

# Space Station Grounding Requirements

## International Space Station

Revision C

December 22, 1998



**NASDA**

National Space Development  
Agency of Japan



agenzia spaziale italiana  
(Italian Space Agency)

National Aeronautics and Space Administration  
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**esa**

European Space Agency



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**REVISION AND HISTORY PAGE**

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-	Draft Revision B: SDR Version	03-22-94
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## PREFACE

This document defines the requirements for primary power grounds, secondary power grounds, signal reference grounds, signal return grounds, grounds for user-conditioned power returns/references, and the grounding electrode system for the International Space Station (ISS) Program equipment and structures. The Space Station Grounding Requirements shall be implemented on all ISS Program contractual and internal activities and shall be included in any existing contracts. This document is under the control of the Space Station Control Board.

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**NASA/ASI**

**INTERNATIONAL SPACE STATION PROGRAM  
SPACE STATION GROUNDING REQUIREMENTS  
DECEMBER 22, 1998**

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For NASA

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**NASA/CSA**

**INTERNATIONAL SPACE STATION PROGRAM  
SPACE STATION GROUNDING REQUIREMENTS**

**DECEMBER 22, 1998**

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**INTERNATIONAL SPACE STATION PROGRAM  
SPACE STATION GROUNDING REQUIREMENTS**

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

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**NASA/NASDA**

**INTERNATIONAL SPACE STATION PROGRAM  
SPACE STATION GROUNDING REQUIREMENTS**

**DECEMBER 22, 1998**

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**INTERNATIONAL SPACE STATION PROGRAM  
SPACE STATION GROUNDING REQUIREMENTS**

**LIST OF CHANGES  
DECEMBER 22, 1998**

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

<b>SSCBD</b>	<b>ENTRY DATE</b>	<b>CHANGE</b>	<b>PARAGRAPH(S)</b>
1481	12/22/98	2.0	Applicable Documents
		2.1	Reference Documents
Editorial	12/22/98	1.1	Introduction
		1.4	Intended Use
		3.1.1	Bonding
		3.1.2	Cable/Wire Grounding Treatment
		3.2.2.6	Returns, Signals Below Four Megahertz
		3.2.3	Grounding to Equipment/Vehicle not permanently attached to the Space Station
		4.0	Quality Assurance Provisions
		Appendix A	Abbreviations and Acronyms
		Appendix B	Glossary
		Appendix C	Approved Tailoring/Interpretation Agreements

**TABLES**

None

**FIGURES**

None



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## **1.0 GENERAL**

### **1.1 INTRODUCTION**

This document defines the requirements for Space Station grounding including primary power grounds, secondary power grounds, signal reference grounds, signal return grounds and grounds for user-conditioned power return/references. These requirements are in accordance with the specifications in SSP 30243.

### **1.2 PURPOSE**

These requirements are intended to provide assurance of successful on-orbit integration and operation of the diverse segments of the Space Station. These requirements support modularity, growth, replacement, and configuration independence.

### **1.3 OBJECTIVE**

The objectives of the grounding requirements are crew safety, proper operation of fault avoidance/detection and electromagnetic interference reduction. The Space Station configuration consists of many electrically parallel components that provide conductive paths between flight elements, systems, subsystems, and equipment. The parallel conductive paths provide the opportunity for ground loops and spurious common impedance sources for noise coupling. Ground loops capture and circulate induced, multifrequency signals of varying levels, referred to as noise. Noise represents a varying, uncontrolled, and detrimental contribution to the performance of electrical, electronic, and electromechanical equipment. The grounding strategy represented in this document is designed to preclude the effects of the configuration and environment effects such as  $V \times B$  that cause structure potential differences.

### **1.4 INTENDED USE**

The requirements in this document apply to Space Station segments, subsystems, assembly elements, and equipment including the primary electrical power distribution, secondary electrical power distribution, signal circuits, signal references, primary structure, secondary structure, and interfaces. The requirements of this document also apply to all flight support equipment, orbital support equipment, and to the interface between the ground support equipment and flight hardware. Requirements for bonding are given in SSP 30245.

### **1.5 PRECEDENCE**

SSP 41000 defines the design and performance requirements for the Space Station Program and invokes SSP 30243. This document is invoked by SSP 30243 for grounding requirements. If there is any conflict, SSP 30243 shall take precedence.

