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IEEE-ISTO STD MOSA-IF-S-001: COMMON PAYLOAD INTERFACE STANDARD – COMMAND AND DATA HANDLING

Authored by

SPACE SYSTEMS MOSA INTERFACE STANDARDS ALLIANCE

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1. SCOPE

1.1 Scope

This interface standard documents a Command and Data Handling (C&DH) architecture to enable major defense acquisition satellite program conformance to a modular open systems approach, as defined in the 2017 National Defense Authorization Act. Intra-satellite Open Systems Interconnect layer 1 (physical layer) C&DH requirements are defined herein for interfaces between the satellite's Bus-subsystem and the Centralized Payload Manager (CPM), the Bus-subsystem and the payloads, CPM and the payloads, and between CPMs.

1.2 Application

These requirements are applicable to Satellites developed for U.S. Department of Defense applications.

2. APPLICABLE DOCUMENTS

2.1 General

The documents listed in this section are specified in sections 3, 4, or 5 of this standard. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, or 5 of this standard, whether or not they are listed.

2.2 Reference Documents

2.2.1 Government Specifications, Standards, and Handbooks

The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

S-311-P18, "Thermistor, (Thermally Sensitive Resistor), Insulated and Uninsulated, Negative Temperature Coefficient, Specification", National Aeronautics and Space Administration.

2.2.2 Other Government Documents, Drawings, and Publications

The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

[NDAA 2017] 2017 National Defense Authorization Act, Public Law 328.

2.2.3 Non-Government Publications

The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

2.2.3.1 Industry Standards or Specifications

ANSI/TIA/EIA-644 Standard

RapidIO Interface Specification, version 2.1, RapidIO Trade Association.

2.2.3.2 Other Standards

[ITU-T-T O.150 with corrigendum May 2002] Series O: Specifications of Measuring Equipment, Equipment for the measurement of digital and analogue/digital parameters, Series O.150 (with Corrigendum May 2002), May 1996, International Telecommunication Union.

[ECSS-E-ST-50-12C] SpaceWire Links, Nodes, Routers and Networks Rev. 1, May 15, 2019

2.3 Order of precedence

Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

TABLE 1. Table of Definitions

Term	Definition
Active high signal	An active high signal is asserted with a Logic 1 and de-asserted with a Logic 0. Such signals are designated in this document without an overbar. (e.g., ActiveHighSignalName)
Active low signal	An active low signal is asserted with a Logic 0 and de-asserted with a Logic 1. Such signals are designated in this document with an overbar. (e.g., $\overline{\text{ActiveLowSignalName}}$)
Active Mode	A CPM Mode. In the Active Mode, the Basic-portion performs C&DH functions with the Bus-subsystem and payloads; and, the Router-portion performs routing functions with the payloads. Additionally, when in a Hot-Hot configuration, includes performance of information exchange between the two CPM basic portions.
AOC	Active Optical Cable
Basic Mode	A CPM Mode. In the Basic mode, the Basic-portion performs C&DH functions with the Bus-subsystem and payloads. In preparation for a mode transition, the Basic-portion may initialize or decommission the Router portion. Routing functions are not performed.
Basic Portion	The CPM has two primary section or portions: Basic and Router. The Basic portion provides the C&DH interfaces that interface with the Bus-subsystem and the payloads.
Bus Domain Time	Time standard used by the bus.
C&DH	Command and Data Handling
Contingency Mode	[TR-2013-00093; Recommended Satellite System Safe Mode Requirements; The Aerospace Corporation.] An intermediate satellite safing mode in which, unlike safe mode, mission operations may continue. Also, unlike safe mode, contingency modes may, for example, configure to an Earth-pointing or mission-pointing orientation and may not turn off non-essential equipment. This intermediate safing mode may enable the satellite to return to normal mission operations more quickly than if the satellite had entered safe mode. Often satellite developers incorporate a hierarchy of contingency modes into their satellites permitting varying levels of satellite configuration changes to accommodate the current fault response. When contingency mode operations do not result in satellite fault recovery, the satellite will likely be transitioned into safe mode.
CoPaIS	The Common Payload Interface Standard (CoPaIS). This standard, CoPaIS-C&DH, defines a Modular Open Systems Approach (MOSA) so each standard conforming satellite-contractor would provide a common set of interfaces between their satellite's Bus-subsystem and its Payload-subsystem. Additionally, conformance with this standard also ensures that all Payload C&DH interfaces and inter-payload mission data routing interfaces would also satisfy a common MOSA.
CPM	A Centralized Payload Manager (CPM) is a physical unit that serves as a Command and Data Handling (C&DH) interface between the Bus-subsystem (i.e., individual On-Board Computer (OBC) or Spacecraft Control Processor (SCP)) and the individual payload (primary and hosted) interfaces. The CPM enables standardization of the bus-payload(s) interface, is responsible for most of the payload management duties thereby minimizes changes to the Bus-subsystem flight software (including associated schedule and non-recurring expense costs) when new/different payloads are applied, enables greater payload modularization in the future, and enables each CoPaIS- C&DH conforming satellite Bus-subsystem to provide a common/standardized MOSA for Payload C&DH and mission data interfaces.

TABLE 1. Table of Definitions

Term	Definition
Diagnostic mode	A CPM Mode. In the Diagnostic mode, the Basic-portion communicates with the Bus-subsystem to diagnose a problem with the Basic-portion and/or the Router-portion. Depending upon the problem, the CPM may perform C&DH functions with the Bus-subsystem and each payload.
Gbps	Giga-bits per second.
Giga	One billion, base 10.
Hard reset	Resets key microelectronic circuitry (e.g., processor, controller, router) to reinitialize it and causes the processor(s) to execute start-up code (usually from a start-up read-only memory).
Hot-Cold	A unit redundancy scheme where one unit is on and active (“Hot”) and a second unit is off (“Cold”). In this case the switch over time from the Hot unit to the Cold unit is roughly equivalent to the unit’s power-on startup time (minutes). Of the three general types (Hot-Cold, Hot-Warm, Hot-Hot), Hot-Cold uses the least power and consequently yields the highest reliability.
Hot-Hot	A unit redundancy scheme where both units are on (“Hot”) but one is in an “active” mode and the other is in a “monitor” mode. This configuration is used when there is a requirement for the failed currently “active” unit to be rapidly replaced by the “monitor” unit as the new “active” unit. The “monitor” unit continuously ingests the most recent telemetry in preparation for quickly becoming the new “active” unit. As a result, there may be a need for the two units to have a special interface between them and is not needed in other redundancy schemes. This Hot-Hot configuration may find use in applications where mission performance or availability is tightly dependent upon time, such as a Global Positioning Satellite mission. In this case the switch over time from the original “active” Hot unit to the Hot “monitor” unit is roughly less than one second. Of the three general types (Hot-Cold, Hot-Warm, Hot-Hot), Hot-Hot uses the most power and consequently yields the lowest reliability.
Hot-Warm	A unit redundancy scheme where one unit is on (“Hot”) and the other unit also on and ready to enter service but is in an effective wait state and has the processor on but all other equipment that can be is off or in a low power mode. This scheme avoids the time needed to turn the unit on; consequently, the time needed for the “Warm” unit to replace the originally “Hot” unit is in the range of seconds. Of the three general types (Hot-Cold, Hot-Warm, Hot-Hot), Hot-Warm uses the more power than Hot-Cold but less than Hot-Hot and its reliability is also between those two.
Idle mode	A CPM Mode. In the Idle mode, the Basic-portion has completed its initialization and is ready to perform flight software operations when authorized. Authorization could stem from a SpaceWire command from the Bus-subsystem or from a previously loaded variable in the CPM’s non-volatile, reprogrammable memory.
I/F	Interface
LVDS	Low Voltage Differential Signaling
Mbps	Mega-bits per second.
Mega	One million, base 10. 2^{20} base 2.
Mode	A predefined manner of performing a prescribed function or set of functions or subset of functions.

TABLE 1. Table of Definitions

Term	**Definition**
Monitor mode	A CPM Mode. Reserved for use when the two CPMs are in a Hot-Hot configuration, where rapid recovery from a CPM fault is necessary for purposes of payload availability. During normal operations in the Hot-Hot configuration, one CPM is in the Active Mode and the other is in the Monitor Mode. When the CPMs are operating in that configuration the Monitor Mode CPM does not communicate with the payloads. Additionally, the Active Mode CPM continuously (rate defined by program/mission) provides the latest CPM and Payload status & telemetry information to the Monitor Mode CPM via a SpaceWire interface dedicated for use in the Hot-Hot configuration. When the current Active Mode CPM fails, one of its discrete signals informs the current Monitor Mode CPM that it failed. The current Monitor Mode CPM transitions to Active Mode and performs the Active Mode function (including assuming payload interface management control).
MOSA	[NDAA 2017]: In accordance with a US Government law, a major defense acquisition program that receives Milestone A or Milestone B approval after January 1, 2019, shall be designed and developed, to the maximum extent practicable, with a modular open system approach to enable incremental development and enhance competition, innovation, and interoperability. The term ‘modular open system approach’ means, with respect to a major defense acquisition program, an integrated business and technical strategy that— (A) employs a modular design that uses major system interfaces between a major system platform and a major system component, between major system components, or between major system platforms; (B) is subjected to verification to ensure major system interfaces comply with, if available and suitable, widely supported and consensus-based standards; (C) uses a system architecture that allows severable major system components at the appropriate level to be incrementally added, removed, or replaced throughout the life cycle of a major system platform to afford opportunities for enhanced competition and innovation while yielding— (i) significant cost savings or avoidance; (ii) schedule reduction; (iii) opportunities for technical upgrades; (iv) increased interoperability, including system of systems interoperability and mission integration; or (v) other benefits during the sustainment phase of a major weapon system
Major System Component	[NDAA 2017]: (A) means a high-level subsystem or assembly, including hardware, software, or an integrated assembly of both, that can be mounted or installed on a major system platform through well-defined major system interfaces; and (B) includes a subsystem or assembly that is likely to have additional capability requirements, is likely to change because of evolving technology or threat, is needed for interoperability, facilitates incremental deployment of capabilities, or is expected to be replaced by another major system component.

TABLE 1. Table of Definitions

Term	Definition
Major System Interface	[NDAA 2017]: (A) means a shared boundary between a major system platform and a major system component, between major system components, or between major system platforms, defined by various physical, logical, and functional characteristics, such as electrical, mechanical, fluidic, optical, radio frequency, data, networking, or software elements; and (B) is characterized clearly in terms of form, function, and the content that flows across the interface in order to enable technological innovation, incremental improvements, integration, and interoperability.
Major System Platform	[NDAA 2017]: The highest-level structure of a major weapon system that is not physically mounted or installed onto a higher-level structure and on which a major system component can be physically mounted or installed.
NDAA	National Defense Authorization Act
OBC	On-Board Computer
Operational State	A state of the CPM where power is applied to the basic portion and to the router portion.
Payload Time Domain	Time standard used by the Payload
Router Portion	The CPM has two primary section or portions: Basic and Router. The Router portion provides Serial RapidIO (SRIO) interfaces and routing function for the payloads.
Safe Mode	[TR-2013-00093: Recommended Satellite System Safe Mode Requirements; The Aerospace Corporation] A temporary state of minimized satellite operations that is transitioned into as a result of an autonomously irreconcilable satellite fault or safety threat. This state discontinues mission Payload operations; configures satellite assets for sufficient power collection and minimal power usage; maintains equipment health and command and telemetry communications with the satellite command and control segment; and yields fault/safety threat corrective action and operating state control authority to the satellite command and control segment.
SCP	Spacecraft Control Processor
SGLS	Space-Ground Link System
Soft Reset	A signal that serves a high priority interrupt to the processor within the unit. Where the interrupt causes the software to reload its operating system and flight software to loaded parameters. It does not reset any circuitry.
SRIO	Serial RapidIO.
Standby State	A state of the CPM where power is applied to the basic portion and power is not applied to the router portion.
State	A constrained operational condition of an item.
USB	Unified S-Band

4. GENERAL REQUIREMENTS

4.1 CoPaIS-C&DH Interface Architecture

The Common Payload Interface architecture in its most elemental form consists of 1) a standardized C&DH interface between the Bus-subsystem and a redundant-pair of Centralized Payload Manager (CPM) units, 2) a standardized C&DH interface between a redundant-pair of CPMs and each payload on the satellite, and 3) a serial RapidIO interface between each CPM and each payload on the satellite. See FIGURE 1.

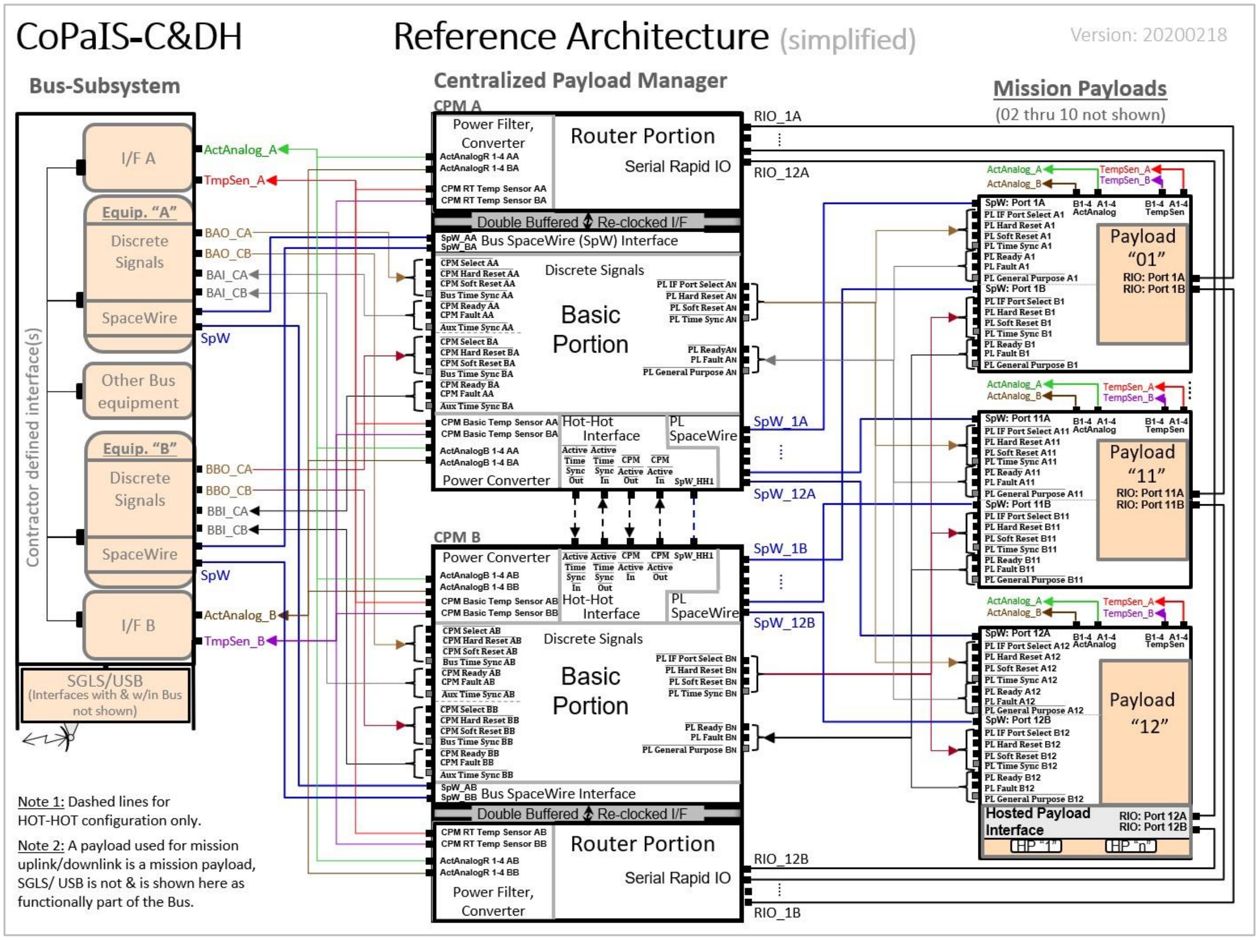


FIGURE 1. CoPaIS-C&DH Reference Architecture Diagram.

4.1.1 Interface Types

4.1.1.1 Passive Analog (Resistive)

A passive analog is an input to the Bus-subsystem from the CPM and the payloads used for a resistive sensor such as a thermistor (e.g., S-311-P-18, dash number 5 (i.e., 5K ohm @ 25 degrees Celsius)).

4.1.1.1.1 A Passive Analog (Resistive) signal shall provide a resistive impedance ranging from 1190K Ohms to 425 Ohms.

4.1.1.1.2 The Passive Analog (Resistive) signal shall provide 5K Ohms resistance at ambient temperature.

4.1.1.2 Discrete Signal Interface

Note: Low voltage differential driver and receiver devices employed in the CPM to Payload interfaces should have inherent cold-spare capabilities (i.e., high impedance or otherwise provide current limiting) such that device stress is prevented when the CPM is operated in a Hot-Cold redundancy configuration.

4.1.1.2.1 Each LVDS Command and Telemetry Discrete shall be a differential signal compatible with the ANSI/TIA/EIA-644 Standard.

4.1.1.2.2 Each LVDS signal shall be a balanced differential with the circuit referenced to secondary power ground at the transmitting and receiving ends.

4.1.1.2.3 Each LVDS discrete command receiver input shall default to a logic 1 when not actively driven.

4.1.1.2.4 Impedance controlled 100 Ohm (+/- 6 Ohms) wire shall be used in the harness (in compliance with ANSI/TIA/EIA-644) to match the LVDS receiver 100 Ohm termination resistor.

4.1.1.2.5 Upon the application of equipment (e.g. CPM, Payload) power, the initial state of each LVDS external interface output signal shall be de-asserted.

4.1.1.3 SpaceWire

Note: Bus-subsystem and CPM Bus-subsystem—to—CPM differential driver and receiver devices should have inherent cold-spare capabilities (i.e., high impedance or otherwise provide current limiting) such that device stress is prevented when operated in a Hot-Cold redundancy configuration

4.1.1.3.1 SpaceWire interfaces shall comply with the SpaceWire standard ECSS-E-ST-50-12C.

4.1.1.3.2 Each CPM and Payload C&DH SpaceWire interface shall use a Type A SpaceWire connector as defined in ECSS-E-ST-50-12C Section 5.3.3.1.b.

4.1.1.3.3 Each CPM and Payload C&DH interface SpaceWire connector shall have the pinout specified in TABLE 2.

TABLE 2. SpaceWire Connector Pinout

Connector pin #	**SpaceWire Signal**	**Differential Signal Polarity**
1	Din	P
2	Sin	P
3		
4	Sout	N
5	Dout	N
6	Din	N
7	Sin	N
8	Sout	P
9	Dout	P

Note: The above SpaceWire signal names are consistent with the SpaceWire standard. Applied signal names may vary.

4.1.1.4 SRIO

The CPM SRIO Fat pipe (4x lane) interface mates with an interface cable using copper wire to transport the signals or with an AOC using a fiber optic cable and associated transceivers to transport the signals. When an AOC is used, the transceivers at either end of the interface must receive power from the respective unit they are connected to. Standard SRIO signals combined with AOC control interface signals are defined below.

Note: SRIO driver and receiver devices should not violate maximum input signal specified by the Rapid Interface Specification identified in section 2 herein.

4.1.1.4.1 Each SRIO interface shall comply with the RapidIO Part 6: LP-Serial Physical Layer Specification Revision 2.1 (Level I Long Run Serial Links).

4.1.1.4.2 Each SRIO interface shall be a full duplex 4-lane channel bonded port, known as a Fat-pipe.

4.1.1.4.3 Each SRIO full duplex lane shall support a minimum baud rate of 3.125 Gbps.

4.1.1.4.4 The SRIO connector shall satisfy attributes specified in TABLE 3:

TABLE 3. SRIO Connector Attributes

Line item	**SRIO Connector Attributes**
a.	Micro-D type connector
b.	Supports SRIO Fat-pipe at 3.125 Gbps per lane
c.	Two rows of contacts
d.	Supports a minimum of 24 AWG wire

4.1.1.4.5 Each SRIO connector (i.e., unit, harness) shall have the pinout specified in TABLE 4.

TABLE 4. SRIO Connector Pinout

Pin #	**SRIO Interface Cable Signal Description/Name**	When a line item is marked with an "X", the associated pin is reserved for use with an Active Optical Cable (AOC).
1	+3.3V	X
2	+2.5V	X
3	RIO1_ReadyL	X
4	GND	
5	RIO1_SelectL	X
6	GND	
7	RIO_TX1_N	
8	RIO_TX1_P	
9	GND	
10	RIO_TX2_N	
11	RIO_TX2_P	

Pin #	**SRIO Interface Cable Signal Description/Name**	When a line item is marked with an "X", the associated pin is reserved for use with an Active Optical Cable (AOC).
12	GND	
13	RIO_TX3_N	
14	RIO_TX3_P	
15	GND	
16	RIO_TX4_N	
17	RIO_TX4_P	
18	GND	
19	GND	
20	GND	
21	GND	
22	RIO1_SDATA	X
23	RIO1_InterruptL	X
24	RIO1_SCLK	X
25	RIO1_ResetL	X
26	GND	
27	RIO_RX1_N	
28	RIO_RX1_P	
29	GND	
30	RIO_RX2_N	
31	RIO_RX2_P	
32	GND	
33	RIO_RX3_N	
34	RIO_RX3_P	
35	GND	
36	RIO_RX4_N	
37	RIO_RX4_P	
38	GND	
39	GND	
40	GND	
41	GND	

4.1.1.5 Active Analog Signals

Active analog signals are provided by payloads and each CPM as inputs to the Bus-subsystem in support of its fault management functions. The technical description (i.e., meaning) of the voltage range output by the source equipment (e.g., a payload) is defined by each analog signal sourcing equipment's active analog signal requirements.

4.1.1.5.1 An Active Analog output signal shall provide a maximum voltage range between +10 volts DC and -10 volts DC.

4.1.1.5.2 Each Active analog signal shall be a single-ended signal, with a return.

4.1.1.5.3 Each non-return Active Analog signal shall have a series resistance of 10k ohm between its interface connector pin and its internal signal source.

4.1.1.5.4 The input resistance of each Active Analog signal input shall be a minimum of 1 Mega-Ohms.

4.1.1.5.5 The input capacitance of each Active Analog signal input shall be a maximum of 200 pico-Farad shunt capacitance.

4.1.2 Bus-subsystem to CPM Interfaces

4.1.2.1 Bus-subsystem to CPM Interface

4.1.2.1.1 The Bus-subsystem shall provide separate primary and redundant SpaceWire interfaces to each CPM.

4.1.2.1.2 The Bus-subsystem SpaceWire interface shall be used to transport all non-discrete digital command and telemetry information between the Bus-subsystem and each CPM.

4.1.2.1.3 Each Bus-subsystem Discrete Signal output base-name (name without the trailing Bus-subsystem side or CPM side designator) function shall conform to the following summary description:

Subparagraph	Discrete Signal Base-name	Description
a.	$\overline{\text{CPM Select}}$	Enables/Disables CPM serial communication with the Bus-subsystem over a specific SpaceWire port
b.	$\overline{\text{CPM Hard Reset}}$	Causes CPM to perform a hard reset.
c.	$\overline{\text{CPM Soft Reset}}$	Causes CPM to perform a soft reset.
d.	$\overline{\text{Bus Time Sync}}$	Assertion indicates when a pre-coordinated exact time has occurred.

