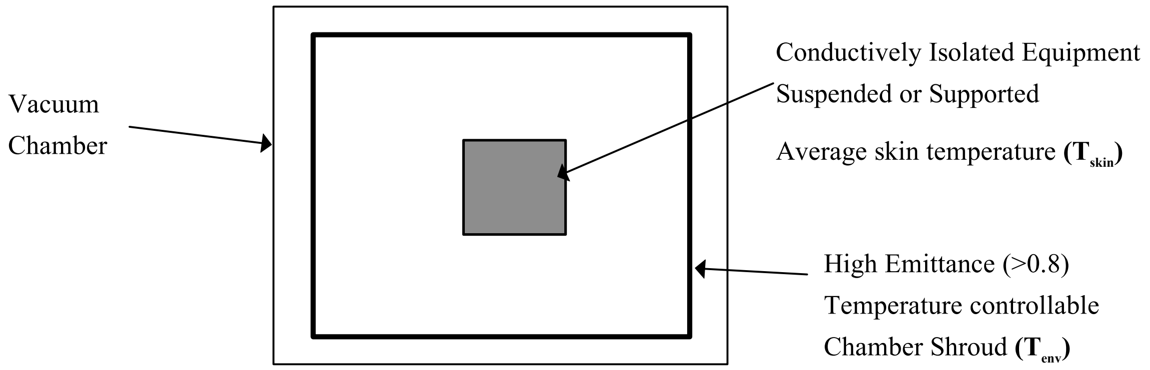


FIGURE 10.8/1 : EQUIPMENT THERMAL VACUUM TEST ARRANGEMENT (radiative equipment)

10.8.1.4 Test arrangement for internally mounted "conductive" equipment

i) The test arrangement required for equipment having temperature limits referred to the average baseplate temperature **(T_{base})** is shown in figure 10.8/2 and described below.

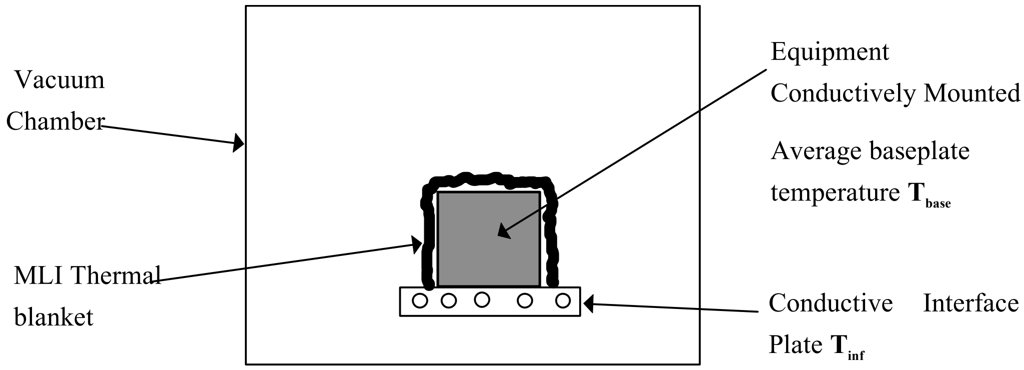
ii) The equipment shall be bolted directly on a thermally controlled conductive heat sink using correct bolt and bolt torques as specified in §9.2. (Supplier to provide thermal interface filler between equipment and heat sink).

iii) During the test the conductive heat sink temperature shall be controlled to give the required temperature level on the equipment reference temperature (T_{base} or previously agreed reference point). The qualification temperatures to be reached are defined in §7.1.4.

iv) During the test the radiative exchanges shall be thermally controlled with a MLI blanket on equipment (option A) or the chamber radiative shroud may be controlled to the same temperature as the equipment baseplate (option B). the choice between both options has to be submitted to Prime for approval.

v) For non-isothermal equipments, the temperature of the heat sink shall be monitored by the hottest reference point during hot phases and by the coldest reference point during cold phases.

OPTION A:



OPTION B :

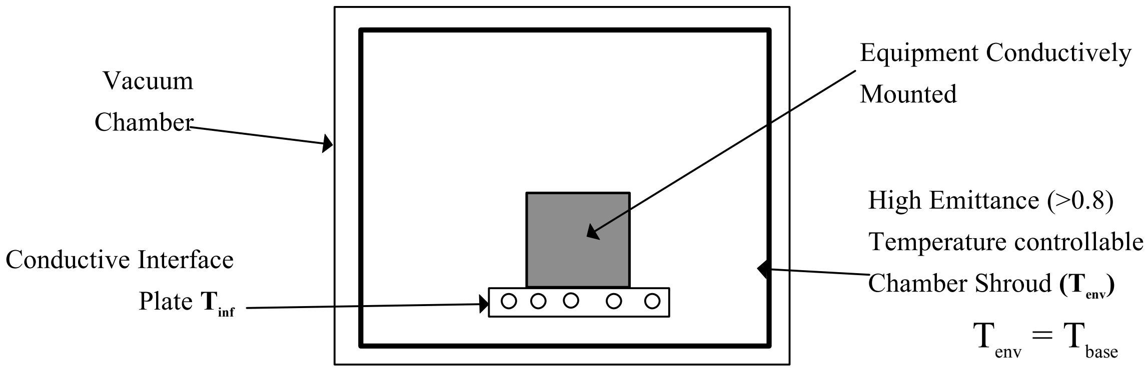


FIGURE 10.8/ 2 : EQUIPMENT THERMAL VACUUM TEST ARRANGEMENT (conductive equipment)

10.8.1.5 Test arrangement for special internal equipment

Certain internally mounted equipment will require special test provisions. Examples of such equipment would be:

- Sensors having viewing apertures seeing space.
- High power equipments having direct radiating surfaces.
- High power equipment mounted on heat pipes (TWT for example)
- Radiatively decoupled equipments (OMUX for example)

In such cases the required approach is to modify the test methods given in §10.8.1.3 and §10.8.1.4 to the extent needed to give a reasonably representative test environment.

Potential problems in this respect should be brought to the attention of the Prime Contractor and agreement found prior to testing.

10.8.1.6 Test arrangement for externally mounted equipment

The test arrangement must be designed to give the required qualification or acceptance temperatures on the equipment with approximately representative heat flows to and from the environment.

Where heat flows to and from the external environment predominate, the equipment shall be tested under space simulation conditions with the test chamber cold wall at liquid nitrogen (LN_2) temperature and an infra-red radiation source equivalent to at least one solar constant in the test plane to control temperatures over the required ranges for at least 10 cycles.

