10.7.4 AVIONICS ELECTRICAL COMPATIBILITY

Circuit returns, isolation of circuit returns for DC signal circuits, and the handling of shield grounds, shall be as follows in the subparagraphs below.

10.7.4.1 Cargo Element Power and Signal Returns Isolation

The basic ground reference isolation requirement for cargo elements is: A minimum of one megohm (Mohm) D.C. isolation between each of the following: Orbiter primary D.C. returns, Orbiter primary A.C. returns, Orbiter secondary power/signal references, and the structure ground as measured in the cargo element. The structure reference shall be provided in the Orbiter. Primary power return isolation requirements are more completely specified in Paragraph 10.7.4.3. When an exception to this basic requirement occurs with any payload, the payload shall restrict the level of 28V D.C. current through structure to less than 10 amperes peak including transients.

10.7.4.1.1 Payload with Power Referenced to Structure

For payloads using a single point ground reference to structure for power and signal interfaces, the payload shall restrict the level of 28 VDC current through structure to less than 10 amperes peak including transients. The heavier load currents shall be returned to the Orbiter via wire only. Hardwire

return for the light current loads grounded to cargo element structure shall be provided by dioding between the heavy load and the light load returns so that current flows from the light load return to the heavy load return. The circuit shall be equivalent to that shown in the Figure 10.7.4.1.1-1.
The following subparagraphs are also acceptable techniques by which the 28V D.C. power return structure ground in the cargo element may be made compatible with the Orbiter.

10.7.4.1.1.1 (Reserved)

10.7.4.1.1.2 (Reserved)

10.7.4.1.1.3 (DELETED)

10.7.4.1.1.4 (DELETED)

10.7.4.1.1.5 (DELETED)

10.7.4.1.1.6 (DELETED)

10.7.4.1.1.7 (DELETED)

10.7.4.1.2 Circuit Return Referencing Criteria

The following subparagraphs contain criteria for the referencing of typical circuit returns used in the Shuttle.

10.7.4.1.2.1 Orbiter Signal Interfaces

10.7.4.1.2.1.1 Non-Coaxial Interfaces

All cargo element signal interfaces to Orbiter avionics equipment that do not utilize coaxial cabling shall be differential and isolated from structure by at least 10 kohms.

10.7.4.1.2.1.1.1 (Reserved)

10.7.4.1.2.1.1.2 (Reserved)

10.7.4.1.2.1.1.3 (Reserved)

10.7.4.1.2.1.1.4 (Reserved)

10.7.4.1.2.1.1.5 (Reserved)

10.7.4.1.2.1.1.6 (Reserved)

10.7.4.1.2.1.1.7 (Reserved)

10.7.4.1.2.1.2 Controlled Impedance Signals

10.7.4.1.2.1.2.1 (Reserved)

10.7.4.1.2.1.2.2 RF Signals

All pulse or clock interface circuits having a pulse repetition rate of greater than 50 kPPS or signals with fundamental frequencies greater than 50 kHz or circuits processing pulse rise/fall times equal to or less than 10 microseconds shall carry an RF classification. The distribution shall be via shielded-twisted-pair cabling. The method of shield termination shall be via wire pigtails to the connector backshell. No RF circuit shield shall be broken out such that more than 2.0 inches of wiring is exposed within the connector metal backshield. RFI backshells with individual shield grounding provisions are required for multiple RF shield terminations.

10.7.4.1.2.1.3 Electrical Explosive Device (EED) Firing Circuitry

EED firing circuits, if utilized, shall be isolated from other electrical circuits and each other. Each firing circuit shall be routed as a shielded, twisted pair and the shield shall be multipoint grounded. Each EED circuit conductor shall be connected to structure at one point only by a bleeder resistor. EED's and Firing Circuits shall comply with the requirements of specification NSTS 08060 and/or NSTS 1700.7, Paragraph 210. Further requirements are specified in Paragraph 7.5.4, if Orbiter power is utilized. The EED firing circuit is defined as the circuit between the Pyro Initiator Control Function and the pyro.

10.7.4.1.2.1.4 Wire Shield Reference

See grounding and shielding diagrams for individual avionics subsystems in Section 8.

10.7.4.1.2.1.4.1 (Reserved)

10.7.4.1.2.1.4.2 (Reserved)

10.7.4.1.2.1.4.3 RF Circuits

All digital data, pulse and high frequency circuits with a basic frequency greater than 50 kHz or having a rise or fall time less than 10 microseconds shall be considered RF circuits. The shields of RF circuits shall be referenced to structure at the source and load and at all intermediate breakpoints.

