Space Station Electromagnetic Emission and Susceptibility Requirements

International Space Station

Revision D

June 12, 1998

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National Space Development Agency of Japan

esa
european space agency

agenzia spaziale italiana
(Italian Space Agency)

Canadian Space Agency
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National Aeronautics and Space Administration
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INTERNATIONAL SPACE STATION PROGRAM

SPACE STATION ELECTROMAGNETIC EMMISION AND SUSCEPTIBILITY REQUIREMENTS

JUNE 12, 1998

INTERNATIONAL SPACE STATION PROGRAM

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LIST OF CHANGES

JUNE 12, 1998

All changes to paragraphs, tables, and figures in this document are shown below:

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000008 R1	6–3–94	Revision B	All
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PREFACE

The Space Station Electromagnetic Emission and Susceptibility Requirements for Electromagnetic Compatibility document establishes the requirements for the control of the electromagnetic emission and susceptibility characteristics of electronic, electrical and electromechanical equipment and subsystems designed or procured for use by the International Space Station Alpha Program. The contents of this document are intended to be consistent with the requirements of SSP 30243, Space Station Requirements for Electromagnetic Effects and SSP 41000, System Specification for the Space Station. The Space Station Electromagnetic Emission and Susceptibility Requirements for Electromagnetic Compatibility shall be implemented on all SSP contracts and internal activities. This document is under the control of the Space Station Control Board.

INTERNATIONAL SPACE STATION PROGRAM OFFICE

SPACE STATION ELECTROMAGNETIC EMMISION AND SUSCEPTIBILITY REQUIREMENTS

JUNE 12, 1998

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INTERNATIONAL SPACE STATION PROGRAM

SPACE STATION ELECTROMAGNETIC EMISSION AND SUSCEPTIBILITY REQUIREMENTS

JUNE 12, 1998

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INTERNATIONAL SPACE STATION PROGRAM

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ESA Concurrence: Reference SSP 50019 Joint Management Plan and JESA 30000, Section 3, Appendix B. DATE

NASA/NASDA

INTERNATIONAL SPACE STATION PROGRAM

SPACE STATION ELECTROMAGNETIC EMISSION AND SUSCEPTIBILITY REQUIREMENTS

JUNE 12, 1998

For NASA DATE

For NASDA DATE

Caveat: Concur with, subject to completion of detailed review and coordination of paragraph 3.2.4.2.2 with NASA.

1.0 INTRODUCTION

1.1 PURPOSE

This requirements document establishes the design requirements for the control of the electromagnetic emission and susceptibility characteristics of electronic, electrical and electromechanical equipment and subsystems designed or procured for use by the International Space Station Program. Such equipment and subsystems may be used independently or as an integral part of other subsystems or systems.

1.2 APPLICATION

The requirements of this document are applicable to Space Station electrical and electronic equipment. The applicability of the emission and susceptibility requirements is dependent upon the intended location or installation of the equipment or subsystem. Where deviation from the test level requirements is made based on intended installation and location, the deviation shall be documented and approved by the Electromagnetics Technical Advisory Team. Waiver or deviation shall be submitted per Data Requirement (DR): PC09 (Waiver and Deviations).

1.3 EMISSION AND SUSCEPTIBILITY DESIGNATIONS

The emission and susceptibility requirements in this document and corresponding test methods of SSP 30238 are designated in accordance with an alphanumeric coding system where:

C = Conducted

R = Radiated

E = Emission

L = Leakage

S = Susceptibility.

1.4 PRECEDENCE

SSP 41000 defines the design and performance requirements for the Space Station Program and invokes SSP 30243. SSP 30243 involves this document for electromagnetic emission and susceptibility requirements. In the event of any conflict between SSP 30243 and this document, SSP 30243 shall take precedence.

2.0 DOCUMENTS

The documents in this paragraph, of exact issue shown in the current issue of SSP 50258, are applicable to the extent specified in the referenced paragraphs. Inclusion of applicable documents does not supersede the order of precedence identified in 1.4. The references show where each applicable document is cited in this document.

DOCUMENT NO.	TITLE
SSP 30238	Space Station Electromagnetic Techniques Paragraphs: 3.1, 3.2, 3.2.2.1.3 and 3.4.1
SSP 30243	Space Station Requirements for Electromagnetic Compatibility Paragraph: 3.3
SSP 30482	Electrical Power Specifications and Standards,Volume 1: EPS Electrical Performance Specifications Paragraphs: 3.2.1.3.2 and 3.2.2.2
SSP 41173	Space Station Quality Assurance Requirements Paragraph: 4.0

3.0 REQUIREMENTS

3.1 DEFINITION OF ELECTROMAGNETIC EMISSION AND SUSCEPTIBILITY REQUIREMENTS

Electronic, electrical, electromechanical equipment and subsystems emissions and susceptibilities shall comply with these requirements. Testing of the equipment to ensure compliance to the requirements of this document shall be performed using the test methods given in SSP 30238.

3.1.1 SELF–COMPATIBILITY

The Equipment Under Test (EUT), designed in accordance with the Space Station Electromagnetic Compatibility (EMC) requirements, shall not malfunction and performance shall not be degraded during Electromagnetic Inference (EMI) testing.

3.2 EQUIPMENT EMISSION AND SUSCEPTIBILITY LIMITS

This paragraph defines emission and susceptibility test limits for Space Station flight equipment and subsystems, including payloads. General EMI test techniques are contained in SSP 30238. Approval of design procedures and techniques does not relieve the supplier of the responsibility of meeting the emission, and susceptibility test limits. A waiver is required for equipment which cannot meet the emission and susceptibility test requirements. The threshold of susceptibility shall be determined for equipment unable to meet the susceptibility test limits.

3.2.1 CONDUCTED EMISSIONS

Wiring between two or more Orbital Replacement Unit (ORU) shall be exempt from the conducted emission test requirements provided the specific ORUs are tested as a single unit. Wiring external to the group of ORUs tested as a unit shall meet the test limit requirements of this document.

3.2.1.1 CE01, CONDUCTED EMISSIONS

Direct current power, low frequency, 30 hertz (Hz) to 15 kilohertz (kHz).

3.2.1.1.1 APPLICABILITY

CE01 is applicable only for narrowband emissions between 30 Hz and 15 kHz on direct current (dc) leads which obtain power from or provide power to other equipment, distribution panels or subsystems.

3.2.1.1.2 CE01 LIMITS

Electromagnetic emissions shall not appear on dc leads in excess of the following values as shown below. The emission limit shown below is for equipment drawing one amp or less. For equipment drawing more than one amp, the limit, in decibels (dB) as shown in Table 3.2.1.1.2–1 shall be raised by 20 x log I, where I equals the total dc current used by the equipment under test.

TABLE 3.2.1.1.2–1 CE01 EMISSION LIMIT

Frequency	Emissions
30 Hz–200 Hz	110 dB above 1 microampere
200 Hz–15 kHz	Decreasing log–linearly with increasing frequency from 110 to 74 dB above 1 microampere

The limits shall be measured with an effective bandwidth not exceeding 100 Hz. See appendix C for exception from Electromagnetic Effects Control Board (EMECB) TIA–0025.