4.1.2.1.4 Each Bus-subsystem Discrete Signal input base-name (name without the trailing Bus-subsystem side or CPM side designator) function shall conform to the following summary description:

Subparagraph	Discrete Signal Base-name	Description
a.	$\overline{\text{CPM Ready}}$	CPM completed initialization, does not have a fault, and is ready to communicate with the Bus-subsystem.
b.	CPM Fault	CPM internal watchdog timer has timed-out, SpaceWire communication with the Bus-subsystem may not be operational.
c.	$\overline{\text{Aux Time Sync}}$	Assertion indicates when a precoordinated exact time has occurred.

4.1.2.1.5 The Bus-subsystem shall provide at least two Passive Analog (Resistive) input interfaces per CPM.

4.1.2.1.6 The Bus-subsystem shall monitor all discrete telemetry from each CPM.

4.1.2.1.7 The Bus-subsystem SpaceWire used to interface with the CPM shall be initialized for AutoStart.

4.1.2.1.8 Each CPM SpaceWire used to interface with the Bus-subsystem shall be initialized for LinkStart.

4.1.3 Bus-subsystem to Payload-subsystem Interface

4.1.3.1 Bus-subsystem to Individual Payload Interface

While the quantity and type of payloads vary by mission, the following general interface requirements apply to individual payloads.

4.1.3.1.1 The Bus-subsystem shall provide the quantity and type of telemetry signal inputs to accommodate each thermal sensor signal required by each mission and hosted Payload C&DH interface.

4.1.3.1.2 The Bus-subsystem shall provide the quantity and type of active analog signal inputs to accommodate each active analog signal required by each mission and hosted Payload C&DH interface.

4.1.4 CPM to Payload Interfaces

4.1.4.1 CPM to Payload C&DH Interface

4.1.4.1.1 Each CPM shall provide a SpaceWire interface to each payload interface.

4.1.4.1.2 The CPM SpaceWire interface shall be used be used to transport all non-discrete digital command and telemetry information between the CPM and each payload.

4.1.4.1.3 Each CPM Discrete Signal output base-name (name without the trailing payload side or CPM side designator) function shall conform to the following summary description:

Subparagraph	Discrete Signal Base-name	Description
a.	$\overline{\text{PL IF Port Select}}$	Selects which payload interface port will be used to communicate with a CPM.
b.	$\overline{\text{PL Hard Reset}}$	Causes PL interface to perform a hard reset.

Subparagraph	Discrete Signal Base-name	Description
c.	$\overline{\text{PL Soft Reset}}$	Causes PL interface to perform a soft reset.
d.	$\overline{\text{PL Time Sync}}$	Assertion indicates when a pre-coordinated exact time has occurred.

4.1.4.1.4 Each CPM Discrete Signal input base-name (name without the trailing payload side or CPM side designator) function shall conform to the following summary description:

Subparagraph	Discrete Signal Base-name	Description
a.	$\overline{\text{PL Ready}}$	PL completed initialization, does not have a fault, and is ready to communicate with the CPM.
b.	PL Fault	PL internal watchdog timer has timed-out, SpaceWire communication with the CPM may not be operational.
c.	$\overline{\text{PL General Purpose}}$	Reserved for a payload unique purpose such as payload related status, time or event synchronization, etc. For example, if a payload served as a time source, it could use this signal to synchronize the CPM to the payload time.

4.1.4.1.5 Each CPM shall monitor all discrete telemetry from each Payload C&DH interface.

4.1.4.1.6 Each CPM SpaceWire used to interface with a Payload C&DH interface shall be initialized for AutoStart.

4.1.4.1.7 Each Payload C&DH SpaceWire used to interface with a CPM shall be initialized for LinkStart.

4.1.4.1.8 An active CPM shall provide SRIO where each SRIO fat-pipe port lane supports at least a baud rate of 3.125 Gbps.

4.1.5 CPM Redundancy Configurations

Directly related to architecture, interfaces and CPM responsibilities, there are three redundancy configurations (Hot-Cold, Hot-Warm, and Hot-Hot) that CPMs can support depending upon the fault management warranted by mission requirements.

4.1.5.1 CPM Redundancy Configuration Types

4.1.5.1.1 The CPM shall be capable of being configured into Hot-Cold, Hot-Warm, or Hot-Hot redundancy configurations in support of mission-level fault management requirements.

4.1.5.2 CPM Hot-Hot Redundancy Interfaces

4.1.5.2.1 The CPM shall have one (1) SpaceWire port (in addition to those for the CPM to Bus-subsystem interface and the CPM to Payload interfaces) reserved for continuous Active-CPM to Monitor-CPM transfer of information and telemetry needed for the Monitor-CPM to become the new Active-CPM within a period defined by the mission requirements.

4.1.5.2.2 When configured in a Hot-Hot redundancy configuration, the Active CPM Hot-Hot SpaceWire interface shall be initialized for AutoStart.

4.1.5.2.3 When configured in a Hot-Hot redundancy configuration, the Monitor CPM Hot-Hot SpaceWire interface shall be initialized for LinkStart.

4.1.6 CPM C&DH Responsibilities

4.1.6.1 CPM C&DH Interface Responsibilities

4.1.6.1.1 The active CPM shall collect discrete signal status and telemetry, and digital telemetry via SpaceWire from each payload interface at rates necessary to support payload fault management and the mission(s).

4.1.6.1.2 The active CPM shall perform payload telemetry processing and formatting to satisfy the Bus-subsystem telemetry format requirements.

4.1.6.1.3 The active CPM shall provide payload telemetry (discrete signal telemetry and digital telemetry via SpaceWire) to the Bus-subsystem via SpaceWire.

4.1.6.1.4 The active CPM shall provide CPM discrete status and telemetry signals for use by each redundant input of the Bus-subsystem (e.g., OBC or SCP).

4.1.6.1.5 The active CPM shall provide inputs to support discrete command output signals from the Bus-subsystem (e.g., OBC or SCP).

4.1.6.1.6 The active CPM shall sample, collect, and process discrete signal status and serial (SpaceWire) telemetry provided by the Bus-subsystem at rates necessary to support fault management and the mission(s).

4.1.6.1.7 The CPM shall obtain, maintain, and perform relative to a time-reference provided by a payload or the Bus-subsystem.

4.1.6.1.8 The CPM Basic portion shall initialize, configure, monitor the status of, and manage the Router portion.

4.1.6.2 CPM C&DH Software Requirements

This document is an interface standard; consequently, CPM Software requirements are not defined in this standard.

5. DETAILED REQUIREMENTS

5.1 Bus Domain

This section contains the C&DH interface requirements of the Bus-subsystem to the CPMs and payloads. The interface requirements include the functional and physical characteristics for each interface.

5.1.1 Bus Interfaces

5.1.1.1 Bus to CPM Interfaces

5.1.1.1.1 Power Interface

The Bus-subsystem will provide power to each CPM and each payload. The prime power requirements for each payload will be specified by their own requirements documents just as the CPM prime power requirements would be defined by the CPM specification. However, each CPM has two independent power converters, one for its C&DH basic-portion and the other for its router-portion, and their power sequencing is critical to ensure router operations are properly controlled. Therefore, limited CPM power sequencing requirements are included below.

5.1.1.1.1.1 Power Interface Characteristics

5.1.1.1.1.1.1 Equipment within the Bus-subsystem shall be able to individually control the application of power for each power interface (i.e., Basic portion, Router portion) of each CPM (i.e., A or B).

5.1.1.1.1.1.2 The Bus-Subsystem shall apply power to the Router portion of a CPM only after all conditions in the following subparagraphs are satisfied:

Subparagraph	**Conditions**
a.	The CPM's Basic portion is powered
b.	the CPM has asserted its $\overline{\text{CPM Ready}}$ signal
c.	the Bus-Subsystem has asserted one of the CPM's $\overline{\text{CPM Select}}$ discretes

5.1.1.1.1.2 Power Interface Quantity

5.1.1.1.1.2.1 The Bus-subsystem shall provide separate, current-limited, switched primary power inputs to each CPM Basic portion and Router portion.

5.1.1.1.1.3 Power Interface Connector

The prime power connector used on the Bus-subsystem side is not specified herein; however, it must not pose an incompatibility with the prime power connectors used by the CPM. Additionally, a connector used by the Bus-subsystem to provide CPM power should be keyed to preclude incorrect connections.

5.1.1.1.1.3.1 The Bus-subsystem power interface cable connector interfacing to each CPM power input shall be compatible with the following CPM connectors: M24308/24-122, M24308/24-152 or its interface equivalent.

5.1.1.1.1.4 Power Interface Pinout

The power connector used on the Bus-subsystem side is not specified herein; however, the CPM power connector is.

5.1.1.1.1.4.1 The Bus-subsystem power interface connected to each CPM power input shall use the pinout specified by TABLE 5.

TABLE 5. CPM Power Connector Pinout

Signal Name	Connector Pin
Vin	3
Vin	4
Vin	5
Vin	6
Vin	7
Vin	22
Vin	23
Vin	24
Vin	25
Vin	26
Return	12
Return	13
Return	14
Return	15
Return	16
Return	30
Return	31
Return	32
Return	33
Return	34

5.1.1.1.2 SpaceWire

SpaceWire is used as the primary medium for transporting commands and telemetry between the Bus-subsystem and the CPM. When the Bus-subsystem uses a SpaceWire router node to interface with a CPM, the router latency should be minimized to avoid delaying urgent fault management related commands issued to protect a mission asset (e.g., photonics).

5.1.1.1.2.1 SpaceWire Characteristics

5.1.1.1.2.1.1 After initialization, each Bus-subsystem SpaceWire receive and transmit interface to the CPM shall independently support a maximum data rate of 100 Mbps.

5.1.1.1.2.1.2 The Bus-subsystem to CPM SpaceWire external interface shall be designed to preclude damage while it is off and being actively driven by the CPM.

5.1.1.1.2.1.3 The Bus-subsystem to CPM SpaceWire external interface shall be designed to preclude damage by a 3.9 V differential input.

5.1.1.1.2.1.4 The Bus-subsystem to CPM SpaceWire external interface shall be designed to limit the unterminated, maximum differential output to a 3.6 V differential.

5.1.1.1.2.2 SpaceWire Quantity

5.1.1.1.2.2.1 The Bus-subsystem shall provide two (2) SpaceWire unit connectors per redundancy side, one used to interface with CPM A and the other to interface with CPM B.
<u>Note</u>: See FIGURE 1.

5.1.1.1.2.3 SpaceWire Connector

While the CPM SpaceWire connector for Bus-subsystem to CPM SpaceWire interface is specified in section 5.2, the Bus-subsystem is not required to use a specific connector for its SpaceWire interfaces. However, the connectors used by the Bus-subsystem should be appropriate for the application.

5.1.1.1.2.4 SpaceWire Pinout

While the CPM SpaceWire connector for Bus-subsystem to CPM SpaceWire interface is specified in section 5.2, the Bus-subsystem is not required to use a specific connector pinout for its SpaceWire interfaces. However, the connector pinout used by the Bus-subsystem should be appropriate for the application.

5.1.1.1.3 Discrete Signals

All Discrete Signals in the Bus-subsystem to CPM interface are defined as LVDS signals. Discrete signals are used to implement discrete command and discrete telemetry signals used for configuration, status, and fault management operations.

5.1.1.1.3.1 Bus-subsystem Input (from CPM) Discrete Signal Quantity and Names

5.1.1.1.3.1.1 Each redundant side of the Bus-subsystem shall provide two independent sets of discrete signal inputs, one set of inputs for Discrete Signal outputs from CPM A and the other for CPM B.

5.1.1.1.3.1.2 The Bus-subsystem shall identify the input Discrete Signals from the CPMs as follows:
<u>Note</u>: each signal below is differential, has a (-) and a (+) signal.

Subparagraph	Signal Name	Signal Type	Bus-system side	From: CPM
a.	$\overline{\text{CPM Ready AA}}$	Discrete Signal	A	A
b.	CPM Fault AA	Discrete Signal	A	A
c.	$\overline{\text{Aux Time Sync AA}}$	Discrete Signal	A	A
d.	$\overline{\text{CPM Ready AB}}$	Discrete Signal	A	B
e.	CPM Fault AB	Discrete Signal	A	B
f.	$\overline{\text{Aux Time Sync AB}}$	Discrete Signal	A	B
g.	$\overline{\text{CPM Ready BA}}$	Discrete Signal	B	A
h.	CPM Fault BA	Discrete Signal	B	A
i.	$\overline{\text{Aux Time Sync BA}}$	Discrete Signal	B	A
j.	$\overline{\text{CPM Ready BB}}$	Discrete Signal	B	B
k.	CPM Fault BB	Discrete Signal	B	B
l.	$\overline{\text{Aux Time Sync BB}}$	Discrete Signal	B	B

5.1.1.1.3.2 Bus-subsystem Output (to CPMs) Discrete Signal Quantity and Names

5.1.1.1.3.2.1 Each redundant side of the Bus-subsystem shall provide two sets of four output Discrete Signals, one set for CPM A and the other for CPM B.

5.1.1.1.3.2.2 The Bus-subsystem shall identify the output Discrete Signals to the CPMs as follows:
Note: each signal below is differential, has a (-) and a (+) signal.

Subparagraph	Signal Name	Signal Type	From: Bus-subsystem side	To: CPM
a.	$\overline{\text{CPM Select AA}}$	Discrete Signal	A	A
b.	$\overline{\text{CPM Hard Reset AA}}$	Discrete Signal	A	A
c.	$\overline{\text{CPM Soft Reset AA}}$	Discrete Signal	A	A

Subparagraph	Signal Name	Signal Type	From: Bus-subsystem side	To: CPM
d.	$\overline{\text{Bus Time Sync AA}}$	Discrete Signal	A	A
e.	$\overline{\text{CPM Select AB}}$	Discrete Signal	A	B
f.	$\overline{\text{CPM Hard Reset AB}}$	Discrete Signal	A	B
g.	$\overline{\text{CPM Soft Reset AB}}$	Discrete Signal	A	B
h.	$\overline{\text{Bus Time Sync AB}}$	Discrete Signal	A	B
i.	$\overline{\text{CPM Select BA}}$	Discrete Signal	B	A
j.	$\overline{\text{CPM Hard Reset BA}}$	Discrete Signal	B	A
k.	$\overline{\text{CPM Soft Reset BA}}$	Discrete Signal	B	A
l.	$\overline{\text{Bus Time Sync BA}}$	Discrete Signal	B	A
m.	$\overline{\text{CPM Select BB}}$	Discrete Signal	B	B
n.	$\overline{\text{CPM Hard Reset BB}}$	Discrete Signal	B	B
o.	$\overline{\text{CPM Soft Reset BB}}$	Discrete Signal	B	B
p.	$\overline{\text{Bus Time Sync BB}}$	Discrete Signal	B	B

5.1.1.1.3.3 Discrete Signal Connector

While the CPM Discrete Signal connector for CPM to Bus-subsystem interface is specified in section 5.2, the Bus-subsystem is not required to use a specific connector for its Discrete Signal interfaces. However, the Bus-subsystem connector should have appropriate performance characteristics for the application.

5.1.1.1.3.4 Discrete Signal Pinout

While the CPM Discrete Signal connector for CPM to Bus-subsystem interface is specified in section 5.2, the Bus-subsystem is not required to use a specific Bus-subsystem interface connector pinout.

5.1.1.1.3.5 Bus-subsystem Output (to CPM) Discrete Signal Characteristics

5.1.1.1.3.5.1 $\overline{\text{CPM Select}}$

5.1.1.1.3.5.1.1 The Bus-subsystem shall assert a $\overline{\text{CPM Select}}$ with logic 0.

5.1.1.1.3.5.1.2 The Bus-subsystem shall de-assert its $\overline{\text{CPM Select}}$ with logic 1.

5.1.1.1.3.5.1.3 The A-side of the Bus-subsystem shall provide a logic 0 to the $\overline{\text{CPM Select AA}}$ signal to enable CPM A SpaceWire communication with Bus-subsystem side-A.

5.1.1.1.3.5.1.4 The B-side of the Bus-subsystem shall provide a logic 0 to the $\overline{\text{CPM Select BA}}$ signal to enable CPM A SpaceWire communication with Bus-subsystem side-B.

5.1.1.1.3.5.1.5 The A-side of the Bus-subsystem shall provide a logic 0 to the $\overline{\text{CPM Select AB}}$ signal to enable CPM B SpaceWire communication with Bus-subsystem side-A.

5.1.1.1.3.5.1.6 The B-side of the Bus-subsystem shall provide a logic 0 to the $\overline{\text{CPM Select BB}}$ signal to enable CPM B SpaceWire communication with Bus-subsystem side-B

5.1.1.1.3.5.1.7 The A-side of the Bus-subsystem shall provide a logic 1 to the $\overline{\text{CPM Select AA}}$ signal to disable CPM A SpaceWire communication with Bus-subsystem side-A.

5.1.1.1.3.5.1.8 The B-side of the Bus-subsystem shall provide a logic 1 to the $\overline{\text{CPM Select BA}}$ signal to disable CPM A SpaceWire communication with Bus-subsystem side-B.

5.1.1.1.3.5.1.9 The A-side of the Bus-subsystem shall provide a logic 1 to the $\overline{\text{CPM Select AB}}$ signal to disable CPM B SpaceWire communication with Bus-subsystem side-A.

5.1.1.1.3.5.1.10 The B-side of the Bus-subsystem shall provide a logic 1 to the $\overline{\text{CPM Select BB}}$ signal to enable CPM B SpaceWire communication with Bus-subsystem side-B.

5.1.1.1.3.5.2 $\overline{\text{CPM Hard Reset}}$

5.1.1.1.3.5.2.1 The Bus-subsystem shall assert its $\overline{\text{CPM Hard Reset}}$ Discrete with logic 0.

5.1.1.1.3.5.2.2 The Bus-subsystem shall de-assert its $\overline{\text{CPM Hard Reset}}$ Discrete with logic 1.

5.1.1.1.3.5.2.3 The Bus-subsystem shall assert the $\overline{\text{CPM Hard Reset}}$ Discrete for greater than or equal to 10 milliseconds then de-assert for greater than or equal to 10 milliseconds to cause the CPM to perform a Hard Reset.

5.1.1.1.3.5.3 $\overline{\text{CPM Soft Reset}}$

5.1.1.1.3.5.3.1 The Bus-subsystem shall assert its $\overline{\text{CPM Soft Reset}}$ Discrete with logic 0.

5.1.1.1.3.5.3.2 The Bus-subsystem shall de-assert its $\overline{\text{CPM Soft Reset}}$ Discrete with logic 1.

5.1.1.1.3.5.3.3 The Bus-subsystem shall assert the $\overline{\text{CPM Soft Reset}}$ Disccrete for greater than or equal to 10 milliseconds and then de-assert it for greater than or equal to 10 milliseconds to cause the CPM to perform a Soft Reset.

5.1.1.1.3.5.4 Bus Time Sync

The Bus-subsystem will assert the Bus Time Sync discrete signal when it has reached a specific time. Typically, the Bus-subsystem would use SpaceWire to send the CPM the value of an approaching time for subsequent loading into a CPM timer; and, once that exact time is reached the Bus-subsystem would immediately assert its Bus Time Sync discrete. When the CPM edge detects the assertion of the Bus Time Sync signal, it would load the predefined time value into a timekeeping register within the CPM. This process is repeated periodically to ensure that Bus-subsystem time and CPM time are synchronized.

5.1.1.1.3.5.4.1 The Bus-subsystem shall assert its Bus Time Sync discrete when the CPM is to synchronize its time with the Bus-subsystem time.

5.1.1.1.3.5.4.2 The Bus-subsystem shall de-assert its Bus Time Sync discrete at least 100 microseconds after asserting it.

5.1.1.1.3.6 Bus-subsystem Input (from CPM) Discrete Signal Characteristics

5.1.1.1.3.6.1 CPM Ready

This signal will be used by the CPM to indicate when it has powered up successfully and is ready for operation.

5.1.1.1.3.6.1.1 The Bus-subsystem shall interpret logic 0 on the CPM Ready discrete signal as an indication that the CPM is ready to begin C&DH SpaceWire transactions with the Bus-subsystem.
Note: SpaceWire use of Auto-start will permit early SpaceWire initialization, well in advance of when a CPM may be initially ready for C&DH SpaceWire transactions.

5.1.1.1.3.6.1.2 The Bus-subsystem shall interpret a logic 1 on the CPM Ready discrete as an indication that the CPM is not ready to perform C&DH SpaceWire operations.

5.1.1.1.3.6.1.3 The Bus-subsystem CPM Ready LVDS receiver shall implement the failsafe feature to interpret the CPM's CPM Ready driver unpowered condition as a logic 1.

5.1.1.1.3.6.2 CPM Fault

5.1.1.1.3.6.2.1 The Bus-subsystem shall interpret logic 1 on the CPM Fault discrete as an indication that the CPM has encountered one of the following faults:

Subparagraph	
a.	SpaceWire communications with the Bus-subsystem are not operational
b.	CPM processor watchdog timer timeout
c.	Detection of an uncorrectable memory error within the basic portion of the CPM

5.1.1.1.3.6.2.2 The Bus-subsystem shall interpret a logic 0 on the CPM Fault discrete as an indication that the CPM has not detected a CPM fault.

5.1.1.1.3.6.2.3 When the CPMs are configured in a Hot-Hot configuration and the Active CPM asserts its CPM Fault (indicating it has failed), the Bus-subsystem shall command the Active CPM to Diagnostic Mode and, after allowing the current Monitor CPM time to transition to Active Mode, transition all SpaceWire communications to the new Active Mode CPM.

5.1.1.1.3.6.2.4 The Bus-subsystem CPM Fault LVDS receiver shall implement the failsafe feature to interpret the CPM's CPM Fault driver unpowered condition as a logic 1.

5.1.1.1.3.6.3 **$\overline{\text{Aux Time Sync}}$**

This signal is used to synchronize the Bus-subsystem with CPM time. In an operational environment, the CPM would assert the $\overline{\text{Aux Time Sync}}$ discrete signal to the Bus-subsystem when a CPM internally-clocked timekeeping register has reached a specific time. Typically, the CPM would use SpaceWire to send the Bus-subsystem the value of an approaching time for subsequent loading into a Bus-subsystem timer; and, once that exact time is reached the CPM would immediately assert its $\overline{\text{Aux Time Sync}}$ discrete. When the Bus-subsystem edge detects the assertion of the $\overline{\text{Aux Time Sync}}$ signal, it would load the predefined time value it received from the CPM into a timekeeping register within the Bus-subsystem. This process is repeated periodically to ensure that CPM time and Bus-subsystem time are synchronized.

5.1.1.1.3.6.3.1 The Bus-subsystem shall use the falling edge (logic 1 to 0 transition) of the $\overline{\text{Aux Time Sync}}$ signal to serve as the time of reference instance for synchronization.

5.1.1.1.4 Passive Analog

5.1.1.1.4.1 Passive Analog (Resistive) Interface Characteristics

Each side of the Bus-subsystem will receive thermal telemetry signals from the CPM for purposes of CPM internal temperature diagnostics.

The return side of each thermistor is ganged together, isolated from all grounds as shown in FIGURE 2. The CPM thermistors will be S-311-P-18, dash number 5 (5k ohm at nominal) or equivalent.