10.7.4.1.2.1.4.4 (Reserved)

10.7.4.2 Electrical Bonding

The Orbiter-to-Cargo electrical bonding interface shall be electrically bonded to provide homogeneous electrical characteristics. All electrical and mechanical elements shall be securely bonded to structure in compliance with MIL-B-5087. All aluminum surfaces used for bonding shall be originally cleaned to bare metal and then chemical filmed per MIL-C-5541, Class 3 (gold alodine 1200LN9368, or equivalent). Three classes of bonds per MIL-B-5087 are applicable: Class S, C, and R. These bond classes are defined in the next three subparagraphs.

a. Static Bond-Class S. Refer to Paragraph 10.7.4.2.3.5.

b. Fault-Current Bond-Class C. All cargo elements using Orbiter power shall have mechanically secure electrical connection to the Orbiter structure capable of carrying the maximum trip return current.

c. RF Potentials Bond-Class R. Cargo elements containing electrical circuits which generate radio frequencies or circuits which are susceptible to radio frequency interference may require a low-impedance path to structure in order to meet the EMC requirements of Paragraph 10.7.2.2 or 10.7.3.2. The DC resistance of a Class R bond shall be less than 2.5 milliohms.

10.7.4.2.1 Electrical Bonding of Equipment

Equipment containing electrical circuits which may generate radio frequencies or circuits which are susceptible to radio frequency, shall be so installed that there will be a continuous, low-impedance path from the equipment enclosure to structure. The metallic shells of all equipment electrical connectors shall be electrically bonded to the equipment case or the bulkhead mount with a DC resistance of less than 2.5 milliohms. Procurement specifications require that the DC resistance between the mated halves of the connectors shall not exceed 50 milliohms.

Wire harness shields external to equipment, requiring grounding at the equipment, shall have provisions for grounding the shields to the equipment through the harness connector backshell, or for carrying single point grounded shields through the connector pins.

All equipment electrical bonds and their respective interfaces shall comply with MIL-B-5087.

10.7.4.2.2 Electrical Bonding of Structures

10.7.4.2.2.1 Cargo-to-Orbiter Main Bond

10.7.4.2.2.1.1 Primary PL Bus Connector Bond

Payloads shall utilize one of the wires in each power connector as the principle Orbiter/Cargo electrical bond.

This bond shall meet the appropriate bond class requirements of paragraph 10.7.4.2.

10.7.4.2.2.1.2 Cargo-to-Orbiter Bond Strap

The cargo-to-orbiter bond strap shall be connected between Orbiter structure and cargo ground stud provisions. This bond shall meet the appropriate bond class requirements of paragraph 10.7.4.2.

10.7.4.2.2.2 (Reserved)

10.7.4.2.2.3 (Reserved)

10.7.4.2.2.4 (Reserved)

10.7.4.2.2.5 Bonding for Deployable/Retrievable Cargo Element
All cargo elements which are deployable and/or retrievable shall be electrically bonded when in the cargo bay. A provision shall be made to provide a Class-S electrical bond to Orbiter structure.

Cargo elements which utilize Orbiter power shall be required to provide a Class-C electrical bond to Orbiter structure when electrically mated to the Orbiter.

Cargo elements which utilize Orbiter command signal or data interfaces may be required to provide a Class-R electrical bond to meet the EMC requirements of paragraph 10.7.2.2 & 10.7.3.2.

RMS users are an exception as defined in Paragraph 14.4.2.

10.7.4.2.3 Electrical Bonding for Static Protection
All Orbiter and cargo interfaces shall comply with Paragraph 10.7.4.2.

10.7.4.2.3.1 (Reserved)

10.7.4.2.3.2 (Reserved)

10.7.4.2.3.3 (Reserved)

10.7.4.2.3.4 (Reserved)

10.7.4.2.3.5 Static Electricity Protection

All cargo hardware elements shall comply with the Class S bond requirements of MIL-B-5087. All conducting items subject to triboelectric (frictional) or any other charging mechanism shall have a mechanically secure electrical connection to the cargo element structure. The resistance of the connection shall be less than one (1) ohm.

10.7.4.2.3.5.1 Bonding of Thermal Blankets
Thermal blankets of metalized multilayer construction and metalized surfaces shall be bonded as follows:

- Blanket bond tab to structure - D.C. resistance shall be less than 10.0 Ohms.

- Blanket test tab to test tab - D.C. resistance shall be less than 1000 Ohms prior to connecting a bond tab to structure.

The number of bond tabs and associated bond straps (or wires) shall be determined by the blanket area as defined in the following table:

BLANKET AREA (SQ. CM)	NO. OF REQ. BOND STRAPS (OR WIRES)
0 TO 100.0	0
100.0 TO 1000.0	1
1000.0 TO 40000.0	2
>40000.0	ADD 1 STRAP (OR WIRE) FOR EACH ADDITIONAL 40000 SQ. CM.