3.2.1.2 CE03, CONDUCTED EMISSIONS

Direct current power leads, 15 kHz to 50 megahertz (MHz).

3.2.1.2.1 APPLICABILITY

CE03 is applicable only for narrowband emissions between 15 kHz and 50 MHz on dc leads which obtain power from other sources or provide power to other equipment, distribution panels or subsystems.

3.2.1.2.2 CE03 LIMITS

Electromagnetic emissions shall not appear on dc power leads in excess of the following values as shown below for narrowband emissions: The limit shown below is for equipment drawing one amp or less. For equipment drawing more than one amp, the limit as shown in Table 3.2.1.2.2–1 shall be raised by 20 x log I, where I equals the total dc current used by the equipment under test. See appendix C for exception (EMECB TIA–0024, EMECB TIA–0025, EMECB TIA–0028, EMECB TIA–0039, EMECB TIA–0043, EMECB TIA–0053, and EMECB TIA–0057) to this paragraph.

TABLE 3.2.1.2.2–1 CE03 EMISSION LIMITS

Frequency	Emissions
15 kHz–500 Hz	Decreasing log–linearly with increasing frequency from 74 to 45 dB above 1 microampere
500 kHz–50 MHz	45 dB above 1 microampere

3.2.1.3 CE07, CONDUCTED EMISSIONS

Direct current power leads, spikes, time domain.

3.2.1.3.1 APPLICABILITY

CE07 is applicable for dc input power leads.

3.2.1.3.2 CE07 LIMITS

CE07 on/off and mode switching transients shall not exceed the envelope defined by the following values listed in Table 3.2.1.3.2–1. Repetitive on/off and mode switching transients shall not occur more frequently than every 100 milliseconds. See appendix C for exception (EMECB TIA–0014, EMECB TIA–0027, EMECB TIA–0049, EMECB TIA–0050, EMECB TIA–0055, and EMECB TIA–0057) to this paragraph.

TABLE 3.2.1.3.2–1 CE07 MODE SWITCHING TRANSIENTS ENVELOPE

Time (Micro–Seconds)	Percentage of Nominal Line Voltage
0.1–10	+ 50 percent
10–50	Decreasing log–linearly with increasing time from + 50 percent to + 20 percent
50–1000	Decreasing log–linearly with increasing time from + 20 percent to + 5 percent or + 6 volts(V), whichever is greater
1000–10,000	+ 6 percent or + 0.5V, whichever is greater
10,000–100,000	+ 5 percent or + 0.5V, whichever is greater

3.2.2 CONDUCTED SUSCEPTIBILITY

3.2.2.1 CS01, CONDUCTED SUSCEPTIBILITY

Direct current power leads, 30 Hz to 50 kHz.

3.2.2.1.1 APPLICABILITY

CS01 is applicable to equipment and subsystems using dc power.

3.2.2.1.2 CS01 LIMITS

The EUT 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 Table 3.2.2.1.2–1.

TABLE 3.2.2.1.2–1 CS01 ELECTROMAGNETIC ENERGY INJECTION

Frequency	Voltage
30 Hz–2 kHz	5 V root mean square (rms) or 10 percent of the supply voltage (E1), whichever is less
2 kHz–50 kHz	Decreasing log–linearly with increasing frequency from 5 Vrms, or E1 whichever is less, to either 1 Vrms or 1 percent of the supply voltage, whichever is less

3.2.2.1.3 ALTERNATE CS01 LIMITS

The requirement is also met when the audio power source specified in SSP 30238 adjusted to dissipate 50 W in a 0.5–ohm load, cannot develop the required voltage at the EUT power input terminals, and the EUT is not susceptible to the output of the signal source.

3.2.2.2 CS02, CONDUCTED SUSCEPTIBILITY

Direct current power leads, 50 kHz to 50 MHz.

3.2.2.2.1 APPLICABILITY

CS02 is applicable between 50 kHz and 50 MHz for equipment and subsystem dc power leads, including power returns which are not grounded internally to the equipment or subsystem**.**

3.2.2.2.2 CS02 LIMITS

The equipment a subsystem 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 1 Vrms from a 50–ohm source. The test signal shall be applied to the equipment power line near the equipment input terminals. The requirement is also met under the following condition: A 1 Watt source of 50–ohms impedance cannot develop the required voltage at the EUT power input terminals, and the EUT is not susceptible to the output of the signal source. See appendix C for exception (EMECB TIA–0023 and EMECB TIA–0051) to this paragraph.

3.2.2.3 CS06, CONDUCTED SUSCEPTIBILITY

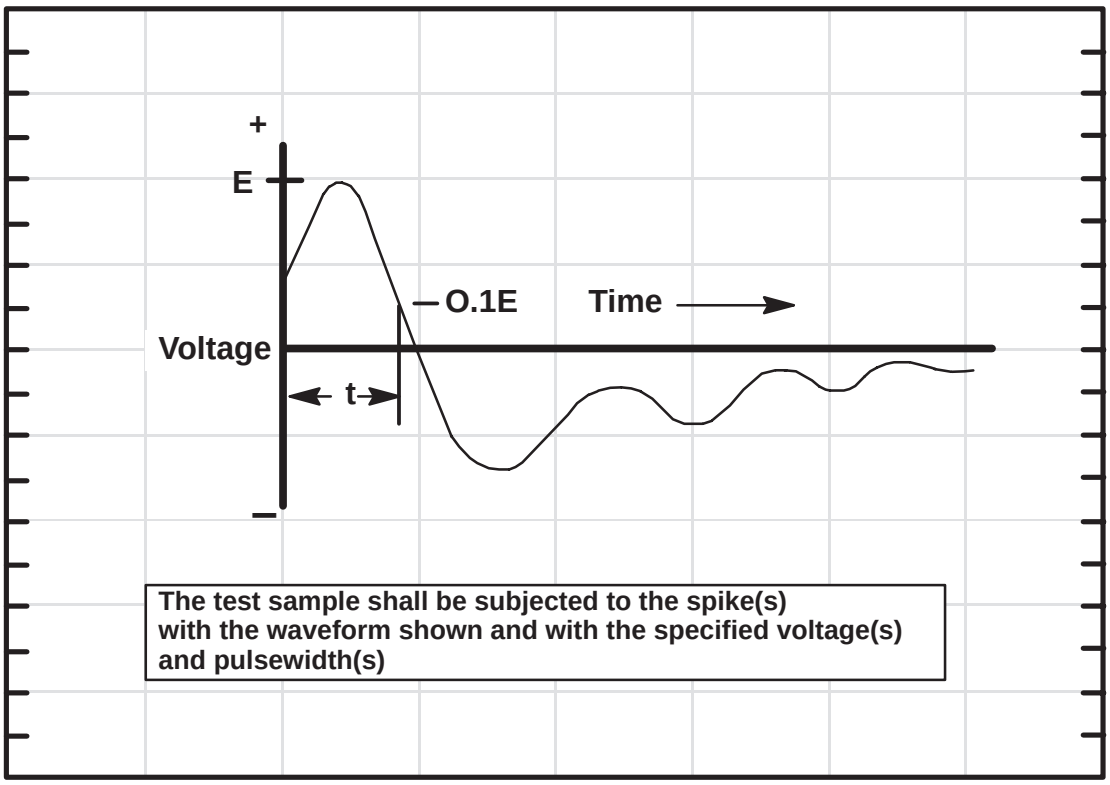
Spikes, power leads.