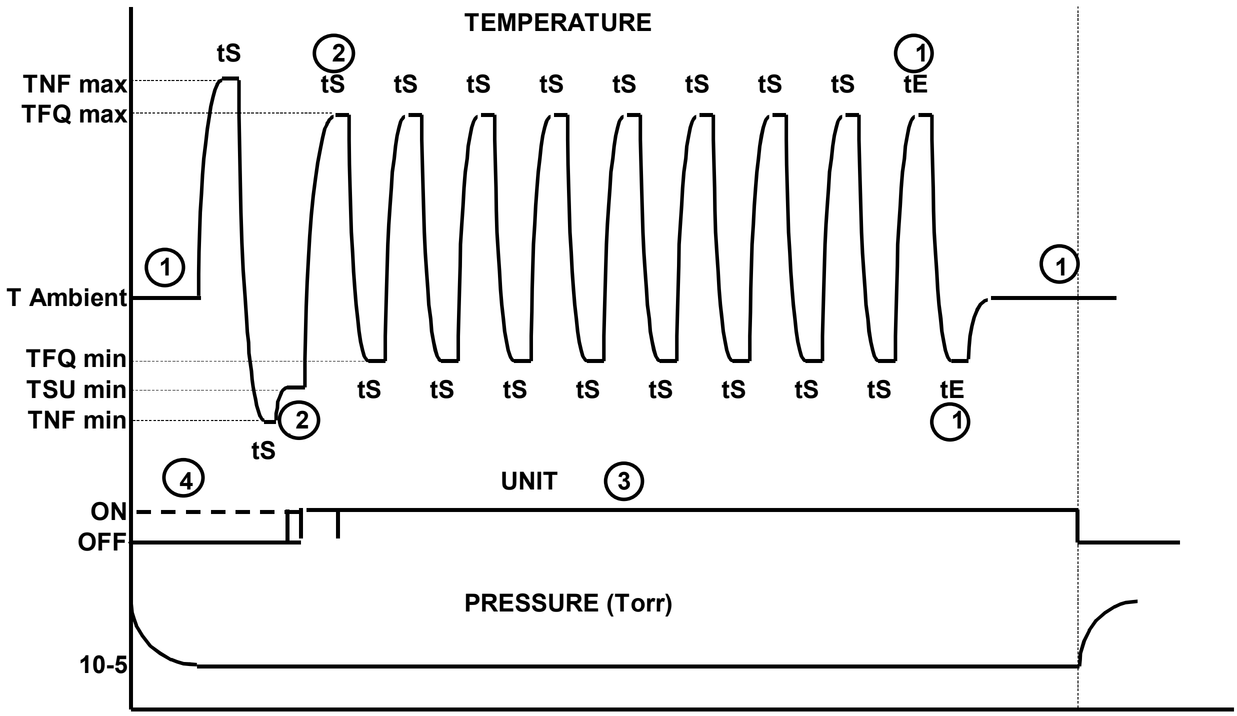
10.8.1.7 Test sequence

During qualification testing, the same item shall be tested, in the normal post-lift-off sequence, to the thermal environments appropriate to non-operating, switch-on (start-up) and operating qualification temperature limits. The performance of the test, i.e. number of cycles, temperature ranges and duration are shown in figure 10.8/3. If preferred, the temperature cycle profile in figure 10.8/3 can be changed to give a hot phase first (for cycling with unit ON).

Note : dT/dt =< 2°C per minute applies only to equipment within the satellite. For equipment outside the satellite higher gradients will be specified in the appropriate equipment specification.

Nomenclature (figure 10.8/3) :

TNF max	Maximum non functioning temperature
T ambient	Ambient temperature
TFQ max	Maximum qualification temperature
TFQ min	Minimum qualification temperature
TNF min	Minimum non functioning temperature
TSU min	Minimum start up temperature
P	Pressure
tS	Minimum stabilised temperature time: 1 hour
tE	Minimum stabilised temperature time prior to start performance test : 4 hours.



1 Limited Performance Test
2 Unit ON/OFF (Verification of ON/OFF switching capability at TSU and TFQ)
3 At all times when unit is ON, a selected set of major parameters (current...) are continously monitored (Typically 1 point per minute)
4 For CORONA test, some units are ON during pressure drop (see §10.4)

dT/dt < 2°C per min (see §10.8.1.7), except if specified in the equipment specification

FIGURE 10.8/3: THERMAL VACUUM QUALIFICATION TEST AT EQUIPMENT LEVEL

10.8.2 Thermal acceptance test

A functional performance test shall be performed on the equipment in vacuum with the temperature of the equipment controlled, measured and selected such that it can be guaranteed that the test item experiences actual temperatures equal to or beyond the maximum and minimum acceptance operating temperatures. Refer to §9.2.2 and §9.2.3 for tolerances and measurement accuracy. In order to ensure the application of the maximum stress condition, the unit shall be operated continuously throughout the test, with a limited performance test performed 4 times at the first ambient plateau (reference test) at a hot and at a cold plateau and at the final ambient plateau, and adequate monitoring during the remainder of the test. The required sequence is shown in figure 10.8/4. If preferred, the temperature cycle profile can be changed to give a hot phase first (for cycling with unit ON).

The nomenclature of figure 10.8/4 is as follow :

TNF max	Maximum non functioning temperature
TFA max	Maximum acceptance temperature
TFA min	Minimum acceptance temperature
TSU min	Minimum start up temperature
TNF min	Minimum non functioning temperature
tS	Minimum stabilised temperature time: 1 hour
tE	Minimum stabilised temperature time prior to starting performance test: 2 hours.

Sealed pressurised equipments whose proper operation depends on the presence of the sealed-in gas shall be subjected to the temperature extremes test under the following conditions:

- The external pressure shall be less than 10^{-5} torr.
- The unit may be switched-off after the performance test at the second temperature extreme and removed from the vacuum chamber prior to the performance test at ambient temperature.
- Detection means shall be used in the vacuum facility to ascertain whether the sealed equipment is leaking.