All tabs should be located on blanket edges and spaced such that the maximum distance from any one point on the blanket to the nearest BOND or TEST TAB is less than 1.0 meter.

TEST TABS function as resistance (continuity) test points between different areas of a blanket, or between different areas of any two adjacently connected blankets. BOND TABS function as connection points for static electrical bonding to cargo structure as well as test tabs for continuity checks between different areas of a blanket, or between different areas of any two adjacently connected blankets.

If a thermal blanket is fabricated of two or more sections, and these sections are electrically bonded to each other, then the entire electrically common blanket shall be considered to be one blanket for determination of the number and placement of bond tabs and test tabs.

10.7.4.2.3.5.2 High Volume Resistivity Materials

Cargo elements using high volume resistivity materials (greater than 10^9 OHM CM) shall be designed to prevent differential charging between cargo element parts and the Orbiter. The specific requirements and design methods employed shall be negotiated with STS.

10.7.4.2.4 Circuit Reference Symbols

The circuit reference symbols for use on the Space Shuttle program shall be as shown in Figure 10.7.4.2.4-1.

10.7.4.3 Power Circuit Isolation and Grounding

10.7.4.3.1 (Reserved)

10.7.4.3.2 DC Power Ground Reference

Refer to Section 20 paragraph, 20.3

Note: A non-compliance condition exists between the Orbiter and the MIGHTY. Refer to Section 20 for the definition of the unique interface requirement.

The Orbiter D.C. power return from a Cargo element shall be structure referenced in the Orbiter and D.C. isolated from structure ground in the Cargo element by a minimum of 1 megohm except as specified in Paragraph 10.7.4.1. The Orbiter D.C. power return system shall be a combination of a hardwired return system and a structure-return system, with the use of the wire return restricted to specific load-sensitive areas as shown in Figure 10.7.4.3.2-1.

10.7.4.3.3 (Reserved)

10.7.4.3.4 (Reserved)

10.7.4.3.5 Cargo Bay Power-Circuit Returns

When Orbiter power is supplied to the Cargo Bay, the returns shall be referenced to structure in the Orbiter only, except as specified in Paragraph 10.7.4.1 and during Orbiter power to payload internal power changeover switching (switch-over time duration greater than 200 milliseconds shall be reported to STS for review).

10.7.4.3.6 Signal-Circuit Returns

Cargo equipment may have primary power returns connected to signal returns if treated per Paragraph 10.7.4.1.

10.7.4.3.7 Ground Support Equipment Isolation and Grounding

GSE interfacing with payloads shall be isolated from payload circuits (power and signal return lines) by a minimum of 1 megohm, except where balanced differential circuits are used. In the case of balanced differential circuits, each side of the circuit shall be balanced to ground by no less than 4000 ohms. Coax cables, with their inherent grounding of the signal return to structure, are permitted, providing their interface with other LRU’s or systems does not propagate that ground to circuits which are already referenced to ground at some other point.