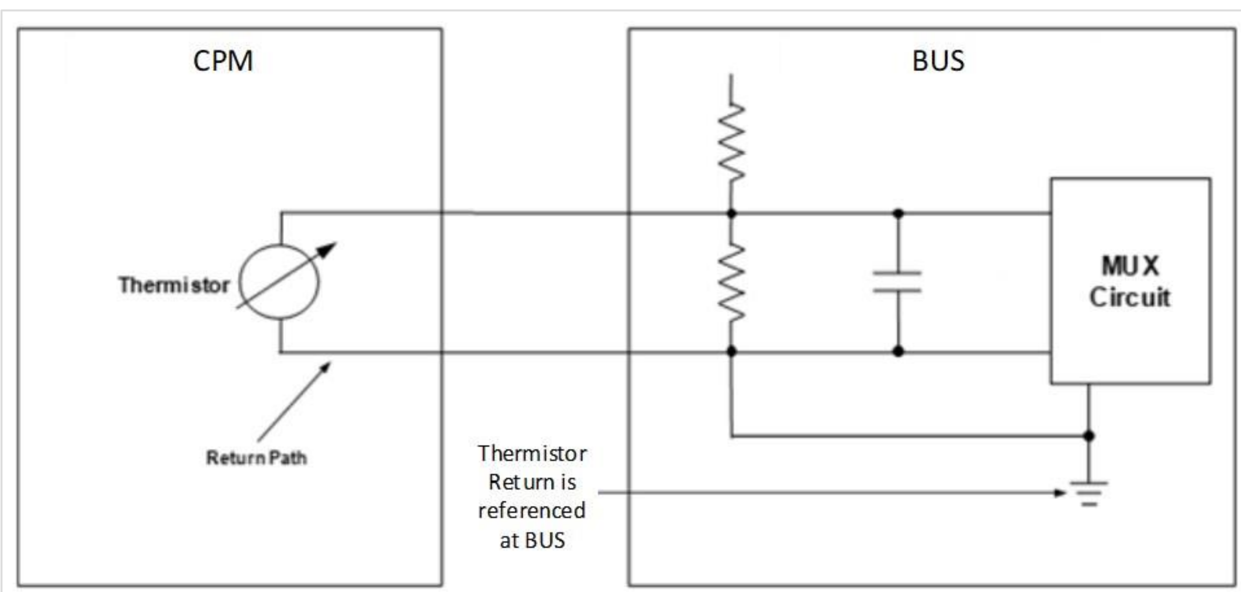


FIGURE 2. CPM to Bus Passive analog interface example.

5.1.1.1.4.1.1 Each CPM passive analog signal provided to the Bus-subsystem shall be a single-ended signal, with a return.

5.1.1.1.4.2 Passive Analog (Resistive) Signal Quantity and Names

5.1.1.1.4.2.1 The Bus-subsystem shall identify the CPM Passive Analog Signals as follows:

Subparagraph	Signal Name	Signal Type	Bus-system side	From: CPM	CPM Portion
a.	CPM Basic Thermal Sensor AA	Passive Analog (Resistive)	A	A	Basic
b.	CPM RT Thermal Sensor AA	Passive Analog (Resistive)	A	A	Router
c.	CPM Basic Thermal Sensor BB	Passive Analog (Resistive)	B	B	Basic
d.	CPM RT Thermal Sensor BB	Passive Analog (Resistive)	B	B	Router
e.	CPM Basic Thermal Sensor AB	Passive Analog (Resistive)	A	B	Basic
f.	CPM RT Thermal Sensor AB	Passive Analog (Resistive)	A	B	Router
g.	CPM Basic Thermal Sensor BA	Passive Analog (Resistive)	B	A	Basic
h.	CPM RT Thermal Sensor BA	Passive Analog (Resistive)	B	A	Router

5.1.1.1.4.2.2 Each Bus-subsystem side shall receive up to eight Passive Analog (Resistive) telemetry interfaces from each CPM for monitoring the temperature of high-power consumption area within the CPM.

5.1.1.1.4.3 Passive Analog (Resistive) Signal Connector

While the CPM Passive Analog Signal connector for CPM to Bus-subsystem interface is specified in section 5.2, the Bus-subsystem is not required to use a specific Bus-subsystem interface connector pinout.

5.1.1.1.4.3.1 The Bus-subsystem shall use a connector for Passive Analog signals that allows a CPM to use connector part number M24308/23-151 or its interface equivalent.

5.1.1.1.5 Bus-subsystem Active Analog Inputs From CPM

5.1.1.1.5.1 Each redundant side of the Bus-subsystem shall accommodate eight (8) active analog input signals from each redundancy instance of CPM. Note: Bus-subsystem “side-A” would receive eight (8) active analog inputs from CPM A and eight (8) from CPM B. Of those eight (8) per CPM, four (4) are from the CPM Basic portion and four (4) are from the CPM Router portion.

5.1.1.1.5.2 The Bus-subsystem shall use a connector for Active Analog signals that allows a CPM to use connector part number M24308/23-152 or its interface accommodating equivalent.

5.1.1.2 Bus to Payload

5.1.1.2.1 Power Interface

5.1.1.2.1.1 Power Interface Characteristics

Payload primary power characteristics (e.g., voltage and current levels) can vary widely and they are not directly related to C&DH; consequently, payload primary power is not specified by this standard.

5.1.1.2.1.2 Power Interface Quantity

Power interface quantity is mission and payload dependent. Consequently, requirements for them is not specified herein.

5.1.1.2.1.3 Power Interface Connector

Bus to payload power connectors are not specified herein.

5.1.1.2.1.4 Power Interface Pinout

Bus to payload power connector pinouts are not specified herein.

5.1.1.2.2 Discrete Signals

There are no C&DH discrete signals directly between the payloads and the Bus-subsystem.

5.1.1.2.3 Passive Analog

5.1.1.2.3.1 Passive Analog (Resistive) Interface Characteristics

Each side of the Bus-subsystem may receive thermal telemetry signals from each payload for purposes of payload internal temperature diagnostics.

The return side of each thermistor is ganged together, isolated from all grounds as shown in FIGURE 3. The thermistors will be S-311-P-18, dash number 5 (5k ohm at nominal) or equivalent.

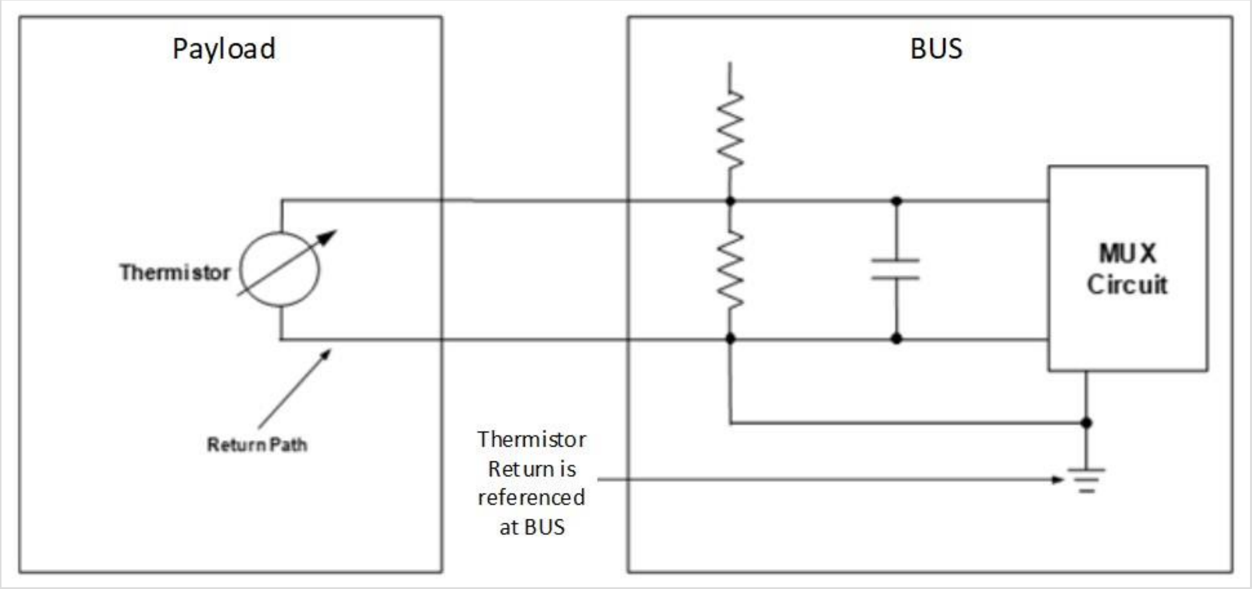


FIGURE 3. Payload to Bus passive analog interface example.

5.1.1.2.3.1.1 Each payload passive analog signal provided to the Bus-subsystem shall be a single-ended signal, with a return.

5.1.1.2.3.1.2 The Bus-subsystem shall isolate each payload passive analog signal from its chassis by > 1 Mega Ohm.

5.1.1.2.3.2 Passive Analog (Resistive) Signal Quantity

5.1.1.2.3.2.1 Each Bus-subsystem side shall receive up to eight Passive Analog (Resistive) telemetry interfaces from each payload for monitoring the temperature of high-power consumption area within the payload.

5.1.1.2.3.3 Passive Analog Connector

5.1.1.2.3.3.1 The Bus-subsystem shall use a connector for Passive Analog signals that allows a payload to use connector part number M24308/23-151 or it's interface equivalent.

5.1.1.2.3.4 Passive Analog Pinout

5.1.1.2.3.4.1 Each Passive Analog single-ended and return discrete signal set in a connector shall be isolated from other signals by a minimum of 2 pins in each direction.
Note: The two passive analog signals in a set may be adjacent to each other.

5.1.1.2.4 Bus-subsystem Active Analog Inputs from Payloads

5.1.1.2.4.1 Each redundant side of the Bus-subsystem shall accommodate 4 active analog input signals from each Payload.

5.1.1.2.4.2 The Bus-subsystem shall use a connector for Active Analog signals that allows a Payload to use connector part number M24308/23-152 or its interface accommodating equivalent.

5.1.2 Bus Functional Requirements

5.1.2.1 States and Modes

The Bus-subsystem has the ability to set CPM states and modes. The CPM has two portions: Basic and Router. In the Standby state, only the Basic portion has power applied. In the Operational state power must be applied to the basic and router portion of the CPM. The Bus-subsystem can command the CPM into any valid mode. The Monitor mode is only used in support of a Hot-Hot configuration. The CPM states and modes are shown in FIGURE 4.

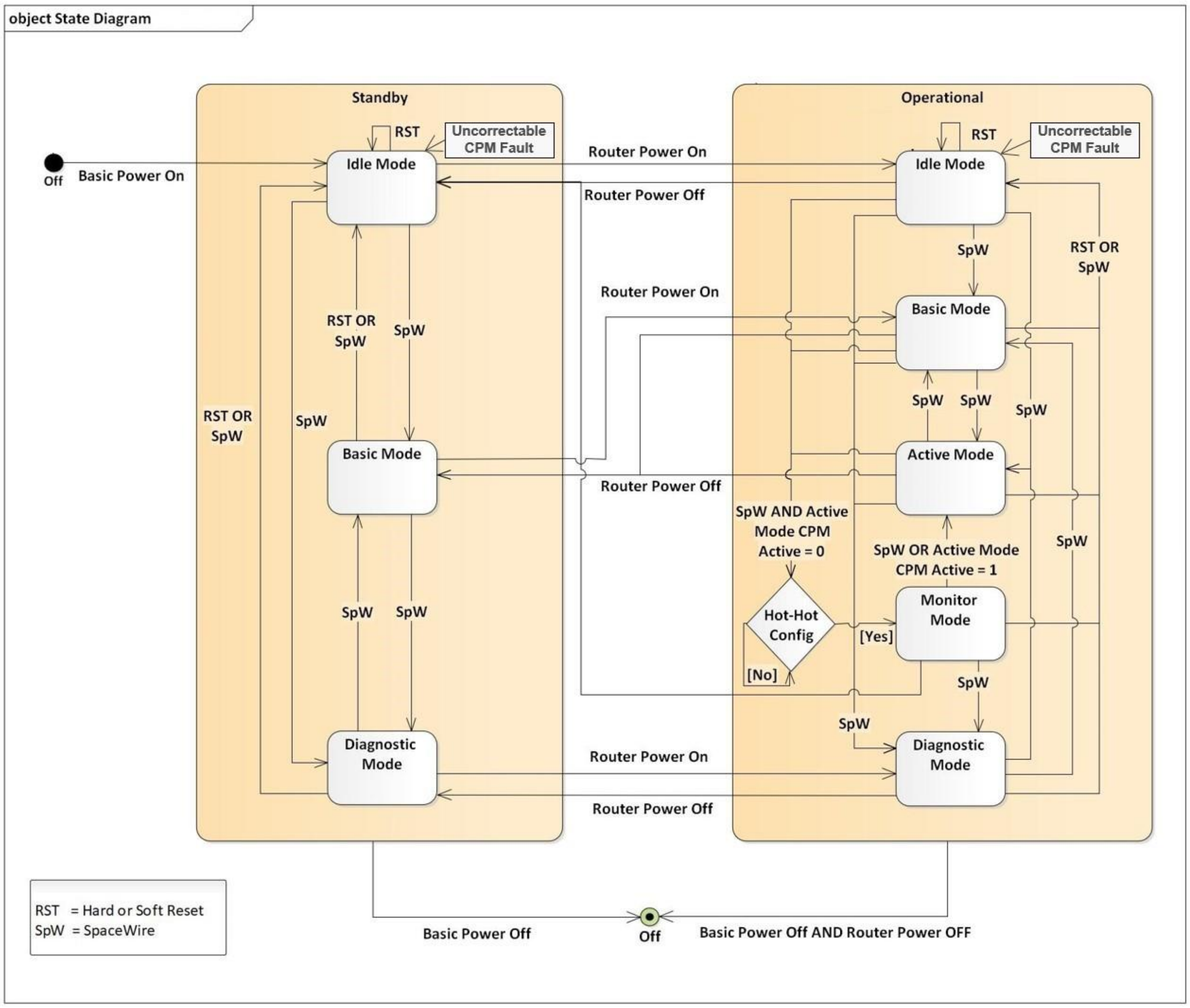


FIGURE 4. CPM States and Modes.

5.1.2.1.1 States

States of the Bus-subsystem are up to the Bus-subsystem provider. This standard imposes no requirements upon the Bus-subsystem for its states.

5.1.2.1.1.1 To cause a CPM to attain the Standby state, the Bus-subsystem shall apply power to the CPM basic portion without applying power to the router portion.

5.1.2.1.1.2 To cause the CPM to attain the Operational state, the Bus-subsystem shall apply power to the CPM basic portion and router portion.

5.1.2.1.1.3 The Bus-subsystem shall apply power to the router portion of the CPM only after it detects that the CPM's $\overline{\text{CPM Ready}}$ signal is asserted.

5.1.2.1.2 Modes

Modes of the Bus-subsystem are up to the Bus-subsystem provider. This standard imposes no requirements upon the Bus-subsystem for its modes.

5.1.2.1.2.1 The Bus-subsystem shall use SpaceWire commanding to transition a CPM into any valid mode, as shown in FIGURE 4 (CPM States and Modes).
Note: The Monitor Mode is only available when the CPM are configured in a Hot-Hot configuration.

5.1.2.1.2.2 To cause a CPM to enter Idle Mode without using a SpaceWire command the Bus-subsystem shall assert the $\overline{\text{CPM Hard Reset}}$ or $\overline{\text{CPM Soft Reset}}$ discrete signal.

5.1.2.1.2.3 When the CPMs are in a Hot-Hot configuration, the Bus-subsystem shall command no more than one CPM into the Active mode.

5.1.2.2 Telemetry

5.1.2.2.1 The Bus-subsystem shall send to and receive digital telemetry from the CPM via SpaceWire and discrete signals.

5.1.2.3 Time Management

5.1.2.3.1 Bus Time Services

5.1.2.3.1.1 The Bus-subsystem shall synchronize and distribute Bus time domain services.

5.1.2.3.1.2 The Bus-subsystem shall use Event Triggered commands to send time messages.
Note: Event-triggered commands will have two components. One component is a time value transmitted via SpaceWire in advance of an event notification provided by the assertion of a discrete signal. The second component is the event notification which is accomplished by the assertion of a discrete signal that defines the exact moment when the time value is valid.

5.1.2.3.1.3 The SpaceWire portion of the Event Triggered command shall specify the time it would be when the $\overline{\text{Bus Time Sync}}$ discrete signal is asserted.

5.1.2.3.1.4 The Bus-subsystem shall ensure that the time interval between its issuance of the SpaceWire time message and the assertion of the $\overline{\text{Bus Time Sync}}$ discrete signal is less than 200 mS.

5.1.2.3.1.5 The Bus-Subsystem shall provide a CPM command that selects which time domain (i.e., Bus Domain Time or Auxiliary Payload Domain Time) to use for Payload synchronization.

5.1.2.3.1.6 When the CPMs are in a Hot-Hot configuration, the Bus-Subsystem shall provide a CPM command that selects which time domain (i.e., Bus Domain Time or Auxiliary Payload Domain Time) to use for CPM to CPM time synchronization.

5.1.2.3.2 Bus Time Synchronization With CPM

The Bus-Subsystem time is periodically synchronized with the CPM time. Bus-subsystem time synchronization may be accomplished through CPM to Bus-subsystem communications via a SpaceWire time message that provides the value of an approaching time followed by the assertion of the $\overline{\text{Aux Time Sync}}$ discrete. The $\overline{\text{Aux Time Sync}}$ discrete signals exactly when the CPM time value is to be loaded into the Bus-Subsystem's counter.

5.1.2.3.2.1 The Bus-Subsystem shall support synchronizing Bus-Subsystem Internal Time to CPM Time.

5.1.2.3.2.2 Upon receipt of a SpaceWire time message (which contains an approaching CPM time value) from the CPM, the Bus-Subsystem shall prepare to load that time value into its Bus-Subsystem Time Counter. Note: That value would be the CPM time at next occurrence of the $\overline{\text{Aux Time Sync}}$ discrete.

5.1.2.3.2.3 If the $\overline{\text{Aux Time Sync}}$ discrete is not asserted within 10 mS of receiving a SpaceWire message from the CPM containing a new time value, the Bus-Subsystem shall report the issue to the CPM and not update its clock until a valid SpaceWire message and associated $\overline{\text{Aux Time Sync}}$ signal are received.

5.1.2.3.2.4 If the $\overline{\text{Aux Time Sync}}$ discrete is asserted within 10 mS of receiving a SpaceWire message from the CPM containing a new time value, the Bus-Subsystem shall set the Bus-Subsystem Time Counter to the pending time value.

5.1.2.4 Fault Management

5.1.2.4.1 Power

The Bus-subsystem remains solely responsible for managing CPM and Payload power, and for placing the vehicle into safe mode.

5.1.2.4.1.1 The Bus-subsystem shall be solely responsible for the application and removal of power from the CPMs and the payloads.

5.1.2.4.1.2 Unless safety critical, the Bus-subsystem shall notify the CPM with 1 second (+/- 20%) notice that power is to be removed from a payload.

5.1.2.4.1.3 The Bus-subsystem shall notify the CPM after it applies power to a payload.

5.1.2.4.1.4 Within 1/2 second after it removes power from a payload, the Bus-subsystem shall send a command to the CPM informing it which payload had power removed.

5.1.2.4.2 Discrete Signals

5.1.2.4.2.1 Upon detection of a CPM asserting its CPM Fault discrete signal, the Bus-subsystem shall interpret the signal to indicate a CPM fault has occurred.

5.2 CPM Domain

This section contains the C&DH, mission data, and power interface requirements applicable to the CPM domain. The CPM domain includes the interfaces between the Bus-subsystem and each of the two non-redundant CPM units and the interfaces between each CPM and the payload(s).

5.2.1 CPM Interfaces

5.2.1.1 CPM to Bus-subsystem Interfaces

5.2.1.1.1 Power Interface

Each CPM has two power interfaces, one for the router portion and another for the basic portion. Each power interface includes inputs for positive voltage and return.

5.2.1.1.1.1 CPM Power Interface

5.2.1.1.1.1.1 The CPM shall accept separate, switched, primary power inputs to each CPM basic portion and router portion

5.2.1.1.1.2 CPM Power Interface Connector

5.2.1.1.1.2.1 The primary power unit connector for the basic portion of each CPM shall be a 37-pin D-subminiature (M24308/24-152) or its interface equivalent (M24308/24-122).

5.2.1.1.1.2.2 The primary power unit connector for the router portion of each CPM shall be a 37-pin D-subminiature (M24308/24-152) or its interface equivalent (M24308/24-122).

5.2.1.1.1.3 CPM Power Interface Connector Pinout

5.2.1.1.1.3.1 Each CPM unit power connector shall have the pinout specified in TABLE 5.

5.2.1.1.2 SpaceWire

SpaceWire is used as an interface between the Bus-subsystem and each CPM to exchange commands and telemetry. For example, commands from the Bus-subsystem for a payload are sent to the CPM, the CPM would temporarily log the command, and forward the command to the appropriate payload; that is, a CPM-based SpaceWire router is not used between the CPM and the Bus-subsystem or payloads. This method will also enable the CPM, although not required by this standard, to perform Bus-Subsystem to CPM command anomaly detection as part of its cyber security role.

5.2.1.1.2.1 SpaceWire Interface Characteristics

5.2.1.1.2.1.1 After initialization, each CPM SpaceWire receive and transmit interface to the Bus-subsystem shall independently support a maximum data rate of 100 Mbps.

5.2.1.1.2.1.2 Each CPM to Bus-subsystem SpaceWire external interface shall be designed to preclude damage while the CPM is off and being actively driven by the Bus-subsystem.

5.2.1.1.2.1.3 A CPM-based SpaceWire router shall not be used to transfer information (e.g., commands, data) between itself and the Bus-subsystem.

Note: The CPM will receive, process, and individually forward commands and data to the target payload.

5.2.1.1.2.1.4 The CPM to Bus-subsystem SpaceWire external interface shall be designed to preclude damage by a 3.9 V differential input.

5.2.1.1.2.1.5 The CPM to Bus-subsystem SpaceWire external interface shall be designed to limit the unterminated, maximum differential output to a 3.6 V differential.

5.2.1.1.2.2 SpaceWire Quantity

5.2.1.1.2.2.1 Each CPM shall provide two (2) SpaceWire unit connectors as part of its Bus-subsystem interface, one used to interface with the A-side of the Bus-subsystem and the other to interface with the B-side of the Bus-subsystem.
Note: See FIGURE 1.

5.2.1.1.2.3 SpaceWire Connector

5.2.1.1.2.3.1 Each CPM CPM-to-Bus-subsystem SpaceWire unit connector shall be a rectangular, 9-pin, M83513 (e.g., /04 or /19) connector.

5.2.1.1.2.4 SpaceWire Pinout

5.2.1.1.2.4.1 Each CPM to Bus-subsystem-side SpaceWire unit connector shall have the pinout specified in TABLE 2.

5.2.1.1.3 Discrete Signals

All Discrete Signals in the CPM domain are defined as LVDS signals. Discrete signals are used to implement discrete commands and discrete telemetry signals used for domain configuration and fault management operations.

5.2.1.1.3.1 CPM Input (from Bus-subsystem) Discrete Signal Quantity and Names

5.2.1.1.3.1.1 Each CPM basic portion shall provide four redundant (qty. 8) Discrete Signal inputs provided by the Bus-subsystem.