## 2.0 APPLICABLE DOCUMENTS

The following documents of exact issue shown in the current issue of SSP 50257 form a part of this document to the extent specified herein.

<b>DOCUMENT NO.</b>	<b>TITLE</b>
SSP 30245	Space Station Electrical Bonding Requirements Reference paragraph 3.2.3
SSP 41173	Space Station Quality Assurance Requirements Reference paragraph 4.0

## 2.1 REFERENCE DOCUMENTS

The following documents are cited as references to guide the user in the application of this standard.

<b>DOCUMENT NO.</b>	<b>TITLE</b>
SSP 30242	Space Station Cable/Wire Design and Control Requirements for Electromagnetic Compatibility Reference paragraph 3.2.2.6

### **3.0 REQUIREMENTS**

#### **3.1 DEFINITION OF OVERALL GROUNDING CONCEPT**

System design shall prevent intentional electrical current from flowing in ground references except under fault conditions. Space Station segments, flight elements, subsystems, equipment metallic components, surfaces, and electrical and electronic parts generally will be referenced to the Space Station conductive structure. The electrical design shall be such that the electromagnetic environment due to grounding is not configuration dependent. Equipment external electrical signal and power grounds shall be dc isolated from each other at the Orbital Replaceable Unit (ORU) level. Each separately derived electrical power source shall be electrically connected to structure at no more than one point. Analog and digital signal grounds external to a system, subsystem, or equipment shall be electrically isolated from each other at the ORU level. Grounding within electrical or electronic equipment is at the discretion of the designer as long as the external power and external signal return isolation requirements are met.

##### **3.1.1 BONDING**

To ensure the integrity of the interconnected conductive elements that will function as the electrical power system fault return path and ground reference, the Space Station systems, assembly elements, flight elements, subsystems, and equipment complies with the electrical bonding requirements of SSP 30245. The chassis and/or structure of all equipment, assembly elements, flight elements, systems, and subsystems operating from a common power source shall be bonded such that maximum electrical fault currents can be conducted without creating a thermal or electrical hazard. Electrical bonds between all components of equipment, subsystems, systems, flight elements, and assembly elements shall be designed to control potential differences.

##### **3.1.2 CABLE/WIRE GROUNDING TREATMENT**

The wire treatment grounding and shielding procedures and requirements of SSP 30242 applies to all flight elements, systems, and equipment to control electromagnetic effects and reduce electromagnetic interference. SSP 30242 defines the requirements to isolate sensitive circuits and minimize radiated and conductive coupling by wire cable bundling, routing, separation, shielding, and grounding based on the circuit classifications. Requirements for wire and cable shield terminations are also included in SSP 30242.

### **3.2 CHARACTERISTICS**

#### **3.2.1 ELECTRICAL POWER**

##### **3.2.1.1 PRIMARY ELECTRICAL POWER**

The Space Station primary electrical power system shall be distributed single point grounded. Users of power shall be direct current (dc) isolated such that the primary electrical power ground

configuration is not dependent on the presence or absence of flight elements, systems, subsystems, equipment, or users. Primary electrical power shall be dc isolated from chassis, structure, equipment conditioned power return/reference, and signal returns by a minimum of 1 megohm, individually, when grounds are not terminated to chassis or structure.

### **3.2.1.2 SECONDARY AND TERTIARY ELECTRICAL POWER**

Secondary and tertiary electrical power shall be single point grounded. Secondary electrical power shall be dc isolated from chassis, structure, equipment conditioned power return/reference, and signal circuits by a minimum of 1 megohm, individually, when all grounds are not terminated to chassis or structure.

### **3.2.1.3 CONTROL POWER BUS RETURN**

The dc power control bus shall be independent of the primary electrical power and shall be referenced to the system reference at a single location.

### **3.2.1.4 ISOLATED ELECTRICAL POWER WITHIN EQUIPMENT**

Within equipment, conditioned electrical power shall be dc isolated from chassis and structure except at no more than one electrically conductive common point. Where termination is desired, the equipment designer has the option of either bringing the single point reference external to the equipment for termination to the nearest structure ground or, of terminating the reference point to the chassis internal to the equipment; both methods may be used simultaneously.

