EMC Requirements Definition

for the European Physiology Modules Facility (EPM)

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Project Management: P. Dank / OHB Date: 12.11.02
ESA Approval: R. Nasca / ESA Date: }

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**EPM**

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**ESA Approval: R. Nasca / ESA Date:**
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<td>More detailed information about the Rack Facility Power Consumers.</td>
</tr>
</tbody>
</table>
# Table of Contents

1. **INTRODUCTION** ................................................................. 1

1.1 **SCOPE** .............................................................................. 1

2. **APPLICABLE DOCUMENTS** ..................................................... 2

3. **EPM ELECTRICAL ARCHITECTURE** ............................................. 3

4. **EPM DETAILED EMC SPECIFICATION** ........................................... 6

4.1 **EPM EMC SUSCEPTIBILITY** .................................................. 6

4.1.1 **Conducted Susceptibility** .................................................. 6

4.1.1.1 **COLUMBUS DC Power Ripple and Transient Limits at Payload Power Interfaces** .......................................................... 6

4.1.1.2 **COLUMBUS DC Power Bus Transients (CS06)** ......................... 8

4.1.2 **EPM DC Power Ripple and Transient Limits at Payload Power Interfaces** .......................................................... 9

4.1.2.1 **EPM DC Power Bus Ripple (CS01)** ......................................... 9

4.1.2.2 **EPM DC Power Bus Ripple (CS02)** ......................................... 10

4.1.2.3 **EPM DC Power Bus Transients (CS06)** ................................. 10

4.1.2 **Radiated Susceptibility** .................................................. 11

4.1.2.1 **E-Field Susceptibility** .................................................. 11

4.1.2.2 **Magnetic Field Susceptibility** ........................................... 12

4.1.3 **EMC EMISSION** .................................................. 12

4.1.3.1 **COLUMBUS Conducted Emission** ........................................ 12

4.1.3.1.1 **COLUMBUS Load NB Current Emission** ............................... 13

4.1.3.1.2 **COLUMBUS Load BB Voltage Emission** ............................... 13

4.1.3.1.3 **COLUMBUS Load Transients** ........................................... 14

4.1.3.2 **EPM Conducted Emission** ............................................... 14

4.1.3.2.1 **EPM Conducted Ripple Emission (CE01)** .............................. 14

4.1.3.2.2 **EPM Conducted RF Emission (CE03)** .................................. 15

4.1.3.2.3 **EPM Load Transients (CE07)** ........................................... 16

4.1.3.3 **EPM Radiated Emissions** ................................................ 17

4.1.3.3.1 **Narrowband E-Field Emission** ........................................ 17

4.1.3.3.2 **Broadband E-Field Emission** .......................................... 17

4.1.3.3.3 **AC Magnetic Field Emission** .......................................... 19

4.1.3.4 **COLUMBUS Line Impedance Stabilization Network (LISN)** .... 19

4.1.4 **ARC Discharge Susceptibility** ............................................ 21

4.2 **EPM GROUNDING AND BONDING CONCEPT** ................................. 22

4.2.1 **Bonding Requirements** ............................................... 24

4.2.1.1 **Radio Frequency Bonding** ............................................ 25

4.2.1.2 **Primary Connector Bond** ............................................. 25

4.2.1.3 **Payload Surface Electrostatic Charging** ............................... 25

4.2.2 **Power Circuit Isolation and Grounding** .................................. 25

4.2.2.1 **Ground Support Equipment Isolation and Grounding** ............ 26

4.2.2.2 **Payload Isolation and Grounding** ...................................... 26

5. **EMC VERIFICATION MATRIX** .................................................. 27
List of Figures