5.2.1.1.3.1.2 The Discrete Signals to the CPM from the Bus-subsystem shall be identified and connected as follows:

Subparagraph	Signal Name	Signal Type	From: Bus-subsystem side	To: CPM	CPM Connector
a.	$\overline{\text{CPM Select AA}}$	Discrete Signal	A	A	M24308/23-162
b.	$\overline{\text{CPM Hard Reset AA}}$	Discrete Signal	A	A	M24308/23-162
c.	$\overline{\text{CPM Soft Reset AA}}$	Discrete Signal	A	A	M24308/23-162
d.	$\overline{\text{Bus Time Sync AA}}$	Discrete Signal	A	A	M24308/23-162

Subparagraph	Signal Name	Signal Type	From: Bus-subsystem side	To: CPM	CPM Connector
e.	$\overline{\text{CPM Select AB}}$	Discrete Signal	A	B	M24308/23-162
f.	$\overline{\text{CPM Hard Reset AB}}$	Discrete Signal	A	B	M24308/23-162
g.	$\overline{\text{CPM Soft Reset AB}}$	Discrete Signal	A	B	M24308/23-162
h.	$\overline{\text{Bus Time Sync AB}}$	Discrete Signal	A	B	M24308/23-162
i.	$\overline{\text{CPM Select BA}}$	Discrete Signal	B	A	M24308/23-162
j.	$\overline{\text{CPM Hard Reset BA}}$	Discrete Signal	B	A	M24308/23-162
k.	$\overline{\text{CPM Soft Reset BA}}$	Discrete Signal	B	A	M24308/23-162
l.	$\overline{\text{Bus Time Sync BA}}$	Discrete Signal	B	A	M24308/23-162
m.	$\overline{\text{CPM Select BB}}$	Discrete Signal	B	B	M24308/23-162
n.	$\overline{\text{CPM Hard Reset BB}}$	Discrete Signal	B	B	M24308/23-162
o.	$\overline{\text{CPM Soft Reset BB}}$	Discrete Signal	B	B	M24308/23-162
p.	$\overline{\text{Bus Time Sync BB}}$	Discrete Signal	B	B	M24308/23-162

5.2.1.1.3.2 CPM Output (to Bus-subsystem) Discrete Signal Quantity and Names

5.2.1.1.3.2.1 Each CPM shall provide three redundant (qty. 6) Discrete Signals to The Bus-subsystem.

5.2.1.1.3.2.2 The Discrete Signals from the CPMs shall be identified and connected as follows:
Note: Each signal below is differential.

Subparagraph	Signal Name	Signal Type	From: CPM	CPM Connector	To: Bus-system side
a.	$\overline{\text{CPM Ready AA}}$	Discrete Signal	A	M24308/23-162	A
b.	CPM Fault AA	Discrete Signal	A	M24308/23-162	A

Subparagraph	Signal Name	Signal Type	From: CPM	CPM Connector	To: Bus-system side
c.	$\overline{\text{Aux Time Sync AA}}$	Discrete Signal	A	M24308/23-162	A
d.	$\overline{\text{CPM Ready BA}}$	Discrete Signal	A	M24308/23-162	B
e.	CPM Fault BA	Discrete Signal	A	M24308/23-162	B
f.	$\overline{\text{Aux Time Sync BA}}$	Discrete Signal	A	M24308/23-162	B
g.	$\overline{\text{CPM Ready AB}}$	Discrete Signal	B	M24308/23-162	A
h.	CPM Fault AB	Discrete Signal	B	M24308/23-162	A
i.	$\overline{\text{Aux Time Sync AB}}$	Discrete Signal	B	M24308/23-162	A
j.	$\overline{\text{CPM Ready BB}}$	Discrete Signal	B	M24308/23-162	B
k.	CPM Fault BB	Discrete Signal	B	M24308/23-162	B
l.	$\overline{\text{Aux Time Sync BB}}$	Discrete Signal	B	M24308/23-162	B

5.2.1.1.3.3 Discrete Signal Connector

5.2.1.1.3.3.1 The CPM Discrete Signal unit connector shall be part number M24308/23-162 or equivalent (M24308/23-174).

5.2.1.1.3.4 Discrete Signal Pinout

5.2.1.1.3.4.1 The CPM A Discrete Signals interfacing with the Bus-subsystem side A shall conform to the following pinout:

Subparagraph	Bus	CPM	Signal name	Differential Signal Polarity	CPM Connector	Connector pin #
a.	A	A	Gnd		M24308/23-162	1
b.	A	A	$\overline{\text{CPM Select AA}}$	P	M24308/23-162	2
c.	A	A	$\overline{\text{CPM Select AA}}$	N	M24308/23-162	3
d.	A	A	$\overline{\text{CPM Hard Reset AA}}$	P	M24308/23-162	4

Subparagraph	Bus	CPM	Signal name	Differential Signal Polarity	CPM Connector	Connector pin #
e.	A	A	$\overline{\text{CPM Hard Reset AA}}$	N	M24308/23-162	5
f.	A	A	$\overline{\text{CPM Soft Reset AA}}$	P	M24308/23-162	6
g.	A	A	$\overline{\text{CPM Soft Reset AA}}$	N	M24308/23-162	7
h.	A	A	Gnd		M24308/23-162	9
i.	A	A	Gnd		M24308/23-162	10
j.	A	A	$\overline{\text{Bus Time Sync AA}}$	P	M24308/23-162	11
k.	A	A	$\overline{\text{Bus Time Sync AA}}$	N	M24308/23-162	12
l.	A	A	$\overline{\text{CPM Ready AA}}$	P	M24308/23-162	13
m.	A	A	$\overline{\text{CPM Ready AA}}$	N	M24308/23-162	14
n.	A	A	CPM Fault AA	P	M24308/23-162	15
o.	A	A	CPM Fault AA	N	M24308/23-162	16
p.	A	A	Gnd		M24308/23-162	18
q.	A	A	Gnd		M24308/23-162	19
r.	A	A	Gnd		M24308/23-162	26
s.	A	A	$\overline{\text{Aux Time Sync AA}}$	P	M24308/23-162	24
t.	A	A	$\overline{\text{Aux Time Sync AA}}$	N	M24308/23-162	25

5.2.1.1.3.4.2 The CPM A Discrete Signals interfacing with the Bus-subsystem side B shall conform to the following pinout:

Subparagraph	Bus	CPM	Signal name	Differential Signal Polarity	CPM Connector	Connector pin #
a.	B	A	Gnd		M24308/23-162	1

Subparagraph	Bus	CPM	Signal name	Differential Signal Polarity	CPM Connector	Connector pin #
b.	B	A	$\overline{\text{CPM Select BA}}$	P	M24308/23-162	2
c.	B	A	$\overline{\text{CPM Select BA}}$	N	M24308/23-162	3
d.	B	A	$\overline{\text{CPM Hard Reset BA}}$	P	M24308/23-162	4
e.	B	A	$\overline{\text{CPM Hard Reset BA}}$	N	M24308/23-162	5
f.	B	A	$\overline{\text{CPM Soft Reset BA}}$	P	M24308/23-162	6
g.	B	A	$\overline{\text{CPM Soft Reset BA}}$	N	M24308/23-162	7
h.	B	A	Gnd		M24308/23-162	9
i.	B	A	Gnd		M24308/23-162	10
j.	B	A	$\overline{\text{Bus Time Sync BA}}$	P	M24308/23-162	11
k.	B	A	$\overline{\text{Bus Time Sync BA}}$	N	M24308/23-162	12
l.	B	A	$\overline{\text{CPM Ready BA}}$	P	M24308/23-162	13
m.	B	A	$\overline{\text{CPM Ready BA}}$	N	M24308/23-162	14
n.	B	A	CPM Fault BA	P	M24308/23-162	15
o.	B	A	CPM Fault BA	N	M24308/23-162	16
p.	B	A	Gnd		M24308/23-162	18
q.	B	A	Gnd		M24308/23-162	19
r.	B	A	Gnd		M24308/23-162	26
s.	B	A	$\overline{\text{Aux Time Sync BA}}$	P	M24308/23-162	24
t.	B	A	$\overline{\text{Aux Time Sync BA}}$	N	M24308/23-162	25

5.2.1.1.3.4.3 The CPM B Discrete Signals interfacing with the Bus-subsystem side A shall conform to the following pinout:

Subparagraph	Bus	CPM	Signal name	Differential Signal Polarity	CPM Connector	Connector pin #
a.	A	B	Gnd		M24308/23-162	1
b.	A	B	$\overline{\text{CPM Select AB}}$	P	M24308/23-162	2
c.	A	B	$\overline{\text{CPM Select AB}}$	N	M24308/23-162	3
d.	A	B	$\overline{\text{CPM Hard Reset AB}}$	P	M24308/23-162	4
e.	A	B	$\overline{\text{CPM Hard Reset AB}}$	N	M24308/23-162	5
f.	A	B	$\overline{\text{CPM Soft Reset AB}}$	P	M24308/23-162	6
g.	A	B	$\overline{\text{CPM Soft Reset AB}}$	N	M24308/23-162	7
h.	A	B	Gnd		M24308/23-162	9
i.	A	B	Gnd		M24308/23-162	10
j.	A	B	$\overline{\text{Bus Time Sync AB}}$	P	M24308/23-162	11
k.	A	B	$\overline{\text{Bus Time Sync AB}}$	N	M24308/23-162	12
l.	A	B	$\overline{\text{CPM Ready AB}}$	P	M24308/23-162	13
m.	A	B	$\overline{\text{CPM Ready AB}}$	N	M24308/23-162	14
n.	A	B	CPM Fault AB	P	M24308/23-162	15
o.	A	B	CPM Fault AB	N	M24308/23-162	16
p.	A	B	Gnd		M24308/23-162	18
q.	A	B	Gnd		M24308/23-162	19
r.	A	B	Gnd		M24308/23-162	26
s.	A	B	$\overline{\text{Aux Time Sync AB}}$	P	M24308/23-162	24

Subparagraph	Bus	CPM	Signal name	Differential Signal Polarity	CPM Connector	Connector pin #
t.	A	B	Aux Time Sync AB	N	M24308/23-162	25

5.2.1.1.3.4.4 The CPM B Discrete Signals interfacing with the Bus-subsystem side B shall conform to the following pinout:

Subparagraph	Bus	CPM	Signal name	Differential Signal Polarity	CPM Connector	Connector pin #
a.	B	B	Gnd		M24308/23-162	1
b.	B	B	CPM Select BB	P	M24308/23-162	2
c.	B	B	CPM Select BB	N	M24308/23-162	3
d.	B	B	CPM Hard Reset BB	P	M24308/23-162	4
e.	B	B	CPM Hard Reset BB	N	M24308/23-162	5
f.	B	B	CPM Soft Reset BB	P	M24308/23-162	6
g.	B	B	CPM Soft Reset BB	N	M24308/23-162	7
h.	B	B	Gnd		M24308/23-162	9
i.	B	B	Gnd		M24308/23-162	10
j.	B	B	Bus Time Sync BB	P	M24308/23-162	11
k.	B	B	Bus Time Sync BB	N	M24308/23-162	12
l.	B	B	CPM Ready BB	P	M24308/23-162	13
m.	B	B	CPM Ready BB	N	M24308/23-162	14
n.	B	B	CPM Fault BB	P	M24308/23-162	15
o.	B	B	CPM Fault BB	N	M24308/23-162	16
p.	B	B	Gnd		M24308/23-162	18

Subparagraph	Bus	CPM	Signal name	Differential Signal Polarity	CPM Connector	Connector pin #
q.	B	B	Gnd		M24308/23-162	19
r.	B	B	Gnd		M24308/23-162	26
s.	B	B	$\overline{\text{Aux Time Sync BB}}$	P	M24308/23-162	24
t.	B	B	$\overline{\text{Aux Time Sync BB}}$	N	M24308/23-162	25

5.2.1.1.3.5 CPM Input (from Bus-subsystem) Discrete Signal Characteristics

5.2.1.1.3.5.1 $\overline{\text{CPM Select}}$

5.2.1.1.3.5.1.1 Each CPM shall interpret its $\overline{\text{CPM Select}}$ discrete input as asserted when the signal is a logic 0.

5.2.1.1.3.5.1.2 The CPM A shall enable SpaceWire communication with Bus-subsystem side-A when the $\overline{\text{CPM Select AA}}$ signal is asserted.

5.2.1.1.3.5.1.3 The CPM A shall disable SpaceWire communication with Bus-subsystem side-A when the $\overline{\text{CPM Select AA}}$ signal is de-asserted.

5.2.1.1.3.5.1.4 The CPM A shall enable SpaceWire communication with Bus-subsystem side-B when the $\overline{\text{CPM Select BA}}$ signal is asserted.

5.2.1.1.3.5.1.5 The CPM A shall disable SpaceWire communication with Bus-subsystem side-B when the $\overline{\text{CPM Select BA}}$ signal is de-asserted.

5.2.1.1.3.5.1.6 The CPM B shall enable SpaceWire communication with Bus-subsystem side-A when the $\overline{\text{CPM Select AB}}$ signal is asserted.

5.2.1.1.3.5.1.7 The CPM B shall disable SpaceWire communication with Bus-subsystem side-A when the $\overline{\text{CPM Select AB}}$ signal is de-asserted.

5.2.1.1.3.5.1.8 The CPM B shall enable SpaceWire communication with Bus-subsystem side-B when the $\overline{\text{CPM Select BB}}$ signal is asserted.

5.2.1.1.3.5.1.9 The CPM B shall disable SpaceWire communication with Bus-subsystem side-B when the $\overline{\text{CPM Select BB}}$ signal is de-asserted.

5.2.1.1.3.5.2 CPM Hard Reset

5.2.1.1.3.5.2.1 When the CPM Hard Reset Discrete Command input is driven to logic 0 for 10 milliseconds (+/-10%) and subsequently transitions to logic 1 for at least 10 milliseconds, the CPM shall perform a hard reset.

5.2.1.1.3.5.2.2 After processing a Hard Reset the CPM shall enter the Idle mode.

5.2.1.1.3.5.3 CPM Soft Reset

5.2.1.1.3.5.3.1 When the CPM Soft Reset C&DH interface signal input is driven to logic 0 for 10 milliseconds (+/-10%) and subsequently transitions to logic 1 for at least 10 milliseconds, the CPM shall reload its operating system and flight software.

5.2.1.1.3.5.3.2 After processing a soft reset the CPM shall enter the Idle mode.

5.2.1.1.3.5.4 Bus Time Sync

Setting time is a two-step process. The Bus-subsystem would send the CPM the value of an approaching time via SpaceWire. When that time is reached, the falling edge of the Bus-subsystem's Bus Time Sync signal will occur and, in response to that signal, the CPM would load the time value into an internal time-keeping register.

5.2.1.1.3.5.4.1 The CPM shall use the falling edge (logic 1 to 0 transition) of the **Bus Time Sync** signal to serve as the time of reference instance for synchronization.

5.2.1.1.3.6 CPM Output (to Bus-Subsystem) Discrete Signal Characteristics

5.2.1.1.3.6.1 CPM Ready

This signal will be used by the CPM to indicate when it has powered up successfully and is ready for operation.

5.2.1.1.3.6.1.1 Assertion of the CPM Ready discrete output shall be logic 0.

5.2.1.1.3.6.1.2 The CPM shall assert its CPM Ready discrete output after the following conditions have been met:

Subparagraph	
a.	The CPM has successfully booted up
b.	CPM has passed post-boot diagnostic tests
c.	Local version of flight software ready for use
d.	SpaceWire services are ready for operations

5.2.1.1.3.6.1.3 CPM Ready shall be logic 1 when the CPM SpaceWire is not ready for operations or reset (hard reset or soft reset) occurs.

5.2.1.1.3.6.2 CPM Fault

5.2.1.1.3.6.2.1 Assertion of the CPM Fault discrete output shall be logic 1.

5.2.1.1.3.6.2.2 The CPM Fault discrete output shall be asserted when it detects that any of the following conditions occur:

Subparagraph	
a.	SpaceWire communications with the Bus-subsystem are not operational

b.	CPM processor watchdog timer timeout
c.	Detection of an uncorrectable memory error within the basic portion of the CPM

5.2.1.1.3.6.2.3 A CPM fault status shall be clearable by SpaceWire command from the Bus-subsystem. Note: There are multiple options for attempting to clear unit faults (e.g., unit reset [hard or soft], or command) and the method used may depend upon fault type.

5.2.1.1.3.6.3 Aux Time Sync

This signal is used to synchronize the Bus-subsystem with CPM time. The CPM will assert the Aux Time Sync discrete signal when it has reached a specific time. Typically, the CPM would use SpaceWire to send the Bus-subsystem the value of an approaching time for subsequent loading into a Bus-subsystem timer; and, once that exact time is reached the CPM would immediately assert its Aux Time Sync discrete. When the Bus-subsystem edge detects the assertion of the Aux Time Sync signal, it would load the predefined time value into a timekeeping register. This process is repeated periodically to ensure that CPM time and Bus-subsystem time are synchronized.

5.2.1.1.3.6.3.1 The CPM shall assert the Aux Time Sync discrete when the Bus-Subsystem is to synchronize its time with the CPM time.

5.2.1.1.3.6.3.2 The CPM shall de-assert its Aux Time Sync discrete at least 100 microseconds after asserting it.

5.2.1.1.3.6.3.3 The CPM assertion of its Aux Time Sync shall have an accuracy of 25 nS or less relative to the clock used to maintain time within the CPM.

5.2.1.1.4 Passive Analog

5.2.1.1.4.1 Passive Analog (Resistive) Interface Characteristics

Each CPM provides thermal telemetry to the Bus-subsystem for purposes of CPM internal temperature diagnostics.

The return side of each thermistor is ganged together, isolated from all grounds and continues to Bus-subsystem as shown in FIGURE 5. The thermistors will be S-311-P18 (5k ohm at nominal) or equivalent.

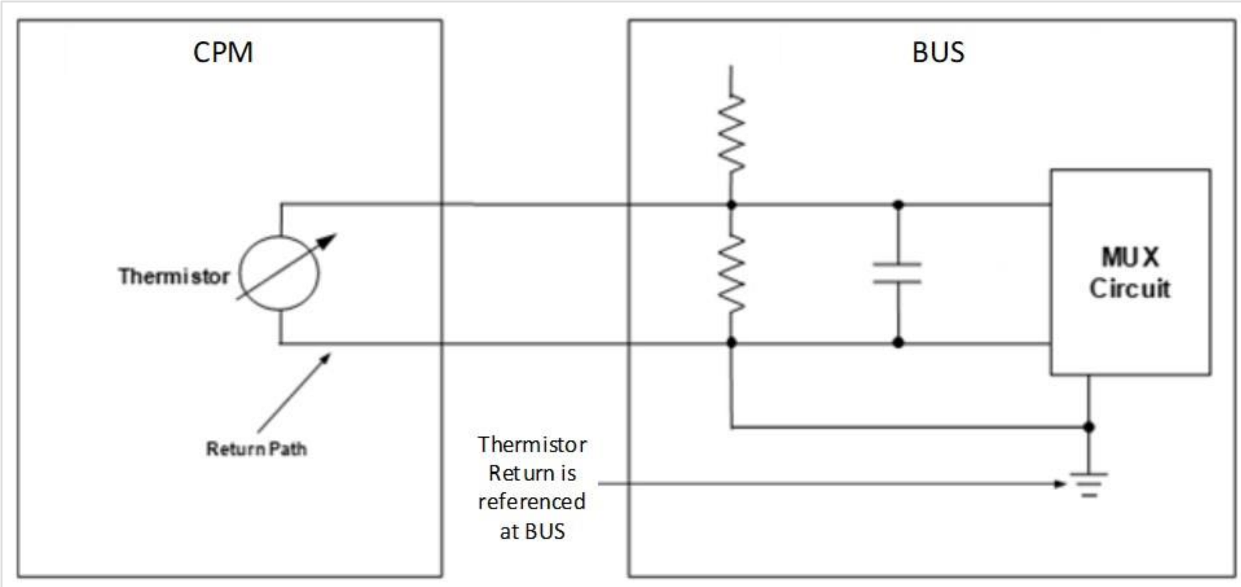


FIGURE 5. CPM to Bus Passive Analog Interface Example.

5.2.1.1.4.1.1 Each CPM passive analog signal shall be a single-ended signal, with a return.

5.2.1.1.4.1.2 The thermistor shall be an S-311-P-18, dash number 5 (5k ohms at nominal) or equivalent.

5.2.1.1.4.1.3 Each CPM passive analog signal shall be isolated from chassis by > 1 Mega Ohm.

5.2.1.1.4.1.4 The Passive Analog high and return wiring in the harness shall be a Twisted-Shield Pair.

5.2.1.1.4.2 Passive Analog (Resistive) Signal Quantity

5.2.1.1.4.2.1 Each CPM portion (i.e., Basic, Router) shall provide at least one and up to four Passive Analog (Resistive) telemetry interfaces to each side of the Bus-subsystem.

Note: Thermal sensors should be placed near the hottest area of each portion of the CPM.

5.2.1.1.4.3 Passive Analog (Resistive) Signal Connector

5.2.1.1.4.3.1 The CPM shall use unit connector part number M24308/23-151 or equivalent (M24308/23-121) for the Passive Analog interface signals.

5.2.1.1.4.3.2 Each CPM portion (e.g., Basic, Router) shall use a separate Passive Analog (Resistive) Signal connector for each Bus-Subsystem side.

5.2.1.1.4.3.3 Passive Analog signals shall have the pinout as specified by TABLE 6.

TABLE 6. CPM Passive Analog Signal Connector Pinout

Connector pin #	Signal name
2	CPM_Therm1
3	CPM_Therm1_RTN
9	CPM_Therm2
10	CPM_Therm2_RTN
17	Spare 1

18	Spare 1 return
24	Spare 2
25	Spare 2 return

5.2.1.1.4.3.4 The Passive Analog pins shall be isolated from the Power discrete signals by a minimum of 2 pins in adjacent rows on the connector.

5.2.1.1.5 CPM Active Analog Output Signals

5.2.1.1.5.1 CPM (Basic Portion) Active Analog Output Signals

5.2.1.1.5.1.1 Each CPM (Basic Portion) redundancy instance shall provide 4 Active Analog output signals for monitoring by the Bus-subsystem.

5.2.1.1.5.1.2 Each CPM redundancy instance shall use connector part number M24308/23-152 or its interface equivalent for its Active Analog output signals.

5.2.1.1.5.1.3 For each CPM (Basic Portion) redundancy instance, the Active Analog output signal connector pin assignments shall be as follows:

Sub-¶	Pin #	Signal identification		Sub-¶	Pin #	Signal identification
a.	1	Ground		n.	14	
b.	2			o.	15	
c.	3	AA01CPMX (+)		p.	16	AA01CPMX (-)
d.	4			q.	17	
e.	5	AA02CPMX (+)		r.	18	AA02CPMX (-)
f.	6			s.	19	
g.	7	AA03CPMX (+)		t.	20	AA03CPMX (-)
h.	8			u.	21	
i.	9	AA04CPMX (+)		v.	22	AA04CPMX (-)
j.	10			w.	23	
k.	11			x.	24	
l.	12			y.	25	
m.	13					

Note: “X” in signal name reserved for redundancy identification (e.g., A, B).

5.2.1.1.5.2 CPM (Router Portion) Active Analog Output Signals

5.2.1.1.5.2.1 Each CPM (Router Portion) redundancy instance shall provide 4 Active Analog output signals for monitoring by the Bus-subsystem.