Testing (acceptance only) at ambient pressure may be authorised by the Prime Contractor provided that :

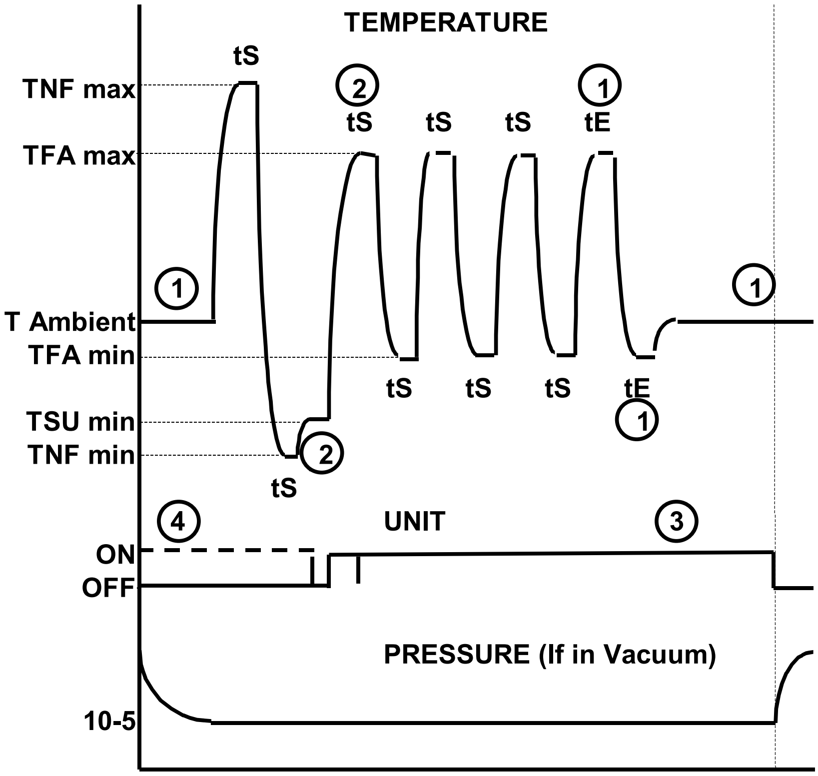
- At least 3 identical units at flight standard have already successfully gone through vacuum test
- The Supplier can demonstrate that this has no (or minor) impact on the accuracy of performance testing.

The equivalence of a specifically configured ambient test should be demonstrated by analysis to achieve all critical temperatures to within +5/-2°C for hot acceptance tests and +2/-5°C for cold acceptance tests in comparison to those expected for vacuum acceptance testing. In addition, in order to avoid a specific corona test for units ON during launch, the Subcontractor shall demonstrate that the workmanship cannot induce corona sensitivity (see §10.4).

A formal approval from the Prime Contractor is mandatory before the test. In any case the Supplier shall be able to perform acceptance thermal vacuum testing, when requested.

10.8.3 Thermal life tests

For material / process sensitive to numerous thermal cycle a thermal life test is required. The conditions of this thermal life test will be approved by the Prime Contractor.



1 Limited Performance Test
2 Unit ON/OFF (Verification of ON/OFF switching capability at TSU and TFA)
3 At all times when unit is ON, a selected set of major parameters (current...) are continously monitored (Typically 1 point per minute)
4 For CORONA test, some units are ON during pressure drop (see §10.4)

FIGURE 10.8/4: EQUIPMENT ACCEPTANCE TEMPERATURE CYCLE TEST

11 APPENDIX A : ELECTRICAL DATA SHEET (FOR ILLUSTRATION ONLY)

Formats for connector and pin function data sheets are given hereafter and the reader must refer to RD5 (from chapter 3) to get detailed explanations and typical examples, on how to fill the formats.

ELECTRICAL DATA SHEET 1/2					SATELLITE :	
					MODEL :	
ISSUE SHEET:					ISSUE DATE:	
NEW *	SUBSYSTEM	EQUIPEMENT	CONNECTOR NAME	CONNECTOR TYPE	CONNECTOR DESIGNATION	SPECIFIC REQUIREMENTS

ELECTRICAL DATA SHEET 2/2				SATELLITE :											
				MODEL :											
	ISS. SHEET:			ISS. DATE :											
NEW *	UNIT	CONNECTOR NAME	PIN Nb	RETURN PIN	SIGNAL / LINE NAME	Link Type	EMC Type	I / F Draw.	L / S	Volt (V)	Curr (mA)	Res. (ž)	Capa. (pF)	Freq. (Hz)	Specific Requir.

12 APPENDIX B : MECHANICAL DATA SHEET AND ICD

Unit Name	ICD reference	Unit Number	Location in S/C

§3.2. *(1)*

§4.1.5.

I.C.D.'s MATRIX OF COMPLIANCE

on text and tables	Compliance/NC	on drawings	Compliance/NC
ICD reference number / issue		"dimensioned" views, including footprint	
Identification of the unit		foot thickness + washers if any	
Current Mass per unit		IRD in dot lines	
Mass change per unit		Viewing aperture and field of view	
Center of Gravity location		Unit size (length, width, heigth)	
Momentum of Inertia		Mounting surface + material +flatness+surface finish	
Data source (computed/Measured)		Surface treatment	
Tolerance of each Data		bolts / washers types and torque	
alignment requirements + tolerances		shielding thickness	
environmental stability		connectors type, orientation, positions	
tolerances between faces of each mirror		Grounding point(s) positions + necessity of straps	
comments (if any)		positions of the mirror cubes (if any)	
		thermal capacity, dissipation, op/funct temperatures	

§5.1.

MECHANICAL DESIGN REQUIREMENT

Mechanical Analysis Report :	

STIFFNESS			
item	requirement	computed	measured
1st frequency (2)	> 100 Hz		

NOTCHING

SAFETY MARGIN (w.r.t. Design loads=1,5*flight)			
item	(1)	requirement	computed
yield stress of metallic parts		0%	
ultimate stress(except composite)	(3)	25%	
first ply failure of composite parts	(3)	25%	
elastic buckling		10%	

§5.1.4. & 10.7. **EQUIPMENT SUBJECT TO LIFE TIME DEGRADATION**

ESTLTD class :	(4)		
DESIGN RULES			
items	requirement	as design	as tested
redundancy	as DIET §5.1.4.1.		
Actuation factor (5)	Ms > 2		
Nbr of cycles (6)	(6)		
lubrification (7)	(7)		
end stops	as DIET §5.1.4.5.		
latching / locking	as DIET §5.1.4.6.		
release devices (8)	full redundancy		
pre_loaded ball bearings	as DIET §5.1.4.8.		
flushing	as DIET §5.1.4.9.		

QUALIFICATION (before LIFE TEST)		
test	**as requested**	**as tested**
assembly mounting	representative	
loads applied	worst case	
test conditions	at ambiant	
test conditions	at Tminlife-20°C	
test conditions	at Tmaxlife+20°C	
test conditions	worst Tgradient	
ACCEPTANCE		
as qualification test, without life test		
LIFE TEST (6)		
tested as design (see the note, and also DIET § 10.7.3.)		