Figure 3-1 EPM Functional Architecture Block Diagram ...........................................................................5
Figure 4-1 COLUMBUS Sine Wave Susceptibility .....................................................................................7
Figure 4-2 Transient Pulse Definition ...........................................................................................................8
Figure 4-3 Limit for CS01 ...............................................................................................................................9
Figure 4-4 Acceptable Waveshape for CS06 .............................................................................................10
Figure 4-5 E-Field Radiated Susceptibility for COLUMBUS Internal Equipment ........................................11
Figure 4-6 COLUMBUS AC Magnetic Field Susceptibility Level .................................................................12
Figure 4-7 Narrow Band Conducted Emission Current Equipment Limit ......................................................13
Figure 4-8 Limit for CE01 Narrowband Emission ......................................................................................14
Figure 4-9 Limit for CE03 Narrowband Emissions ..................................................................................15
Figure 4-10 Limit for CE03 Broadband Emissions ....................................................................................16
Figure 4-11 Narrowband Radiated Emission E-Field Limit .......................................................................17
Figure 4-12 Broadband Radiated Emission E-Field Limit .........................................................................18
Figure 4-13 AC Radiated Emission B-Field Equipment Limits ...................................................................19
Figure 4-14 LISN Schematic Diagram (COLUMBUS) ...............................................................................20
Figure 4-15 COLUMBUS LISN Source Impedance ..................................................................................20
Figure 4-16 PDU LISN Source Impedance ...............................................................................................21
Figure 4-17 COL – EPM - SM: Grounding and Bonding Diagram ............................................................23
Figure 4-18 SM Grounding and Bonding .................................................................................................24

List of Tables

Table 5-1 EPM EMC Verification Matrix .....................................................................................................27
1 INTRODUCTION

OHB-System AG establishes this EPM EMC Requirements Definition as the fundamental document for the EMC tests that have to be performed in order to proof the compliance to the COLUMBUS IRD COL-RIBRE-SPE-0164 and the therein applicable documents. The identification of the related EMC environment of EPM and the derived requirements are described in AD2.

The requirements provided in this document are defined for individual payload components (SAC mounted equipment) to be used inside the EPM Carrier Rack. They all together have to fulfill the SPE-164 requirements. Therefore the individual requirements are sometimes higher than the requirements specified for the carrier. Cabin mounted equipment has to fulfill the specifications of the SPE-164 with respect to radiated EMI requirements.

1.1 Scope

This document addresses the EMC requirements that have to be verified by test by using the EMC-chamber environment as well as tests concerning the grounding and bonding requirements. All other EMC-related requirements, as Grounding, Bonding and Isolation, are subject of additional specifications, if not already specified in higher level documents, and to be documented in unique verification reports.

The payload hardware covered by this specification is described in section 3 of this document. Section 4 addresses the EMC requirements identified to be applicable for the EPM Carrier and the EPM related Science Modules. The EMC Verification Matrix, as a summary of this document and the relation to applicable documents is depicted in section 5.
2 APPLICABLE DOCUMENTS

This document shall be read in conjunction with the documents listed hereafter, which form part of this document to the extent specified herein. In case of a conflict between any provisions of this document and the provisions of the documents listed hereafter, the content of the contractually higher document shall be considered as superseding.

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<td>30 Mar 01</td>
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<td>08 May 00</td>
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<td>Jan 1989</td>
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<td>AD11</td>
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<td>15 Aug 1990</td>
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3 EPM ELECTRICAL ARCHITECTURE

The European Physiology Modules facility (EPM) is a modular facility onboard the European ISS module Columbus, for support experiments in different disciplines of Human Physiology. The Columbus Laboratory is a pressurized, habitable module which will be attached to Node 2 of the Station. The facility will be configurable in flight. EPM will be outfitted initially for a first flight in support of a certain experiment complement. It is the intention to exchange modules for later flights, in order to comply with scientific requirements.

Therefore the EPM infrastructure will be capable of supporting as much as 8 experiments dedicated payloads (science modules) accommodated in standard 4- or 8 panel containers as well as deployable experiments located in the cabin area. All experiments have access to a number of centralized services which will be provided by the rack infrastructure as standard services. The centralized services (from the electrical point of view) listed below are accessible to all of the experiments. Specific locations are indicated where only a limited set of resources respectively services are available.