5.2.1.1.5.2.2 Each CPM redundancy instance shall use connector part number M24308/23-152 or its interface equivalent for its Active Analog output signals.

5.2.1.1.5.2.3 For each CPM redundancy instance, the Active Analog output signal connector pin assignments shall be as follows:

Sub-¶	Pin #	Signal identification		Sub-¶	Pin #	Signal identification
a.	1	Ground		n.	14	
b.	2			o.	15	
c.	3	AA05CPMX (+)		p.	16	AA05CPMX (-)
d.	4			q.	17	
e.	5	AA06CPMX (+)		r.	18	AA06CPMX (-)
f.	6			s.	19	
g.	7	AA07CPMX (+)		t.	20	AA07CPMX (-)
h.	8			U.	21	
i.	9	AA08CPMX (+)		v.	22	AA08CPMX (-)
j.	10			w.	23	
k.	11			x.	24	
l.	12			y.	25	
m.	13					

Note: "X" in signal name reserved for redundancy identification (e.g., A, B).

5.2.1.2 CPM to Payload Interfaces

Each CPM will accommodate up to twelve (12) single-string Payload C&DH (SpaceWire) and high-speed router (SRIO Fat-pipe) interfaces. A second CPM accommodates Payload C&DH and high-speed router interface port redundancy.

5.2.1.2.1SpaceWire

SpaceWire is used as a point-to-point serial command and telemetry interface between each CPM and each payload. A CPM-based SpaceWire router is not used between the CPM and payloads. This method will also enable the CPM, although not required by this standard, to perform payload-to-payload command anomaly detection as part of its cyber security role.

5.2.1.2.1.1 SpaceWire Interface Characteristics

5.2.1.2.1.1.1 After initialization, each CPM SpaceWire receive and transmit interface to each Payload shall independently support a maximum data rate of 100 Mbps.

5.2.1.2.1.1.2 Each CPM to payload SpaceWire external interface shall be designed to preclude damage while it is off and being actively driven by a payload.

5.2.1.2.1.1.3 A CPM-based SpaceWire router shall not be used to transfer information (e.g., commands, data) to or from a payload.
Note: The CPM will receive, process, and, when necessary, individually forward commands and data from a source to a target payload or the Bus-subsystem. An objective, for fault management response purposes, is to minimize information transfer latency, which a router may not be able to accomplish.

5.2.1.2.1.1.4 The CPM to payload SpaceWire external interface shall be designed to preclude damage by a 3.9 V differential input.

5.2.1.2.1.1.5 The CPM to payload SpaceWire external interface shall be designed to limit the unterminated, maximum differential output to a 3.6 V differential.

5.2.1.2.1.2 SpaceWire Quantity

5.2.1.2.1.2.1 Each CPM shall provide 12 SpaceWire ports, one for each (up to 12) payload.
Note: See FIGURE 1.

5.2.1.2.1.3 SpaceWire Connector

5.2.1.2.1.3.1 Each CPM CPM-to-Payload SpaceWire unit connector shall be a rectangular, 9-pin, M83513 (e.g., /04 or /19) connector.

5.2.1.2.1.4 SpaceWire Connector Pinout

5.2.1.2.1.4.1 Each CPM to Payload SpaceWire port shall have the pinout specified in TABLE 2.

5.2.1.2.2 Discrete Signals

5.2.1.2.2.1 CPM Output (to payloads) Discrete Signal Quantity and Names

5.2.1.2.2.1.1 Each CPM shall provide four Discrete Signal outputs to each payload.

5.2.1.2.2.1.2 The Discrete Signals from the CPMs to each payload shall be identified as follows:

Subparagraph	Signal Name (“N” used to simplify iterations 1-12) [CPM & payload signal base names are identical]	From: CPM	To: Payload Interface Port Side	To: Suggested payload #
a.	$\overline{\text{PL IF Port Select A "N"}}$	A	A	“N”
b.	$\overline{\text{PL Hard Reset A "N"}}$	A	A	“N”
c.	$\overline{\text{PL Soft Reset A "N"}}$	A	A	“N”
d.	$\overline{\text{PL Time Sync A "N"}}$	A	A	“N”
e.	$\overline{\text{PL IF Port Select B "N"}}$	B	B	“N”
f.	$\overline{\text{PL Hard Reset B "N"}}$	B	B	“N”
g.	$\overline{\text{PL Soft Reset B "N"}}$	B	B	“N”
h.	$\overline{\text{PL Time Sync B "N"}}$	B	B	“N”

5.2.1.2.2.2 CPM Input (from payloads) Discrete Signal Quantity and Names

5.2.1.2.2.2.1 Each CPM shall receive three Discrete Signal inputs from each payload.

5.2.1.2.2.2.2 One of the Discrete Signals inputs shall be reserved for general purpose use.
Note: If a payload is used to provide an alternate time sync signal, for example, the CPM input designated for general purpose use would be used to receive that time sync signal.

5.2.1.2.2.2.3 The CPM Discrete Signals inputs from the payloads shall be identified as follows:

Subparagraph	**Signal Name** (“N” used to simplify iterations 1-12) [CPM & payload signal base names are identical]	**To:** **CPM**	**From:** **Suggested payload #**
a.	$\overline{\text{PL Ready A "N"}}$	A	“N”
b.	PL Fault A “N”	A	“N”
c.	$\overline{\text{PL General Purpose A "N"}}$	A	“N”
d.	$\overline{\text{PL Ready B "N"}}$	B	“N”
e.	PL Fault B “N”	B	“N”
f.	$\overline{\text{PL General Purpose B "N"}}$	B	“N”

5.2.1.2.2.3 Discrete Signal Connector

5.2.1.2.2.3.1 The CPM Discrete Signal unit connector part number shall be M24308/23-165 or equivalent (M24308/23-177).

5.2.1.2.2.4 CPM Output and Input Discrete Signal Pinout

5.2.1.2.2.4.1 The CPM Discrete Signals interfacing with the payloads shall conform to the pinout specified in Appendix A, TABLE 9 for CPM A and TABLE 10 for CPM B.

5.2.1.2.2.5 CPM Output (to payloads) Discrete Signal Characteristics

5.2.1.2.2.5.1 $\overline{\text{PL IF Port Select}}$

5.2.1.2.2.5.1.1 To enable a specific Payload port to actively communicate with a CPM, the CPM shall apply a logic 0 to its $\overline{\text{PL IF Port Select}}$ signal dedicated for that payload.

5.2.1.2.2.5.1.2 To disable a specific Payload C&DH interface, the CPM shall apply a logic 1 to the respective payload’s $\overline{\text{PL IF Port Select}}$ signal.

5.2.1.2.2.5.2 $\overline{\text{PL Hard Reset}}$

5.2.1.2.2.5.2.1 To cause a payload to perform a hard reset, the CPM shall set the respective payloads $\overline{\text{PL Hard Reset}}$ signal to logic 0 for 10 milliseconds (+/-10%) and subsequently transition to logic 1 for at least 10 milliseconds.

5.2.1.2.2.5.3 $\overline{\text{PL Soft Reset}}$

5.2.1.2.2.5.3.1 For a CPM to cause a specific Payload C&DH interface to abort execution of its application software, without removing power (primary or secondary) or resetting the payloads hardware functions, the CPM shall apply a logic 0 to the respective payload's $\overline{\text{PL Soft Reset}}$ discrete for 10 milliseconds (+/-10%) and then apply a logic 1 for at least 10 milliseconds.

5.2.1.2.2.5.4 $\overline{\text{PL Time Sync}}$

The $\overline{\text{PL Time Sync}}$ signal is a discrete output to payloads to synchronize their internal time to a common time domain. The CPM provides a payload time management function. The original source of the time to be synchronized is either the Bus-subsystem or a payload.

5.2.1.2.2.5.4.1 To notify a specific payload when a predefined time occurs, the CPM shall generate a logic 0 pulse for 100 microseconds to the respective payloads $\overline{\text{PL Time Sync}}$ output.

5.2.1.2.2.5.4.2 The CPM shall use the falling edge (logic 1 to 0 transition) of the $\overline{\text{PL Time Sync}}$ signal to serve as the time of reference instance for synchronization.

5.2.1.2.2.5.4.3 The CPM $\overline{\text{PL Time Sync}}$ shall have an accuracy of 25 nS or less relative to the falling edge of the clock used to maintain time within the CPM.

5.2.1.2.2.6 CPM Input (from Payloads) Discrete Signal Characteristics

5.2.1.2.2.6.1 $\overline{\text{PL Ready}}$

The $\overline{\text{PL Ready}}$ discrete represents an input to the CPM from the Payload domain. The discrete will become a logic 1 during a payload power-on or Hard Reset event and will return to a logic 0 once the payload is ready to conduct C&DH SpaceWire transactions with the CPM.

5.2.1.2.2.6.1.1 The CPM shall individually recognize each $\overline{\text{PL Ready}}$ input as valid after the input has been a logic 0 for 10 microseconds.

5.2.1.2.2.6.1.2 The CPM shall only initiate command and data handling SpaceWire transactions with a payload after that payload has asserted a valid $\overline{\text{PL Ready}}$ input to the CPM.

5.2.1.2.2.6.2 PL Fault

The PL Fault discrete represents an input to the CPM from the Payload domain. After a payload is ready its PL Fault discrete will only become a logic 1 if the payload is reporting a fault or it is no longer operational (e.g., power was removed).

5.2.1.2.2.6.2.1 The CPM shall individually recognize each PL Fault input as valid after the input has been a logic 1 for 10 microseconds.

5.2.1.2.2.6.2.2 The state of each PL Fault input shall be registered and accessible by the CPM processor.

5.2.1.2.2.6.2.3 A valid PL Fault logic 1 shall be capable of interrupting the CPM processor.

5.2.1.2.2.6.3 Alt Source Time Sync

This payload sourced signal is not commonly provided by payloads; consequently, a discrete signal is not directly specified for this function. Instead, this signal would use the

PL General Purpose signal, which may be used for this or another unique payload to CPM discrete signaling.

The CPM PL Time Sync signal is a discrete output to payloads to synchronize their internal time to a common time domain. While the CPM provides a Payload time management function, its original source of time is either the Bus-subsystem or a payload. Consequently, the CPM PL Time Sync signal timing is derived from either the Bus Time Sync signal from the Bus-subsystem or the Alt Source Time Sync signal from a payload.

5.2.1.2.2.6.3.1 When a payload provides an Alt Source Time Sync across its PL General Purpose discrete signal, the CPM shall interpret the assertion of that signal as a transition from a logic 1 state to transition logic 0 state.

5.2.1.2.2.6.4 PL General Purpose

The PL General Purpose signal is reserved for use in the event that there is a need for a payload to provide a unique signal to the CPM units. For example, if a payload includes a time source useful to the system or managing the payloads, that payload could provide an auxiliary or primary time sync pulse to the CPM. In fact, the Alternate Source Time Source signal specified in this standard, which would stem from only one payload, would use this general-purpose signal.

5.2.1.2.2.6.4.1 The CPM shall interpret an event indication on each PL General Purpose discrete signal as a transition from a logic 1 state to transition logic 0 state.

5.2.1.2.2.6.4.2 Each CPM shall be able to select whether the PL General Purpose input would set a CPM processor interrupt or be used to reload the Auxiliary Payload Time Domain Source Time Sync register.

5.2.1.2.2.6.4.3 The state of each PL General Purpose discrete signal shall be registered and accessible by the CPM processor.

5.2.1.2.2.6.4.4 When the PL General Purpose signal is used to drive a CPM processor interrupt, a transition from logic 1 to 0 will set the CPM interrupt.

5.2.1.2.2.6.4.5 When the PL General Purpose signal is used to reload the Auxiliary Payload Time Domain register, a transition from logic 1 to 0 will load the register.

5.2.1.2.3 Serial RapidIO

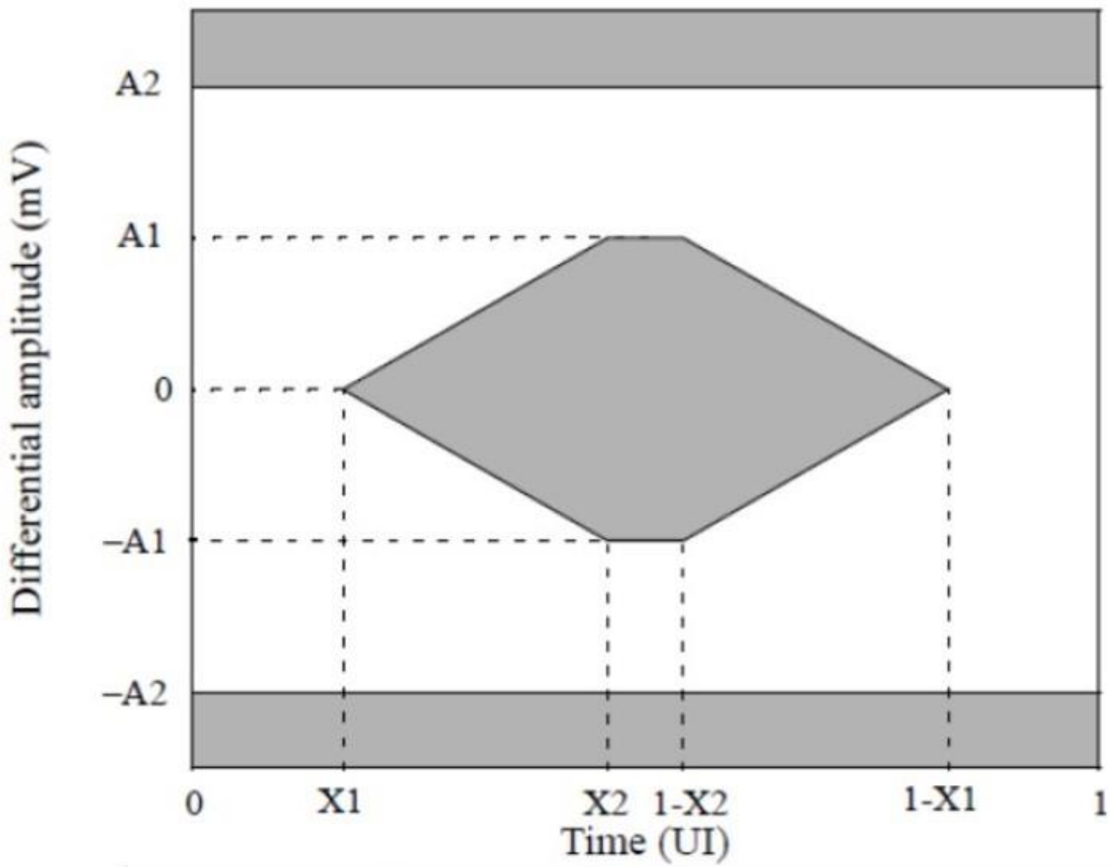
5.2.1.2.3.1 SRIO Characteristics

5.2.1.2.3.1.1 The CPM router portion shall support SRIO packet switching capabilities.

5.2.1.2.3.1.2 CPM SRIO data-transmit far-end (i.e., payload receive side) eye pattern measurements while signaling across a flight application equivalent medium (e.g., copper wire of same gauge, length, performance characteristic) shall satisfy the eye pattern in FIGURE 6.

5.2.1.2.3.1.3 CPM shall correctly recover data that satisfies the SRIO eye pattern in FIGURE 6 with a bit error rate of less than 1E-12 and 95% confidence.

5.2.1.2.3.1.4 A free running pseudo-random bit-sequence per chapter 5.8 of [ITU-T-T O.150 with corrigendum May 2002] shall be used for the testing of bit error rate compliance.



Symbol	Rx At CPM Unit Connector	Units
X1	0.285	UI
X2	0.390	UI
A1	125	mV
A2	800	mV

FIGURE 6. Receive data eye at unit connector (or end of cable).

5.2.1.2.3.1.5 The CPM shall provide an independent Bit Error Rate (BER) built in test (BIT) for each SERDES interface lane.

5.2.1.2.3.1.6 Each CPM SRIO interface shall be designed to preclude damage while it is off and being actively driven by payload.
Note: Active voltage of +/- 0.800 V.

5.2.1.2.3.2 SRIO Quantity and Name

5.2.1.2.3.2.1 Each CPM shall provide twelve (12) SRIO Fat Pipe ports, one for each (up to 12) payload.

5.2.1.2.3.2.2 The SRIO ports to each payload shall be identified and connected as follows:

Subparagraph	Port Name	Signal Type	Provided by:	CPM Connector	To: Payload Interface Port Side	To: Suggested payload #
a.	RIO_1A	SRIO	CPM A	J101	A	1
b.	RIO_2A	SRIO	CPM A	J102	A	2
c.	RIO_3A	SRIO	CPM A	J103	A	3
d.	RIO_4A	SRIO	CPM A	J104	A	4
e.	RIO_5A	SRIO	CPM A	J105	A	5
f.	RIO_6A	SRIO	CPM A	J106	A	6
g.	RIO_7A	SRIO	CPM A	J107	A	7
h.	RIO_8A	SRIO	CPM A	J108	A	8
i.	RIO_9A	SRIO	CPM A	J109	A	9
j.	RIO_10A	SRIO	CPM A	J110	A	10
k.	RIO_11A	SRIO	CPM A	J111	A	11
l.	RIO_12A	SRIO	CPM A	J112	A	12
m.	RIO_1B	SRIO	CPM B	J101	B	1
n.	RIO_2B	SRIO	CPM B	J102	B	2
o.	RIO_3B	SRIO	CPM B	J103	B	3
p.	RIO_4B	SRIO	CPM B	J104	B	4
q.	RIO_5B	SRIO	CPM B	J105	B	5
r.	RIO_6B	SRIO	CPM B	J106	B	6
s.	RIO_7B	SRIO	CPM B	J107	B	7
t.	RIO_8B	SRIO	CPM B	J108	B	8
u.	RIO_9B	SRIO	CPM B	J109	B	9
v.	RIO_10B	SRIO	CPM B	J110	B	10
w.	RIO_11B	SRIO	CPM B	J111	B	11
x.	RIO_12B	SRIO	CPM B	J112	B	12

5.2.1.2.3.2.3 CPM A shall provide an SRIO Fat pipe to port-A of each payload.

5.2.1.2.3.2.4 CPM B shall provide an SRIO Fat pipe to port-B of each payload.

5.2.1.2.3.3 SRIO Connector

5.2.1.2.3.3.1 Each CPM SRIO unit connector shall satisfy the connector attributes specified in TABLE 3.

5.2.1.2.3.4 SRIO Pinout

5.2.1.2.3.4.1 Each CPM SRIO unit connector shall have the pinout specified in TABLE 4.

5.2.1.3 CPM to CPM Interfaces

5.2.1.3.1 SpaceWire

When the CPMs are configured to support a Hot-Hot redundancy configuration, there is a need for CPM A and CPM B to communicate with each other to ensure the monitor CPM receives the latest telemetry information from the currently active CPM. SpaceWire is used as the means for the active CPM to provide that information to the monitor CPM, thereby enabling the monitor CPM (e.g., CPM B), in the event of a failure of the currently active CPM (e.g., CPM A), to rapidly take over the role as the new active CPM. Each CPM has a discrete signal output to an input on the other CPM indicating whether the CPM is in the Active mode.

5.2.1.3.1.1 SpaceWire Interface Characteristics

5.2.1.3.1.1.1 In support of the Hot-Hot configuration, the CPM A SpW_Hot port shall interface with the CPM B SpW_Hot port.

5.2.1.3.1.1.2 In the Hot-Hot configuration, after initialization, each CPM SpaceWire receive and transmit interface to the other CPM shall independently support a maximum data rate of 100 Mbps.

5.2.1.3.1.2 SpaceWire Quantity and Names

5.2.1.3.1.2.1 Each CPM shall provide a SpaceWire port dedicated for use only when the CPMs are configured for a Hot-Hot configuration.

5.2.1.3.1.2.2 In support of the Hot-Hot configurations, the SpaceWire ports between the CPM A and CPM B shall be identified and connected as follows:

Subparagraph	From CPM	Port Name	To CPM
a.	A	SpW_Hot	B
b.	B	SpW_Hot	A

5.2.1.3.1.3 SpaceWire Connector

5.2.1.3.1.3.1 The CPM CPM-to-CPM SpaceWire unit connector part number shall be a rectangular, 9-pin, M83513 (e.g., /04 or /19) connector.

5.2.1.3.1.4 SpaceWire Pinout

5.2.1.3.1.4.1 The CPM to CPM SpaceWire unit connector pinouts shall have the pinout specified in TABLE 2.

5.2.1.3.2 Discrete Signals

5.2.1.3.2.1 Discrete Signal (Output) Interface

5.2.1.3.2.1.1 When a CPM is commanded by the Bus-subsystem to enter Monitor Mode, it shall set the $\overline{\text{CPM Active Out}}$ discrete to logic 1.

5.2.1.3.2.1.2 When a CPM is commanded by the Bus-subsystem to enter Active Mode, it shall set the $\overline{\text{CPM Active Out}}$ discrete to logic 0.

5.2.1.3.2.1.3 When a CPM in the Active Mode detects that its watchdog timer timed-out or the CPM detects a multi-bit memory error it shall set the $\overline{\text{CPM Active Out}}$ discrete to logic 1.

5.2.1.3.2.1.4 When a CPM is in the Monitor Mode and it detects that the other CPM has set its $\overline{\text{CPM Active Out}}$ discrete to logic 1, the CPM that is currently in Monitor Mode shall transition to Active Mode and perform the Active Mode function (including assuming payload interface management control) within 500 milliseconds, unless otherwise specified by mission requirements.

5.2.1.3.2.1.5 When in the Hot-Hot configuration, to notify the Monitor CPM when a predefined time (transported via CPM to CPM SpaceWire interface) occurs, the Active CPM shall assert its $\overline{\text{Active Time Sync Out}}$ discrete with a logic 0 for at least 100 microseconds then de-asserted with a logic 1.

5.2.1.3.2.1.6 The falling edge (logic 1 to 0 transition) of the Active CPM's $\overline{\text{Active Time Sync Out}}$ signal shall occur within 25 nS of the predefined time.

5.2.1.3.2.2 Discrete Signal (Output) Quantity and Names

5.2.1.3.2.2.1 The Hot-Hot Discrete Signal output of each CPM shall be identified and connected as follows:

Subparagraph	Signal Name	CPM Connector	Pin #	Polarity
a.	Gnd	M24308/23-119	1	
b.	$\overline{\text{CPM Active Out}}$	M24308/23-119	2	P
c.	$\overline{\text{CPM Active Out}}$	M24308/23-119	3	N
d.	$\overline{\text{Active Time Sync Out}}$	M24308/23-119	10	P
e.	$\overline{\text{Active Time Sync Out}}$	M24308/23-119	11	N

Note: The CPM to CPM Discrete Signal output and input signals use the same connector.

5.2.1.3.2.3 Discrete Signal (Input) Interface

5.2.1.3.2.3.1 A CPM shall interpret a logic 1 from its $\overline{\text{CPM Active In}}$ input signal that the other CPM is in Monitor Mode.

5.2.1.3.2.3.2 A CPM shall interpret a logic 0 from its $\overline{\text{CPM Active In}}$ input signal that the other CPM is in Active Mode.