§5.2. **INTERFACE INFORMATION'S**

	REQUESTED			COMPUTED			MEASURED		
MASS	kg	+/-		kg	+/-		kg	+/-	maxi
CENTER OF GRAVITY along Xeq	mm	+/-		mm	+/-		mm	+/-	
CENTER OF GRAVITY along Yeq	mm	+/-		mm	+/-		mm	+/-	
CENTER OF GRAVITY along Zeq	mm	+/-		mm	+/-		mm	+/-	
INERTIA Ixx	kg.m2	+/-		kg.m2	+/-		kg.m2	+/-	
INERTIA Iyy	kg.m2	+/-		kg.m2	+/-		kg.m2	+/-	
INERTIA Izz	kg.m2	+/-		kg.m2	+/-		kg.m2	+/-	

LENGTH	mm	+	
WIDTH	mm	+	
HEIGHT	mm	+	

Number of bolts	

Remarks :	

§5.2. **INTERFACE REQUIREMENTS**

FIXATION		
items	**required**	**design/built**
bolt type	M4 (Titanium)	
embedded central bolt	prohibited	
diameter hole	4,4 +/-0,1mm	
hole position tolerance	< 0,15mm	
diametre-disc footprint of the foot	> 17mm	
foot thickness	3 +/-0,2mm	
1 thickness/unit	yes	
provision for washer	Φ = 8mm	
provision for washer	thickness = 1mm	
no protusion above holes	no go volume	
minimum distance between inserts	> 25mm	
axial load / bolt under 1g (14)	20N	
equipment with critical alignment	statical feet	
flatness (15)	(15)	
surface finish	<3,2 µm	
mounting faces	paint free	
protective coat	conducting	
damping support (in the EQ itself)	none	
I/F filler (if any) (16)	non curing gasket	
I/F filler (if any)	conductive	

GROUNDING PROVISIONS		
items (13)	**requested**	**design/built**
chassis material	electr.conductive	
+ compatibility	with structure	
bonding stud	one or two	
size	M3 threaded stud	
threaded length	8 +/-2mm	
location	lateral face	
other grounding	by one foot	

ALIGNMENT (22)		
items	**required**	**design/built**
I/F fasteners	self locking class	
need of optical ref. mirror/cube	if acc. < +/- 0,25°	
position(s) + tolerances	xx +/- xmm	
F.O.V in S/C	visible	
if dismountable mirror	repeatability	
alignement about 2 axis (9)	1 / 2 reflect.mirrors	
alignement about 3 axis (9)	2 reflect.mirrors	
RF axis v.s. ICD axis tol. (10)	< |+/- 20"|	
90° between mirror faces (9)	tolerance < +/- 5"	
reflecting surface (9)	optically polished	
reflecting surface flatness (9)	within λ/4 (Na yellow)	
optical references size (9)	> 15 mm	
optical references size (9)	thickness > 6 mm	
stability during life time (11)	+/- 30"	
mirror brkt I/F (12)	3-point fixation	
tolerances between faces of 1cube	< |+/- 10"|	
mirror on a rigid part of the equipment functional part		

Mass/C.o.g/Inertias TOLERANCES			
tolerances	**requested**	**computed**	**built**
in mass (17) (18)			
in c.o.g. (19)	+/- 1mm		
in Inertias (20)	5%		if possible
inertias through cog			

CONNECTORS		
items	**requested**	**design/built**
location	lateral face	
overall height location (21)	50mm<l<100mm	

§10.1.2.

RANDOM

QUALIFICATION / PROTOQUALIFICATION

perpendicular to I/F plane				at I/F plane (equipment lateral axis)			
as requested		as tested		as requested		as tested	
Freq.range	Spectral Density	Freq.range	Spectral Density	Freq.range	Spectral Density	Freq.range	Spectral Density
	dB/Oct				dB/Oct		
Overall level	g RMS	Overall level		Overall level	g RMS	Overall level	
Duration Q	120s	Duration Q		Duration Q	120s	Duration Q	
Duration PQ	60s	Duration PQ		Duration PQ	60s	Duration PQ	
		Unit ON/OFF				Unit ON/OFF	
		Unit tested				Unit tested	

ACCEPTANCE

perpendicular to I/F plane				at I/F plane (equipment lateral axis)			
as requested		as tested		as requested		as tested	
Freq.range	Spectral Density	Freq.range	Spectral Density	Freq.range	Spectral Density	Freq.range	Spectral Density
	dB/Oct				dB/Oct		
Overall level	g RMS	Overall level		Overall level	g RMS	Overall level	
Duration A	60s	Duration A		Duration A	60s	Duration A	
		Unit ON/OFF				Unit ON/OFF	
		Unit tested				Unit tested	

	Requirement Spec	Test Report	STATUS
Random			
Commentary :			

§10.1.3. **SINUS**

QUALIFICATION / PROTOQUALIFICATION			
separetly along the three axis			
as requested		as tested	
Freq.range	acceleration	Freq.range	acceleration
Sweep rates Q	2 octaves/minute	Sweep rates Q	
Sweep rates PQ	4 octaves/minute	Sweep rates PQ	
		Unit ON/OFF	
		Unit tested	

ACCEPTANCE : not applicable (Qualif. / ProtoQualif. only)

§10.2. **CONSTANT ACCELERATION**

QUALIFICATION / PROTOQUALIFICATION			
separetly along the three axis			
as requested		as tested	
Axis	acceleration	Axis	acceleration
X axis	20g	X axis	
Y axis	20g	Y axis	
Z axis	20g	Z axis	
Duration Q	60s	Duration Q	
Duration PQ	60s	Duration PQ	
		Unit ON/OFF	
		Unit tested	

ACCEPTANCE : not applicable (Qualif. / ProtoQualif. only)

	Requirement Spec	Test Report	STATUS
Sinus			
Constant acceleration			

Commentary :

§10.3. **SHOCK**

QUALIFICATION / PROTOQUALIFICATION

deployable antenna release

all three axis

as requested		**as tested**	
Area	D	Unit ON/OFF	
		Unit tested	

S/C clampband release

all three axis

as requested		**as tested**	
Freq.	SRS acceleration	Freq.	SRS acceleration
Area	C	Unit ON/OFF	
		Unit tested	

