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MARTIAN MOONS EXPLORATION (MMX) MISSION

COMPONENT ELECTRICAL DESIGN CRITERIA

REVISION AND HISTORY PAGE

Status	Revision Number	Change Number	Description	Release Date

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1. INTRODUCTION

1.1. Purpose and scope of this document

This document (MMX-C-EDC) describes the criteria on electrical interface designs for Martian Moons Exploration (MMX) on-board components.

In case of conflict, the MMX-I-IRD will take precedence over this document.

For any component that raises issues in satisfying the requirements, coordinate with the MMX system team.

1.2. Reference documents

See Section 12.

1.3. Notation

[TBD-Sys] [TBC-Sys]

The results of previous study for MMX or other projects are described as reference information for systems and the PI instrument. They will be established by system design in Phase A or beyond.

[TBD-Sys/PI] [TBC-Sys/PI]

The results of previous study for MMX or other projects are described as reference information for systems and the PI instrument. They will be established through coordination between the PI instrument and systems in Phase A or beyond.

[TBD-Doc] [TBC-Doc]

Information that can be described through coordination with design standards and other documents. (Phase A or beyond)

[TBD-Plan] [TBC-Plan]

Information determined after government approval of the project plan.

2. TYPES OF ELECTRICAL INTERFACES

This document specifies electrical interfaces for the following items:

(1) Power supply interface

An unregulated primary electrical power (hereinafter called “bus power”) obtained from the solar cells and the batteries is provided from a power control unit (PCU) to each component. The bus power should be used after voltage conversion and stabilization by isolated DC-DC converters at each component. If it is desirable that a component use the bus power without isolated converters, such as an NEA driver, it shall be coordinated with the MMX system team.

(2) Command/telemetry interface

All commands and telemetry data shall be handled over SpaceWire (SpW) interface with RMAP protocol. However, components such as in communications systems or sensors in attitude control systems, which only have limited command/telemetry items, will be connected to component having SpW interface to have indirect SpW interfaces.

(3) Passive analog/active analog interface

Analog signals of component without SpW interfaces.

(4) Heater control interface

In principle, heaters to be used for maintaining operational temperature ranges of on-board component shall be controlled by Heater Control Electronic (HCE). HCE shall measure temperatures of heater control points for heater on/off controls. The subsystem team shall individually perform special heater controls, for the purpose of controlling temperature of limited hardware within components.

(5) Spacecraft external interface

The spacecraft has externally accessible interfaces for the necessity of system tests or firing range operations.

(6) Signal interface between components

Signal interface between components is SpW.

3. POWER SUPPLY INTERFACE

3.1. Configuration and Distribution of Power Supply Systems

Each component should use the bus power distributed by the PCU after voltage conversion and stabilization by isolated DC-DC converters at the component. If it is desirable that a component use the bus power without isolated converters, such as an NEA driver, it shall be coordinated with the MMX system team.

3.2. Bus Power Supply Interface

(1) Electrical power bus

① Power supply method: unregulated, direct current

② Output voltage: +32.5 V to +52.0 V (PCU output end)

Note: The voltage of the power bus at each component drops from the bus specs due to the line impedance. Electrical instruments shall be designed so that voltage drop of the bus power will be 200 mV or less both at the HOT and the RTN sides.

③ Power bus line impedance: TBD-Sys

④ Bus voltage changing speed (Bus transient)

Bus voltage fluctuates due to transients when a component with large power is turned on/off, etc., or when operation mode of the bus power supply system changes at boundaries between sunshine and shade. Any component that uses the bus power shall operate properly even at such changing speeds.

・Changes between sunshine and shade: TBD-Sys

(2) Current monitor

Electric current consumption of a bus power supply is measured by the PCU for each distribution system and is generated to telemetry.

(3) Turning on/off of a bus power supply of component

The PCU shall have a function to turn on or off a bus power supply for the purpose of separating the power bus power supply against overload during a failure of a component using the bus power as well as of a single event latch-up release.

Note that each component shall perform protection of devices against a single event latch-up as shown in 3.3.6.

(4) Overcurrent protection of bus power supplies

The PCU shall be provided an overcurrent protection function (a current limiter or a circuit breaker) for each distribution system in order to protect the spacecraft power supply system from overload during a component failure as well as to separate the failure. Figure 3.2-1 shows a block diagram of the overcurrent protection function. After shut-down, the power supply returns to the previous state only through a command after the failure location is confirmed via telemetry.

The overcurrent protection circuit has the following features:

① A bus power supply on/off (FET) switch

② A current limiter or a circuit breaker

③ A current monitor

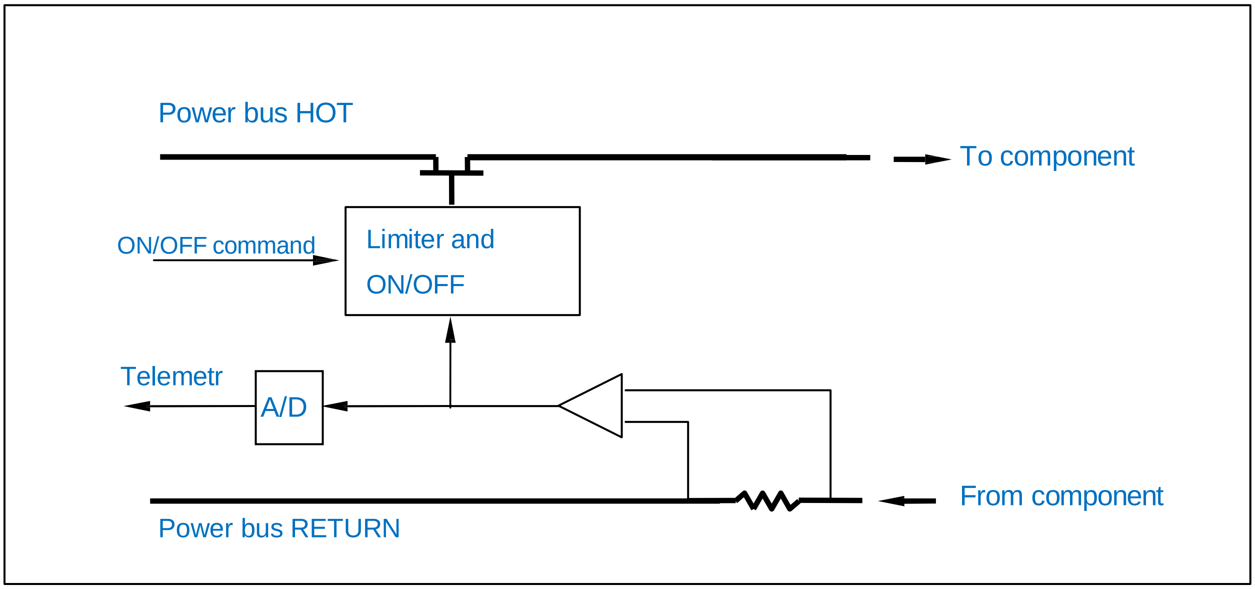


Figure 3.2-1 Block Diagram of Overcurrent Protection Function in PCU

(5) Input capacity of component using a bus power

In order to keep rush current within a specified value during the PCU's bus power supply distribution switch being turned on, input capacity of a component using bus power shall be equal to or less than 300μF(TBD-Sys). If input capacity exceeds the specified value, each subsystem team shall present the characteristics to the MMX system team for coordination.

3.3. Power Supplies in General

3.3.1. Power Supply Return

In principle, power supply returns shall be set separately according to the types of power supplies shown in Table 3.3.1-1 in order to reduce interference and noise.

Table 3.3.1-1 Type of Power Supply Returns

Category	Applied Secondary Voltage	Abbreviation for Return	Purpose of Usage
Primary power bus	———	COM(1)	Bus power supply return
Secondary power lines	+5 V +12 V −12 V	COM(2)	Secondary power supply return
	+12 V(RL)	COM(RL)	Relay-operated return
	+29 V	COM(29)	Heater power supply return RCS thruster drive return
	Other than the above	COM(voltage for use)	Individual usage

3.3.2. Grounding and Shields

(1) Types of grounding

A. Housing ground

Grounding of a component housing is called “housing ground.”