3.2.2.3.1 APPLICABILITY

CS06 is applicable to equipment and subsystem dc power leads, including grounds and returns which are not grounded internally to the equipment or subsystem.

3.2.2.3.2 CS06 LIMITS

The EUT 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 the test spikes, each having the waveform shown on Figure 3.2.2.3.2–1, 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 = ± Twice the nominal line voltage, t=10 microseconds ± 20 percent

SPIKE #2 E = ± Twice the nominal line voltage, t=0.15 microseconds ± 20 percent

FIGURE 3.2.2.3.2–1 CS06 AND RS02 EQUIPMENT LIMIT

3.2.3 RADIATED EMISSIONS

3.2.3.1 RE02, RADIATED EMISSIONS

Electric field, 14 kHz to 10 GHz (narrowband), 13.5–15.5 GHz.

3.2.3.1.1 APPLICABILITY

RE02 is applicable for radiated emissions from equipment and subsystems, cables (including control, pulse, IF, power and antenna transmission lines) and interconnecting wiring of the test sample; for narrowband emissions, it applies at the fundamental frequencies and all spurious emissions including harmonics, but does not apply for radiation from antennas. This requirement is applicable for narrowband emissions from 14 kHz to 10 GHz and 13.5–15.5 GHz.

3.2.3.1.2 RE02 LIMITS

E–field emissions shall not be radiated in excess of those specified in the following paragraphs. Above 30 MHz, the limits shall be met for both horizontally and vertically polarized waves. Measurement shall be made in the peak detector mode. See appendix C for exception (EMECB TIA–0001, EMECB TIA–00044, EMECB TIA–0048, EMECB TIA–0052, EMECB TIA–055, EMECB TIA–0057, and EMECB TIA–0065) to this paragraph.

3.2.3.1.2.1 NARROWBAND ELECTRIC FIELD EMISSIONS

Narrowband E–field emissions shall not be radiated in excess of the values as shown in Table 3.2.3.1.2.1–1 and in Figure 3.2.3.1.2.1–1 at the required test distance of 1 m.

TABLE 3.2.3.1.2.1–1 FIELD EMISSION LIMITS

Frequency	Emissions
14 kHz–10 MHz	56 dBµV/m
10 MHz–259 MHz	Increasing log–linearly with increasing frequency from 56 to 86 dBµV/m (16dB per decade)
259 MHz–10 GHz	Increasing log–linearly with increasing frequency from 46 to 72 dBµV/m (16dB per decade)
13.5–15.5 GHz	72 dBµV/m

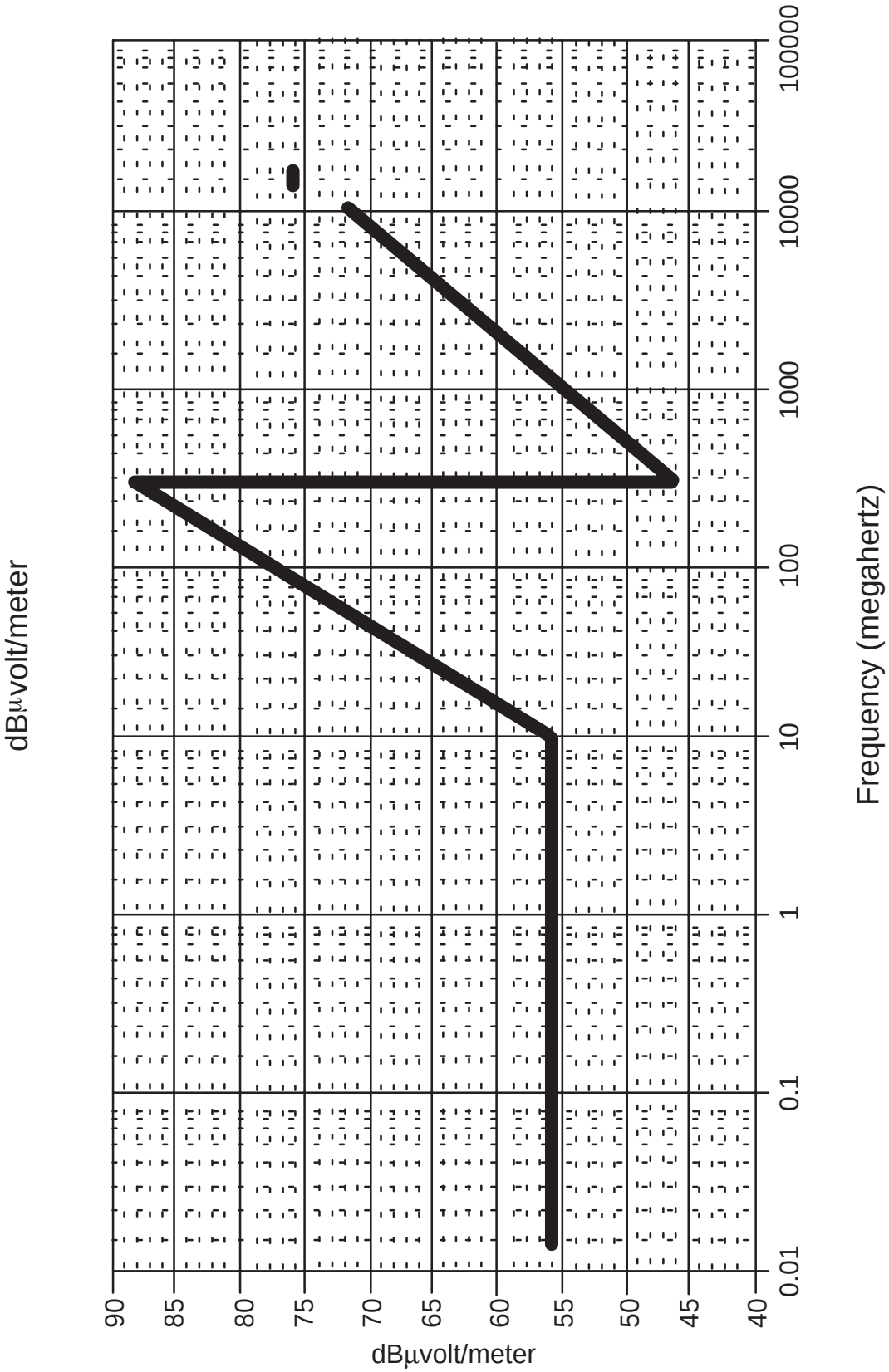


FIGURE 3.2.3.1.2.1–1. ISS EMISSION LIMITS

3.2.4 RADIATED SUSCEPTIBILITY

3.2.4.1 RS02, RADIATED SUSCEPTIBILITY

Magnetic induction field.