solar array release

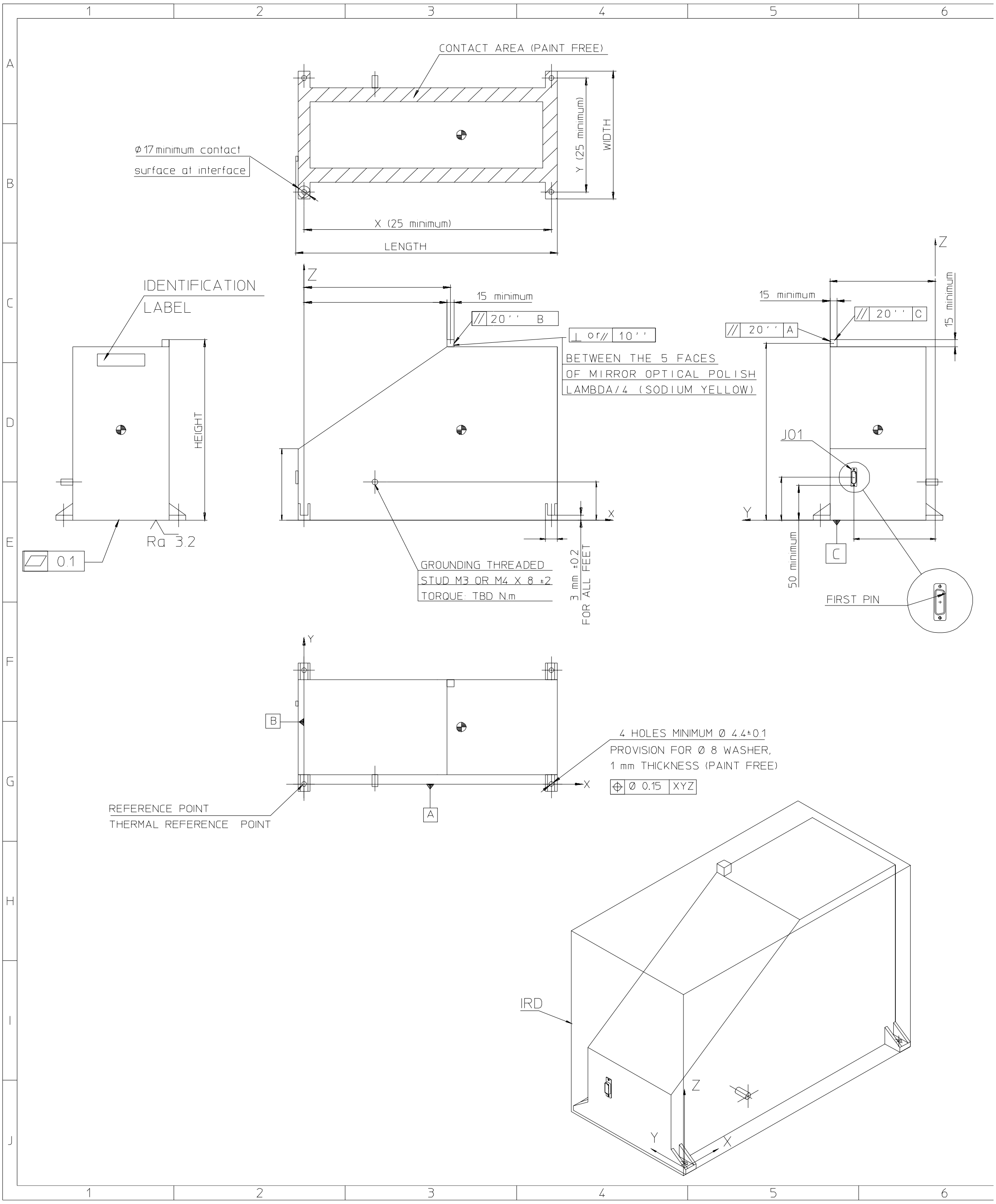
all three axis

as requested		**as tested**	
Freq.	SRS acceleration	Freq.	SRS acceleration
parallel to mounting plane		parallel to mounting plane	
perpendicular to mounting plane		perpendicular to mounting plane	
Area	S	Unit ON/OFF	
		Unit tested	

ACCEPTANCE : not applicable (Qualification / ProtoQualification only)

	Requirement Spec	Test Report	STATUS
Shock			
Commentary :			

NOTES	
location	text
(1)	(1): limit loads = acceptance loads = maximum loads seen during the equipment life // design loads = 1.5x limit loads
(2)	(2): different frequency for S.A,battery,tanks,antennae,MW, brackets...
(3)	(3) : printed circuit board is as composite parts.
(4)	(4): 'D'eployement or 'P'ointing'/S'witching or 'R'otating or 'L'inear devices or eq subject to gas/liquid 'T'roughput
(5)	(5): Ms = Fa/Fr - 1 . See DIET §5.1.4.2. for details
(6)	(6): D>50&2*total nbr // P/S&L>50&1.5xtotal nbr // R>50&1.5x total nbr/time // L>1,5xtotal nbr // T : see DIET§5.1.4.3.
(7)	(7): covered by (6)
(8)	(8): see DIET §5.1.4.7. for the "full redundancy" definition.
(9)	(9) = see DIET § 5.2.2.2. a) to i)
(10)	(10): 1'=0.017° changed to 20"=0,0056° (from GDIR 2000+ to DIET 3000)
(11)	(11): 9"=0,0025° changed to 30"=0,008° (from GDIR 2000+ to DIET 3000)
(12)	(12): a 2-point fixation has a too-easy 180°-symetry
(13)	(13)= first grounding = I/F surface /// 2nd gr.=stud /// Third gr.= by foot
(14)	(14)= 20 Newtons per insert and per g quasistatic in any direction is under review
(15)	(15)= 0.1mm/100mm
(16)	(16): Baseline=DRYJOINT // Back-Up #1=SIGRAFLEX (non curing;on panel skin) // B.U.#2=DC93500 (curing;on HP)
(17)	(17)= mass computed accuracy : minimum of 3% and 0,2Kg
(18)	(18)= mass measured accuracy : up to 20Kg = +/-0,01kg /// 20 to 200kg = +/-0,05Kg
(19)	(19)= for C.O.G : If Inertia < 0,2kg.m.m, Then calculated values only.
(20)	(20)= for Inertias : only computed if the model is good enough in mass & c.o.g.
(21)	(21)= tyraps to be mounted along box faces if l>100 mm
(22)	(22): AIT people can measure angles with a tolerance of 10"=0,00278°
(23)	none


CONTACT AREA (PAINT FREE)
Ø 17 minimum contact surface at interface
Y (25 minimum)
WIDTH
X (25 minimum)
LENGTH
IDENTIFICATION LABEL
HEIGHT
Ra 3.2
0.1
15 minimum
20'' B
⊥ or // 10''
BETWEEN THE 5 FACES OF MIRROR OPTICAL POLISH LAMBDA/4 (SODIUM YELLOW)
20'' A
20'' C
J01
50 minimum
FIRST PIN
GROUNDING THREADED STUD M3 OR M4 X 8 ±2
TORQUE: TBD Nm
3 mm ±0.2 FOR ALL FEET
4 HOLES MINIMUM Ø 4.4±0.1
PROVISION FOR Ø 8 WASHER,
1 mm THICKNESS (PAINT FREE)
Ø 0.15 XYZ
REFERENCE POINT
THERMAL REFERENCE POINT
IRD