B. Structure ground

Grounding of the spacecraft structure is called “structure ground.”

(2) Grounding of power supply return

Requirements for grounding of power supply return are shown below (see Figure 3.3.2-1):

A. Primary power bus

Power bus return shall be grounded at a single point of the PCU housing and shall be grounded through the housing to the spacecraft structure. Therefore, the power bus hot and return lines in each component shall be insulated electrically from the housing and the spacecraft structure. Insulation resistance shall be DC 1MΩ or more.

If the requirement above is not satisfied, it shall be coordinated with the MMX system team.

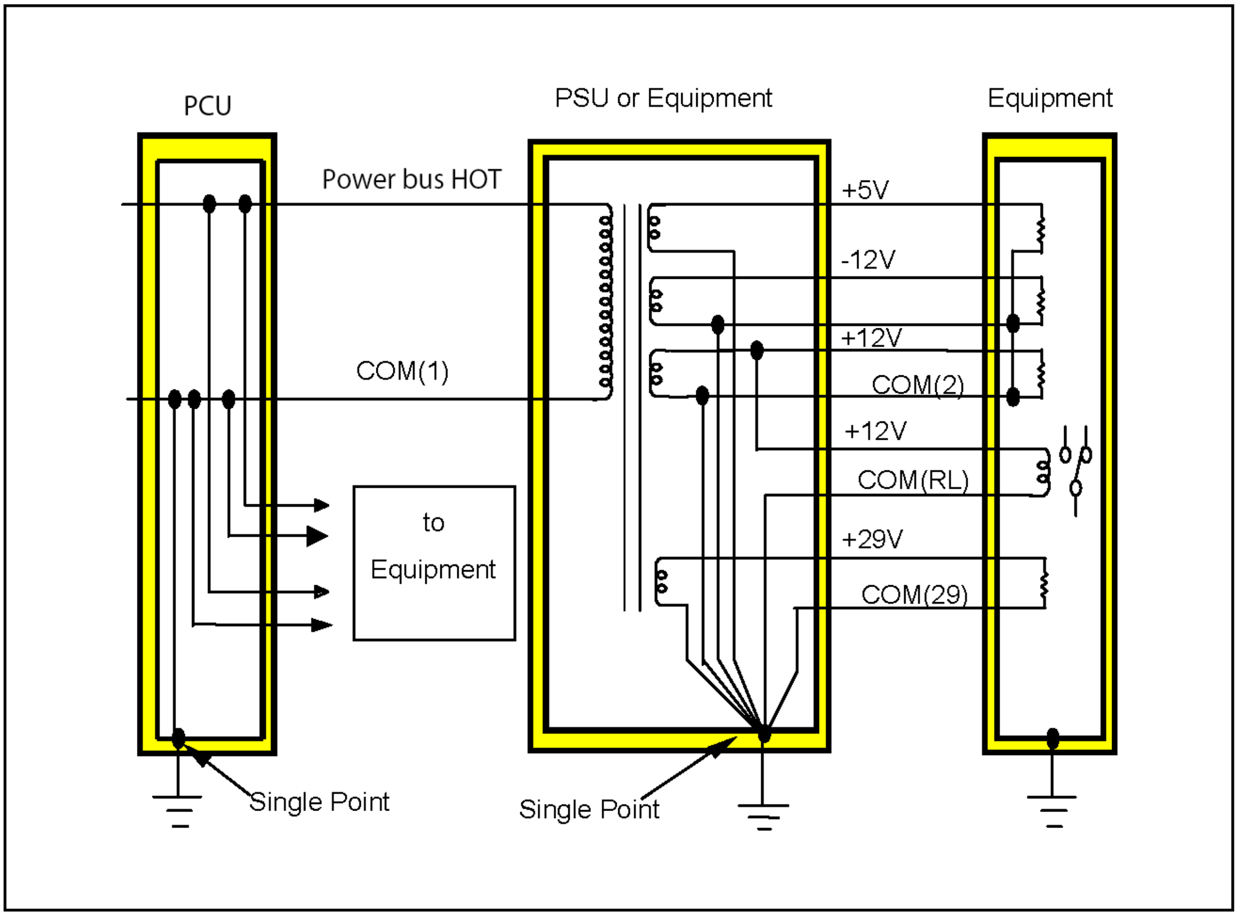


Figure 3.3.2-1 System Diagram for Grounding

B. Secondary power line

In principle, secondary power return of each component shall be grounded at a single point of the housing of the secondary power supply converter of each component and shall be grounded through the housing to the spacecraft structure (see Type B of Figure 3.3.2-2).

With respect to components without a secondary power supply converter, secondary power return shall be insulated electrically from the housing and the spacecraft structure. Insulation resistance shall be DC 1MΩ or more (see Type A of Figure 3.3.2-2).

C. Connection of power return to housing ground through capacitance

If it is necessary to connect the power bus return or secondary power return to housing ground through capacitance (Type C in Figure 3.3.2-2), it shall be coordinated with the MMX system team in order to avoid AC ground loop.

Exception: if it is necessary to insert capacitance between the bus power return and the housing ground to suppress the common mode noise on the secondary power line generated by the power converter, there is no need for such coordination.

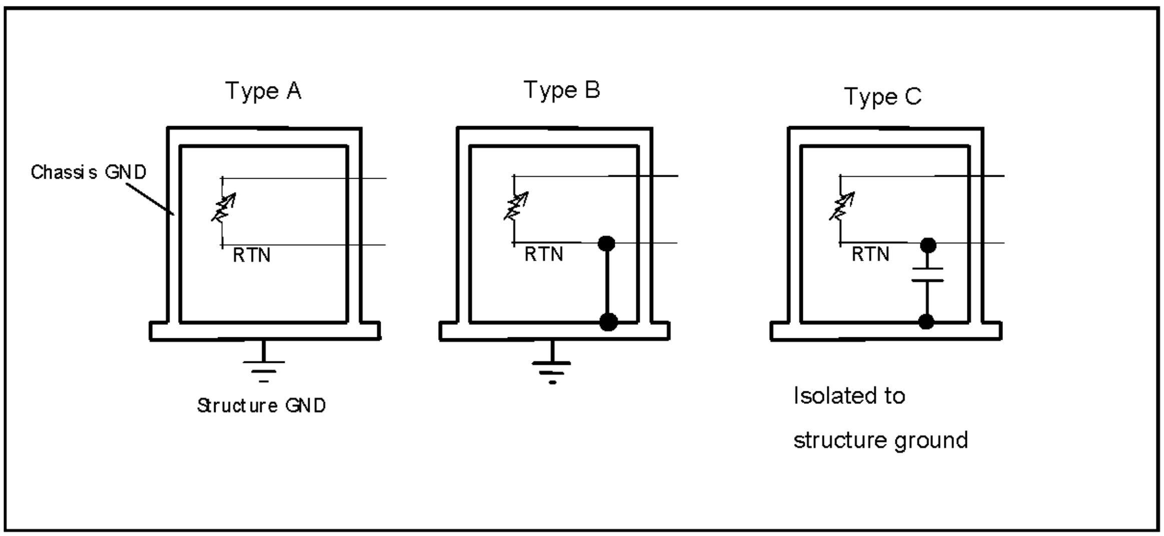


Figure 3.3.2-2 Grounding of Power Supply Return and Housing

(3) Grounding of shield shells

If shield shells of shield wires, coaxial cables, shield tapes, etc. are grounded to GND, they shall basically be drawn into the respective component via connector pins of the component so that they will be connected to the housing ground or secondary power return in that component or to the housing ground via connector shells.

In addition, if shield shells are connected to a secondary power return, the other end shall basically be open. (Connection between secondary power returns of different components, or connection between a secondary power return and a housing ground of different components shall not be made with shield shells or shield tapes.)