- Power Services
  - 28V DC, up to 10A

- Data Management Services
  - IEEE 802.3 LAN for Intercommunication
  - RS 485 Data I/F for Intercommunication
  - High Rate Data (HRD) Link (accessible via UDP only)
  - Video I/F (accessible via UDP only)
  - RS 422 Synchronization I/F
  - Discrete Signal I/F (digital, analogue, temperature)
  - RS 422 Data I/F for Intercommunication (accessible via UDP only)

In order to provide the mentioned services to the various types of experiments, the EPM electrical architecture copes with the following items:

PDU  Power Distribution Unit that performs main power reception from COLUMBUS, power switching, protection and conditioning. Switching and protection is provided through Solid State Power Controllers (SSPCs) part of the PDU dedicated Exchangeable Standard Electronic Modules (ESEMs).

PIB  Power Interconnection Bracket acts as an wiring aid to simplify the rack internal power harness

PSU  Power Switching Unit facilitates the FCC-software controlled power routing and switching to the Science Modules.
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<tr>
<th>Code</th>
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<td>FCC</td>
<td>Facility Control Computer which performs the fundamental control and supervisor functions of the EPM-Rack-Facility as well as data management tasks mainly related to the communication with COLUMBUS. The FCC will be based on a 5 slot standard SPLC that implements standard SPOE SPLC cards.</td>
</tr>
<tr>
<td>SMSC</td>
<td>Science Module Support Computer, that manages all the communication and control tasks which are related to the Science Modules. It also includes the Ethernet HUB functionality that is based on the IEEE802.3 10/100BaseT standard.</td>
</tr>
<tr>
<td>AAA</td>
<td>Avionic Air Assembly comprising the Fan, its electronics and the heat exchanger (HX). The AAA generates the air circulation inside the rack in order to provide air cooling service to the experiments. The AAA is a SPOE item.</td>
</tr>
<tr>
<td>AFS</td>
<td>Air Flow Shutter, that enables the capability to adjust the air flow rate for each of the SM dedicated active container depending on its power consumption. This functionality optimized the utilization of the restricted air cooling capacity of the AAA w.r.t. EPM needs.</td>
</tr>
<tr>
<td>SDA</td>
<td>Smoke Detector Assembly, that form part of the Fire Detection and Suppression (FDS) system. The SDA will be controlled by the COLUMBUS Vital Telemetry and Command Controller (VTC) via the FDS/Main interface. The smoke sensor is a NASA Standard Payload Outfitting Equipment.</td>
</tr>
<tr>
<td>LTU</td>
<td>Facility Laptop Unit, used as crew command interface. The facility laptop will be a COTS item. The LTU will be connected via the utility distribution panel.</td>
</tr>
<tr>
<td>RMSA</td>
<td>Rack Maintenance Switch Assembly will be accommodated on the EPM rack front panel in order to support rack maintenance. Toggling the Rack maintenance switch to the off-position will deactivate the rack dedicated main and auxiliary power feeder. Activated power will be indicated by a LED located at the RMSA and powered by the rack internal PDU.</td>
</tr>
<tr>
<td>UDP</td>
<td>Utility Distribution Panels offer additional resources to external or deployed science modules and, if necessary, to the EPM active container front panels.</td>
</tr>
</tbody>
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The EPM overall Functional Architecture Block Diagram is shown in Figure 3-1.
Figure 3-1 EPM Functional Architecture Block Diagram
4 EPM DETAILED EMC SPECIFICATION

4.1 EPM EMC Susceptibility

4.1.1 Conducted Susceptibility

Exposure to the conducted interference levels identified herein shall not cause EPM and the Science Modules, rack-mounted as well as deployed, to present a hazard to COLUMBUS or personnel. The DC ripple, AC modulation, and transient spike environment in which EPM operates is the result of COLUMBUS and Payload conducted emissions sources, whereas for the Science Modules and facility equipment only EPM internal sources are relevant. The internal sources are the complement of science modules, the rack facility active components and the power conditioning and distribution equipment. See the following sections for the DC Power Ripple and Transient limits. To ensure EPM and Science Modules predictable and reliable working, each EPM facility element and the Science Modules shall be designed to withstand that environment. The susceptibility test criteria defined in AD2 characterizes the COLUMBUS module environment and is sufficient for determining EPM compatibility within that environment. The test criteria for the EPM internal equipment (addresses also the deployed equipment connected to the power sources of the EPM facility) defined in AD4 Part3 (Class A2/ Categories A2a) is sufficient to assure unrestrained operations of each EPM internal element.