7	8	9	10

MODIFICATIONS OU AMENDEMENT

ED.	ZONE	LIBELLE	NOM	DATE
00	-	FIRST ISSUE	*****	**/**/**

THERMAL INTERFACE

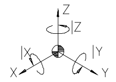
ABSORTIVITY	EMISSIVITY	CONTACT AREA (mm 2)	THERMAL CAPACITY (J/K)	THERMAL DISSIPATION PER UNITS (WATT)		OPERATING RANGE (°C)				QUALIF START UP MINI °C	NON OPERATING RANGE (°C)		COMMENTS
				NOMINAL	OTHER	ACCEPTANCE		QUALIF					
						MIN	MAX	MIN	MAX		MIN	MAX	

THERMAL NOTES : - CONTACT AREA -ELECTRICALY CONDUCTING
-FINISH
-MATERIAL
- SURFACE TREATMENT

MECHANICAL INTERFACE

(G)

SPHERICAL Ø2 XYZ



INERTIES THROUGH COG

MASS (Kg)	TOLERANCE	SEE NOTE *	CENTER OF GRAVITY			SEE NOTE *	MOMENT OF INERTIA (Kg.m)			TOLERANCE	SEE NOTE *	MOUNTING SURFACE	
			Xg	Yg	Zg		|X	|Y	|Z			FLATNESS	TEXTURE

MECHANICAL NOTES :
- EMBEDDED CENTRAL BOLT PROHIBITED
- NO PROTUSION ABOVE FIXINGS HOLES
- * : C = COMPUTED , M = MEASURED , TBD = TO BE DEFINED , E = ESTIMATION
- ENVIRONMENT STABILITY OF MIRROR CUBES AND ITS INTERFACES < ±20'' DURING LIFETIME
- ALIGNMENT REQUIREMENT + TOLERANCES

OPTICAL MIRROR CUBE IN XYZ

	X	Y	Z
CUBE	TBD	TBD	TBD

DIRECTOR COSINUS

	X	Y	Z
X CUBE	TBD	TBD	TBD
Y CUBE	TBD	TBD	TBD
Z CUBE	TBD	TBD	TBD

ELECTRICAL INTERFACE

CONNECTION NUMBER	J01		J02	
SUPPLIER'S REFERENCE				
SUPPLIER				
REFERENCE				
REQUIRED TORQUE				
	PIN	SIGNAL	PIN	SIGNAL
	1		1	
	2		2	

ELECTRICAL NOTES :
- WHERE CONNECTORS ARE LOCATED MORE THAN 100 mm ABOVE THE MONTING INTERFACE TIE-WRAP SUPPORTS FOR THE HARNESS MUST BE PROVIDED
- GROUDING STUD = BASELINE
STRAP FIXED ON A FOOT = BACK UP

GENERAL NOTES

- SHIELDING THICKNESS : TBD
- FIELD OF VIEW : TBD
- MLI VELCRO : TBD
- GENERAL TOLERANCES ± TBD mm

ECHELLE	FORMAT	PROJECT	DESSINE	VERIFIE	VISE	QUALITE
:	A*		NOM ****			
			DATE **/**/**			
			BUREAU D'ETUDES			

DESIGNATION

NAME

MATRA MARCONI SPACE

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RADICAL	N° ARTICLE	CDE GEST	FEUILLE	ED
	REF. NUMBER	ICD	**	00

7	8	9	10

13 APPENDIX C : THERMAL DATA SHEET

UNIT :		
SUBSYSTEM :		
FunctioningTemperature (°C)		
Functioning Operating	TFO Min	
	TFO Max	
Functioning Acceptance	TFA Min	
	TFA Max	
Functioning Qualification	TFQ Min	
	TFQ Max	
Non Functioning Temperature (°C)		
Non Functioning	TNF Min	
	TNF Max	
Start up Temperature (°C)		
	Min :	
Ground Storage Temperature (°C)		
	Min :	
	Max :	
Unit wall sizing L(mm)*l(mm)*h(mm) :		
Unit baseplate sizing L(mm)*l(mm) :		
Unit contact area (cm2) :		
Unit radiative area (cm2) :		
Unit emittance :		
Unit solar absorptivity		
Unit thermal capacitance (J/°C) :		

DATE :			
ISSUE :			
Mission phase	**nb of working unit**	**Dissipation per working unit**	
		Min (W)	**Max (W)**
Launch			
Transfer sun			
eclipse			
Drift			
In orbit sun			
eclipse			
Safe mode			
Unit individual cold/hot failure			

Remarks : (to precise dissipations in all the existing modes and measured values)

Comments :

Unit individual hot failure dissipation shall be computed for maximum figure; duration shall be given if applicable.

When applicable, heat dissipation profile shall be provided on a separate sheet.

Unit dissipation values of the different modes to be provided in addition of Min & Max figures.

Mission phase description :

Launch : from lift-off to separation from launcher

Transfer : from separation from launcher to solar array deployment

Drift : from solar array deployment to earth acquisition

In orbit : when at its operational station longitude

14 APPENDIX D : EUROSTAR 3000 EVOLUTION AT 100V

The Eurostar 3000 regulated voltage will evolve to 100V. The aim of this section is to give some information on the performance of this voltage, to be used as a guideline for any new 100V equipment development.

- Main bus voltage :

The main bus voltage is controlled by the power supply regulator in sunlight from the solar arrays, and in eclipse from the battery.

DC voltage at user primary power connector input is 100 V ± 1% + 1Vrms ripple superimposed (sine wave signal 50 Hz to 10 MHz) +0/-350mV (harness voltage drop).

All users shall meet full performance under these conditions.

- Current and voltage ripple :

Equipments shall not inject on the power main bus, current ripple exceeding requirements of figure 10.3/2.

Equipments are required to meet full performance when the power main bus presents the voltage ripple defined in §10.3.3.2.1.

- Transients due to load switching :

Units shall be switched On in a sequential way only : multiple unit simultaneous switch-on is forbidden.

For a step load, the bus voltage disturbance will not exceed ± 3% with a leading or a falling edge rate of 50V/ms, followed by an exponential recovery time of less than 5 ms. The repetition rate of the transient due to load switching will not exceed 10Hz.