3.2.4.1.1 APPLICABILITY

RS02 is applicable for all equipment and subsystems. These susceptibility signals are electromagnetically coupled into the equipment or subsystem wiring.

3.2.4.1.2 RS02 LIMITS

The EUT 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 sequentially to the test spikes, shown in Figure 3.2.2.3.2–1 each having the waveform with the values of E and t are given below:

— Spike #1 E = ± Twice the nominal line voltage, t = 10 microseconds ± 20 percent

— Spike #2 E = ± Twice the nominal line voltage, t = 0.15 microseconds ± 20 percent.

3.2.4.2 RS03, RADIATED SUSCEPTIBILITY

Electric field, 14 kHz to 20 GHz.

3.2.4.2.1 APPLICABILITY

RS03 is applicable for all equipment and subsystems between 14 kHz and 20 GHz. Above 10 GHz, this requirement applies only at specific frequencies and amplitudes known to be present at the Space Station. Below 10 GHz, this requirement shall be increased only at specific frequencies and amplitudes known to be present at the ISS. Module shielding effectiveness can be used to limit the levels applied.

3.2.4.2.2 RS03 LIMITS

The EUT 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 the radiated electric fields less than or equal to those specified herein. Above 30 MHz, the requirement shall be met for both horizontally and vertically polarized waves. As a minimum, the levels shown in Table 3.2.4.2.2–1 apply at either the specific frequencies stated or across the ranges stated. See appendix C for exception (EMECB TIA–0005, EMECB TIA–0055, EMECB TIA–0059, EMECB TIA–0062, and EMECB TIA–0063) to this paragraph.

TABLE 3.2.4.2.2–1 RS03 LIMIT LEVELS

Frequency/Range	Radiated Electric Field Level
14 kHz–10 MHz	5 V/m
200 MHz–8 GHz	60 V/m
8 GHz–10 GHz	20 V/m
2.2 GHz	161V/m
8.5 GHz	79 V/m
13.7 GHz–15.2 GHz	250 V/m

3.2.5 LEAKAGE EMISSIONS

3.2.5.1 LE01, AC POWER USER LEAKAGE CURRENT

3.2.5.1.1 APPLICABILITY

LE01 is applicable for all equipment and subsystems that use ac power.

3.2.5.1.2 LE01 LIMITS

The leakage current for all equipment and subsystems using ac power, as measured between chassis and input power, at the power frequency, shall not exceed 5 milliamperes.

3.3 DOCUMENTATION

Documentation shall be per the requirements of SSP 30243.

3.4 VERIFICATION

3.4.1 TESTING REQUIREMENTS

The test requirements and techniques of SSP 30238 shall be used to determine compliance with the applicable emission and susceptibility test limit requirements of this document. When an EUT susceptibility is noted, the thresholds of susceptibility shall be determined. Equipment that is intended to be operated as a subsystem shall be tested as such to the applicable emission and susceptibility limits whenever practical.

4.0 QUALITY ASSURANCE PROVISIONS

All quality assurance provisions shall be in accordance with the Space Station Program Quality Assurance Program Requirements as specified in SSP 41173.

4.1 RESPONSIBILITY FOR INSPECTION

Unless otherwise specified, the supplier is responsible for the performance of inspection requirements as specified herein. Except as otherwise specified, the supplier may use his own facilities or any other commercial laboratory acceptable to National Aeronautics and Space Administration (NASA) or responsible (International Partner) IP agencies. NASA or IP agencies reserves the right to perform any of the inspections set forth in the requirements document where such inspections are deemed necessary to assure supplies or services conform with prescribed requirements.

APPENDIX A ABBREVIATIONS AND ACRONYMS

ac	alternating current
amp	ampere
BDCU	Battery Discharge Charge Unit
CDRA	Carbon Dioxide Removal Assembly
CMG	Control Moment Gyro
COTS	Commercial–Off–the–Shelf
dB	decibel
dBm	Decibel relative to one milliwatt
dBmV	Decibel relative to one millivolt
dBV	decibel relative to one volt
dBμA	Decibel relative to one microampere
dBμV/m	Decibel relative to one millivolt per meter
dc	direct current
DDCU	DC–to–DC converter unit
DR	Discrepancy Report
ECOMM	Early Communications
EMC	Electromagnetic Compatibility
EME	Electromagnetic Effects
EMECB	Electromagnetic Effects Control Board
EMI	Electromagnetic Interference
EUT	Equipment Under Test
EVA	Extravehicular Activity
FGB	Functional Cargo Block
GHz	Gigahertz

APPENDIX A ABBREVIATIONS AND ACRONYMS (Continued)

HCU	Heater Control Unit
Hz	hertz
IEA	Integrated Equipment Assembly
IF	Intermediate Frequency
ILC	
IMV	Intermodule Ventilation
IP	International Partner
ISS	International Space Station
kHz	kilohertz
m	meter
mA	milliampere
mV	millivolt
MBS	Mobile Remote Servicer Base System
MDA	Motor Drive Assembly
MDM	Multiplexer/Demultiplexer
MHz	Megahertz
NASA	National Aeronautics and Space Administation
ORU	Orbital Replaceable Unit
PCB	Printed Circuit Board
PCS	Portable Computer System
PDB	Power Distribution Box
PEHG	Payload Ethernet Hub/Gateway
PFCS	Pump and Flow Control Subassembly
PV	Photovoltaic

APPENDIX A ABBREVIATIONS AND ACRONYMS (Concluded)

PVR	Photovoltaic Radiator
RF	Radio Frequency
RGA	Rate Gyro Assembly
rms	root mean square
RPCM	Remote Power Controller Module
sec	second
SMPS	Switch Mode Power Supply
SPEL	Space Power Electronics Lab
TCCV	Temperature Control Check Value
µ	Micro
USL	U. S. Laboratory
V	Volt
VC	Vacuum Cleaner
V/m	volt per meter
Vrms	Volt root mean square
W	Watt

APPENDIX B GLOSSARY

CABLE, ELECTRICAL

Two or more solid or stranded conductors insulated from each other and routed together or enclosed by a common covering; or one conductor enclosed by, but insulated from another conductor or a metallic shield.

EQUIPMENT

Any electrical, electronic, or electromechanical device or collection of devices intended to operate as a single unit and to perform a single function. As used herein, equipment includes but is not limited to the following: receivers; transmitters; transponders; power supplies; hand tools; processors; test apparatus; and test instruments.

SUBSYSTEM

A collection of equipment designed and integrated to perform a single function where in any equipment within the subsystem is not required to function as an individual equipment.

SYSTEM

A collection of equipment, subsystems, skills, and techniques capable of performing or supporting an operational role. A complete system includes related facilities, equipment, subsystems, materials, services, and personnel required for its operation to the degree that it can be considered self–sufficient within its operational environment.

WIRE, ELECTRICAL

A single current–carrying conductor of one or more strands covered with a suitable insulating material.