4.1.1.1 COL DC Power Ripple and Transient Limits at Payload Power Interfaces

Ripple and transient limits for electrical power provided by COLUMBUS at the payload interface will not exceed the voltage values specified in the following paragraphs. During normal equipment operation voltage transients of opposite polarity will not occur simultaneously on the positive and return DC power busses.

This requirement is only applicable for that equipment utilizing the primary COL power. In particular these requirements are applicable for:

- Power Distribution Unit (PDU)
- Smoke Detector Assembly (SDA)
- Avionics Air Assembly (AAA)
- Power Switching Unit (PSU)
4.1.1.1.1 COLUMBUS DC Power Bus Ripple

The EPM-Facility and its subsystems that are directly connected to the COL primary power shall not exhibit any malfunction, degradation of performance, or deviation from specified indications beyond the tolerances indicated in the individual equipment or subsystem specification when subjected to electromagnetic energy injected onto its power leads less than or equal to the values as shown in Figure 4-1.

Ref.: AD2 §4.1.7.1
4.1.1.1.2 COLUMBUS DC Power Bus Transients (CS06)

The EPM Rack Facility and its subsystems that are directly connected to the COL primary power shall not exhibit any malfunction, degradation of performance or deviation from specified indications beyond the tolerances indicated in the equipment and subsystem specification when the test spikes, each having the waveform shown on Figure 4-2 are applied sequentially to the dc power input leads.

The values of E and t are given below. Each spike shall be superimposed on the powerline voltage waveform.

— Spike #1 \( E = \pm \) Twice the nominal line voltage, \( t = 10 \) microseconds \( \pm 20 \) percent
— Spike #2 \( E = \pm \) Twice the nominal line voltage, \( t = 0.15 \) microseconds \( \pm 20 \) percent.

For the COL Power interfaces of the EPM rack a pulse of 240V shall be superimposed on the nominal line voltage of 120VDC.

Ref.: AD7 §3.2.2.3.2

Figure 4-2 Transient Pulse Definition
4.1.1.2 EPM DC Power Ripple and Transient Limits at Payload Power Interfaces

Ripple and transient limits for electrical power provided by EPM at the subsystem or Science Module (deployed and rack-mounted) interface will not exceed the voltage values specified in the following paragraphs. During normal equipment operation voltage transients of opposite polarity will not occur simultaneously on the positive and return DC power busses.

This requirement is applicable for all the equipment utilizing the primary EPM-Power.

4.1.1.2.1 EPM DC Power Bus Ripple (CS01)

The EPM facility as well as the Science Modules (deployed and rack-mounted) shall not exhibit any malfunction, degradation of performance or deviation from specified parameters beyond tolerances given by the corresponding specification when subjected to electromagnetic energy injected onto its power-leads less than or equal to the values of Figure 4-3. (AD4 §6.)
4.1.1.2.2 EPM DC Power Bus Ripple (CS02)

The EPM facility as well as the Science Modules (deployed and rack-mounted) shall not exhibit any malfunction, degradation of performance or deviation from specified parameters beyond tolerances given by the corresponding specification when subjected to 1V from a 50Ω source in the range from 50kHz to 50MHz. (AD4 §7.)

4.1.1.2.3 EPM DC Power Bus Transients (CS06)

The EPM facility as well as the Science Modules (deployed and rack-mounted) shall not exhibit any malfunction, degradation of performance or deviation from specified parameters beyond tolerances given by the corresponding specification, when the test spikes having the waveform and the amplitude of twice the supply voltage shown in Figure 4-4 are applied to the DC-Power input leads for a period of not less than 1 minute at each phase position, and for a total test period not exceeding 15 minutes in duration. (AD7 §3.2.2.3)

a) Spike #1 – E1=56Volts; t1=10µs ±20%
b) Spike #2 – E1=56Volts; t2=0.15µs ±20%

NOTE: The test sample shall be subjected to the spike(s) with the waveform shown and with the specified voltage(s) and pulselength(s).