3.3.3. Interconnection of Secondary Power Returns of Multiple Components

(1) For using a common secondary power supply converter

The components using a common secondary power supply converter shall be connected so that the secondary power return and the common secondary power supply converter are connected in a star configuration. In principle, there shall be no cross connections, including the return side of signals (see Figure 3.3.3-1).
(A C-MOS single-end interface or a differential interface shall be used for signal connection between components. See Table 9.1-1)

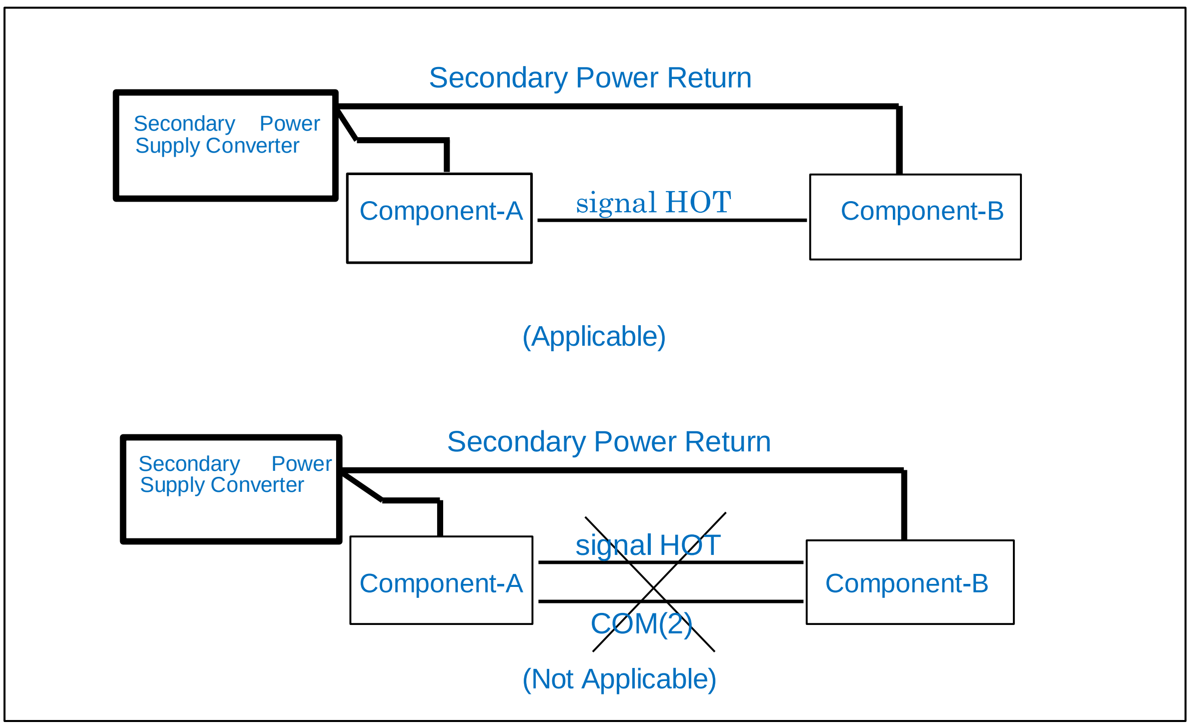


Figure 3.3.3-1 Prohibition of Mutual Connection of Secondary Power Supply Returns in Case of Using a Common Secondary Power Supply Converter

(2) For using different secondary power supply converters

In principle, when components use different DC/DC converters, cross connection of secondary power returns, including the return path of signals, shall not be permitted (Figure 3.3.3-2). (Differential interfaces shall be used for signal connection between components. See Table 9.1-1)

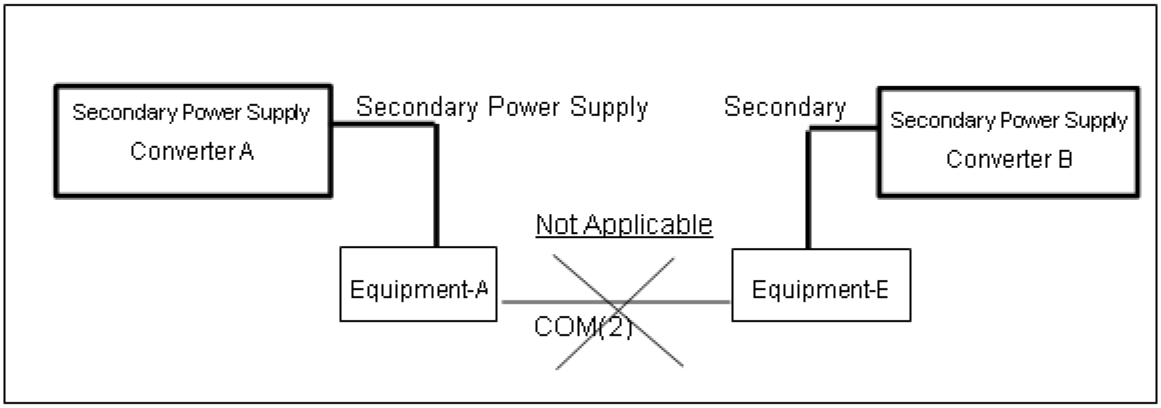


Figure 3.3.3-2 Prohibition of Mutual Connection of Secondary Power Supply Returns in Case of Using Different Secondary Power Supply Converters

3.3.4. Rush Current

(1) Rush current when a bus power supply is turned on (if the PCU has a switch)

In order to limit the rush current when a bus power supply of a component is turned on/off, capacity for the bus power supply shall be equal to or less than 300μF(TBD-Sys).

(2) Rush current when a bus power supply is turned on, etc. (if the PCU does not have a switch)

Rush current due to the operations such as the turning on/off of a component, including the turning on/off of bus power supplies, shall satisfy the conditions shown in Table 9-2 (CE15) . This term is applied for the instruments that are turned on at the moment when external power is supplied to the spacecraft.

(3) Rush current when a component using a secondary power supply is turned on

Components to which a secondary power is supplied from other components shall be designed to satisfy the rush current criteria that are specified by the supplier components.
Note: this term does NOT specify the primary power rush current caused by the component.

(4) Prevention of rush current when a relay in component is turned on

No large capacitor shall be connected after the relay: this rule is set to reduce rush current which occurs when a relay connected to the bus power or a secondary power in a component is turned on, etc. If it is difficult to take such measures, a resistance R1 shall be inserted in a previous step (see Figure 3.3.4-1)

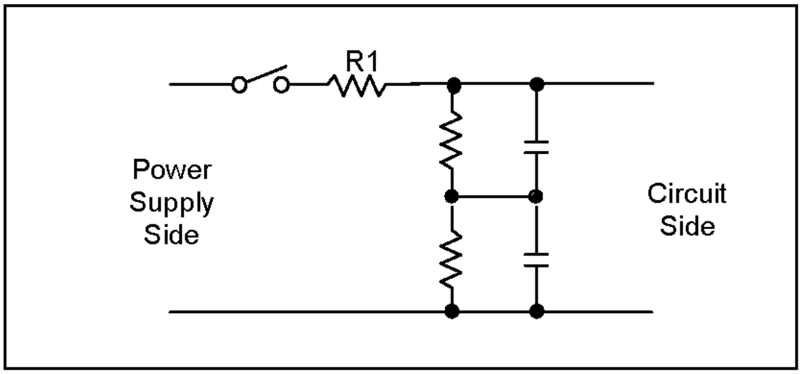
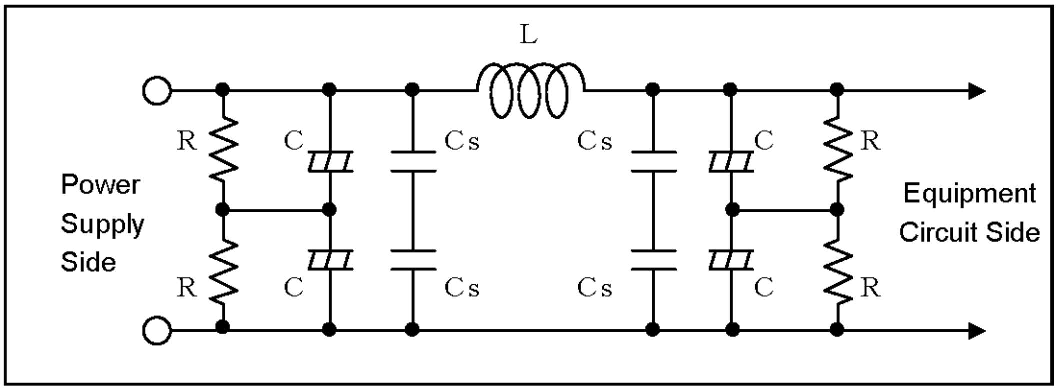


Figure 3.3.4-1 Reduction of Rush Current by Insertion of Resistance

3.3.5. Power Supply Line Filter

A filter with sufficient capability of attenuating the noise coupling between system electrical components on the power line and the component shall be inserted at power supply input ends of each component. The filter circuit shall conform to Figure 3.3.5-1. Values for L and C shall be chosen properly.