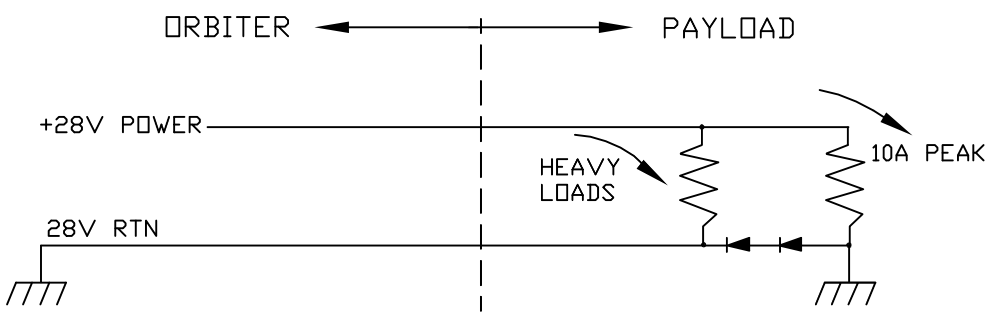


FIGURE 10.7.4.1.1-1 TYPICAL PAYLOAD BASIC GROUND ISOLATION DIAGRAM

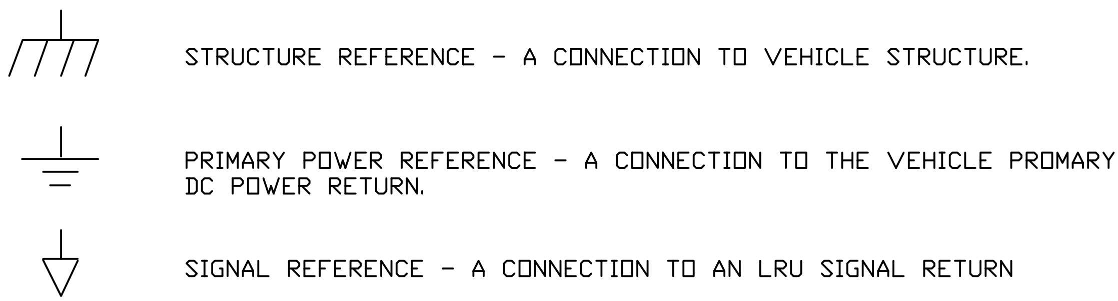
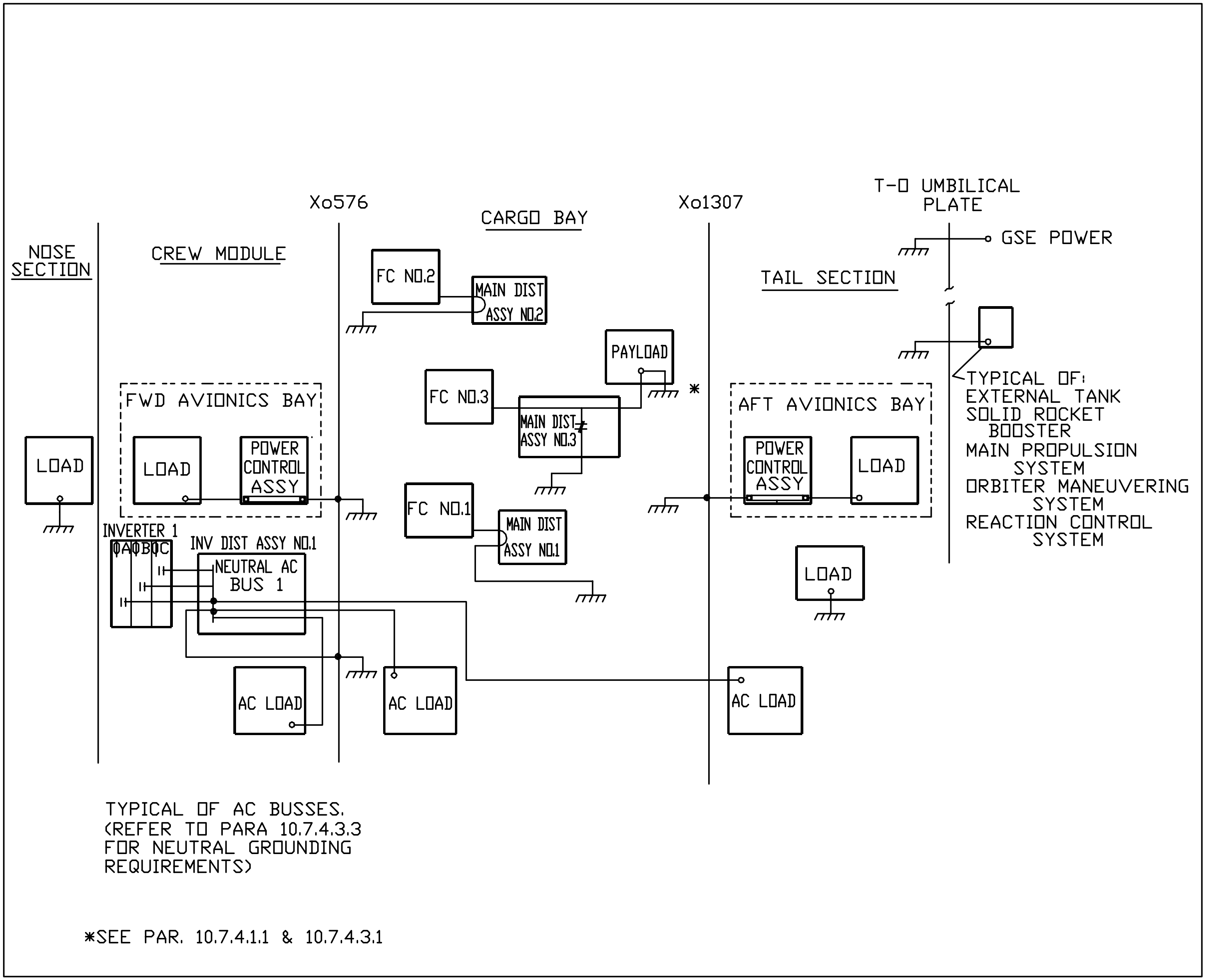


FIGURE 10.7.4.2.4-1 CIRCUIT REFERENCE SYMBOLS

FIGURE 10.7.4.3.2-1 SHUTTLE PRIMARY AC AND DC POWER GROUNDING SYSTEMS



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