5.2.1.3.2.4 Discrete Signal (Input) Quantity and Names

5.2.1.3.2.4.1 The Hot-Hot Discrete Signal input of each CPM shall be identified and connected as follows:

Subparagraph	Signal Name	CPM Connector	Pin #	Polarity
a.	$\overline{\text{CPM Active In}}$	M24308/23-119	4	P
b.	$\overline{\text{CPM Active In}}$	M24308/23-119	5	N

Subparagraph	Signal Name	CPM Connector	Pin #	Polarity
c.	Gnd	M24308/23-119	8, 9, 15	
d.	Active Time Sync In	M24308/23-119	12	P
e.	Active Time Sync In	M24308/23-119	13	N

Note: The CPM to CPM Discrete Signal output and input signals use the same connector.

5.2.1.3.2.5 Discrete Signal Connector

5.2.1.3.2.5.1 The unit connector part number for CPM to CPM Discrete signals shall be M24308/23-120.

5.2.1.3.2.6 Discrete Signal Pinout

5.2.1.3.2.6.1 The Hot-Hot CPM-to-CPM Discrete signal interface shall conform to the following pinout:

Subparagraph	Signal name	Differential Signal Polarity	CPM Connector	Connector pin #
a.	GND		M24308/23-120	1
b.	CPM_Active_Out	P	M24308/23-120	2
c.	CPM_Active_Out	N	M24308/23-120	3
d.	CPM_Active_In	P	M24308/23-120	4
e.	CPM_Active_In	N	M24308/23-120	5
f.	GND		M24308/23-120	8
g.	GND		M24308/23-120	9
h.	Active_Time_Sync_Out	P	M24308/23-120	10
i.	Active_Time_Sync_Out	N	M24308/23-120	11
j.	Active_Time_Sync_In	P	M24308/23-120	12
k.	Active_Time_Sync_In	N	M24308/23-120	13
l.	GND		M24308/23-120	15

5.2.2 CPM Functional Requirements

5.2.2.1 Power On and Off

5.2.2.1.1 Upon initial application of power to the CPM basic portion, it shall enter Standby state.

5.2.2.1.2 After initial power on, the CPM shall enter Idle mode.

5.2.2.1.3 When power is applied to the basic portion and the router portion, the CPM shall enter Operational state.

5.2.2.2 States and Modes

The diagram in FIGURE 7 depicts valid CPM states and modes. While the CPM flight software may include autonomous actions to transition from one mode to another, those actions are not capabilities associated with this interface standard; hence, they are not shown here.

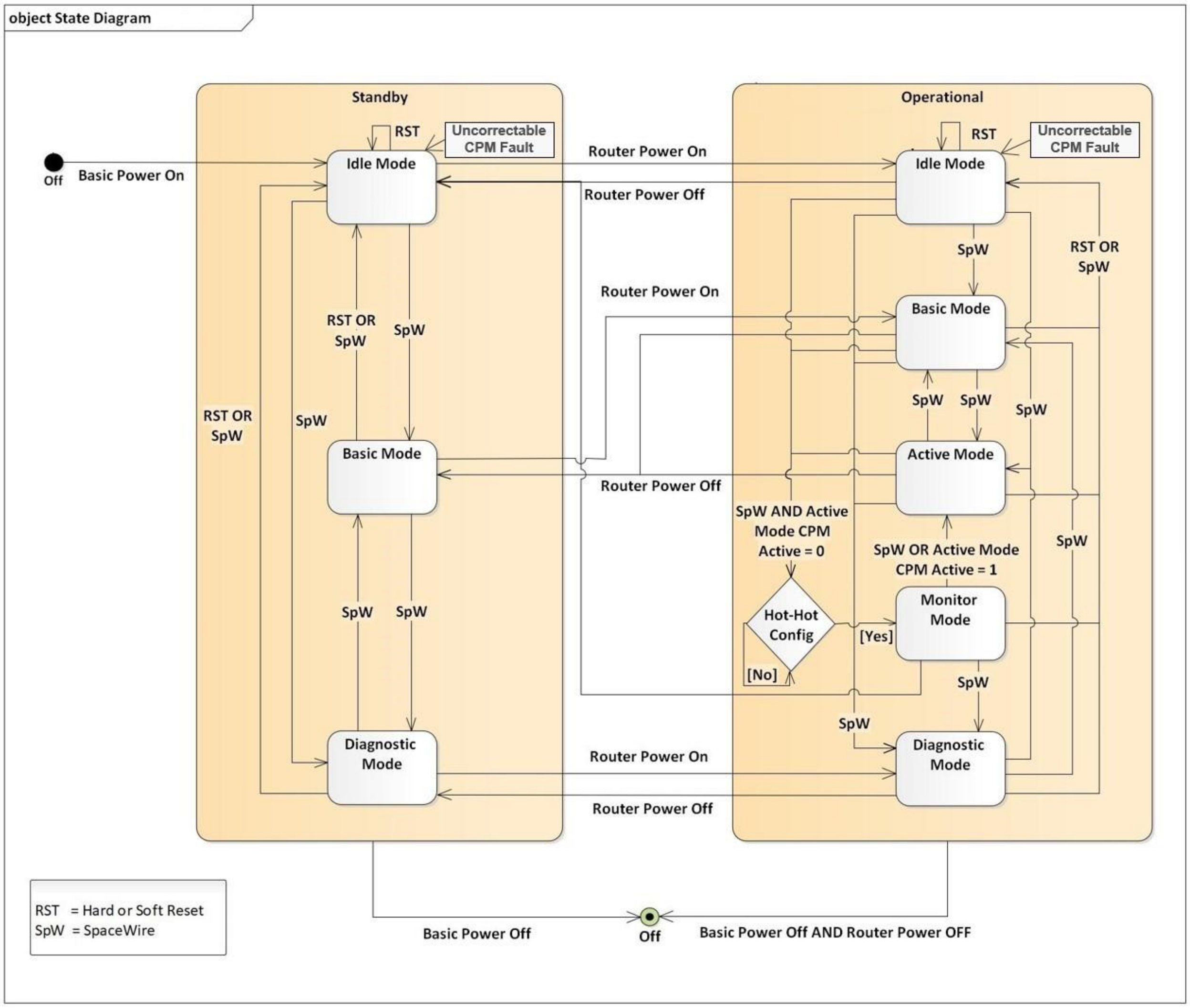


FIGURE 7. CPM States and Modes.

5.2.2.2.1 States

5.2.2.2.1.1 A CPM shall be in a Standby state when its basic portion is powered on and its router portion is off.

5.2.2.2.1.2 A CPM shall be in an Operational state when its basic portion and router portion is powered on.

5.2.2.2.2 Modes

5.2.2.2.2.1 The CPM shall enter a valid mode when commanded (via SpaceWire) by the Bus-subsystem to enter that mode.

5.2.2.2.2.2 When commanded by the Bus-subsystem (via SpaceWire) to reset the Router portion, the CPM Basic shall cause the Router portion to perform a hard reset.

5.2.2.2.2.3 When commanded by the Bus-subsystem (via SpaceWire) to reinitialize the Router portion flight software, the CPM Basic shall cause the Router portion to perform a soft reset.

5.2.2.2.3 Standby State and Modes

5.2.2.2.3.1 In the Standby state, a CPM shall have only three modes: Idle, Diagnostic, and Basic.

5.2.2.2.3.2 In Standby state, all mode changes shall be commanded by the Bus-subsystem.
Note: A command may be sent to set a logic value in non-volatile CPM memory that if checked after a CPM entered Idle mode would authorize that CPM to autonomously enter another valid mode, such as Basic.

5.2.2.2.3.3 A CPM shall be capable of transitioning to the Standby state under the following conditions:

Subparagraph	Conditions
a.	From a power off condition after power is supplied to the Basic portion only.
b.	When power is supplied to the Basic portion and Router portion but is then removed from the Router portion.

5.2.2.2.3.4 In the Standby state and Idle mode, the following CPM functionality shall be enabled:

Subparagraph	Functionality
a.	Communication with the Bus-subsystem via SpaceWire
b.	All discrete signals with the Bus-subsystem
c.	When configured in a Hot-Hot configuration, all discrete signals with the other CPM
d.	When configured in a Hot-Hot configuration, communication with the other CPM over the SpW_Hot SpaceWire interface

5.2.2.2.3.5 In the Standby state and Basic mode, the following CPM functionality shall be enabled:

Subparagraph	Functionality
a.	Communication with the Bus-subsystem via SpaceWire
b.	All discrete signals with the Bus-subsystem

Subparagraph	Functionality
c.	When configured in a Hot-Hot configuration, all discrete signals with the other CPM
d.	When configured in a Hot-Hot configuration, communication with the other CPM over the SpW_Hot SpaceWire interface
e.	All discrete signals with the payloads
f.	Communication with the payloads via SpaceWire

5.2.2.2.3.6 The CPM shall use the Standby state, Diagnostic mode to communicate with the Bus-subsystem to diagnose a problem with the CPM.

5.2.2.2.4 Operational State and Modes

5.2.2.2.4.1 In the Operational state, a normally operating CPM shall be able to achieve the following modes:

Subparagraph	Modes
a.	Idle
b.	Basic
c.	Active Mode
d.	Diagnostic Mode
e.	Monitor Mode (only applicable when CPMs are configured in a Hot-Hot configuration)

5.2.2.2.4.2 Upon entering Active Mode, a CPM shall assume payload interface management control.

5.2.2.2.4.3 The CPM shall support mission data routing while in the Active Mode and Diagnostic Mode.

5.2.2.2.4.4 In a Hot-Hot configuration when neither of the CPMs are in the Idle, Basic, or Diagnostic Mode, one CPM shall be in the Operational state and Active mode while the other is in the Operational state and Monitor mode.

5.2.2.2.4.5 While operating in the Hot-Hot configuration, the CPM currently in Monitor mode shall receive from the CPM in Active mode all of the bus-subsystem and payload state and telemetry information necessary for the Monitor mode CPM to, upon detection of a fault in the Active mode CPM, subsume the role of an Active CPM within the transition period (e.g., 1 second) required by the mission.

5.2.2.2.4.6 While operating in the Hot-Hot configuration, the CPM currently in Active mode shall set and maintain its $\overline{\text{CPM Active Out}}$ discrete to a logic 0 until it detects an internal fault (e.g., watchdog timeout, double-bit memory error).

5.2.2.2.4.7 While operating in the Hot-Hot configuration, when the Active mode CPM detects an internal fault warranting setting its $\overline{\text{CPM Active Out}}$ discrete to logic 1, it shall – within 1 mS - set its CPM Fault discrete signals to the Bus-subsystem to logic 1 and terminate payload interface control.

5.2.2.2.4.8 While operating in the Hot-Hot configuration, when the Monitor CPM detects a logic 1 from its $\overline{\text{CPM Active In}}$ discrete, it shall set its $\overline{\text{CPM Active Out}}$ discrete to a logic 0.

5.2.2.2.4.9 When two CPMs are functioning properly in a Hot-Warm configuration, one CPM shall be in the Operational state and Active mode while the other is in the Standby state and Idle mode.

5.2.2.2.4.10 When in a Hot-Cold configuration, one CPM shall be powered off while the other is in a valid state and mode.

5.2.2.3 Telemetry

5.2.2.3.1 The CPM shall send and receive digital telemetry via SpaceWire and discrete signals.

5.2.2.3.2 Upon receiving a telemetry request from the Bus-subsystem, the CPM shall respond with the requested telemetry via SpaceWire.

5.2.2.3.3 A CPM in the Active Mode shall request telemetry from each Payload interface via SpaceWire.

5.2.2.3.4 The CPM shall store (at a minimum) the most recent telemetry sourced by the CPM and each payload.

5.2.2.3.5 In a Hot-Warm configuration, a CPM in the Basic Mode shall request telemetry from each Payload interface via SpaceWire.

5.2.2.3.6 In a Hot-Hot configuration, only one CPM in the Basic Mode shall request telemetry from each Payload interface via SpaceWire.

5.2.2.4 Time Management

5.2.2.4.1 CPM Time Management

5.2.2.4.1.1 The CPM shall collect, synchronize, and distribute spacecraft time domain services. Note: The time domain may be synchronized to a Bus-subsystem provided time, or a payload provided time (or both) depending on the mission requirements.

5.2.2.4.1.2 The CPM time source (i.e., Bus-subsystem time or Auxiliary Payload time) provided to the payloads shall be software selectable.

5.2.2.4.1.3 The CPM time source (i.e., Bus-subsystem time or Auxiliary Payload time) to be used for CPM to CPM time synchronization in a Hot-Hot configuration shall be software selectable.

5.2.2.4.1.4 The CPM shall ensure that the time interval between its issuance of the SpaceWire time message and the assertion of the $\overline{\text{Aux Time Sync}}$ signal is within 200 mS.

5.2.2.4.1.5 The CPM shall ensure that the time interval between its issuance of the SpaceWire time message and the assertion of the $\overline{\text{PL Time Sync}}$ signal is within 200 mS.

5.2.2.4.1.6 In a hot-hot configuration, the Active CPM shall ensure that the time interval between its issuance of the SpaceWire time message and the assertion of the $\overline{\text{Active Time Sync Out}}$ signal is within 200 mS.

5.2.2.4.2 CPM Time Synchronization with The Bus-Subsystem

The CPM time is periodically synchronized with the Bus-subsystem time or (less commonly) with an Auxiliary Payload (e.g., GPS receiver) time. Bus-subsystem time synchronization may be accomplished through Bus-subsystem to CPM communications via a SpaceWire time message that provides the value of an approaching time followed by the assertion of the

$\overline{\text{Bus Time Sync}}$ discrete. The $\overline{\text{Bus Time Sync}}$ discrete signals exactly when the Bus-subsystem time value is to be loaded into the CPM's counter (Bus Domain Time Counter).

5.2.2.4.2.1 The CPM shall support synchronizing CPM Internal Time to Bus-subsystem Time.

5.2.2.4.2.2 Upon receipt of a SpaceWire time message (which contains an approaching Bus-subsystem time value) from the Bus-subsystem, the CPM shall prepare to load that time value into its Bus Domain Time Counter.
Note: That value would be the Bus-subsystem time at next occurrence of the $\overline{\text{Bus Time Sync}}$ discrete.

5.2.2.4.2.3 If the $\overline{\text{Bus Time Sync}}$ discrete is asserted within 200 mS of receiving a SpaceWire message from the Bus-subsystem containing a new time value, coincident with the $\overline{\text{Bus Time Sync}}$ assertion.

5.2.2.4.2.4 If the $\overline{\text{Bus Time Sync}}$ discrete is not asserted within 200 mS of receiving a SpaceWire message from the Bus-subsystem containing a new time value, the CPM shall report the issue to the Bus-subsystem and not update its clock until a valid SpaceWire message and associated $\overline{\text{Bus Time Sync}}$ are received.

5.2.2.4.2.5 If the $\overline{\text{Bus Time Sync}}$ discrete is not asserted within 200 mS of receiving a SpaceWire message from the Bus-subsystem containing a new time value, the CPM shall emulate the Bus-subsystem timing domain signals and messages to the Payload domain using its internal clock until the Bus-subsystem time domain is reestablished

5.2.2.4.2.6 The CPM Bus Domain Time Counter shall have a maximum increment period of 25 nS.

5.2.2.4.2.7 After receiving a SpaceWire message from the Bus-Subsystem containing an approaching time value and receiving the assertion of the $\overline{\text{Bus Time Sync}}$ discrete within 200 mS of that message, the CPM shall update its Bus Domain Time Counter with the provided value within 25 nS of the assertion of the $\overline{\text{Bus Time Sync}}$ discrete signal.

5.2.2.4.3 CPM Time Synchronization with an Auxiliary Payload

The CPM time is periodically synchronized with the Bus-subsystem time or (less commonly) with an Auxiliary Payload (e.g., GPS receiver) time. Auxiliary Payload time synchronization may be accomplished through Auxiliary Payload to CPM communications via a SpaceWire time message that provides the value of an approaching time followed by the assertion of a discrete signal from the Auxiliary Payload (i.e., the Auxiliary Payload's reserved discrete [$\overline{\text{PL General Purpose}}$]). The Auxiliary Payload Time Sync discrete signals exactly when the Auxiliary Payload time value is to be loaded into the CPM's counter (Auxiliary Payload Time Counter).

5.2.2.4.3.1 The CPM shall support synchronizing CPM Internal Time to Auxiliary Payload Time.

5.2.2.4.3.2 The CPM shall maintain a counter (Auxiliary Payload Time Counter) containing Auxiliary Payload time.

5.2.2.4.3.3 The CPM Auxiliary Payload Time Counter shall have a maximum increment period of 25 nS.

5.2.2.4.3.4 Upon receipt of a SpaceWire time message (which contains an approaching Auxiliary Payload time value) from the Auxiliary Payload, the CPM shall prepare to load that time value into its Auxiliary Payload Time Counter.
Note: That value would be the Auxiliary Payload time at next occurrence of the Auxiliary Payload's reserved ($\overline{\text{PL General Purpose}}$) discrete.

5.2.2.4.3.5 If a $\overline{\text{PL General Purpose}}$ discrete (when used for purposes of payload time synchronization) is asserted within 200 mS of receiving a SpaceWire message from that Payload containing a new Auxiliary Payload time value, the CPM shall set its Auxiliary Payload Time Counter to the pending time value.

5.2.2.4.3.6 If a $\overline{\text{PL General Purpose}}$ discrete (when used for purposes of payload time synchronization) is not asserted within 200 mS of receiving a SpaceWire message from that Payload containing a new Auxiliary Payload time value, the CPM shall report the issue to the Auxiliary Payload and not update its clock until a valid SpaceWire message and associated $\overline{\text{PL General Purpose}}$ signal assertion are received.

5.2.2.4.3.7 If a $\overline{\text{PL General Purpose}}$ discrete is not asserted within 200 mS of receiving a SpaceWire message from that Payload containing a new Auxiliary Payload time value, the CPM shall emulate the Auxiliary Payload time domain and issue timing messages to the Payload domain (& Bus-subsystem if it is using payload time) using its internal clock until the Auxiliary Payload time domain is reestablished.

5.2.2.4.3.8 After receiving a SpaceWire message from a Payload containing an approaching Auxiliary Payload Time and receiving the assertion of the $\overline{\text{PL General Purpose}}$ discrete within 200 mS of that message, the CPM shall update its Auxiliary Payload Time Counter with the provided value within 25 nS of the assertion of the $\overline{\text{PL General Purpose}}$ discrete signal.

5.2.2.4.4 Payload time Synchronization with CPM

The CPM time is periodically synchronized with the Bus-subsystem time or with an Auxiliary Payload (e.g., GPS receiver) time. The CPM is responsible for synchronizing the payloads (unless the payload is a timing source) with its time. Payload time synchronization is accomplished through CPM to payload communications via a SpaceWire message followed by the CPM's assertion of the $\overline{\text{PL Time Sync}}$ discrete to relevant payloads. The $\overline{\text{PL Time Sync}}$ discrete signals exactly when the CPM time value is to be loaded into each PL's time counter (PL Time Counter).

5.2.2.4.4.1 The CPM shall broadcast CPM Time via a SpaceWire time message containing a "time now" value to each payload (except for an Auxiliary Time Payload) and subsequently assert its $\overline{\text{PL Time Sync}}$ discrete signals within 25 nS of when that "time now" occurs.

5.2.2.4.4.2 Unless system requirements state otherwise, the CPM shall broadcast CPM Time to the payloads (except for an Auxiliary Time Payload) once per second.

5.2.2.4.5 Monitor CPM Time Synchronization with Active CPM

5.2.2.4.5.1 In a Hot-Hot configuration, the CPMs shall support synchronizing the clock of the Monitor CPM to the clock of the Active CPM.

5.2.2.4.5.2 In the Hot-Hot configuration, the Active CPM shall send a SpaceWire message to the Monitor CPM informing it whether to maintain Bus Domain time or Payload Domain time.

5.2.2.4.5.3 In a Hot-Hot configuration, the Active CPM shall send a SpaceWire time message containing a new (e.g., approaching) time value to the Monitor CPM and subsequently assert its $\overline{\text{Active Time Sync Out}}$ discrete within 25 nS of when the new time occurs.

5.2.2.4.5.4 In a Hot-Hot configuration, unless system requirements state otherwise, the Active CPM shall send CPM Time to the Monitor CPM once per second.

5.2.2.4.5.5 In a Hot-Hot configuration, upon receipt of a SpaceWire time message (which contains an approaching Active CPM time value) from the Active CPM, the Monitor CPM shall prepare to load that time value into its respective Time Counter.

5.2.2.4.5.6 In a Hot-Hot configuration, if the $\overline{\text{Active Time Sync In}}$ discrete is asserted within 200 mS of receiving a SpaceWire message from the Active CPM containing a new time value, the Monitor CPM shall set the respective Time Counter to the pending time value.

5.2.2.4.5.7 In a Hot-Hot configuration, if the $\overline{\text{Active Time Sync In}}$ discrete is not asserted within 200 mS of receiving a SpaceWire message from the Active CPM containing a new time value, the Monitor CPM shall report the issue to the Active CPM and not update its clock until a valid SpaceWire message and associated $\overline{\text{Active Time Sync In}}$ are received.

5.2.2.4.5.8 In a Hot-Hot configuration, if the $\overline{\text{Active Time Sync In}}$ discrete is not asserted within 200 mS of receiving a SpaceWire message from the Active CPM containing a new time value, the Monitor CPM shall emulate the selected time using its internal clock until the Active CPM time domain is reestablished.

5.2.2.4.5.9 In a Hot-Hot configuration, after receiving a SpaceWire message from the Active CPM containing an approaching time value and receiving the assertion of the $\overline{\text{CPM Time Sync}}$ discrete within 200 mS of that message, the CPM shall update its respective Time Counter with the provided value within 25 nS of the assertion of the $\overline{\text{CPM Time Sync}}$ discrete signal.

5.2.2.4.5.10 The receiving CPM shall use the falling edge (logic 1 to 0 transition) of the $\overline{\text{Active Time Sync In}}$ signal to serve as the time of reference instance for synchronization of the respective time counter (i.e., Bus Domain Time or Aux PL Time).

5.2.2.4.5.11 The receiving CPM shall use the falling edge (logic 1 to 0 transition) of the $\overline{\text{Active Time Sync In}}$ signal to serve as the time of reference instance for synchronization of the respective time counter (i.e., Bus Domain Time or Aux PL Time).

5.2.2.4.6 Bus-subsystem Time and Auxiliary Payload Time Correlation

5.2.2.4.6.1 When a CPM receives Bus-subsystem time and Auxiliary Payload time, the CPM shall be able to correlate Bus Domain Time with Payload Domain Time and report the correlation in telemetry to the Bus-subsystem.
Note: Correlation consists of tracking the difference between Bus-subsystem time and payload time at regular intervals.

5.2.2.5 Interface Fault Management

5.2.2.5.1 CPM Redundancy

5.2.2.5.1.1 The CPM shall support the following redundancy configurations:

Subparagraph	Redundancy Configuration
a.	Hot-Cold
b.	Hot-Warm
c.	Hot-Hot

5.2.2.5.1.2 When in the Hot-Hot configuration during operations, the Active CPM shall provide all information via SpaceWire (SpW_Hot) to the monitor CPM that it would need to resume operations in the event that currently Active CPM failed.

5.2.2.5.1.3 When CPMs are in the Hot-Hot configuration and the Active CPM encounters a fault, it shall de-assert its $\overline{\text{CPM Active Out}}$ discrete and discontinue operations as the Active CPM.