APPENDIX C APPROVED TAILORING/INTERPRETATION AGREEMENTS

EMECB TIA–0001

C.3.2.3.1.2 RE02 LIMITS

Exception: Relax RE02 limit for the Battery Discharge Charge Unit (BDCU) (CI No. 360PG2)/Battery operating system by 2.8db from 4.8 MHz to 5.0 MHz, by 0.4db at 3.403 MHz, and by 2.0db at 12.02 MHz.

Rationale: The BDCU/Battery subsystem will be located on the Integrated Equipment Assembly (IEA) which is part of PG2's Photovoltaic (PV) Module. The PV modules will be launched as part of launch packages PV Modules P6, P4, S6, and S4. The PV module is the primary power system which is controlled by PG2. The only equipment that is located on a PV module that is not controlled by PG2 is PG1's S–band communication equipment and PG1's Multiplexer/Demultiplexer (MDM). The S–band receiver sensitivity performance is required at 1.3775 GHz and the MDM must comply SSP 30237 RS03 requirements. The primary power system has been integrated and operating in Rocketdyne's Space Power Electronics Lab (SPEL) facility for many years with no detrimental EMI effects ever attributed to Battery Discharge Charge Unit (BDCU) radiated emissions. System compatibility for the actual flight configuration will be demonstrated during the IEA EMC test.

EMECB TIA–0005

C.3.2.4.2.2 RS03 LIMITS

Exception: PG–3 developed hardware will maintain the tailored RS03 limits as specified in Table C.3.2.4.2.2–1, as design and test requirements. The components identified in Table C.3.2.4.2.2–2 will additionally be tested at 60 V/m from 200 MHz – 1 GHz. No additional testing or analysis will be done at frequencies above 1 GHz. Items in Table C.3.2.4.2.2–3 do not require additional RS03 testing.

Rationale: Based on a technical review by the Prime/MDAC/PG–3 Electromagnetic Effects (EME) teams on January 16, 1997 the recommendation to the program is to accept the above tailoring as this is the most cost effective solution to the situation. Any risk will be mitigated during the Node 1 EMC testing.

TABLE C.3.2.4.2.2–1 PG3 U.S. LABORATORY (USL) TAILORED RS03 LIMITS

Frequency/Range	Radiated Electric Field Level
14 kHz – 200 MHz	5 V/M
200 MHz – 10 GHz	20 V/m
13.7 GHz – 15.2 GHz	8.5 V/m

TABLE C.3.2.4.2.2–2 PG3 H/W TO BE TESTED TO HIGHER RS03 LIMITS

CI or Part Number	Nomenclature
FDA001A	Area Smoke Detector
ITCS01A	Pump Package Assembly

TABLE C.3.2.4.2.2–2 PG3 H/W TO BE TESTED TO HIGHER RS03 LIMITS – Concluded

CI or Part Number	Nomenclature
EVS003A	Pressure Control Panel
683I23A	Utility Outlet Panel
ITCS12A	Three Way Mix Valve
EVS001A	OIV/NIV
EVS004A	Vent Relief Valve
CDRA01A	CDRA
SSF9665	Avionics Air Assembly
ITCS09A	System Flow Control Assembly
EVS006A	IMV Valve Assembly
SV809114	TCCV Actuator
SSF9619	IMV Fan Assembly
408A40A	General Luminaire Assembly
SSF9664	Inlet ORU

TABLE C.3.2.4.2.2–3 PG3 FLIGHT 2A H/W NOT APPLICABLE TO HIGHER RS03 TEST

CI or Part Number	Nomenclature	Rationale
RV4SAYSD501E	Resistor, Variable, Comp.	Not Susceptible
ARS36	Valve, 3–way (.125)	Not Susceptible
408A40C	Remote Power on/off switch	Not Susceptible

EMECB TIA–0014

C.3.2.1.3.2 CE07 LIMITS

Exception: The CE07 requirement of SSP 30237, paragraph 3.2.1.3, for the Remote Power Controller Module (RPCM) is relaxed for the first 1 microsecond of power initialization from +/– 50 percent to +50 percent to –90 percent.

Rationale: When an RPCM is initialized it powers up its internal electronics only and all source power output feeds to downstream loads are zero volts (switch open). However, once one channel is feeding output power to a user load, turning on an adjacent channel to feed another RPCM will result in a common impedance transient being seen by the user load. This transient should not impact user load performance since all Space Station ORUs are required to not be susceptible to SSP 30237, CS06, 10 microseconds transients which are +/– 2 times the line voltage of 120 volts. There is no survivability issue since all loads are required to be immune to a power drop out of 60 microseconds in accordance with SSP 30482, Volume 1.

EMECB TIA–0023

C.3.2.2.2.2 CS02 LIMITS

Exception: The BDCU (CI No. 360PG2) power control input bus SSP 20327 CS02 requirements are relaxed by 2.5 dB for the frequency range of 26.7 MHz to 28.7 MHz. The requirement of 1 Vrms minus 2.5 dB equals 0.75 Vrms.

Rationale: The dc control power bus was configured in Rocketdyne's SPEL facility per flight drawings (cable lengths, wire twisting, wire shielding/terminations) and routed two inches above a ground plane and bus ripple voltages were measured for various modes of operation. The voltage ripple measured (time domain) at the BCDU control power input port was never greater than 600 mV p–p (0.214 V rms). The ripple at 26 MHz (frequency domain measurement) is much less, around 10 mV. Therefore, there is at least a 10 dB EMI safety margin that exists between the actual threat and the actual susceptibility threshold. Therefore, the source bus current telemetry readings will be in tolerance during all mission scenarios.

EMECB TIA–0024

C.3.2.1.2.2 CE03 LIMITS

Exception: The CE03 limit for the BDCU (CI No. 360PG2) control power input lines is relaxed by 89dB at 402 kHz and by 10dB at 5.84 MHz. The CE03 limit for the BDCU control power output lines is relaxed to the following limit curve:

a. 15 Khz to 300 kHz CE03 limit = 80 dB uA.

b. 300 kHz to 50 MHz CE03 limit is decreased log–linearly from 92 dB uA to 55 dB uA.

Rationale: The CE03 limit in SSP 30237 was derived to guarantee 1 Vrms power quality (30 Hz to 30 MHz) for the 52 Amp secondary power bus with an impedance characterized by 120 feet of 4 gauge wire. The dc control bus is a 6 Amp bus with an impedance characterized by 30 feet of 16 gauge wire. Since the control power bus impedance and currents are both less than the secondary system values, the resulting voltage ripple will be less as the data below shows. The dc control power bus was configured in Rocketdyne's SPEL facility per flight drawings (lengths, wire twisting, wire shielding/terminations, inductance of beta gimbal roll rings). The primary power system which provides and uses the dc control power was exercised in all modes of operation while measuring the control bus voltage and current in both time and frequency domains. The measurements were performed at all four control power outputs and at all four control power inputs. All time domain ripple voltages measured were less than 2.0 Volts peak to peak (0.71 Vrms). Therefore even though the CE03 limit was exceeded, a 6 dB EMI safety margin still exists. The control power is routed via twisted shielded wire therefore radiated emissions are controlled to be within RE02 limits except for 5 frequencies exceeding the limit by less than 3 dB.