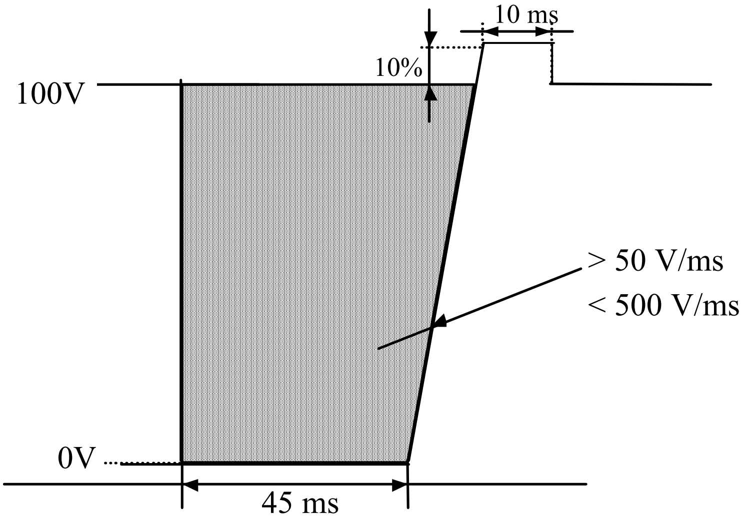
- Transients due to fuse clearing :

During such events, the bus voltage will be within hatched areas - 100% to ± 10% according to figure Appendix D/1.

Platform equipments shall remain fully operational in case of a 1 ms power drop from 100V with 50V/ms minimum primary voltage slope at recovery, according to figure Appendix D/1.

For power drops of up to 45 ms, all users are not required to meet performance parameters under these conditions, but must ensure that they survive the event and that no overstressing of the system occurs during or recovering from it, so that proper operations can resume (autonomously or not) after the power bus transient, with nominal performance.

All software and configuration data (e.g. RAM, registers) integrity shall be guaranteed during at least 100 ms with 0V power bus voltage, in order to be insensitive to the specified transients.



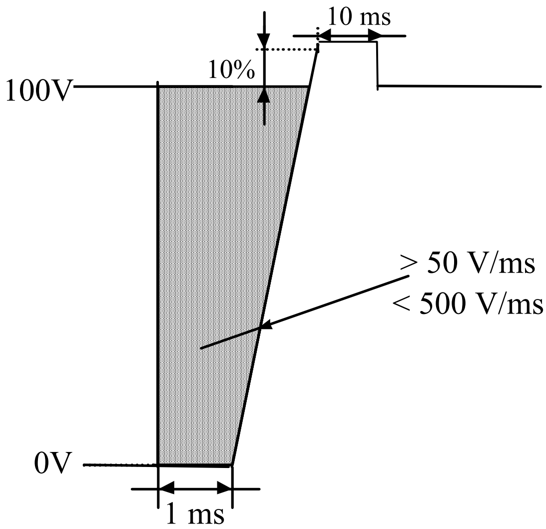


FIGURE Appendix D/1 : Transient due to fuse clearing

- Abnormal mode :

General

All equipments shall not be stressed when power bus voltage is between 0V and 100V ± 1% whatever duration and settling rate, or with overvoltage (up to 110 V during 10 ms). Fuse deratings shall be met under these conditions.

An Under/Over Voltage Detection should be implemented.

There shall be no turn-off mode for the command subsystem.

Any conceivable bus voltage or environmental conditions shall not result in spurious command generation or execution.

Requirements shall be demonstrated by test or analysis.

Platform units

The platform equipments shall continue to operate functionally when the power bus voltage goes down to a voltage of 75 Vdc, in the same conditions as under normal bus voltage, with the exception that the telemetry transmitter performance may be degraded by no more than 3 dB in output power and ± 10% modulation index.

Some critical platform units may have more stringent low voltage specified value in their equipment specification.

Payload units

For payload equipments, an automatic switch-off shall be implemented ; low voltage thresholds shall be set to 45 +0/-1V for a duration greater than 5 ms (filtering at detection), response time not exceeding 5 ms (from detection to complete switch-off). Restart shall be performed by external command only.

- Main bus protection :

The general principle for the main power bus is that it is generated in such a manner that it is single point failure free at the distribution point (i.e. no failure of a part or insulation can cause the loss of the power bus) to ensure the bus remains reliable when users are connected to it ; the users of the main bus shall protect the bus from overload caused by equipment failure.

Protection shall be either by current limiting or by fuses, combined with double insulation between the power distribution point and the limiting device.

The integrity of the double insulation shall be verifiable following integration of the equipment on the spacecraft.

If compliance with this requirement is implemented by any automatic means other than fusing or current limiting, a provision for ground override shall be made.

Current limitation - If current limitation is chosen, the following requirements shall apply :

- After any equipment failure, the user shall limit the current consumption to 1.5 time the maximum steady state current within 1 ms.
- For loads above 30 Watts, the current limiter shall initiate an automatic turn-off within 5 seconds.

Fuses - When fuses are used to protect the bus :

- The input relay of the unit shall be sized to switch twice the manufacturer's fuse rating current.
- Fuses shall not be implemented inside equipments, unless with the prior consent of the Prime Contractor.
- Fuses shall be placed such that required fuse blowing current is available to the fuse.
- The fuse temperature shall be considered in the range [-40°C ; +85 °C].
- Fuses in vacuum shall have a current derating according to RD1 specifications, for DC current.
- For surge currents, a margin ratio of at least 4 shall be considered with respect to the fuse manufacturer data.
- The fuse sizing shall include unit power off, all operational modes of the unit (e.g. including EHT switching on and off for TWTA payload units), and abnormal modes and all surge current situations (e.g. non exhaustive list : inrush current at switch on, with or without precharged filter ; surge currents induced by transients with maximum voltage rate of 500 V/ms and whatever the transient duration from 0ms to 45ms ; surge currents induced by abnormal modes of §6.2.1.4.).
- The fuse rating current shall not exceed 15 A, unless with the prior consent of the Prime Contractor.
- Redundant fuses may be used only with the prior consent of the Prime Contractor.
- Fuses which are used to protect any primary bus from primary power user failure, shall comply with the following requirement : any fuse shall blow in vacuum when energised for 45 ms with 4 times the fuse current rating, under all qualification environmental conditions.
- As far as possible, the fuses type shall be MEPCOPAL P600L ; any other type choice shall be justified.
- When current is subjected to significant variations (such as internally thermally regulated equipments, or as resistive loads) with respect to those conditions, the details of current variation shall be given (such as levels and duration, dissipation versus skin temperature, or consumption versus voltage).

The Supplier shall be responsible for the fuse rating sizing, that shall be submitted to Prime for approval.

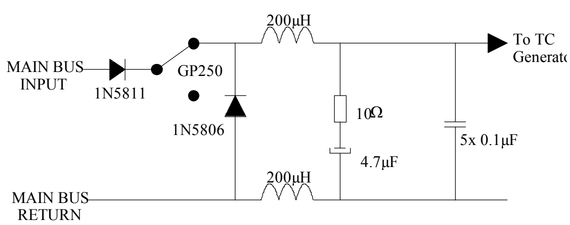
In order, - to assess internal fuse sizing,

- to define spacecraft centralised protection,

- to size external switching elements if any,

- to ensure compatibility of internal switching w.r.t. centralised protection,

[R] the following table shall be fulfilled by the equipment designer each time a protection is needed (power bus, transformer output, telecommands, telemetries, internal functions ...).