C: Tantalum capacitor
Cs: Ceramic capacitor
L: Coil
R: Voltage equalizing resistance

Figure 3.3.5-1 Power Supply Line Filter

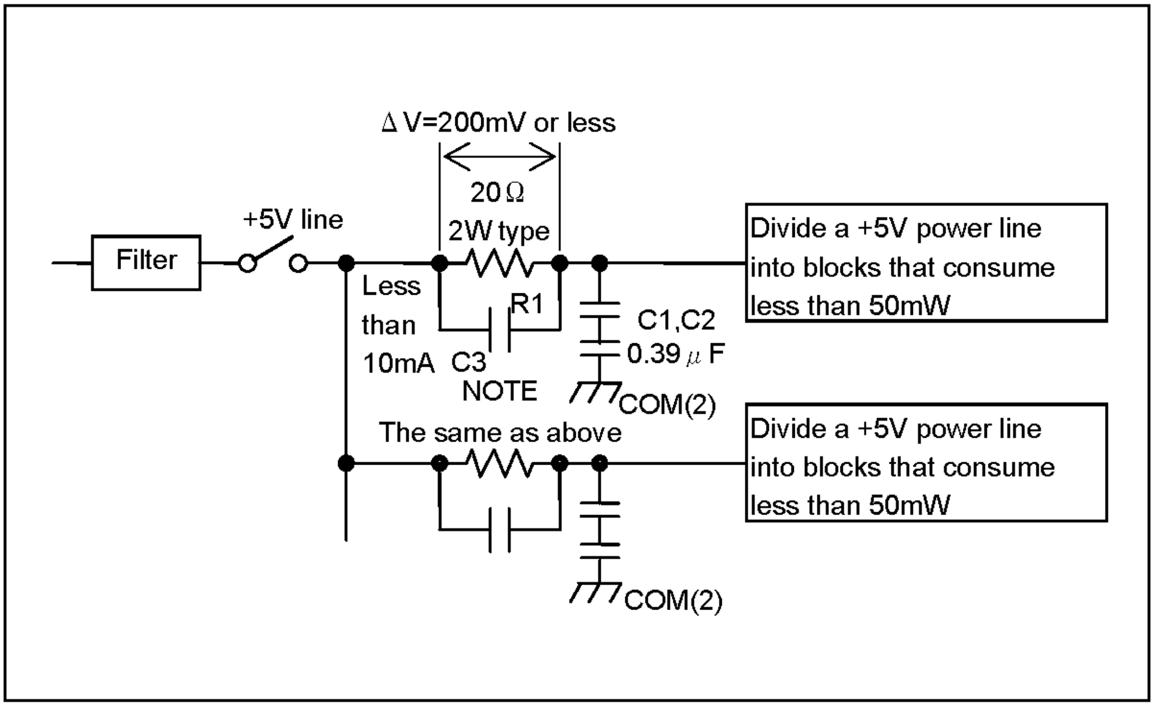
3.3.6. Protection from Overcurrent

As shown in 3.2. (4), the PCU shall be provided an overcurrent protection function in order to protect the spacecraft power supply system from overcurrent during a component failure. However, the subsystem team shall consider protection of their devices from overcurrent due to

C-MOS latch-up. Design criteria per protection method are shown below. Among latch-ups, measures shall be taken for a single-event latch-up (SEL) caused by space radiation in consideration of the SEL-proof (LETth) of devices. However, overcurrent protection measures for SEL are not required for devices of LETth ≧80MeV•cm^2/mg (TBC-Sys/PI).

(1) Overcurrent protection resistance

Figure 3.3.6-1 shows an example of protection resistance circuits. R1, C1, and C2 shall be set in consideration of device characteristics, required line impedance, component mass, power consumption, etc.



Note 1: A suitable capacitor (about 1000pF) shall be inserted if it is necessary to keep the dynamic impedance of power supply lines at low level.

Figure 3.3.6-1 Example of Overcurrent Protection Resistance Circuit

(2) Current limiter

Values for current limiters shall be set within a range where they do not cause failures to devices. In addition, it should be kept in mind that they will not exceed the maximum rated output of secondary power supply converters. Note that the latch-up release of a component is basically performed by turning off the bus power supply of that component using the bus power supply switch in the PCU.

(3) Circuit breaker

If a component uses circuit breakers, all the relevant systems shall be shut down simultaneously in order not to lose the voltage balance in the component. In addition, circuit breakers shall have an OFF command during shut-down, a reset function during re-start, etc., in order to enable an attempt for returning to a normal state.

3.4. Individual Interface of Power Supply Systems

3.4.1. Relay Drive Power Supplies

If multiple relays are to be driven in a component, an appropriate time delay shall be provided in each relay drive sequence. Any method, in which a large number of unnecessary relays are driven simultaneously, shall be avoided.

It should be kept in mind that the components using a PSU shall not exceed the maximum rated output current of the PSU. Unless specially required, latching relays shall be used to save power consumption when relays are not driven.

3.4.2. Heater Power Supplies

(1) Recommended power supplies for use

TBD-Sys/PI

(2) Cautions for heater control

① Decoupling filters are not required for heater power supply lines unless heater current control using the PWM (Pulse-width modulation) is performed.

② Heater shall not be substituted as a series regulator in any component in order to reduce power supply loss. If they are required, it shall be discussed with the MMX system team.

(3) Telemetry status

Any component which requires a heater for storage, even when it is turned off, shall be a permanent power supply component (see 3.4.3.), equipped with a heater control circuit. In this case, heater on/off status, automatic/manual status, etc. shall be properly generated even when the component is turned off.

3.4.3. Permanent Power Supplies

(1) Permanent power supply component

Permanent power supply component is the component in which power supply cannot be turned off using a spacecraft command, etc., once power is supplied to it when a spacecraft power supply is turned on. The component is also a minimum requirement to control the spacecraft.

(2) Permanent power supply circuits in component

With respect to components other than permanent power supply component, the following circuits shall be the ones where “on” state is maintained (permanent power supply circuits) as long as the bus power is supplied to the component.

① Component startup circuits

Circuits minimally required in the first stage of component startup, such as circuits to process commands (for example, CPU_SET/RESET/RUN) for turning necessary circuits on or power-on reset circuits.

② Telemetry processing circuits

Circuits required to process and output telemetry data that is necessary for monitors in spacecraft control even when the component is turned off.

* Examples of telemetry data:
・Component on/off
・Heater on/off, ENA/DIS
・CPU on/off, SET/RESET, RUN/IPL
・HV on/off, HV ENA/DIS

③ Memory circuits for storing programs

The component whose memory for storing programs is not ROM shall have a memory for program storage as a permanent power supply circuit. Note that the permanent power supply memory circuit shall use STATIC C-MOS ICs, etc., in order to reduce power consumption when the component is not operating.

④ Heater control circuits

Heater control circuits when a heater is required even if the component is not operating

3.4.4. High-voltage Circuits

Voltage of 100 V or more is defined as high voltage in this context. Any component using high voltage shall be specified in the component ICD. Also, its high-voltage power supply shall be equipped with a high-voltage enabling circuit shown below:

(1) High-voltage enabling circuit

“High-voltage on” shall be a double command of "HV ENA" + "HV ON."

(2) High-voltage level set

With respect to components in which high-voltage levels need to be changed, it shall be possible to change the levels even in the case of “HV ON” state.

(3) Protection of high-voltage power supplies

Components shall have a function to shut off automatically when any abnormal situation occurs in a high-voltage power supply, so that damage in the component can be minimized. If necessary, HV-ENA plug can be installed to secure safety in activities on the ground.