EMECB TIA–0025

C.3.2.1.1 CE01 LIMITS, C.3.2.1.2.2 CE03 LIMITS

Exception: The limit of the CE01 requirement for the PG–2 Solar Array (CI No. 250PG2) MDA is relaxed by 2.1 dB at 1.8 kHz. The limit of the CE03 requirement for the PG2 MDA is relaxed by 4.1 dB at 1.12 MHz. This relaxation is for an MDA that is pulling 2.7 Amps.

Rationale: The Motor Drive Assembly (MDA) hardware has very limited usage during the Space Station mission. The MDA's are used to deploy and retract the solar array blankets and to unlatch/latch the blanket boxes. All of the loads external to PG2's PV Module that share the PV Module's secondary power source DC–to–DC converter unit (DDCU) are fed by a separate Remote Power Controller Module (RPCM) than the RPCM that feeds the PV Module's secondary loads MDAs, ECU, Pump and Flow Control Subassembly (PFCS), Photovoltaic Radiators (PVR). The common impedance between external PV Module loads and internal PV Module loads is small due to the RPCMs being close to the DDCU output. If all other loads were compliant at these two frequencies the resulting ripple on the secondary power bus with the proposed relaxation would still meet power quality requirements.

Calculations:

1.8 kHz V ripple = ((10exp((mda ce01@1.8k)/20))+(10exp(ce01 limit for remaining loads/20)))(1Amp/10exp6 uA)(Z@1.8k, 238lisn)
= ((10exp(102.2 dBuA/20)) + (10exp((dBuA + 20log(52A–2.7A))/20)) (1 Amp/10exp6uA) (0.158 ohms) = 0.368Vrms

1.1MHz V ripple = ((10exp((mdace03@1.2M)/20)+(10exp(ce03 limit for remaining loads)/20))(1Amp/10exp6 uA)(Zc@1.2m,238lisn)
= ((10exp(57.7 dBuA/20))+(10exp((45.0 dBuA + 20log (52A–2.7A))/20))(1Amp/10exp6 uA) (50.0 ohms) = 0.476Vrms

EMECB TIA–0027

C.3.2.1.3.2 CE07 LIMITS

Exception: The Control Moment Gyro (CMG) (CI No. 222007A) is allowed to fail the SSP 30237 CE07 requirement for turn–off line transient up to –102 volts on a 7.13 microsecond pulse.

Rationale: This unit is in EMC compliance with all other EMC test requirements. It is unlikely that the outage will become the cause of a problem in the integrated system. The CMG is fed from a RPCM type IV which is a current limiting RPCM. This RPCM was not used in the subject test.

EMECB TIA–0028

C.3.2.1.2.2 CE03 LIMITS

Exception: Relax SSP 30237 CE03 specification for the ILC Tech general luminary (CI No. 408A40A) in the frequency ranges as shown in Table C.3.2.1.2.2–1.

TABLE C.3.2.1.2.2–1 ILC TECH GENERAL LUMINARY FREQUENCY RANGES

Frequency Range	Proposed CE03 Amplitude	Current CE03 Amplitude
19.5 kHz to 24.7 kHz	78 dB above 1 micro–ampere	Decreasing log–linearly with frequency from 72.3 to 69.9 dB above 1 micro–ampere
37.9 kHz =/– 1 percent	70 dB above 1 micro–ampere	66.3 dB above 1 micro–ampere

Rationale: The calculated safety margin of the induced bus voltage as a result of these emissions to ORU SSP 30237B CS01 limits and SSP 30482B Volume 1, Interface B, spectral voltage power quality exceeds 32 dB for all frequencies. See Tables C.3.2.1.2.2–2 through C.3.2.1.2.2–6 for calculations. In accordance with Table C.3.2.1.2.2–6, 126 ORUs per bus conducting in–phase at CE03 limits at 37.9 kHz would be needed to use up the CS01 noise margin. There are on the order of 80 loads per bus in the USL, with less than the Node. The emissions would also add randomly on the bus providing additional margin.

TABLE C.3.2.1.2.2–2 CALCULATED CONVERSION OF CE03 MEASURED CURRENT TO POWER BUS VOLTAGE

A	B	C	D
Outage Frequency (Hz)	Maximum CE03 Emission (mA)	SSP 30238 LISN Source Impedance (20 μH) Ω	Calculated CE03 Outage Contribution to Interface B Power Bus Voltage (mV)
18.53E+3	6.6	2.3	15.4
24.67E+3	7.5	3.1	23.2
37.91E+3	3.0	4.8	14.2
Col. A = Outage Frequency from General Luminaire Test. Col. B = Maximum CE03 Outage at Frequency in Col. A. Col. C = 2π * Col A * 20E–6. Col. D = Col. B * Col. C.			

TABLE C.3.2.1.2.2–3 CALCULATED SAFETY MARGIN TO SSP 30237B CS01 SPECIFICATION LIMIT

A	B	C	D
Outage Frequency (Hz)	Calculated CE03 Outage Contribution to Interface B Power Bus Voltage (mV)	SSP 30237B CS01 Limit (mV)	Safety Margin to SSP 30237B CS01 Specification Limit (dB)
18.53E+3	6.6	2.3	15.4
24.67E+3	7.5	3.1	23.2
37.91E+3	3.0	4.8	14.2
Col. A = Outage Frequency from General Luminaire Test. Col. B = Maximum CE03 Outage Contribution from Table C.3.2.1.2.2–2. Col. C = (5 – 2.861*LOG(Col. A/2000))*2000 {CS01 Limit}. Col. D = 20*LOG(Col. C/1000) – 20*LOG(Col. B/1000).			

TABLE C.3.2.1.2.2–4 CALCULATED SAFETY MARGIN TO SSP 30482B VOLUME 1 INTERFACE B SPECTRAL VOLTAGE POWER QUALITY

A	B	C	D	E
Outage Frequency (Hz)	Calculated CE03 Outage Contribution to Interface B Power Bus Voltage (mV)	SSP 30482B Vol. 1 Interface B Spectral Voltage Limit decibel volt (dBV)	SSP 30482B Vol. 1 Interface B Spectral Voltage Limit (mV)	Safety Margin to SSP 30482B Vol. 1 Interface B Spectral Voltage Power (dB)
18.53E+3	15.4	–1.7	821.9	34.6
24.67E+3	23.2	–2.9	712.6	29.7
37.91E.3	14.2	–4.8	575.3	32.1

Col. A = Outage Frequency from General Luminaire Test.
Col. B = Calculated CE03 Outage Contribution from Table C.3.2.1.2.2–2.
Col. C = –9.966*LOG(Col. A/12500) {Interface B Spectral Limit}.
Col. D = ALOG(Col. C/20)*1000.
Col. E = Col.C–20*LOG(Col. B/1000).

