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High voltage safety design criteria for space stations

空间站高电压安全性设计准则

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2 Normative references

This document has no normative references.

4 Design Principles

The design principles for high-voltage safety of the space station are as follows:

a) Emphasis should be placed on aspects such as insulation design, spacing design, overload protection, fault isolation, component selection and use, and cable routing layout. The exhibition aims to eliminate safety hazards such as high-voltage discharge, breakdown, insulation degradation, and unequal potential.

b) Control high-voltage risks within the system from aspects such as system design, equipment design, process use, production, operation protection, and process control. Acceptable range;

c) The system's high-voltage safety design considers testability and inspectability, and incorporates necessary fault-tolerant and anti-misoperation design elements;

d) In the high-voltage safety design and operation of the space station, personnel safety should be given priority to ensure the safety of astronauts operating the space station. Electrical safety during operation, testing, and maintenance;

e) Electrical connectors, equipment, cables, etc., related to high voltage on the space station shall have safety warning designs.

5.1 Components and Sub-assemblies

5.1.1 Selection and Use The selection and usage requirements are as follows:

a) J599 round large contact electrical connectors should be preferred. If other types of electrical connectors are used, they should meet the requirements for low-pressure media. The withstand voltage should not be less than

2.5 times the operating voltage;

b) For multiple high-voltage electrical connectors on the same equipment, different models of electrical connectors should be selected or a misoperation prevention design should be adopted;

c) All electrical connectors for power transmission should be pin-type connectors with a socket for power supply and a pin for power receiving.

d) When using power MOSFETs, consider the effects of lead inductance, load parasitic inductance, or unrepressed circuitry when the load releases its stored energy. Avalanche breakdown caused by small inductance;

e) When selecting the power rating of a DC/DC converter, the principle of backward compatibility should be met, and derating requirements should be satisfied as much as possible. Choose products whose actual power consumption is close to their rated power;

f) DC/DC converters used in parallel should be from the same manufacturer and of the same specifications, and should be used in accordance with product requirements;

g) The DC/DC converter should have the function of protecting the input power bus.

5.1.2 Safety Distances and Isolation The safety distance and isolation requirements are as follows:

a) High-voltage power connectors should not be used interchangeably with other low-voltage connectors. If it is necessary to use different connectors, the arrangement of the connector contacts should be considered. Designed in zones to meet spacing requirements;

b) The positive and negative power supply lines of the same electrical connector should be designed in separate areas for contact allocation, and the positive and negative power supply lines should be... Maintain at least one contact interval;

c) The control signals of the solid-state power controller should be electrically isolated from the main power circuit;

d) When high-voltage and low-voltage lines are on the same printed circuit board, the high-voltage and low-voltage lines should be separated by area, and the number of lines should be reduced as much as possible. The length of the boundary between adjacent high-voltage and low-voltage lines;

5.2 Power supply and distribution equipment

5.2.1 Solar Cell fins The requirements for solar cell wings are as follows:

a) The power supply cables on the solar cell fins should use double-insulated wires;

b) The potential difference between adjacent battery strings should be less than 50V;

c) The current limit for each isolated solar cell string circuit should be less than 1.6A;

d) The insulation resistance between the solar cell substrate and the solar cell circuit should be greater than 10MOmega (DC250V), and the insulation resistance between the solar cell fins and the hull should also be greater than 10MOmega (DC250V). The connection should be grounded with high resistance, with a grounding resistance of 10kOmega to 100kOmega.

e) Isolated metal conductors with an area greater than 1 cm^2 in the solar cell array should be grounded;

f) The output terminal of the solar array circuit corresponding to each shunt regulation circuit should be isolated from the bus by a diode connected in series, and an open-circuit protection mechanism should be adopted. Effective measures;

g) The spacing between solar cell strings shall not be less than

5.2.2 Drive Mechanism The drive mechanism is required to transfer power from the external battery wings to the cabin, with the following requirements.

a) High-resistance grounding measures should be taken for areas where slip rings are not used;

b) The insulation layer thickness between adjacent power slip rings of the same voltage should not be less than

0.7 mm, and the creepage distance between adjacent power slip rings is generally greater than [missing value]. 3.2mm;

c) The insulation layer thickness of adjacent power slip ring components with voltage differences should not be less than 1mm;

d) The spacing between positive and negative slip rings should be no less than twice the thickness of the insulation layer between adjacent slip rings with the same voltage.

5.3 High Voltage Interface and Transmission

5.3.1 High-voltage power supply and distribution interface The requirements for high-voltage power supply and distribution interfaces are as follows:

a) Electrical isolation design should be implemented between different high-voltage power supply busbars;

b) Voltage and current monitoring devices should be installed at the power supply and

distribution interface to measure voltage and current parameters in a timely manner and report the measurement results. Transmitted to the relevant display system;

c) A capacitor array with sufficient capacity should be provided at the high-voltage power supply output terminal. The capacitors should be connected in series or parallel, or connected in series with fuses, to ensure safety. Complete, to prevent short circuits in the capacitor from causing short circuits in the power supply;

d) Voltage measurement points for bus voltage acquisition and closed-loop voltage control should be located nearby, and protective resistors should be installed at the acquisition points;

e) The power supply contacts at the interface should be configured with separate positive and negative contacts, and the distance between the positive and negative contacts of the connector should not be less than 2.5mm;

f) The dynamic range of load changes at the power supply and distribution interface and the corresponding transient characteristics of the bus voltage, under normal and fault conditions. The voltage and current range values at the power supply and distribution interfaces should be clearly specified in the dedicated technical documents.

5.3.2 High-voltage bus transmission The requirements for high-voltage bus transmission are as follows:

a) High-voltage cables should use double-insulated conductors;

b) High-voltage cables should be installed separately in locations inaccessible to personnel, and isolated from low-voltage cables as much as possible; if there are local... If the parts intersect, the intersecting parts should be tied separately;

c) To prevent the concentration of heat effects in the layout of high-voltage cables, heat-generating components (such as shunts, discharge regulators, battery packs, and high-current cables) should be protected. (etc.) should be distributed in a decentralized manner;

d) When laying high-voltage cables, secondary isolation measures should be adopted along the transmission path, especially at the direct contact points between the high-voltage cables and the metal structure of the cabin. When laying insulation material, the width of the insulation material should be no less than 2 to 3 times the diameter of the cable.

5.3.3 Security of power distribution and electrical equipment interfaces The security requirements for interfaces between power distribution and electrical equipment are as follows:

a) The voltage and current ranges at the interface between the power distribution and electrical equipment should be clearly defined under normal operating and fault conditions;