4. TELEMETRY COMMAND INTERFACE

4.1. Overview

Telemetry command interfaces are broadly classified into three types shown below. Telemetry command interfaces of components shall be designed in accordance with one of the following interface criteria (except for interfaces in subsystem components such as a component between sensors and analog electric appliances).

Data formats shall be provided in a telemetry command design criteria.

(1) SpW interface

(2) TCIU interface

Table 4.1-1 shows category of telemetry command interfaces for use.

Table 4.1-1 Category of Telemetry Command Interfaces for Use

Category by Component	Transmission Signal	Interface Type	Interfaced to:
Component using SpW	Command	SpW interface	SMU or “Digital Electronics for Payload”
	Telemetry	SpW interface	SMU or “Digital Electronics for Payload”
Component not using SpW (such as components for communications systems)	Command	TCIU interface	TCIU
	Telemetry	TCIU interface	TCIU

4.2. SpW Interface

SpW interfaces are based on RMAP protocol. See MMX SpW user’s manual and MMX Component Telemetry/Command Design Criteria (MMX-C-TCDC).

4.3. TCIU Interface

TBD-Sys

5. HEATER CONTROL INTERFACE

5.1. Overview

In principle, heaters for thermal control of an entire spacecraft shall be controlled by the HCE (Heater Control Electronics). Heaters within components, which are based on special requirements of the components, shall be controlled by respective component independently. Heaters for thermal control of an entire spacecraft are basically classified into the following:

・Heaters affixed to a spacecraft structure such as base plates or panels
・Heaters affixed to mounting blocks or thermal doublers of component
・Heaters of propulsion systems
・Heaters of batteries

5.2. HCE Interface

The block diagram for heater control by means of the HCE is shown in Diagram 6.2-1. Signals of thermal sensors affixed to locations of the spacecraft are multiplexed in the HCE, are then applied the A/D conversion processing and are used for heater control, as well as being generated as telemetry data.
Heater power is supplied to heaters after being switched by active elements such as transistors in the HCE on the basis of commands or thermal sensor information.

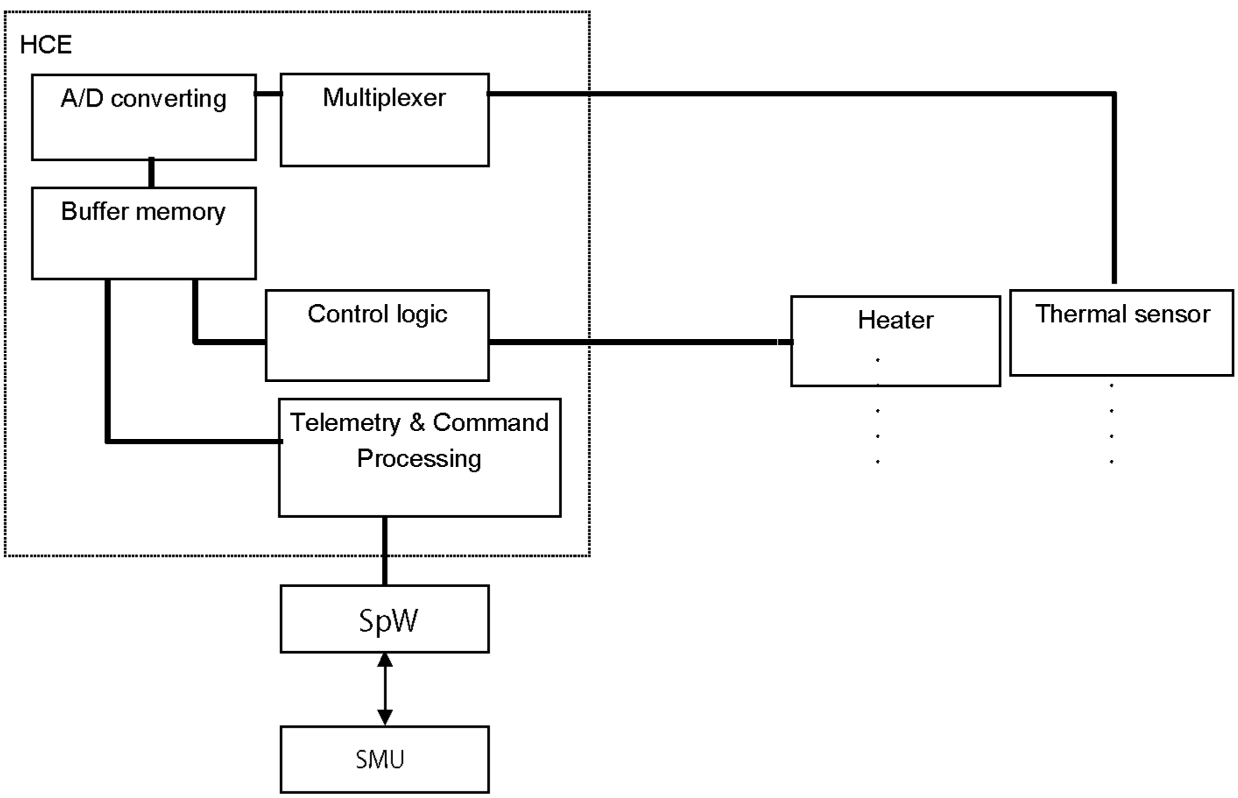


Figure 5.2-1 Block Diagram for Heater Control System

(1) HCE heater interface

Heaters, which are controlled by the HCE, shall be designed under the following conditions:

A. Supply voltage: the power bus voltage (TBD-Sys)

B. Maximum heater supply power: max 1.0A/ch

(2) Temperature sensor interface

If temperature in a component is monitored by the HCE, platinum sensors shown in Table 5.2-1 and Figure 5.2-2 shall be affixed to temperature measurement points.

Table 5.2-1 Specifications of Thermal Sensors for HCE

Item	Specifications
Type	118MF-2000A-*
Manufacturer	Rosemount
Resistance value	2000 Ω ± 1.0% (@0°C)

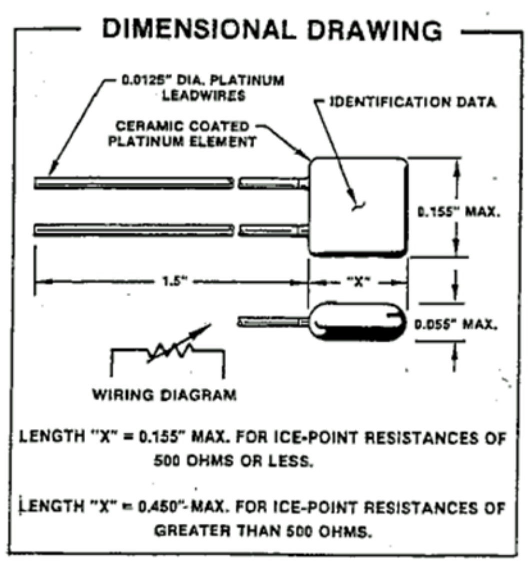


Figure 5.2-2 Dimensional Drawing of Platinum Sensors for HCE

(Note: The above dimensions are indicated in inches.)

(3) HCE heater control methods

A. Automatic control method

A temperature threshold set by a command and a temperature value measured by a thermal sensor are compared. Based on the results of this comparison, a heater is turned on or off.

B. Command control method

A heater is forced to be turned on or off manually by means of a command.

5.3. Heater Controls of Subsystems Other Than HCE

Heaters for a piece of hardware within a component, such as sensors for observation systems, shall be controlled by respective component independently.

Thermal sensor signals in components, which are other than those related to the HCE, shall be applied the A/D conversion at respective component with a dedicated SpW and shall be generated to telemetry for monitors.

Components without SpW, which is interfaced with TCIU, shall generate thermal sensor signals to TCIU for monitors.

6. SATELLITE EXTERNAL CONNECTOR INTERFACE

TBD-Sys

7. ELECTRICAL INSTRUMENT INTERFACE

7.1. Instrument Lines

The following standard cables shall be used for system electrical instruments:

(1) Power supply and heater lines

- ・Annealed copper wire (AWG20)
- ・Annealed copper wire (AWG22)
- ・High-tensile wire (AWG26)

(2) Signal lines

(2-1) Digital signal line

- ・High-tensile wire (AWG26)

(2-2) High-speed digital signal line

- ・High-tensile twist pair shield wire (AWG26)
- ・SpW spec wire (ECSS-E-ST-50-12C)
- ・In case that RF noise radiation level becomes a problem such as a high speed LVDS line, impedance matching shall be taken care of. If shield is required, an outer shield whose both ends are connected to FG with low impedance shall be applied.