5.2.2.5.1.4 When CPMs are in the Hot-Hot configuration and the Active CPM de-asserts its $\overline{\text{CPM Active Out}}$ discrete, the Monitor CPM shall assert its $\overline{\text{CPM Active Out}}$ discrete and assume the role of the Active CPM within the timeframe required by mission requirements.

5.2.2.5.1.5 When operating the CPMs in a Hot-Hot configuration with two working CPMs and the Active CPM fails, the time for the Monitor CPM to become the new Active CPM and regain interface control for the payloads shall be less than 500 milliseconds, unless otherwise specified by mission requirements.

5.2.2.5.1.6 When operating in a Hot-Warm configuration while the backup CPM has not failed but the primary CPM fails, the backup CPM shall commence the performance of full CPM operations in the Operational state and Active mode within 1 minute of the failure, unless otherwise specified by mission requirements.

5.2.2.5.2 Power

5.2.2.5.2.1 The CPM shall survive sudden unplanned loss of main power; and, upon re-application of power, boot up into the Idle Mode.

5.2.2.5.2.2 After power is applied and the CPM achieves Basic Mode, Active Mode, or Diagnostic Mode, it shall be responsible for performing its payload fault management role until commanded otherwise.

5.2.2.5.2.3 Upon notification that the Bus-subsystem re-applied power to a payload and the CPM detects assertion of the $\overline{\text{PL Ready}}$ discrete signal from that payload, the CPM shall enable fault management for that payload.

5.2.2.5.2.4 Upon notification that the Bus-subsystem removed power from a payload, the CPM shall disable fault management for that payload within 1 second, unless otherwise specified by mission requirements.

5.2.2.5.3 Discrete Signals

5.2.2.5.3.1 Upon detection of any of the following CPM faults, the CPM shall assert its CPM Fault discrete signal within 1 microsecond.

Subparagraph	
a.	SpaceWire communications with the Bus-subsystem are not operational
b.	CPM processor watchdog timer timeout
c.	Detection of an uncorrectable memory error within the basic portion of the CPM

5.2.2.5.3.2 A CPM in the Active Mode shall monitor the following types of discrete signals from each payload and provide the status of each in telemetry to the Bus-subsystem:

Subparagraph	
a.	$\overline{\text{PL Ready}}$
b.	PL Fault
c.	$\overline{\text{PL General Purpose}}$

5.2.2.5.3.3 In the Hot-Warm configuration, a CPM in the Basic Mode shall monitor the following types of discrete signals from each payload and provide the status of each in telemetry to the Bus-Subsystem.

Subparagraph	
a.	$\overline{\text{PL Ready}}$
b.	PL Fault
c.	$\overline{\text{PL General Purpose}}$

5.2.2.5.3.4 In the Hot-Hot configuration, only the CPM in the Active Mode shall monitor the following types of discrete signals from each payload and provide the status of each in telemetry to the Bus-Subsystem.

Subparagraph	
a.	$\overline{\text{PL Ready}}$
b.	PL Fault
c.	$\overline{\text{PL General Purpose}}$

5.2.2.5.3.5 Upon detection of the assertion of PL Fault from a payload, the Active CPM shall initiate fault management processes in accordance with associated fault processing requirements associated with that payload.

5.2.2.5.4 SpaceWire

5.2.2.5.4.1 The CPM shall detect and report any SpaceWire interface transaction timeout and, when available, the following:

Subparagraph	
a.	Transaction address
b.	CPM time when error was detected
c.	Error type

5.2.2.5.5 SRIO

5.2.2.5.5.1 The router portion router functions shall be disabled when a CPM basic portion is not Ready, or a basic portion fault occurs.

5.2.2.5.5.2 When a CPM detects any router related error it shall report the error to the Bus-subsystem.

5.2.2.5.5.3 The CPM test shall log SERDES Error counts at the completion of the BER BIT test.

5.2.2.5.5.4 For each error detected during a SERDES BER test the following shall be logged:

Subparagraph	
a	Which SERDES port was tested
b	Start Time of Test.
c	Time of Error
d.	SerDes data rate

5.3 Payload Domain

This section contains the C&DH, mission data, and power interface requirements applicable to the Payload domain. The Payload domain includes the interfaces between the Bus-subsystem and a standard payload C&DH interface and between each CPM and a standard payload.

5.3.1 Payload Interfaces

5.3.1.1 Payload to Bus-subsystem Interfaces

5.3.1.1.1 Power Interface

This C&DH oriented standard does not specify a standard power connector for payloads.

5.3.1.1.2 Passive Analog Telemetry

Each payload provides thermal telemetry to the Bus-subsystem for purposes of payload internal temperature diagnostics. Each redundant side of the Bus-subsystem will accommodate up to four (4) of these passive analog discretes for each payload. The thermistors should be located in the hottest region(s) of the payload area of concern.

The return side of each thermistor is ganged together, isolated from all grounds and continues to Bus-subsystem as shown in FIGURE 8. The thermistors will be S-311-P-18, dash number 5 (5 kΩ nominal) or equivalent.

5.3.1.1.2.1 Passive Analog Characteristics

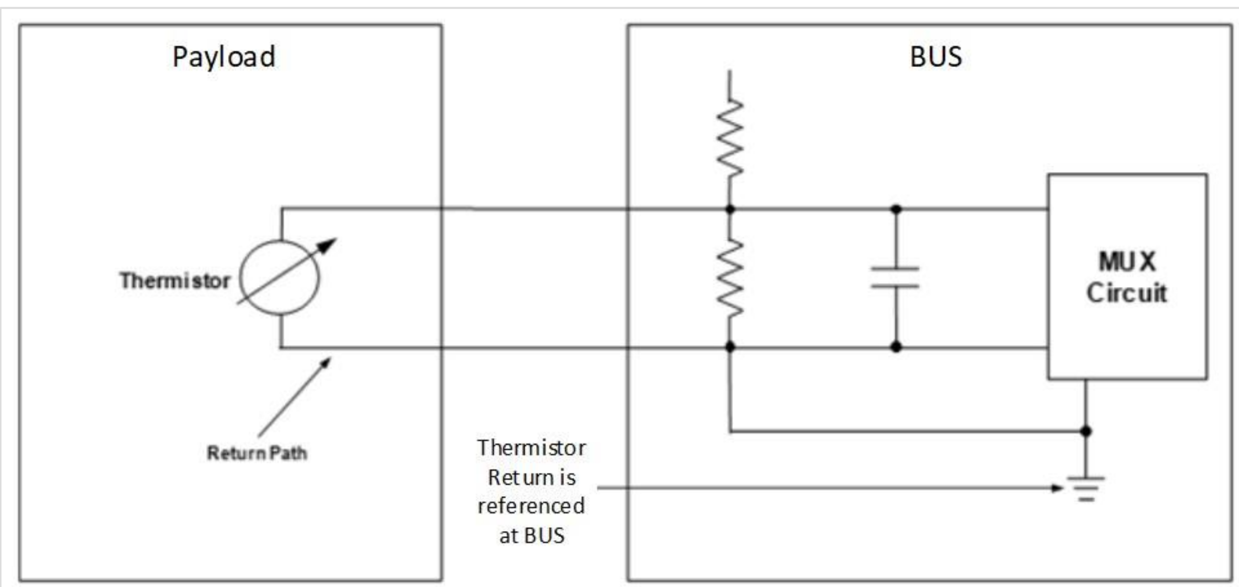


FIGURE 8. Payload to bus passive analog interface example.

5.3.1.1.2.1.1 Each payload passive analog signal shall be a single-ended signal, with a return.

5.3.1.1.2.1.2 The thermistor shall be an S-311-P-18, dash number 5 (5k ohms at nominal) or equivalent.

5.3.1.1.2.1.3 Each payload passive analog signal shall be isolated from chassis by > 1MΩ.

5.3.1.1.2.1.4 The Passive Analog high and return wiring in the harness shall be a Twisted-Shield Pair.

5.3.1.1.2.2 Passive Analog Quantity

5.3.1.1.2.2.1 Each Payload C&DH interface shall provide at least one (1) and no more than four (4) Thermal Passive Analog discretes signal to each redundant side (e.g., A and B) of the Bus-subsystem interface.

5.3.1.1.2.3 Passive Analog Connector

5.3.1.1.2.3.1 The payload shall use connector part number M24308/23-151 or equivalent (M24308/23-121) for the Passive Analog interface signals.

5.3.1.1.2.4 Passive Analog Pinout

5.3.1.1.2.4.1 Each Passive Analog single-ended and return discrete signal set in a connector shall be isolated from other signals by a minimum of two (2) pins in each direction.
<u>Note</u>: the two passive analog signals in a set may be adjacent to each other.

5.3.1.1.2.4.2 Payload Passive Analog signals shall have pinout specified in TABLE 7.

TABLE 7. Payload Passive Analog Signal Connector Pinout

Connector pin #	**Signal name**
2	PL_Therm1
3	PL_Therm1_RTN
9	PL_Therm2
10	PL_Therm2_RTN
17	Spare 1
18	Spare 1 return
24	Spare 2
25	Spare 2 return

5.3.1.1.3 Payload Active Analog Output Signals

5.3.1.1.3.1 Payload Active Analog Output Signals

5.3.1.1.3.1.1 Each Payload shall provide a separate Active Analog Output signal port for each side of the Bus-system.

5.3.1.1.3.1.2 Each Active Analog Output signal port shall include 4 Active Analog output signals for monitoring by the Bus-subsystem.

5.3.1.1.3.1.3 Each Active Analog Output signal port shall use connector part number M24308/23-152 or its interface equivalent for its Active Analog output signals.

5.3.1.1.3.1.4 For each Payload redundancy instance, the Active Analog output signal connector pin assignments shall be as follows:

Sub-¶	**Pin #**	**Signal identification**		**Sub-¶**	**Pin #**	**Signal identification**
a.	1	Ground		n.	14	

Sub-¶	Pin #	Signal identification		Sub-¶	Pin #	Signal identification
b.	2			o.	15	
c.	3	AA01PLNX (+)		p.	16	AA01PLNX (-)
d.	4			q.	17	
e.	5	AA02PLNX (+)		r.	18	AA02PLNX (-)
f.	6			s.	19	
g.	7	AA03PLNX (+)		t.	20	AA03PLNX (-)
h.	8			U.	21	
i.	9	AA04PLNX (+)		v.	22	AA04PLNX (-)
j.	10			w.	23	
k.	11			x.	24	
l.	12			y.	25	
m.	13					

Note 1: "X" in signal name reserved for redundancy identification (e.g., A, B).

Note 2: "N" in the signal name reserved for payload identification.

5.3.1.2 Payload to CPM Interfaces

5.3.1.2.1 SpaceWire

SpaceWire is used as a command and telemetry interface between each payload and the CPM. The CPM should perform cyber related functions, such as evaluating commands from the Bus-Subsystem to a payload or from a payload to another destination (e.g., another payload, Bus-subsystem); consequently, a CPM-based router should not be implemented. Secondarily, a CPM-based router may also induce payload to Bus-subsystem command latency that might adversely affect the performance of a payload during a fault scenario. General requirements regarding SpaceWire are in section 4.

5.3.1.2.1.1 SpaceWire Characteristics

5.3.1.2.1.1.1 SpaceWire signaling transmission and reception shall independently support a data rate maximum of 100 Mbps.

5.3.1.2.1.1.2 Each CPM to Payload SpaceWire external interface shall be designed to preclude damage while it is off and being actively driven by a CPM.

5.3.1.2.1.1.3 The Payload to CPM SpaceWire external interface shall use a two node, point-to-point link SpaceWire connection between it and a CPM.
Note: The CPM will receive, process, and, when necessary, individually forward commands and data to the target payload. While not required, an objective, for fault management response purposes, is to minimize information transfer latency, which a router may not be able to accomplish. In a two-node link, the destination address is not necessary. Also, there is a plan for the CPM to ingest all commands from payloads (and the Bus-subsystem) as part of an integrity assessment function.

5.3.1.2.1.1.4 The Payload to CPM SpaceWire external interface shall be designed to preclude damage by a 3.9 V differential input.

5.3.1.2.1.1.5 The Payload to CPM SpaceWire external interface shall be designed to limit the unterminated, maximum differential output to a 3.6 V differential.

5.3.1.2.1.2 SpaceWire Quantity

5.3.1.2.1.2.1 Each Payload C&DH interface shall provide two SpaceWire ports: one from Payload SpaceWire port A for purposes of interfacing with CPM A and another from Payload SpaceWire port B for purposes of interfacing with CPM B.
Note: See FIGURE 1.

5.3.1.2.1.3 SpaceWire Connector

5.3.1.2.1.3.1 Each Payload Payload-to-CPM SpaceWire unit connector shall implement a rectangular, 9-pin, M83513 (e.g., /04 or /19) connector.

5.3.1.2.1.4 SpaceWire Pinouts

5.3.1.2.1.4.1 Each Payload C&DH SpaceWire unit connector shall have the pinout specified in TABLE 2.

5.3.1.2.2 Discrete Signals

All Discrete Signals in the Payload domain are defined as LVDS signals. Discrete signals are used to implement discrete commands and discrete telemetry signals used for domain configuration and fault management operations.

5.3.1.2.2.1 Discrete Signal Quantity

5.3.1.2.2.1.1 The Discrete Signals from the CPMs to each payload shall be identified as follows:

Subparagraph	Signal Name (“N” used to simplify iterations 1-12)	Payload Port:	To: CPM
a.	$\overline{\text{PL IF Port Select A "N"}}$	A	A
b.	$\overline{\text{PL Hard Reset A "N"}}$	A	A
c.	$\overline{\text{PL Soft Reset A "N"}}$	A	A
d.	$\overline{\text{PL Time Sync A "N"}}$	A	A
e.	$\overline{\text{PL IF Port Select B "N"}}$	B	B
f.	$\overline{\text{PL Hard Reset B "N"}}$	B	B
g.	$\overline{\text{PL Soft Reset B "N"}}$	B	B
h.	$\overline{\text{PL Time Sync B "N"}}$	B	B

5.3.1.2.2.1.2 The Discrete Signals from the payload to the CPM shall be identified as follows:

Subparagraph	Signal Name ("N" used to simplify iterations 1-12)	From: Payload Interface Port Side	To: CPM
a.	PL Ready A "N"	A	A
b.	PL Fault A "N"	A	A
c.	PL General Purpose A "N"	A	A
d	PL Ready B "N"	B	B
e	PL Fault B "N"	B	B
f	PL General Purpose B "N"	B	B

5.3.1.2.2.2 Discrete Signal Connector

5.3.1.2.2.2.1 The Payload C&DH interface Discrete Signal connector part number shall be M24308/23-174 or equivalent (M24308/23-168).

5.3.1.2.2.3 Discrete Signal Pinout

5.3.1.2.2.3.1 The PL Discrete Input Signals interfacing with the CPM shall have a pinout as specified in TABLE 8.

TABLE 8. Payload Discrete Signal Connector Pinout

Signal Name (w/o PL # identification)	Signal Polarity	Connector pin #
Ground		1
PL IF Port Select	P	2
	N	3
PL Hard Reset	P	4
	N	5
PL Soft Reset	P	6
	N	7
		8
Ground		9
PL Time Sync	P	10
	N	11

Signal Name (w/o PL # identification)	Signal Polarity	Connector pin #
		12
		13
		14
		15
		16
		17
		18
Ground		19
$\overline{\text{PL Ready}}$	P	20
	N	21
PL Fault	P	22
	N	23
$\overline{\text{PL General Purpose}}$	P	24
	N	25
Ground		26

5.3.1.2.2.4 Discrete Signal Payload Input Characteristics

5.3.1.2.2.4.1 $\overline{\text{PL Hard Reset}}$

5.3.1.2.2.4.1.1 When the $\overline{\text{PL Hard Reset}}$ Discrete Command input is driven to logic 0 for 10 milliseconds (+/-10%) and subsequently transitions to logic 1 for at least 10 milliseconds, the Payload C&DH interface shall perform a hard reset.

5.3.1.2.2.4.2 $\overline{\text{PL Soft Reset}}$

5.3.1.2.2.4.2.1 When the $\overline{\text{PL Soft Reset}}$ C&DH interface signal input is driven to logic 0 for 10 milliseconds (+/-10%) and subsequently transitions to logic 1 for at least 10 milliseconds, the Payload C&DH interface shall reload its operating system and flight software to loaded parameters.

5.3.1.2.2.4.3 $\overline{\text{PL Time Sync}}$

The $\overline{\text{PL Time Sync}}$ signal is a discrete output from the CPM to payloads and it is used by the payload to synchronize its internal time to CPM time. To accomplish this synchronization, the CPM will provide a time value to the payload, and the payload should prepare to load that time value into its timer upon receipt of the $\overline{\text{PL Time Sync}}$ signal from the CPM. When the $\overline{\text{PL Time Sync}}$ signal is asserted it represents the exact time previously communicated by the CPM and is exactly when the payload should load that time into its timer.

Notice: The requirements in this section do not apply to a payload if it does not have a mission requirement to maintain time synchronization provided by the CPM.

5.3.1.2.2.4.3.1 Upon detection of a transition of the $\overline{\text{PL Time Sync}}$ signal from a logic 1 to a logic 0, the payload shall load into its timer the time value previously provided by the CPM.

5.3.1.2.2.4.4 $\overline{\text{PL IF Port Select}}$

5.3.1.2.2.4.4.1 Each payload shall interpret its $\overline{\text{PL IF Port Select}}$ discrete input as asserted (selected) when the signal is a logic 0.

5.3.1.2.2.4.4.2 When its $\overline{\text{PL IF Port Select}}$ signal is asserted, the payload shall be enabled to actively communicate over the respective SpaceWire interface port (e.g., A, B).

5.3.1.2.2.4.4.3 When its $\overline{\text{PL IF Port Select}}$ signal is de-asserted; the payload shall be disabled from actively communicating over the respective SpaceWire interface port (e.g., A, B).

5.3.1.2.2.5 Discrete Signal Payload Output Characteristics

5.3.1.2.2.5.1 $\overline{\text{PL Ready}}$

The $\overline{\text{PL Ready}}$ discrete represents an input to the CPM from the payload. The discrete will become a logic 1 during a payload power-on or Hard Reset event and will return to a logic 0 once the payload is ready to conduct SpaceWire transactions with the CPM.

5.3.1.2.2.5.1.1 Assertion of the $\overline{\text{PL Ready}}$ discrete output shall be logic 0.

5.3.1.2.2.5.1.2 When the following conditions are met, the payload will be ready for C&DH transactions with the CPM and the payload shall assert its $\overline{\text{PL Ready}}$ discrete output after the following conditions have been met:

Subparagraph	
a.	The payload has successfully booted up
b.	Payload has passed post-boot diagnostic tests
c.	Local version of flight software ready for use
d.	SpaceWire services are ready for operations

5.3.1.2.2.5.1.3 $\overline{\text{PL Ready}}$ shall be logic 1 when the Payload SpaceWire is not ready for operations or reset (Hard Reset or Soft Reset) occurs.

5.3.1.2.2.5.2 PL Fault

The PL Fault discrete represents an input to the CPM from the Payload domain. After a payload is ready, its PL Fault discrete will only become a logic 1 if the payload is reporting a fault or it is no longer operational (e.g., power was removed).

5.3.1.2.2.5.2.1 Each payload shall drive its PL Fault signal to Logic 0 after it resets and until the payload detects it has encountered a valid fault.

5.3.1.2.2.5.2.2 Each payload shall drive its PL Fault signal to Logic 1 when the payload detects a fault. <u>Note</u>: types of faults include uncorrectable memory errors, watchdog timeouts, loss of communications with the SpaceWire interface, etc. SRIO faults would be reported via SpaceWire.

5.3.1.2.2.5.3 Alt Source Time Sync

This payload sourced signal is not commonly provided by payloads; consequently, a discrete signal is not directly specified for this function. Instead, this signal would use the

$\overline{\text{PL General Purpose}}$ signal, which may be used for this or another unique payload to CPM discrete signaling.

The CPM $\overline{\text{PL Time Sync}}$ signal is a discrete output to payloads to synchronize their internal time to a common time domain. While the CPM provides a payload time management function, its source of time synchronization may be the Bus-subsystem or a payload. Consequently, the CPM $\overline{\text{PL Time Sync}}$ signal timing is derived from either the $\overline{\text{Bus Time Sync}}$ signal from the Bus-subsystem or the Alt Source Time Sync signal from a payload.

5.3.1.2.2.5.3.1 When a payload provides an Alt Source Time Sync, that payload's $\overline{\text{PL General Purpose}}$ discrete signal shall be used as the Alt Source Time Sync signal.

5.3.1.2.2.5.3.2 To provide an Alt Source Time Sync across its $\overline{\text{PL General Purpose}}$ discrete signal, a Payload shall use the falling edge (i.e., logic 1 to 0 transition) of the $\overline{\text{PL General Purpose}}$ discrete to serve as the time of reference instance for synchronization.

5.3.1.2.2.5.3.3 When a payload provides an Alt Source Time Sync across its $\overline{\text{PL General Purpose}}$ discrete signal, it shall have an accuracy of 25 nS or less relative to the clock used to maintain time within the payload.

5.3.1.2.2.5.3.4 A Payload shall de-assert the $\overline{\text{PL General Purpose}}$ discrete at least 100 microseconds after asserting it when using it for an Alt Source Time Sync.

5.3.1.2.2.5.4 $\overline{\text{PL General Purpose}}$

The $\overline{\text{PL General Purpose}}$ signal is reserved for use if there is a need for a payload to provide a unique signal to the CPM units. For example, if a payload includes a time source useful to the system or managing the payloads, that payload could provide an auxiliary or primary time sync pulse to the CPM. In fact, the Alternate Source Time Source signal specified in this standard, which would stem from only one payload, would use this general-purpose signal.

5.3.1.2.2.5.4.1 To indicate the occurrence of an event via a discrete signal that is not facilitated by other discrete signals, the payload shall use its $\overline{\text{PL General Purpose}}$ discrete signal.

5.3.1.2.2.5.4.2 To indicate the occurrence of an event, the payload shall transition its $\overline{\text{PL General Purpose}}$ discrete signal from a logic 1 state to a logic 0 state for a duration of at least 100 microseconds.

5.3.1.2.3 SRIO

5.3.1.2.3.1 SRIO Characteristics

5.3.1.2.3.1.1 Payload SRIO data-transmit signaling across a flight application equivalent medium (e.g., copper wire of same gauge, length, performance characteristic) shall have a bit error rate of less than 1E-12.