### **3.2.1.5 ISOLATED ELECTRICAL POWER BETWEEN EQUIPMENT**

Where equipment further conditions and isolates electrical power, e.g., for external channel-to-channel isolation or external signal-to-signal isolation, each secondary conditioned power reference shall be treated individually in the same manner as in 3.2.1.4.

### **3.2.1.6 LOAD CONVERSION**

Where load conversion is done to supply any form of conditioned power to several devices or functions, that conversion shall re-establish a single point reference for the serviced equipment or functions.

## **3.2.2 RETURNS**

### **3.2.2.1 SIGNAL CIRCUIT RETURN GROUNDING**

Signal circuit electrical power shall be dc isolated from chassis, structure, and equipment conditioned power return/reference, by a minimum of 1 megohm, individually, when not

terminated to chassis or structure. Under no circumstances shall separate flight elements, assembly elements, systems, subsystems, or equipment depend on other equipment for signal reference or signal return grounding unless they are also dependent upon the other equipment for power.

### **3.2.2.2 ALTERNATING CURRENT POWER RETURN**

A neutral return wire shall accompany the alternating current input wires to individual equipment loads in the distribution of power.

### **3.2.2.3 ANALOG, DIFFERENTIAL CIRCUIT RETURN**

Each differential analog circuit shall employ a separate return.

### **3.2.2.4 DISCRETE RETURNS**

Low-level discrete signals shall use individual returns.

### **3.2.2.5 PULSE OR CLOCK CIRCUIT RETURNS**

All digital, pulse, or clock circuits that do not use fiber-optic cabling shall use individual returns.

### **3.2.2.6 RETURNS, SIGNALS BELOW FOUR MEGAHERTZ**

Signal circuits external to equipment with frequency content below four megahertz shall be balanced and shall be isolated from chassis, structure, and user-conditioned power return/reference by a minimum of 6,000 ohms, individually (i.e., measured per connection, pin, wire, etc.). Otherwise external signals shall be isolated through optical isolators, transformers, etc. All references for circuits with frequencies below 4 MHz shall be single point grounded to conductive structure. Shield connections shall be made to either connector shells or to connector pins that are grounded when mated. Shield treatment is specified in SSP 30242.

### **3.2.2.7 SIGNALS EQUAL TO AND ABOVE FOUR MEGAHERTZ**

Signals circuits with frequency components equal to or above four megahertz shall use controlled impedance transmission and reception media such as shielded twisted 72-ohm cable, "twin-ax" cable, "tri-ax" cable, or "co-ax" cable. Circuits using "twin-ax" cable shall be balanced and referenced to primary structure at a single point. "Tri-ax" cable shall use the center and inner shield conductors for unbalanced transmission, referenced to primary structure at a single point with the outer shield multipoint grounded as an "overshield". DC isolated, single-ended circuits coupled by coaxial cable with the shield terminated 360 degrees at each end and at available intermediate point, shall be permitted for signals with the lowest frequency component equal to or above 4 MHz.

### **3.2.2.8 BRIDGE WIRE ACTUATED DEVICE GROUNDING**

To preclude adverse electromagnetic effects, Bridge Wire Actuated Device (BWAD) firing circuits, including electroexplosive device firing circuits, shall be isolated from other electrical

circuits and from each other by a minimum of 1 megohm. Each actuating or firing circuit shall be routed as a shielded twisted pair. Each firing circuit shall be returned to the firing power source and shall be isolated from ground by a minimum of 20 kohms. The firing power source shall be isolated so that current cannot be conducted through chassis or structure by the ionized conductive path formed when a BWAD is fired. For electrostatic protection, the firing circuit shall be balanced and referenced to conductive structure ground by more than 20 kohms and less than 1 megohm. In addition, in a “safe” condition, BWAD leads shall be shorted together.

### **3.2.3 GROUNDING TO EQUIPMENT/VEHICLE NOT PERMANENTLY ATTACHED TO THE SPACE STATION**

Structures shall be grounded first before crew contact or other electrical connections are made. Temporary interface power shall be separately derived power (using a dc isolating transformer) with only one connection to structure ground either on the ISS or on the interfacing system. Signal interfaces shall be fiber optic, differential, or isolated return conductor type. Docked or berthed bonding shall correspond to a Class H/R bond in accordance with SSP 30245. End effectors making contact with structures isolated from Space Station ground shall have provisions to bond at first contact through a 10,000-ohm resistance to limit current in the Electrostatic Discharge between the end effector and that structure. See appendix C for exception (EMECB TIA-69) to this paragraph.