(2-3) Voltage monitor line

- ・High-tensile twist pair wire (AWG26)

(2-4) Analog signal line

- ・High-tensile twist pair wire (AWG26)
- ・High-tensile shield wire (AWG26)
- ・High-tensile twist pair shield wire (AWG26)

(2-5) Temperature monitor line

- ・High-tensile twist pair wire (AWG26)

(3) RF interface

- Flexible coaxial cable (MIL name: M17/113-RG316 or its equivalent)
- Semi-rigid coaxial cable (MIL name: M17/130-RG402 or its equivalent)

7.2. Connectors for Instruments

The connectors of components and wire harnesses shall be selected from the JAXA recommended parts list or equivalents.

7.3. Voltage Drop Due to Electrical Instruments

Values shown in Table 7.3-1 shall be the maximum values for voltage drops due to electrical instruments.

Table 7.3-1 Maximum Values of Voltage Drops Due to Instrument Wiring

Power Supply Line	Maximum Voltage Drop Value (mV)
BUS (50 V), COM(1)	200 (TBD-Sys)
–12 V, +12 V	120 (TBD-Sys)
+5 V	50 (TBD-Sys)
COM(2)	50 (TBD-Sys)
+29 V, COM(29)	200 (TBD-Sys)
COM(RL)	120 (TBD-Sys)

8. SIGNAL INTERFACE BETWEEN COMPONENTS

8.1. Digital Signal Interface

In principle, digital signal interfaces between components shall be as shown in Table 8.1-1, except for between sensors and sensor signal-processing circuits.

Table 8.1-1 Digital Signal Interface between Components

Signal	Input		Signal Frequency (Hz)	Use of Secondary Converters	
	Circuit Type	Device Type		Shared	Separately Used
Digital signal	Single end	C-MOS 4050/4049	DC to 65k	O	X
	Differential (low-power type)	EIA(RS)-422A (HS26C32 etc)	65k to 600k	O	O
	Differential (standard		600k to 10M	O	O
	Differential (high-speed type)	ANSI/TIA/EIA-644-A (DS90C32 etc	10M ~	O	O

(Notes) O: Applicable
X: Not applicable

(1) Single-end digital signal interfaces

TBD-Sys

(2) Low-speed differential digital signal interface

TBD-Sys

(3) High-speed differential digital signal interface

TBD-Sys

8.2. Analog Signal Interface

TBD-Sys

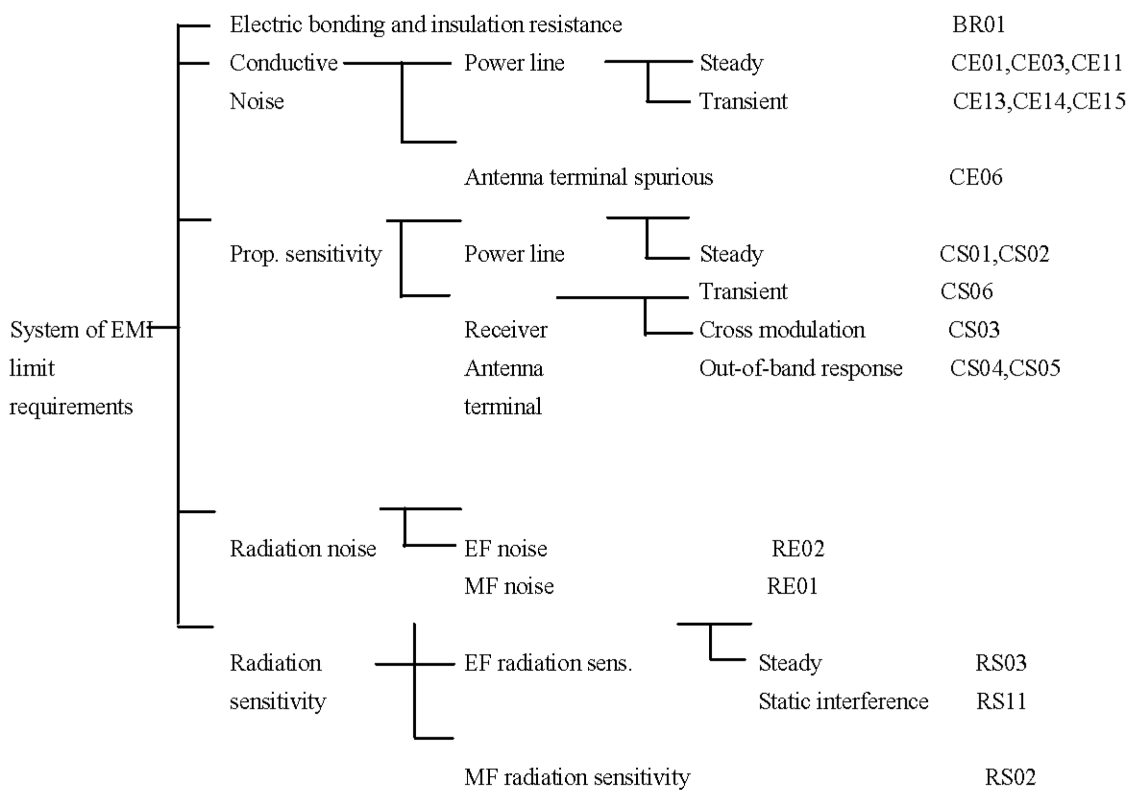
9. EMC DESIGN CRITERIA

Table 9-1 shows a system of electromagnetic compatibility requirements. Table 9-2 shows electromagnetic interference limit requirements.

By means of tests or analyses, verify that each piece of on-board component satisfies these requirements. Tests can be omitted if a previously developed product has past EMC test records and the records meet the requirements.

For any component that raises issues in satisfying the requirements or on specific tests to be conducted, coordinate with the MMX system team.

Table 9-1 System of Electromagnetic Interference Requirements (TBD-Sys/PI)



(Note) Items BR01, CE11, 13, 14, 15, and RS11 are established in this document; they represent symbols that should not be used in the MIL system.

Table 9-2 Electromagnetic Interference Limit Requirements (1/6)

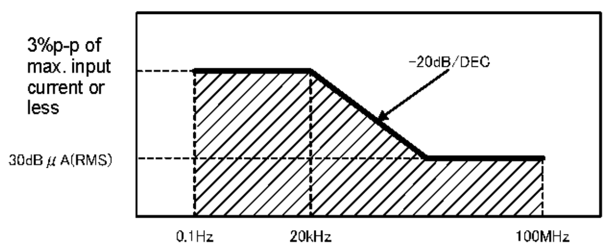
Item	EMI limit
1. Electric bonding and insulation resistance (BR01)	(1) Electric bonding resistance When conducting an EMC test, the electric bonding resistance installed in the EMI shield room between the grounding plate and the component must be 10 mΩ or less. (2) Insulation resistance On each piece of component, the following insulation resistance must be 1 MΩ or greater: a. Between the AC primary power return and the housing b. Between the primary power return and the secondary power return c. Between the secondary power return and the housing (intended component : Type-A component of section 3.3.2.) d. Between the signal return and the housing (intended component : Type-A component of section 3.3.2.)
2. Limit on power line-propagated noise (CE01 and CE03)	The propagation noise current emitted from power lines for any component must not exceed the following allowable levels: 0.1 Hz-20 kHz: 3%$_{P-P}$ of maximum input current or less 20 kHz-100 MHz: Attenuating at -20 dB/DEC from the above value at 20 kHz, minimum level =30 dBμA (RMS) or less 
3. Limit on rebound ripple voltage (CE11)	The rebound ripple voltage emitted from power lines of any component must not exceed the following allowable levels, exclusive of spike components: - DC load input terminal - 10 mVo-p or less (10 W or less) * - 1 mVo-p/W or less (10 W or higher) * - Measurement bandwidth: 10 Hz to 10 MHz * Power is defined as the nominal power consumption value defined for the ICD for each piece of component.