TABLE C.3.2.1.2.2–5 CALCULATED SAFETY MARGIN TO SSP 30482B VOLUME 1 INTERFACE B SPECTRAL VOLTAGE POWER QUALITY

A	B	C	D	E
Frequency (Hz)	SSP 30237B CE03 Specificatgion Limit (1 Amp) (dB µA)	(mA)	SSP 30238 LISN Source Impedance (20µ) Ω	Safety Margin to SSP 30482B Vol. 1 Interface B Spectral Voltage Power (mV)
18.53E+3	72.4	4.2	2.3	9.7
24.67E+3	70.0	3.2	3.1	9.8
37.91E.3	66.4	2.1	4.8	10.0

Col. A = Outage Frequency from General Luminaire Test.
Col. B = 110–19.129*LOG(Col. A/200) {CE03 Limit}.
Col. C = ALOG(Col.B/20)*0.001.
Col. D = 2π * Col A * 20E–6.
Col. E = Col.C*Col.D.

TABLE C.3.2.1.2.2–6 NUMBER OF ORUs REQUIRED TO USE NOISE MARGIN

A	B	C	D	E	F	G
Outage Frequency (Hz)	Calculated CE03 Outage Contribution to Interface B Power Bus Voltage (mV)	CE03 Outage Contribution from All Lights (6 per Bus–In Phase) (mV)	SSP 30237B CS01 Limit (mV)	Noise Margin (mV)	Conversion of CE03 Specification Limit to Voltage (mV)	# ORUs at CE03 limits to use noise margin (in–phase) (# ORUs)
18.53E+3	15.4	92.3	2233.9	2141.5	9.7	221
24.67E+3	23.2	139.5	1878.3	1738.8	9.8	177
37.91E+3	14.2	85.3	1344.4	1259.1	10.0	126

Col. A = Outage Frequency from General Luminaire Test.
Col. B = Calculated C#03 Outage Contribution from Table 2, Col. D.
Col. C = Col. B * 6.
Col. D = (5 – 2.861*LOG(Col. A/2000))*1000 {CS01 Limit}.
Col. E = Col. D – Col. C.
Col. F = Conversion of CE03 Specification Limit to Voltage from Table C.3.2.1.2.2–5, Col. E.
Col. G = Col. E / Col. F.

EMECB TIA–0039

C.3.2.1.2.2 CE03 LIMITS

Exception: The Payload Ethernet Hub/Gateway (PEHG) (CI No.222066A) is allowed to exceed the SSP 30237 CE03 requirement by 2 dB uA at 78 kHz.

Rationale: The high reading is believed to be due to the PEHG power supply switching frequency. The level of non–compliance is believed by MDA to be insignificant, does not warrant the cost and schedule impacts required to push the unit into compliance, and can be accepted.

EMECB TIA–0043

C.3.2.1.2.2 CE03 LIMITS

Exception: The MDM (CI Nos. 222002A and 222004A) is relaxed up to 12 dB of the SSP 30237 CE03 requirements at 85 to 95 kHz due to phase relationships.

Rationale: The three component Switch Mode Power Supply (SMPS) power supplies that make up the MDM power supply can have a number of possible phase relationships even though they are frequency locked together. Each phase relationship produces a different emission profile. The maximum profile is up to 12 dB µA above the limit.

EMECB TIA–0044

C.3.2.3.1.2 RE02 LIMITS

Exception: The MDM (CI Nos. 222002A and 222004A) is allowed to exceed the EMC requirements of SSP 30237 RE02 by up to 7 dB in the frequency range of 0.5 to 1.2 MHz.

Rationale: The out–of–spec condition may be explained by the test interface cable configuration; the cable diameter is nearly 8 inches. This configuration places the wires as much as ten inches above the ground plane making the cable radiated emissions proportionally higher.

EMECB TIA–0048

C.3.2.3.1.2 RE02 LIMITS

Exception: The Rate Gyro Assembly (RGA) is allowed to exceed the SSP 30237 RE02 specifications by 2.8 dB at 300 MHz.

Rationale: The RGA had previously completed this qualification test without exceedances. A minor modification was required for non–EMI reasons. The RGA was retested after the modification. The modification caused this minor exceedance. This outage will not affect components and there are no receivers at this frequency.

EMECB TIA–0049

C.3.2.1.3.2 CE07 LIMITS

Exception: The Vacuum Cleaner (VC) is allowed to exceed the SSP 30237, Rev. C CE07 specification by – 1.88v at 100 millisecond, +2.49v at 230 millisecond, – 2.15v at 195 millisecond, and 1.02v at 245 millisecond.

Rationale: Modification to the VC will impact cost and schedule. The deviation to the CE07 Rev. C requirement is well within the limits of the power quality specification thus it should not impact other ISS systems, and it is not felt redesign and associated cost and schedule impacts are warranted.

EMECB TIA–0050

C.3.2.1.3.2 CE07 LIMITS

Exception: The RPCM CE07 requirements are modified as follows:

a. The CE07 voltage limit during the first 2.0 microseconds after power initialization is from +50 percent to –95 percent.

b. The CE07 voltage limit during the period from 3 to 5 microseconds after power initialization is from +60 percent to –50 percent.

Rationale: When the RPCM is energized, power is applied to its housekeeping electronics only. During this process, all RPCM power channels solid–state relays are open and no DC voltage is applied to the external loads terminals. However, the CE07 voltage transient generated by the

RPCM may appear across the terminals of an adjacent (parallel) RPCM and its subsequent loads. This condition only occurs in the rare case when the emitting RPCM (culprit) is provided power through another series RPCM. Otherwise, both parallel RPCMs are energized together from the same source and no interference occurs. Worst case, this transient should not impact user load performance since all Space Station ORUs are required not to be susceptible to SSP 30237, CS06, 10 microseconds transients which are +/– 2 times the line voltage of 120 volts. There is no survivability issue since all loads are required to be immune to a power drop out of 60 milliseconds in accordance with SSP 30482, Volume 1. Analysis also indicate that any capacitive load greater than 0.1 microFarad will require more than 1 microsecond for its CE07 inrush transient to return to within –50 percent of the DC line voltage.

EMECB TIA–0051

C.3.2.2.2.2 CS02 LIMITS

Exception: For the RPCM the injected CS02 signal may be reduced by 6 dB for test frequencies greater than 45 MHz.

Rationale: Both development and qualification tests on the RPCM indicate the same result – the temperature sensor is susceptible to CS02 signals at 45 MHz and 50 MHz. This susceptibility clears up when the injected CS02 signal is decreased by 6 dB. Also, the temperature sensor is not susceptible at frequencies 1 MHz on either side of 45 MHz or 50 MHz.

The RPCMs are installed only on the secondary power system. The SSP 30482, Volume 1, limits the total steady–state voltage on the secondary power bus to less than 0.1 Vrms for any frequency above 10 MHz. This is 20 dB less than the CS02 requirement. At frequencies above 40 MHz, it is highly unlikely that the secondary power bus can sustain a steady–state,-narrowband, voltage greater than 0.01 Vrms. This is 40 dB less than the CS02 requirement.