Figure 4-4 Acceptable Waveshape for CS06
4.1.2 Radiated Susceptibility
Exposure to the radiated EMI levels identified herein shall not cause the EPM-facility or the Science Modules (accommodated or deployed) to present a hazard to COLUMBUS or personnel. The electric and magnetic field environment in which EPM operates is the result of COLUMBUS and Payload radiated emissions sources. To ensure EPM and Science Module proper function, each EPM element shall be designed to withstand that environment. The susceptibility test criteria defined in AD2 characterizes the internal COLUMBUS module environment and is sufficient for determining EPM, and its related Science Modules compatibility within that environment. These requirements are applicable for all the EPM-internal and external equipment.

4.1.2.1 E-Field Susceptibility
The EPM-facility as well as the Science Modules (deployed and rack-mounted) shall not exhibit any malfunction, degradation of performance or deviation from specified parameters beyond tolerances given by the corresponding specification when irradiated with E-fields as defined in Figure 4-5 (limit up to 10GHz). (AD2 §4.1.8.1.1)
4.1.2.2 Magnetic Field Susceptibility

EPM and its related Science Modules shall not exhibit any malfunction, degradation of performance or deviation from specified parameters beyond tolerances given by the corresponding specification when irradiated with AC magnetic fields from 30Hz to 250kHz with amplitudes given in Figure 4-6. (AD2 §4.1.8.2)

![Figure 4-6 COLUMBUS AC Magnetic Field Susceptibility Level](image)

4.1.3 EMC Emission

4.1.3.1 COLUMBUS Conducted Emission

EPM produced conducted emission limits are as follows:

Load characteristics defined in the following subparagraphs are applicable to each primary DC power user. The test has to be performed at worst case input voltage and full load. The primary power for the EPM facility (PDU input) is the COLUMBUS power. For the rack-facility equipment and the Science Modules, rack-mounted as well as deployed, the primary power is derived from the EPM-PDU. This requirement is only applicable for that equipment utilizing the primary COL power.
4.1.3.1.1 COLUMBUS Load NB Current Emission

Narrowband current emission in the range of 30Hz through 50MHz produced by equipment on each primary power line shall not exceed the limits of Figure 4-7. This limit is adjustable. The conversion rule for current emission limit (in dB µA) is:

\[ \text{dBµA/A} + 10 \log (I(A)) \]

where \( I(A) \) is the equipment current in amperes. For payload equipment, the limit must be adjusted for \( I(A) \leq 1A \). For other system equipment, the limit must be adjusted only for \( I(A) \geq 1A \).

(AD2 §4.1.5.1)

![Figure 4-7 Narrow Band Conducted Emission Current Equipment Limit](image)

4.1.3.1.2 COLUMBUS Load BB Voltage Emission

Equipment/assembly generated broadband voltage ripple an primary DC power buses shall not exceed 300mVpp/A. The limit is adjustable, depending on \( I(A) \). The conversion rule for voltage emission limits in (mVpp) is:

\[ 300mVpp \times \sqrt{I(A)} \text{ or } 2Vpp \text{ whichever is lower} \]

(AD2 §4.1.5.2)
4.1.3.1.3 COLUMBUS Load Transients

Both, positive and negative, transients on primary COLUMBUS DC power buses shall not exceed the envelope defined in Chapt. 4.1.1.1.2 with a maximum Pulse Repetition Rate PRR=10Hz. Higher PRR must be covered by limit in para. 4.1.3.1.2. Time duration of the pulse is evaluated at 10% of transient amplitude. (AD2 §4.1.5.3)

4.1.3.2 EPM Conducted Emission

4.1.3.2.1 EPM Conducted Ripple Emission (CE01)

Electromagnetic emission shall not appear on the power-leads in excess of the values shown in Figure 4-8. The limits shall be met when measured with an effective bandwidth not exceeding 75Hz. (AD7 §3.2.1.1) The limits have to be modified dependent on the drawn current in accordance to §3.2.1.1.2 of AD7.