Table 9-2 Electromagnetic Interference Limit Requirements (2/6)

Item	EMI limit
4. Switching transient limit (CE13) (CE14) (CE16)	(1) Power line noise current (CE13) Under an operational transient during normal operation mode, the following noise current limits must be complied with: ・Peak current: 1.25 times the steady current or less ・Transient time: 50 ms or less ・Absolute value of rate of current change: (|di/dt|) : 1×10^5 A/s or less (2) Transient current (per input) (CE 14) ① When power for each component is on, the maximum value of transient current to the primary power supply line must be the following: ・Steady-state current of 1 A or less: 2 A or less ・1 A to 15 A: not to exceed 2x the steady-state current ・15 A or higher: 30 A or less ② The absolute value of the rate of change of transient current (|di/dt|) must be 2×10^4 A/s or less. For heaters, the rate of change of current must be 1×10^5 A/s or less. ③ The maximum amount of change in charge must be 16m C Coulomb or less. $\Delta Q(\text{coulomb}) = \int_{o}^{I\,peak} Idt$ I peak:amount time to reach peak .④ After a turn-on operation, a steady-state current level must be attained within 50 ms. Note: If there is any component that cannot comply with the above 50-ms limit, coordinate with the MMX system team

Table 9-2 Electromagnetic Interference Limit Requirements (3/6)

<table>
<tr><th>Item</th><th>EMI limit</th></tr>
<tr><td></td><td>(3) Initial in-rush current (CE15)

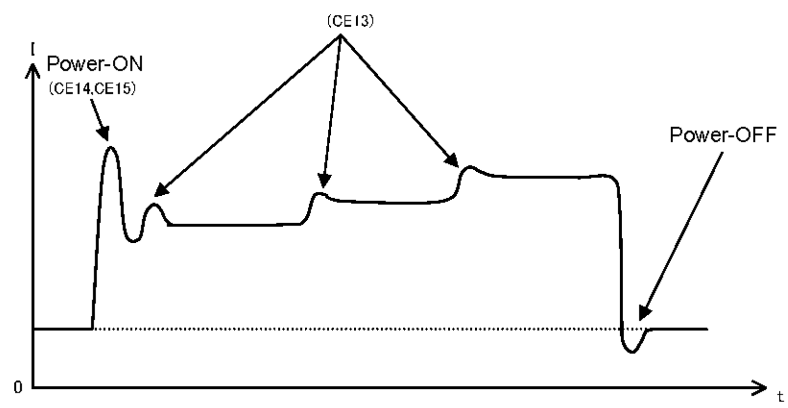
① In the case of a component that has an ON/OFF switch on the power supply side, the amplitude of the initial in-rush current when the switch is turned on must be as follows:
Steady-state current of 1 A or less: 2 A or less
1 A to 5 A: not to exceed 2x the steady-state load current or less
5 A or higher: Steady-state load current plus 5 A or 30 A, whichever is less

② In addition, the absolute value of the rate of change of transient current (|di/dt|) must be 1×10^{5} A/s or less.

③ The maximum amount of change in charge in 1 ms must be 16 mCoulomb or less.

$\Delta Q(\text{coulomb}) = \int_{o}^{Ipeak} I dt$

④ The Δ t from the time the power is turned on until a current peak point is reached must be either 1 ms or the amount of time required to reach the peak point, whichever is less.



Transient current profile (CE13, CE14, CE15)</td></tr>
</table>

Table 9-2 Electromagnetic Interference Limit Requirements (4/6)

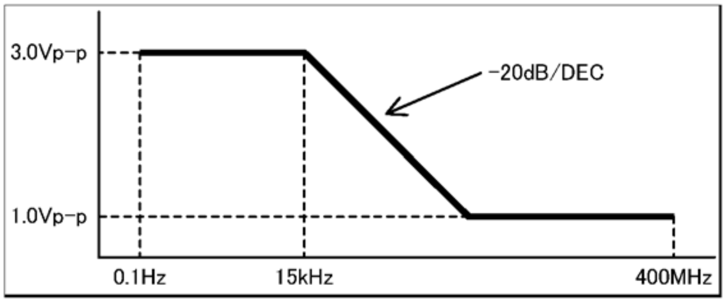
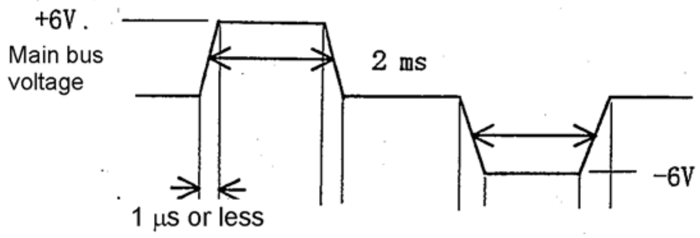
Item	EMI limit
5. Antenna terminal Limit on spurious propagated noise (CE06)	Based upon the antenna terminal spurious characteristics of each transmitter.
6. Limit on power line-propagated sensitivity (CS01, CS02)	If the following sine-wave voltage is superposed on the primary-power supply line for any component, its function and performance must not decrease: - 0.1 Hz to 15 kHz: 3.0 Vp-p - 15 kHz to 400 MHz: -20 dB/dec where 1.0 Vp-p is the minimum level 
7. Transient limit (CS06)	If the following pulse voltage is superposed in the positive and negative directions between the hot and return power supply bus lines and between lines and housing of the component, its function and performance must not decrease: 
8. Receive antenna terminal cross-modulation propagated sensitivity (CS03)	If RF noise with 2 waves or more that can potentially input into the receiver in the antenna unit is input into the receiver, the receiver must not respond to it by cross-modulation. In such a case, the reception frequency band is excluded. Rules on narrow bands are N/A.
9. Receiver antenna terminal out-of-band response propagation sensitivity (CS04, CS05)	Must be based upon the response characteristics of each receiver, external to the antenna terminal band. Rules on narrow bands are N/A.

Table 9-2 Electromagnetic Interference Limit Requirements (5/6)

Item	EMI limit
10. Limit on electric field radiation noise (RE02)	The electric field radiation noise emitted from any component must not exceed the following allowable values. Rules on narrow bands are N/A. [General requirements] MIL-STD-461C Part 3 REO2 Fig3-8 & Fig3-9 (ClassA2a) [Rules for which requirements are subject to adjustment according to the specific location in which the component is mounted] Table 9-3 shows specific requirements per RE02. ● In the case of a high-gain antenna, requirements with respect to out-of-beam field of view areas are adjusted as an antenna gain of 0 dBi. ● Rules on externally mounted components are provided separately, in terms of relative distance and angle with respect to the reception antenna.
11.Limit on magnetic field radiation noise (RE01)	The magnetic field radiation noise emitted from a component must not exceed the following allowable values. The distance of measurement is 7 cm from the surface of the component. Based upon MIL-STD-461C Part3, Figure 3-7.
12. Limit on electric field radiation sensitivity (RS03)	When exposed to the following electric field, any component must not undergo a decrease in its function or performance: [General requirements] 14 kHz - 30 MHz: 10 V/m or less 30 MHz - 10 GHz: 5 V/m or less 10 GHz - 43 GHz: 1 V/m or less [Rules for which requirements are subject to adjustment according to the specific location in which the component is mounted] Table 9-4 shows specific requirements per RE03. ● In the case of a high-gain antenna, requirements with respect to out-of-beam field of view areas are adjusted as an antenna gain of 0dBi. ● Rules on externally mounted components are provided separately, in terms of relative distance and angle with respect to the reception antenna.