The CS02 test voltage can be reduced by 6 dB above 45 MHz without significantly impacting the margin required for RPCM compatibility. The RPCM temperature sensor is used before Thermal Control System becomes active on Flight 4A. Cargo Element 2A test data is at least 16 dB below specification.

EMECB TIA–0052

C.3.2.3.1.2 RE02 LIMITS

Exception: The Heater Control Unit (HCU) (CI No. M 42070 Q) may exceed the Radiated E–Field (RE02) emission requirements of SSP 30237 by up to 10 dB m V/m MAX in the frequency range of 10 MHz to 25 MHz.

Rationale: The outages should not affect other components of the ISS. There are no receivers present in this frequency range. The EMECB determined that there would be no upsets by the excessive emissions in this frequency range.

EMECB TIA–0053

C.3.2.1.2.2 CE03 LIMITS

Exception: The HCU (CI No. M 42070 Q) may exceed the conducted emissions (CE03) requirements of SSP 30237 by 10 dB mA at 600 kHz and 2 dB m A at 1.8 MHz.

Rationale: The outages should not affect other components of the ISS. The EMECB concluded there would be no disruptions to other equipment by conducted emissions at these frequencies.

EMECB TIA–0055

C.3.2.1.3.2 CE07 LIMITS, C.3.2.3.1.2 RE02 LIMITS, C.3.2.4.2.2 RS03 LIMITS

Exception: The early Portable Computer System (PCS) as configured for operation in the battery mode on the ISS is allowed to exceed the SSP 30237 RE02 requirements by up to 0.4 dBuV at 321.38 MHz, 2.9 dBuV at 281.68 MHz, and 0.2 dBuV at 320.86 MHz; CE07 requirements by up to –8.13 V at 5 milliseconds, – 20.7 V at 72 milliseconds, 5.4 at 138 milliseconds, and –21.38 V at 302.5 milliseconds, and the RS03 requirements by RS–03 1.9 GHz at 54.41 V/m and 2.0 GHz at 56.25 V/m.

Rationale: This commercial–off–the–shelf (COTS) early PCS configuration will be used under benign conditions and will be powered from the Space Shuttle Orbiter or FGB only. A TIA will be submitted for the ISS powered COTS PCS configuration for flights after 5A.

EMECB TIA–0057

C.3.2.1.2.2 CE03 LIMITS, C.3.2.1.3.2 CE07 LIMITS, C.3.2.3.1.2 RE02 LIMITS

Exception: The XHR 150–7 Power Supply is allowed to exceed the EMI requirements of SSP 30237 by the following:

CE03: 1.1 dBmA at 61.9 kHz

CE07: OFF to ON is DV = 26.6 V at Dt =206 ms (4.9 kHz)

RE02: 4.4 dBmV/m at 272.3 MHz

Rationale: The out–of–spec conducted emissions may be due to input filter capacitors that are charged at the instant that the Power Supply is turned on. The out–of–spec radiated emission spike may be due to a front PCB board having through–hole mounted capacitors instead of surface mounted capacitors. Four EMI testing series have been conducted to test ongoing EMI modifications. Modifications have resulted in significantly lower emissions compared to the original unit. Any further modifications would be contracted to the manufacturer requiring expensive redesign. There are no receivers in this frequency range and the EMECB determined that these emissions would cause no upsets to other equipment.

EMECB TIA–0059

C.3.2.4.2.2 RS03 LIMITS

Exception: The pass/fail tolerances of the RPCM temperature sensor during SSP 30237 RS03 tests may be increased from +/– 3.9 degrees Celsius to +3.9 to –16 degrees Celsius in the frequency range of 55 MHz to 59 MHz.

Rationale: The EMECB Tailoring/Interpretation Agreement Number 051 (Approved: November 6, 1997) provides for a slight temperature deviations (up to 8 degrees Celsius) during CS02 testing from 45 MHz to 50 MHz. The frequency range of this request (TIA–059) is approximately the same as for TIA–051. Both TIA–051 and TIA–059 address the same RPCM temperature sensor susceptibility at similar CS02 and RS03 test frequencies.

The RS03 test procedure exposed the RPCM electrical connector and cables to much more severe levels of electric field radiation than would occur if the RPCM was RS03 tested in situ on the Space Station. During the RS03 tests, the RPCM test article was positioned with its unshielded cables and open connector end exposed to the RS03 irradiating antenna. The RS03 field was measured at the connector interface. This test procedure was used to simplify the test setup because replicating the actual RPCM installation bay and enclosed cable trays during RS03 testing would be too costly. However, all RPCM installations on the Space Station expose the RPCM's backside (opposite the connector) to the radiation rather than the connector side. The connector interface is protected by the RPCM installation bay and shielded cable tray. The RPCM's temperature sensor will not likely be susceptible to RS03 radiation, both coupling into RPCM on external cables and radiating directly through the open RPCM connector, if the RS03 test configuration is modified to represent the actual Space Station's worst case installation

EMECB TIA–0062

C.3.2.4.2.2 RS03 LIMITS

Exception: The Mobile Remote Servicer Base System (MBS) Video Distribution Unit is allowed to pass the SSP 30237 RS03 requirements at a level 35 V/m in the frequency range of 399 MHz to 417 MHz.

Rationale: It is known that levels above 35 V/m are very unlikely to be experienced in this narrow frequency band, either as a result of ground, station or Orbiter transmissions. The susceptibility noted was a degradation of the signal–to–noise ratio below the somewhat arbitrary levels that have been established for the design. Persons present during the test had no difficulty reading the display. Whether the artificial vision system could cope with the degraded signal is not known, but this consideration is irrelevant, since operations can be completed without it. There is no hazard involved, and this waiver request is regarded as very low risk. The only known emitter in this frequency range is the Extravehicular Activity (EVA) suit radio.

EMECB TIA–0063

C.3.2.4.2.2 RS03 LIMITS

Exception: The MBS Video Signal Converter is allowed to pass the SSP 30237 RS03 requirements at a level of 20 V/m in the frequency range of 236.8 MHz to 239 MHz.

Rationale: It is known that levels above 20 V/m are very unlikely to be experienced in this narrow band at the relatively low frequencies involved, either as a result of ground, station or Orbiter transmissions. The susceptibility noted was a degradation of the signal–to–noise ratio below the somewhat arbitrary levels that have been established for the design. Persons present during the test had no difficulty reading the video display. Whether the artificial vision system could cope with the degraded signal is not known, but this consideration is irrelevant, since operations can be completed without it. There is no hazard involved, and this waiver request is regarded as very low risk. There are no ISS emitters at these frequencies.

EMECB TIA–0065

C.3.2.3.1.2 RE02 LIMITS

Exception: The Power Distribution Box (PDB) may exceed the Radiated E–Field (RE02) emission requirements of SSP 30237 by 5 dB at 190 kHz, from 7 MHz to 9 MHz and around 15–16 MHz up to 8 dB m V/m at 45 kHz and at 90 kHz.

Rationale: The outages should not affect other components of the ISS. There are no receivers at these frequencies on ISS. The EMECB agrees there would be no interference caused by these exceedances.