Figure 4-8 Limit for CE01 Narrowband Emission
4.1.3.2.2 EPM Conducted RF Emission (CE03)

Electromagnetic emission shall not appear on the power leads in excess of the values shown in Figure 4-9 and Figure 4-10 for narrowband and broadband emissions, respectively. Conducted switching spike emission (including ON/OFF switching) on power leads shall meet the requirements of CE07. (AD7 §3.2.1.2) The limits have to be modified dependent on the drawn current in accordance to §3.2.1.2.2 of AD7.
4.1.3.2.3  EPM Load Transients (CE07)

Conducted switching spikes of less than 50µs in duration shall not exceed the following

+50% of nominal line voltage
-150% of nominal line voltage

Conducted switching spikes equal to or greater than 50µs in duration shall meet the transient requirements as specified in the individual equipment or subsystem specifications. The EPM requirements are:

(+ or -) 4V to 100ms
(+ or -) 1V to Infinity

(AD4 §5.)
4.1.3.3 EPM Radiated Emissions

These requirements are applicable for all the EPM-internal and external equipment.

4.1.3.3.1 Narrowband E-Field Emission

Narrowband electrical fields at 1m from equipment installed inside COLUMBUS shall not exceed the limits of Figure 4-11 (general) in the frequency range of 14kHz to 10MHz. Additionally the following limits shall not be exceeded:

- 55dB$_{\mu}$V/m 2.2 – 2.4GHz (S-contingency Space Station)
- 36dB$_{\mu}$V/m 250 - 300MHz (UHF Space Station), (for IVA communications during emergency)
- 36dB$_{\mu}$V/m 420 - 423MHz (CWU Space Station)

(AD2 §4.1.6.1.1)

![Figure 4-11 Narrowband Radiated Emission E-Field Limit](image)

4.1.3.3.2 Broadband E-Field Emission

The equipment installed inside the module shall not exceed the limit of Figure 4-12 in the frequency range 14kHz – 1GHz and additionally, the following limits. (AD2 §4.1.6.2.1)

- 48dB$_{\mu}$V/m/MHz 415 – 428MHz (CWU: Space Station)
- 62 dB$_{\mu}$V/m/MHz 250 – 300MHz (UHF-Space Station for IVA communications during emergency)
82 dBµV/m/MHz 442 – 455MHz (Leaky Coax)

(1): general equipment
(2): external equipment

Figure 4-12 Broadband Radiated Emission E-Field Limit
4.1.3.3 AC Magnetic Field Emission

The generated magnetic fields shall not exceed the levels in Figure 4-13 from 30Hz to 250kHz, for internal or external equipments. (AD2 §4.1.6.3)

![Figure 4-13 AC Radiated Emission B-Field Equipment Limits](image)

4.1.3.4 COLUMBUS Line Impedance Stabilization Network (LISN)

In cases where the tests, described in AD5, requires the utilization of a LISN the following figures are showing the principal circuit diagram as well as the impedance curves for internal and external power sources.
R1, R2 = 0.125 Ohm
R3, R4 = 25 Ohm
C1 = 80,000uF (Z <= 70 mOhm for f = 30 Hz)
L1, L2 = 5 uH

Figure 4-14 LISN Schematic Diagram (COLUMBUS)

Figure 4-15 COLUMBUS LISN Source Impedance
Note:

The values depicted in the figure above should be increased by 50mΩ for the internal rack harness and the PSU to get the SM power line impedance.

The load impedance (power input impedance of the SMs) shall maintain a 3dB magnitude separation above the corrected values for the source impedance.