Table 9-2 Electromagnetic Interference Limit Requirements (6/6)

<table>
<tr><th>Item</th><th>EMI limit</th></tr>
<tr><td></td><td>Rules applicable to launch configurations:

Frequency band | Internal component (unit = V/m) | External component (unit = V/m) | Notes
400 MHz to 500 MHz | 5 | 6 | Rocket command send band
5230 MHz to 5786MHz | 5 | 142 | Rocket radar transponder send band</td></tr>
<tr><td>13. Limit on static interference (RS11)</td><td>Components that can potentially produce a malfunction due to plasma-band electric discharges in space must be tested under the following conditions, and the absence of any abnormality must be verified:
(See MIL-STD-1541, 6.7.2)
・Gap voltage: 10KV (electrostatic arc discharge)
・Pulse rate: 1 pulse/s
・Distance between the component and the gap: 30 cm</td></tr>
<tr><td>14. Limit on magnetic field radiation sensitivity (RS02)</td><td>See MIL-STD-461C Part 3 RS02 Part I, Spike #1. The above test comprises the following two methods:

In some cases, these methods can be unrealistic; therefore, a specific method and required levels must be selected with caution:
(1) Apply a 20A current of the power supply frequency to a test wire; verify that no decrease in performance results.
(2) Apply a prescribed spike current to a test wire with a 5 Ω load; verify that no decrease in performance results.</td></tr>
</table>

Table 9-3 Limits on Electric Field Radiation Noise (RE02): Specific Requirements:

N/A

Table 9-4 Limits on Electric Field Radiation Sensitivity (RS03):Specific Requirements

N/A

*: If a general requirement represents a stronger level than a specific requirement, the general requirement takes precedence.

9.1. Magnetic Bodies

In the component, as much as possible, avoid the use of permanent magnets, electromagnets, and the like. If their use is unavoidable (*1), coordinate with the MMX system team. If more than one magnet or electromagnet is to be used, consider arranging them in a canceling pattern. Document such a deployment in the ICD.

(*1) Electromagnetic valves, RF switches and the like

10. ANTISTATIC MEASURES

10.1. Overview

Antistatic measures shall be performed to prevent accidents due to electrostatic charge in orbit.

10.2. Basic Policy for Antistatic Measures

Basic policy is described below.

(1) Conductive materials exposed to external surfaces of a spacecraft shall be grounded to a structure ground by means of bonding wires, etc.

(2) Even if external surfaces of a spacecraft are insulators but if its interior or inside is conductive, conductive materials of the interior or inside shall be grounded to a structure ground.

(3) If MLI (Multiple Layer Insulator) is used, all metallic surfaces of each layer shall be made conductive and be grounded to a structure ground.

(4) The grounding resistance shall be 1 MΩ or less.

11. OTHERS

11.1. Separation of Permanent Power Supply Circuits

As in the case of interfaces between components, devices, which does not have input protection diodes towards power supplies, shall be basically used for input circuits at interfaces between permanent power supply circuits and other circuits in a component, too. As for the standard C-MOS, CD4050/CD4049 correspond to this. (It is recommended that CD4050 be used, because the noise margin of CD4049 is smaller than that of CD4050.)

This is intended to prevent device in the subsequent step from operating erroneously because, if the power supply of an input circuit is turned off, input signals will go into the power supply through input protection diodes of C-MOS.

If use of devices with protection diodes is unavoidable, the circuit shown in Figure 11.1-1 shall be used.

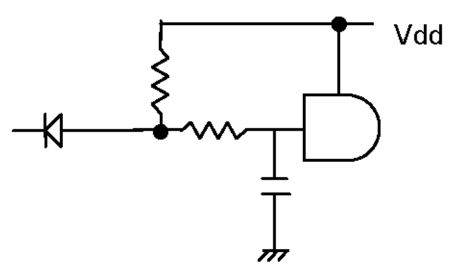


Figure 11.1-1 Separation of An Interruptible Power Supply Circuit

11.2. Prevention of Power Supply Short Circuits due to A Single Component Failure

In principle, the power supply of component, utilizing a bus power supply and a secondary power supply, shall not be re-routed due to failure of a single component constituting such component.

In particular, since tantalum capacitors are likely to cause power supply short-circuits due to short-circuit failures, the preventive measure shown in Figure 11.2-1 shall be provided. In principle, components such as feed through capacitors, which do not allow series redundancy, shall not be used as power supply filters.

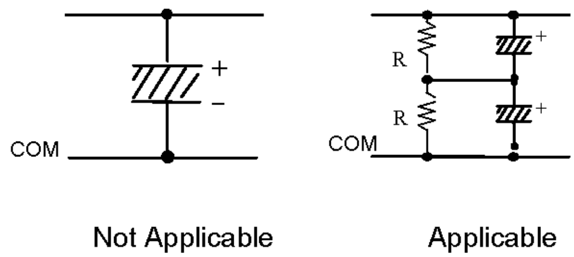


Figure 11.2-1 Short-circuit Prevention Measures for Tantalum Capacitors

11.3. Derating Criteria

In principle, derating shall be based on the provisions of APPENDIX-A in MIL-STD-975. Derating for components that are not described in MIL-STD-975 shall be set-up conforming to the provisions of APPENDIX-A in MIL-STD-975.

11.4. Power-on Reset Circuits

With respect to a power-on reset circuit of a component, the time required from, when the power supply of the spacecraft system turns on, or, when a bus power supply of the component turns on, until the time the power stabilizes shall be designed at no more than 100 msec.

11.5. Electrical Graphic Symbols

The electrical graphic symbol for grounding shall conform to Figure 11.5-1.

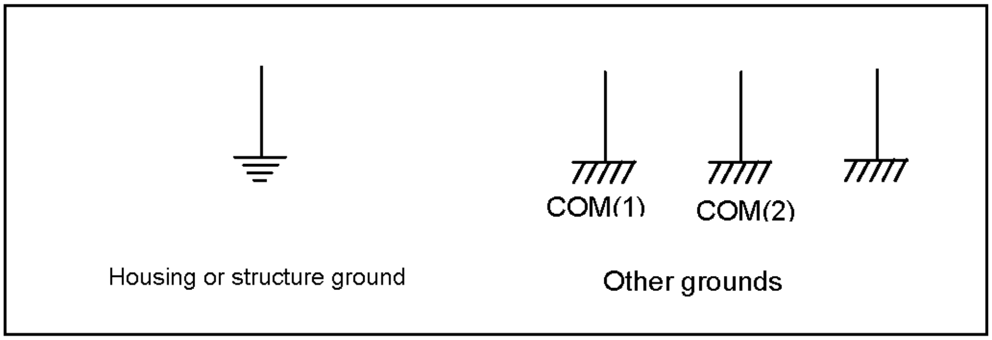


Figure 11.5-1 Grounding Symbol

11.6. Naming of Signal Names and Connector Names

(1) Signal names

・Signal names for output and input shall be the same.

・Even signals of the same specifications shall use different names if their connection destinations are different.

・Interface signals which close in a subsystem shall use unified names in the subsystem.

<Characters for use>

Alphabets (upper case): A to Z

Numbers: 0 to 9

Symbols: + - ・ , ( ) = * /

<Number of characters >

27 characters or less, including blanks

<Naming of component>

If, in the case of power supplies, clocks, etc., it is necessary to differentiate the component for which they are supplied, brackets shall be used to include the name of the component.

(Example): +12V(ABC)

<Serial numbers>

If the same signals are connected in parallel, serial numbers shall be used to differentiate respective lines.

(Example): +12V(ABC)-1
+12V(ABC)-2

<Names of power supply lines>

+5V system line	: +5V	BUS system line	: BUS
+12V system line	: +12V	COM(1) line	: COM-1
-12V system line:	-12V	COM(2) line	: COM-2
+29V system line:	+29V	29V(29) line	: COM-29

(2) Naming of connectors

A hyphen shall be used for a component name with additional serial number per component.

(8 alphanumeric characters or less)

(Example): ABC-1

12. DOCUMENTS

12.1. Applicable documents

(1) JAXA-RPR-MX##### [to be issued]

MMX Space Wire User's Manual

(2) JAXA-RPR-MX16306

MMX Component Telemetry/Command Design Criteria (MMX-C-TCDC)

12.2. Interface documents

(1) JAXA-RPR-MX##### [to be issued]

MMX Interface Control Document (ICD)

13. ACRONYMS

HCE	Heater control electronics
HV	High voltage
ISAS	Institute of Space and Astronautical Science
JAXA	Japan Aerospace Exploration Agency
LET	Linear energy transfer
PCU	Power control unit
PSU	Power supply unit
PI	Principal investigator
RMAP	Remote memory access protocol
SEL	Single-event latch-up
SEU	Single-event upset
SMU	System management unit
SpW	Space Wire
TCIU	Telemetry command interface unit