#### **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 or equivalent document for International Partner (IP) agencies.

#### **4.1 RESPONSIBILITY FOR INSPECTION**

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

**APPENDIX A ABBREVIATIONS AND ACRONYMS**

BWAD	Bridge Wire Actuated Device
dc	Direct Current
IP	International Partner
MDM	Multiplex/Demultiplex
MHz	megahertz
NASA	National Aeronautics and Space Administration
ISS	International Space Station
ORU	Orbital Replaceable Unit

## APPENDIX B GLOSSARY

### ASSEMBLY ELEMENT

A part of a flight element that requires no assembly on orbit and has a functional purpose to which resources may be assigned.

### BOND (NOUN)

Any fixed union existing between two objects that results in electrical conductivity between the objects. Such union occurs either from physical contact between conductive surfaces of the objects, or from the addition of a firm electrical connection between the objects.

### BONDING OR TO BOND

The act of connecting objects to obtain electrical conductivity between them.

### CHASSIS OR STRUCTURE GROUND

Conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the structure ground.

### CIRCUIT REFERENCE

The collection of bonded circuit and conductive structural elements.

### CIRCUIT REFERENCE/COMMON CONNECTION (POWER OR SIGNAL)

A return path or physical tie point usually at a potential of zero volts.

### DISTRIBUTED SINGLE POINT GROUND

A system of multiple, isolated system ground points common to an isolated set of equipment (i.e. single point ground), referenced to a common, large, conductive structure (e.g. equipotential "islands").

### 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.

### FLIGHT ELEMENT

An assembly of Space Station hardware collected as one named group, e.g., segments.

### GROUND

A stable sink capable of conducting large currents with little or no effect on potential differences, providing a reliable reference.

### ISOLATED ELECTRICAL POWER

Secondary electrical power isolated from primary electrical power.

**LEAKAGE CURRENT**

Current flowing in a path between chassis and power single point ground.

**POINT**

A position or location, not intended to be limited to a single fastener (for example a golden rivet) but constitutes an equipotential ground reference.

**PRIMARY ELECTRICAL POWER**

Electrical power taken from power generation units without conditioning or isolation.

**SECONDARY ELECTRICAL POWER**

Electrical power in the Space Station that has been isolated from the primary electrical power before it is distributed to the modules, utility ports, and external payloads.

**SEPARATELY DERIVED POWER**

Power derived from a generator, a transformer, or a converter and with no direct electrical connection to conductors in another system.

**SINGLE POINT GROUND**

A common electrical connection to ground, used as a common reference (typically the common electrical connection is characterized by a minimum, or zero potential difference between each physical connection).

**STRUCTURE BOND**

An electrical connection between structure components or to structure intended to minimize potential differences.

**TERTIARY POWER**

Electrical power derived from secondary power.

## APPENDIX C APPROVED TAILORING/INTERPRETATION AGREEMENTS

### EMECB TIA-0069

#### 3.2.3 GROUNDING TO EQUIPMENT/VEHICLE NOT PERMANENTLY ATTACHED TO THE SPACE STATION

Exception: This requirement is relaxed for the Local End Effector (LEE) (PN 51612-4000-1 N) and applied instead to the Power Data Grapple Fixture (PDGF) or Flight Support Equipment Grapple Fixture (FSEGF) of all free-flyers that the LEE is required to interface with, thus meeting the objective of the requirement. (Therefore the LEE will offer a low-impedance path to ground per the other station requirements.)

Rationale: All ORUs and payloads being moved by the Space Station Remote Manipulator System (SSRMS) on the station are already bonded to structure when picked up by the LEE. Thus the requirement only applied to free-flyers on first contact (and does not therefore apply to the Orbiter which is docked and grounded before arm-operations commence).

It is also highly doubtful whether this requirement is necessary even for free-flyers because the plasma contactor holds the station structure within 40 volts of the plasma potential, which is acquired by any free-flyer within less than a minute.

On the Shuttle Remote Manipulator System (SRMS), a similar requirement is satisfied as proposed in the tailoring/interpretation agreement presented above.