4.1.4 ARC Discharge Susceptibility

EPM and its related Science Modules shall not exhibit any malfunction, degradation of performance or deviation from specified parameters beyond tolerances given by the corresponding specification shall occur when the equipment and its interface lines are exposed to a repetitive electrostatic discharge of at least 5.6mJ energy/15kV. The test must be performed with conducted and radiated ESD sources.
For conducted test only the voltage can be reduced down to 4kV, at minimum without changing the energy value, if any damage risk is envisaged for interface circuits. (AD2 §4.1.9)

4.2 EPM Grounding and Bonding Concept
An overview of the EPM grounding and bonding concept regarding the rack-electronic and the interfaces between Carrier and Science Modules is provided in Figure 4-17.
Figure 4-17 COL – EPM - SM: Grounding and Bonding Diagram
4.2.1 Bonding Requirements

All electrical and mechanical elements must be securely bonded to structure in compliance with AD10. Specific bonding requirements applicable to different classes of payload hardware are identified in the subparagraphs below. The preferred bonding method for electronic equipment within the COLUMBUS area is the class-R-bonding wherever feasible. The bonding shall be preferable accomplished by surface to surface contact that implies the correct surface treatment as specified in MIL-C-5541E.
4.2.1.1 Radio Frequency Bonding

Equipment containing electrical circuits which may generate radio frequencies or circuits which are susceptible to radio frequency interference shall comply with the Class R (rf potentials) requirements of MIL-B-5087B. This equipment must be installed so that there is a continuous, low-impedance path of less than 2.5 mΩ from the equipment enclosure to structure. All payload housing components, including electrical connectors, which enclose these circuits, must be bonded together by less than 2.5 mΩ as well.

4.2.1.2 Primary Connector Bond

Science Modules which are powered portable equipment shall comply with the requirements of MIL-B-5087B, Class C (current path return). These payloads shall utilize one of the contacts in the power connector as the principle Science Module to EPM Carrier electrical bond. Power connector pin assignments are defined in the SMIRD. The bond resistance requirement will vary as a function of the payload circuit protection but will generally be in the range of 10 mΩ to 50 mΩ. This payload unique bond resistance shall be defined in the payload specific ICD. If the bonding resistance can’t be accomplished by means of the case line within the power cord, due to the length and the wire size, the Science Modules shall utilize one of the bonding connectors of the UDP. These connectors are specified in more detail in the SMIRD.

4.2.1.3 Payload Surface Electrostatic Charging

All payload metallic hardware elements or elements which are utilized for the transfer of fluids shall comply with the Class S (static charge) bond requirements of MIL-B-5087B. MLI covering payloads mounted externally to the module shall be subject to Class S bonding as well. These hardware elements shall be designed to prevent the accumulation of electrostatic charge on their surfaces by providing a bond resistance to structure no greater than 1Ω. The specific method employed shall be defined in the payload specific ICD.

4.2.2 Power Circuit Isolation and Grounding

The COLUMBUS or the EPM structure must not be used as an intentional power or signal return line. Circuits which are not isolated from primary power must be isolated from the equipment chassis. Secondary power which is isolated from primary power must be connected to structure ground at one point only.

The following Grounding shall apply to all electronic equipment using EPM secondary power:

- Primary power (primary power of the load is the secondary power of the source) shall be referenced to structure at a single point.
- Secondary power shall be single point grounded.
- Distributed power shall be grounded to a single location preferable within the equipment containing the DC converter.
- The reference point shall be as close as possible to the DC converter.
- The structures of equipment not permanently attached to the rack shall be grounded before crew contact.
4.2.2.1 Ground Support Equipment Isolation and Grounding
Ground support equipment interfacing with payloads shall be isolated from payload circuits (power and signal return lines) by a minimum of 1 MΩ.

4.2.2.2 Payload Isolation and Grounding
The following requirements apply at the payload input when all interfaces are connected:

A. Isolation between primary DC power or return lines and structure must be greater than 1 MΩ shunted by less than 10 µF.
B. Isolation between primary AC power or return lines and structure must be greater than 1 MΩ shunted by less than 10 nF. For three phase circuits, the allowable capacitance from each power line to structure may exceed 10 nF as long as the unbalanced capacitance to structure does not exceed 10 nF or the 400 Hz leakage current to structure does not exceed 3 mA.
C. For external loads to payload secondary power the isolation requirements for primary power loads given above shall apply accordingly. An external load in this context is a box or device physically separated from the box which generates the secondary power and which is individually bonded to the EPM structure.
5 EMC VERIFICATION MATRIX

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