OVERALL FUNCTION	Name of the function or set board e.g. :CVA or heater group 8
REF	Reference in the board part list for internal fuses e.g. :F10
IF(A)	Fuse rating e.g. : 2A
VF(v)	Fuse Max voltage e.g. : 125V
MANUFACTURER	Manufacturer's name and fuse type e.g. : MEPCOPAL P600L 125-2
FUSE FUNCTION	Describe the function of the fuse e.g. : Bus input protection or Capacitor S.C. failure protection
STATUS	I (internal to the unit) or O (outside the unit : centralised protection)
TYPE OF LOAD	R (resistive like heaters) with value R/L (coil) with characteristics @ 25°C P=cte (converter) with value (W) and inductor characteristics
Inom(A) / V(v)	Maximum steady state current w.r.t. nominal voltage and low voltage if applicable e.g. :0.5A/100V 0.57A/90V 0.6A/80V 0.7A/70V
Imax(A) / t (ms)	Max worst case current w.r.t. voltage including pulsed load like telecommand, motor drive during the corresponding duration t. e.g. : 0.45A / 50ms @ 100V
INRUSH	Measured profile of primary (first connection), secondary (start up) and bus transient recovery inrush current if applicable I=f(t) at extreme voltage (70V, 80V,90V and 100V). (simulated profile acceptable at the beginning)
SWITCHING	To identify when existing if a mechanical switching at unit level or an electronic switching is compliant with the selected fuse according to the present document requirements
Nber OF SWITCHINGS	Number of switching expected at unit level if applicable e.g. :1/week or none or N/A ....
OTHER PROTECTIONS	To identify all other protections in series (upstream or downstream) with thresholds and timings Under Voltage UV Overcurrent OVI OverVoltage OVV This shall be indicated even if no fuse is concerned e.g. : Main bus UV 20V/20ms 15V OVI 1A/<1ms
ELECTRICAL SCHEMATIC	Electrical schematic of parts around the fuse (e.g. input filter) with their value  e.g. :
COMMENTS / REMARKS	selectivity constraints with upstream or downstream fuses ....

[G] When fuse sizing is driven by transient margin and leads to a static sizing derating factor lower than 20%, the equipment design shall be modified to lower inrush current.

[R] For units with power consumption above 600 Watts on a given power line, the Prime Contractor should be consulted on the manner in which the load shall protect the power bus. For those units, the failure modes leading to EMC perturbations on the power bus shall be clearly identified and provided with quantitative current effects, and submitted for Prime approval. In any case of failure, the unit current ripple shall not exceed the unit conducted emissions specification +6 dB.

No single failure in the spacecraft including failures of wiring, connectors, etc., shall open or short the main power bus or affect definitely the normal operation of the spacecraft (Single Point of Failure), other than the possible loss of the load path where the failure occurred, provided that the corresponding function is redunded (and not affected by the failure).

All functions with primary or secondary referenced interfaces shall withstand without stress (ratings can be reached) a dc common mode voltage from -100V to +100 V, of whatever duration, with respect to their local electrical ground reference (mechanical structure, chassis, secondary 0V). This requirement is applicable whatever on or off state of the unit.

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P. GREMILLON		X	
S. LECONTE		X	
F. CHAUDON		X	
JM. STEPHAN (PTH)		X	
A. BENOIT		X	
D. PONCET		X	
P. DUMONT		X	
B. LAURENT		X	
C. BELLOC		X	
T. BRAMBLEY		X	
B. POULAIN		X	
B. COLTON (PTH)		X	
E. MOUREMBLES		X	
A. DIDIER		X	
P. PIERRE		X	
L. MALIN (PTH)		X	
T WILDE (PTH)		X	
P. ASPDEN (PTH)		X	
S. EVANS (PTH)		X	
G. RHODES (PTH)		X	
O. CLARKE (PTH)		X	
A. ARMSTRONG (PTH)		X	
A. COUCHMANN (PTH)		X	
V. JACOD (PTH)		X	
J. HUDDLESON (PTH)		X	
R. RIGOLLET		X	
PRODUCT ASSURANCE :			
B. SCHIETECATE		X	

	Overall document		Summary
	Action	Information	
E3000 architects :		X	
C. DUCHENE		X	
R. ARNAUD		X	
C. RICOLLEAU		X	
JF. DIRAISON		X	
P. GREFF		X	
I. LAINE		X	
F. GAULLIER		X	
P. NOIRAULT		X	
P. GUIONNET		X	
F. FORTNER		X	
P. LAFFAYE		X	
F. SOUQUET-BASIEGE		X	
L. TANGUY		X	
A. BROSNAN		X	
M. SEVOZ		X	
B. OLDHAM		X	
C. HUNTER (STV)		X	
H. GRAY (PTH)		X	
PROJETS :			
C. DAGRAS		X	
D. PICHEL		X	
J. PORRAS		X	
P. DOUBRERE		X	
O. THORAL		X	
C. GARRES		X	
P. PHAM		X	
A. HARDY		X	
V. CAZAUBIEL		X	
P. TEMPORELLI		X	
P. BOISSIERE		X	
T. FESQUET		X	
L. IMBERT		X	
S. GUENASSIA		X	
A. FILLATRE		X	
A. CADO		X	
F. ROCHARD		X	
M. LEMOINE		X	
PF. DELVAL		X	
L. BROOKER		X	
P. ROVET		X	
K. KABLY		X	
G. RICHARD		X	
P. MIGNONAT		X	

	Overall document		Summary
	Action	Information	
E. VERCRUYSSE		X	
C. FOURNIER		X	
B. HANIN		X	
A. de ROSNAY		X	
F. AIROLDI		X	
JF. POUSSIN		X	
SKYNET 5 :			
V.ODEDRA (STV)		X	
PROCURMENT :			
A. VAISSIERE	X		
M. ROUX	X		
E. THIEBAULT	X		
P. FERRIERES	X		
L. MURRIS	X		
A. WILD (PTH)	X		
S. GILLARD	X		
JP. ROUJAS	X		
JP. RAPHANEL	X		
E. CRABOS	X		
M. FOWLER (STV)	X		
R. GROOMBRIDGE (STV)	X		
J. THOMAS (STV)	X		
S. EDWARDS (STV)	X		
P. BERNARD	X		
J. FISHER	X		
E. LACROIX	X		
A. PHISBIEN			
Documentation TLS		20	
Documentation STV		5	
Documentation PTH		10	