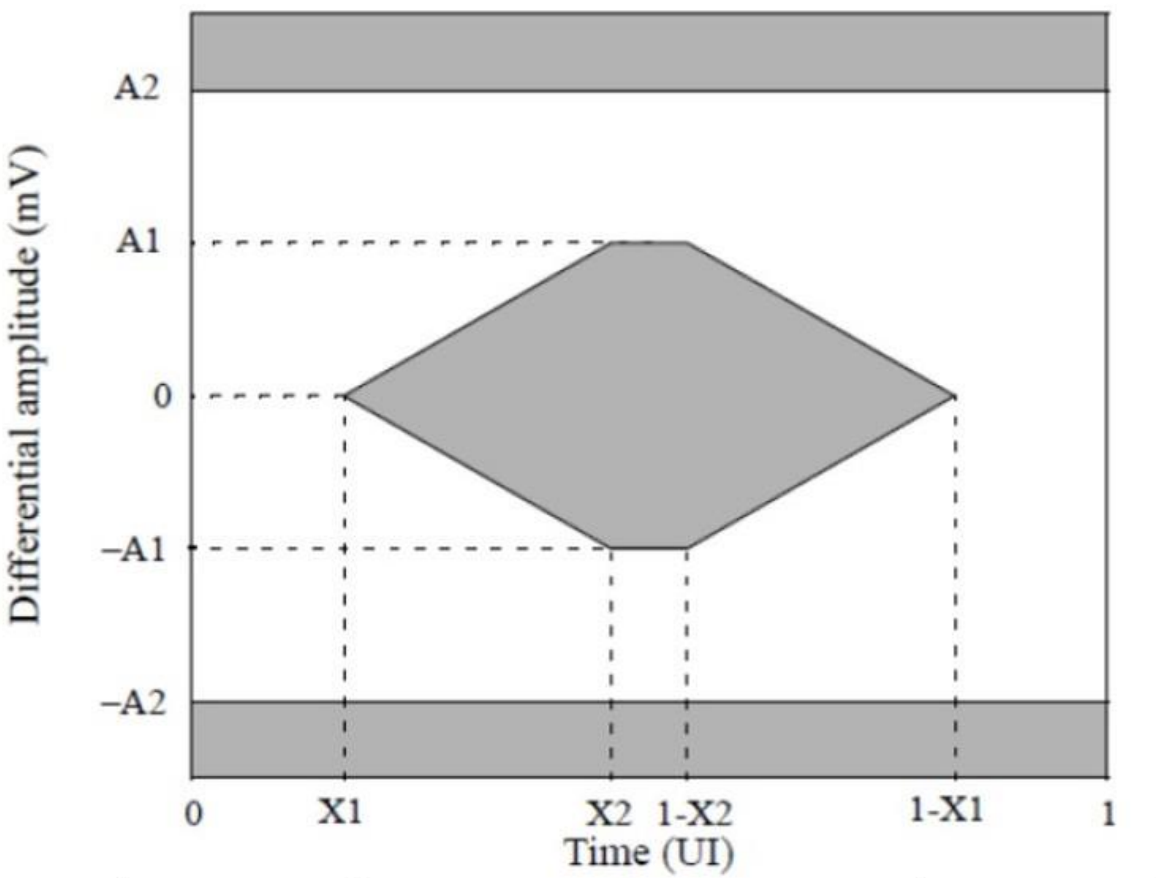
5.3.1.2.3.1.2 The payload shall provide an independent Bit Error Rate (BER) built in test (BIT) for each SERDES interface lane.

5.3.1.2.3.1.3 Each Payload SRIO interface shall be designed to preclude damage while it is off and being actively driven by CPM.
Note: Active voltage of +/- 0.800 V.

5.3.1.2.3.1.4 Payload SRIO data-transmit far-end (i.e., CPM receive side) eye pattern measurements while signaling across a flight application equivalent medium (e.g., copper wire of same gauge, length, performance characteristic) shall satisfy the eye pattern in FIGURE 9 (below).

5.3.1.2.3.1.5 A free running pseudo-random bit-sequence per chapter 5.8 of [ITU-T-T O.150 with corrigendum May 2002] shall be used for the testing of bit error rate compliance.

5.3.1.2.3.1.6 Payload shall correctly recover data that satisfies the SRIO eye pattern in FIGURE 9 (below) with a bit error rate of less than 1E-12 and 95% confidence.



Symbol	Rx At Payload Unit Connector	Units
X1	0.285	UI
X2	0.390	UI
A1	125	mV
A2	800	mV

FIGURE 9. Receive data eye at unit connector (or end of cable).

5.3.1.2.3.2 SRIO Quantity

5.3.1.2.3.2.1 Each payload shall provide one (1) SRIO Fat Pipe port per redundant side.

5.3.1.2.3.3 SRIO Connectors

5.3.1.2.3.3.1 Each Payload SRIO unit connector shall satisfy the attributes specified in TABLE 3.

5.3.1.2.3.4 SRIO Pinouts

5.3.1.2.3.4.1 Each Payload SRIO port unit connector shall have the pinout specified in TABLE 4:

5.3.2 Payload Functional Requirements

5.3.2.1 States and Modes

Payload states and modes can vary widely by payload; consequently, they must be provided to the CPM software developers based on mission requirements. Additionally, satellite modes such as safe mode or contingency mode do not have direct bearing on payload interface requirements.

5.3.2.1.1 Payload states and modes shall be defined by the mission requirements.

5.3.2.2 Telemetry

5.3.2.2.1 Each payload shall support telemetry via SpaceWire and discrete signals.

5.3.2.2.2 Upon receiving a telemetry request from the CPM, the payload shall respond with the requested telemetry via SpaceWire.

5.3.2.2.3 Each payload shall verify commands from the CPM that could adversely impact the health of the payload.

5.3.2.2.4 Ancillary Telemetry

This standard does not require payloads to support Ancillary Telemetry.

5.3.2.2.5 Payload Mission Telemetry

This standard does not require every payload to support Payload Mission Telemetry. If this service is implemented, it is the responsibility of the transmitting and receiving payload pair to coordinate details of the Payload Mission Telemetry report types that are transmitted (e.g., as Type 5 or Type 9 packets) between payloads on the SRIO network.

5.3.2.3 SRIO Network Management

While payloads are users of the SRIO network, the CPM is responsible for performing network management.

5.3.2.4 Time Management

The primary responsibility for time management is upon the Bus-subsystem and the CPM. However, as part of the CPM's time management responsibility, it will periodically provide the payloads with an approaching time value and provide a time synchronization pulse to the payload, so it can update its internal timer(s).

5.3.2.4.1 Payload Time Synchronization

The CPM is responsible for maintaining and managing the time used by the payloads. Part of the CPM time management function is to provide a service to periodically synchronize each payload with the current time. To do this the CPM provides the payload with the value of an approaching time followed by the assertion of the $\overline{\text{PL Time Sync}}$ discrete signal. The $\overline{\text{PL Time Sync}}$ discrete signals exactly when the previously provided time value is to be loaded into the payload's time counter.

5.3.2.4.1.1 The payload shall maintain a counter (Payload Domain Time Counter) containing Payload time.

5.3.2.4.1.2 The Payload Domain Time Counter shall have a maximum increment period of 25 nS.

5.3.2.4.1.3 After receiving a SpaceWire message from the CPM containing an approaching payload time, the payload shall prepare to load that time value into its Payload Domain Time Counter.

5.3.2.4.1.4 The payload shall use the falling edge (logic 1 to 0 transition) of the $\overline{\text{PL Time Sync}}$ signal to serve as the time of reference instance for synchronization.

5.3.2.4.1.5 If the $\overline{\text{PL Time Sync}}$ discrete is asserted within 200 mS of receiving a SpaceWire message from the CPM containing a new time value, the payload shall set the Payload Domain Time Counter to the pending value.

5.3.2.4.1.6 After receiving a SpaceWire message from the CPM containing an approaching time value and receiving the assertion of the $\overline{\text{PL Time Sync}}$ discrete within 200 mS of that message, the Payload shall update its Payload Domain Time Counter with the provided value within 25 nS of the assertion of the $\overline{\text{PL Time Sync}}$ discrete signal.

5.3.2.4.1.7 If the $\overline{\text{PL Time Sync}}$ discrete is not asserted within 200 mS of receiving a SpaceWire message containing a new time value, the payload shall report the issue to the CPM and not update its clock until after another time synchronization message is received followed by assertion of the $\overline{\text{PL Time Sync}}$ within 200 mS.

5.3.2.4.1.8 If the $\overline{\text{PL Time Sync}}$ discrete is not asserted within 200 mS of receiving a SpaceWire message from the CPM containing a new CPM time value, the Payload shall emulate the CPM timing using its internal clock until the CPM time domain is reestablished.

5.3.2.5 Payload Fault Management

The conditions under which a payload would assert its PL Fault discrete signal are defined herein. However, if a payload's non-C&DH-interface exhibits a fault, it must be reported.

5.3.2.5.1 At the completion of the BER BIT test, the payload shall log and report SERDES Error counts to the CPM.

5.3.2.5.2 For each error detected during a SERDES BER test the payload shall report the following to the CPM:

Subparagraph	
a	Which SERDES port was tested
b	Start Time of Test.
c	Time of Error

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful but is not mandatory.)

6.1 Intended use

The Common Payload Interface Standard – Command and Data Handling (C&DH) is used to insure commonality of C&DH interfaces between the Centralized Payload Manager (CPM) and mission payloads, between the Bus-subsystem and the CPM, and between the Bus-subsystem and payloads. This standard includes C&DH interface requirements that a CPM specification should comply with. In addition, this standard should be flowed down as a compliance document to the Bus-subsystem and mission Payload developer(s).

6.2 Acquisition requirements

Acquisition documents should specify the following:

a. Common Payload Interface Standard – Command and Data Handling, TOR-2019-00918, April 15, 2020.

7. APPENDIX A: CPM to Payload Discrete Signal Connections

This appendix contains two tables, one (TABLE 9) defining the Discrete signal connections between CPM A and up to twelve (12) payloads and another (TABLE 10) defining the Discrete signal connections between CPM B and up to twelve (12) payloads.

TABLE 9. CPM A (Payload-Interface) Discrete Signal Pinout

Subparagraph	**Pin #**		**Differential Signal Polarity**	**CPM:** **In (I), Out (O)**	**To:** **Payload Interface Port Side**	**To:** **Suggested payload #**
A1	1	GND			A	
A2	2	PL1_IFPort_Select	P	O	A	1
A3	3	PL1_IFPort_Select	N	O	A	1
A4	4	PL1_IFHard_Reset	P	O	A	1
A5	5	PL1_IFHard_Reset	N	O	A	1
A6	6	PL1_IFSoft_Reset	P	O	A	1
A7	7	PL1_IFSoft_Reset	N	O	A	1
A8	8	PL1_IFTime_Sync	P	O	A	1
A9	9	PL1_IFTime_Sync	N	O	A	1
A10	10	PL1_Ready	P	I	A	1
A11	11	PL1_Ready	N	I	A	1
A12	12	PL1_Fault	P	I	A	1
A13	13	PL1_Fault	N	I	A	1
A14	14	PL1_GeneralPurpose	P	I	A	1
A15	15	PL1_GeneralPurpose	N	I	A	1
A16	16	GND			A	

Subparagraph	Pin #		Differential Signal Polarity	CPM: In (I), Out (O)	To: Payload Interface Port Side	To: Suggested payload #
A17	20	GND			A	
A18	21	GND			A	
A19	22	PL2_IFPort_Select	P	O	A	2
A20	23	PL2_IFPort_Select	N	O	A	2
A21	24	PL2_IFHard_Reset	P	O	A	2
A22	25	PL2_IFHard_Reset	N	O	A	2
A23	26	PL2_IFSoft_Reset	P	O	A	2
A24	27	PL2_IFSoft_Reset	N	O	A	2
A25	28	PL2_IFTime_Sync	P	O	A	2
A26	29	PL2_IFTime_Sync	N	O	A	2
A27	30	PL2_Ready	P	I	A	2
A28	31	PL2_Ready	N	I	A	2
A29	32	PL2_Fault	P	I	A	2
A30	33	PL2_Fault	N	I	A	2
A31	34	PL2_GeneralPurpose	P	I	A	2
A32	35	PL2_GeneralPurpose	N	I	A	2
A33	36	GND			A	
A34	39	GND			A	
A35	40	GND			A	
A36	41	PL3_IFPort_Select	P	O	A	3

Subparagraph	Pin #		Differential Signal Polarity	CPM: In (I), Out (O)	To: Payload Interface Port Side	To: Suggested payload #
A37	42	PL3_IFPort_Select	N	O	A	3
A38	43	PL3_IFHard_Reset	P	O	A	3
A39	44	PL3_IFHard_Reset	N	O	A	3
A40	45	PL3_IFSoft_Reset	P	O	A	3
A41	46	PL3_IFSoft_Reset	N	O	A	3
A42	47	PL3_IFTime_Sync	P	O	A	3
A43	48	PL3_IFTime_Sync	N	O	A	3
A44	49	PL3_Ready	P	I	A	3
A45	50	PL3_Ready	N	I	A	3
A46	51	PL3_Fault	P	I	A	3
A47	52	PL3_Fault	N	I	A	3
A48	53	PL3_GeneralPurpose	P	I	A	3
A49	54	PL3_GeneralPurpose	N	I	A	3
A50	55	GND			A	
A51	59	GND			A	
A52	60	GND			A	
A53	61	PL4_IFPort_Select	P	O	A	4
A54	62	PL4_IFPort_Select	N	O	A	4
A55	63	PL4_IFHard_Reset	P	O	A	4
A56	64	PL4_IFHard_Reset	N	O	A	4

Subparagraph	Pin #		Differential Signal Polarity	CPM: In (I), Out (O)	To: Payload Interface Port Side	To: Suggested payload #
A57	65	PL4_IFSoft_Reset	P	O	A	4
A58	66	PL4_IFSoft_Reset	N	O	A	4
A59	67	PL4_IFTime_Sync	P	O	A	4
A60	68	PL4_IFTime_Sync	N	O	A	4
A61	69	PL4_Ready	P	I	A	4
A62	70	PL4_Ready	N	I	A	4
A63	71	PL4_Fault	P	I	A	4
A64	72	PL4_Fault	N	I	A	4
A65	73	PL4_GeneralPurpose	P	I	A	4
A66	74	PL4_GeneralPurpose	N	I	A	4
A67	75	GND			A	
A68	78	GND			A	
A72	1	GND			A	
A73	2	PL5_IFPort_Select	P	O	A	5
A74	3	PL5_IFPort_Select	N	O	A	5
A75	4	PL5_IFHard_Reset	P	O	A	5
A76	5	PL5_IFHard_Reset	N	O	A	5
A77	6	PL5_IFSoft_Reset	P	O	A	5
A78	7	PL5_IFSoft_Reset	N	O	A	5
A79	8	PL5_IFTime_Sync	P	O	A	5

Subparagraph	Pin #		Differential Signal Polarity	CPM: In (I), Out (O)	To: Payload Interface Port Side	To: Suggested payload #
A80	9	PL5_IFTime_Sync	N	O	A	5
A81	10	PL5_Ready	P	I	A	5
A82	11	PL5_Ready	N	I	A	5
A83	12	PL5_Fault	P	I	A	5
A84	13	PL5_Fault	N	I	A	5
A85	14	PL5_GeneralPurpose	P	I	A	5
A86	15	PL5_GeneralPurpose	N	I	A	5
A87	16	GND			A	
A88	20	GND			A	
A89	21	GND			A	
A90	22	PL6_IFPort_Select	P	O	A	6
A91	23	PL6_IFPort_Select	N	O	A	6
A92	24	PL6_IFHard_Reset	P	O	A	6
A93	25	PL6_IFHard_Reset	N	O	A	6
A94	26	PL6_IFSoft_Reset	P	O	A	6
A95	27	PL6_IFSoft_Reset	N	O	A	6
A96	28	PL6_IFTime_Sync	P	O	A	6
A97	29	PL6_IFTime_Sync	N	O	A	6
A98	30	PL6_Ready	P	I	A	6
A99	31	PL6_Ready	N	I	A	6

Subparagraph	Pin #		Differential Signal Polarity	CPM: In (I), Out (O)	To: Payload Interface Port Side	To: Suggested payload #
A100	32	PL6_Fault	P	I	A	6
A101	33	PL6_Fault	N	I	A	6
A102	34	PL6_GeneralPurpose	P	I	A	6
A103	35	PL6_GeneralPurpose	N	I	A	6
A104	36	GND			A	
A105	39	GND			A	
A106	40	GND			A	
A107	41	PL7_IFPort_Select	P	O	A	7
A108	42	PL7_IFPort_Select	N	O	A	7
A109	43	PL7_IFHard_Reset	P	O	A	7
A110	44	PL7_IFHard_Reset	N	O	A	7
A111	45	PL7_IFSoft_Reset	P	O	A	7
A112	46	PL7_IFSoft_Reset	N	O	A	7
A113	47	PL7_IFTime_Sync	P	O	A	7
A114	48	PL7_IFTime_Sync	N	O	A	7
A115	49	PL7_Ready	P	I	A	7
A116	50	PL7_Ready	N	I	A	7
A117	51	PL7_Fault	P	I	A	7
A118	52	PL7_Fault	N	I	A	7
A119	53	PL7_GeneralPurpose	P	I	A	7

Subparagraph	Pin #		Differential Signal Polarity	CPM: In (I), Out (O)	To: Payload Interface Port Side	To: Suggested payload #
A120	54	PL7_GeneralPurpose	N	I	A	7
A121	55	GND			A	
A122	59	GND			A	
A123	60	GND			A	
A124	61	PL8_IFPort_Select	P	O	A	8
A125	62	PL8_IFPort_Select	N	O	A	8
A126	63	PL8_IFHard_Reset	P	O	A	8
A127	64	PL8_IFHard_Reset	N	O	A	8
A128	65	PL8_IFSoft_Reset	P	O	A	8
A129	66	PL8_IFSoft_Reset	N	O	A	8
A130	67	PL8_IFTime_Sync	P	O	A	8
A131	68	PL8_IFTime_Sync	N	O	A	8
A132	69	PL8_Ready	P	I	A	8
A133	70	PL8_Ready	N	I	A	8
A134	71	PL8_Fault	P	I	A	8
A135	72	PL8_Fault	N	I	A	8
A136	73	PL8_GeneralPurpose	P	I	A	8
A137	74	PL8_GeneralPurpose	N	I	A	8
A138	75	GND			A	
A139	78	GND			A	

Subparagraph	Pin #		Differential Signal Polarity	CPM: In (I), Out (O)	To: Payload Interface Port Side	To: Suggested payload #
A142	1	GND				
A143	2	PL9_IFPort_Select	P	O	A	9
A144	3	PL9_IFPort_Select	N	O	A	9
A145	4	PL9_IFHard_Reset	P	O	A	9
A146	5	PL9_IFHard_Reset	N	O	A	9
A147	6	PL9_IFSoft_Reset	P	O	A	9
A148	7	PL9_IFSoft_Reset	N	O	A	9
A149	8	PL9_IFTime_Sync	P	O	A	9
A150	9	PL9_IFTime_Sync	N	O	A	9
A151	10	PL9_Ready	P	I	A	9
A152	11	PL9_Ready	N	I	A	9
A153	12	PL9_Fault	P	I	A	9
A154	13	PL9_Fault	N	I	A	9
A155	14	PL9_GeneralPurpose	P	I	A	9
A156	15	PL9_GeneralPurpose	N	I	A	9
A157	16	GND				
A158	20	GND				
A159	21	GND				
A160	22	PL10_IFPort_Select	P	O	A	10
A161	23	PL10_IFPort_Select	N	O	A	10

Subparagraph	Pin #		Differential Signal Polarity	CPM: In (I), Out (O)	To: Payload Interface Port Side	To: Suggested payload #
A162	24	PL10_IFHard_Reset	P	O	A	10
A163	25	PL10_IFHard_Reset	N	O	A	10
A164	26	PL10_IFSoft_Reset	P	O	A	10
A165	27	PL10_IFSoft_Reset	N	O	A	10
A166	28	PL10_IFTime_Sync	P	O	A	10
A167	29	PL10_IFTime_Sync	N	O	A	10
A168	30	PL10_Ready	P	I	A	10
A169	31	PL10_Ready	N	I	A	10
A170	32	PL10_Fault	P	I	A	10
A171	33	PL10_Fault	N	I	A	10
A172	34	PL10_GeneralPurpose	P	I	A	10
A173	35	PL10_GeneralPurpose	N	I	A	10
A174	36	GND				
A175	39	GND				
A176	40	GND				
A177	41	PL11_IFPort_Select	P	O	A	11
A178	42	PL11_IFPort_Select	N	O	A	11
A179	43	PL11_IFHard_Reset	P	O	A	11
A180	44	PL11_IFHard_Reset	N	O	A	11
A181	45	PL11_IFSoft_Reset	P	O	A	11

Subparagraph	Pin #		Differential Signal Polarity	CPM: In (I), Out (O)	To: Payload Interface Port Side	To: Suggested payload #
A182	46	PL11_IFSoft_Reset	N	O	A	11
A183	47	PL11_IFTime_Sync	P	O	A	11
A184	48	PL11_IFTime_Sync	N	O	A	11
A185	49	PL11_Ready	P	I	A	11
A186	50	PL11_Ready	N	I	A	11
A187	51	PL11_Fault	P	I	A	11
A188	52	PL11_Fault	N	I	A	11
A189	53	PL11_GeneralPurpose	P	I	A	11
A190	54	PL11_GeneralPurpose	N	I	A	11
A191	55	GND				
A192	59	GND				
A193	60	GND				
A194	61	PL12_IFPort_Select	P	O	A	12
A195	62	PL12_IFPort_Select	N	O	A	12
A196	63	PL12_IFHard_Reset	P	O	A	12
A197	64	PL12_IFHard_Reset	N	O	A	12
A198	65	PL12_IFSoft_Reset	P	O	A	12
A199	66	PL12_IFSoft_Reset	N	O	A	12
A200	67	PL12_IFTime_Sync	P	O	A	12
A201	68	PL12_IFTime_Sync	N	O	A	12

Subparagraph	Pin #		Differential Signal Polarity	CPM: In (I), Out (O)	To: Payload Interface Port Side	To: Suggested payload #
A202	69	PL12_Ready	P	I	A	12
A203	70	PL12_Ready	N	I	A	12
A204	71	PL12_Fault	P	I	A	12
A205	72	PL12_Fault	N	I	A	12
A206	73	PL12_GeneralPurpose	P	I	A	12
A207	74	PL12_GeneralPurpose	N	I	A	12
A208	75	GND				
A209	78	GND				

TABLE 10. CPM B (Payload-Interface) Discrete Signal Pinout.

Subparagraph	Pin #	Signal Name	Differential Signal Polarity	CPM: In (I), Out (O)	To: Payload Interface Port Side	To: Suggested payload #
B1	1	GND			B	
B2	2	PL1_IFPort_Select	P	O	B	1
B3	3	PL1_IFPort_Select	N	O	B	1
B4	4	PL1_IFHard_Reset	P	O	B	1
B5	5	PL1_IFHard_Reset	N	O	B	1
B6	6	PL1_IFSoft_Reset	P	O	B	1
B7	7	PL1_IFSoft_Reset	N	O	B	1
B8	8	PL1_IFTime_Sync	P	O	B	1
B9	9	PL1_IFTime_Sync	N	O	B	1

Subparagraph	Pin #	Signal Name	Differential Signal Polarity	CPM: In (I), Out (O)	To: Payload Interface Port Side	To: Suggested payload #
B10	10	$\overline{\text{PL1\_Ready}}$	P	I	B	1
B11	11	$\overline{\text{PL1\_Ready}}$	N	I	B	1
B12	12	PL1_Fault	P	I	B	1
B13	13	PL1_Fault	N	I	B	1
B14	14	$\overline{\text{PL1\_GeneralPurpose}}$	P	I	B	1
B15	15	$\overline{\text{PL1\_GeneralPurpose}}$	N	I	B	1
B16	16	GND			B	
B17	20	GND			B	
B18	21	GND			B	
B19	22	$\overline{\text{PL2\_IFPort\_Select}}$	P	O	B	2
B20	23	$\overline{\text{PL2\_IFPort\_Select}}$	N	O	B	2
B21	24	$\overline{\text{PL2\_IFHard\_Reset}}$	P	O	B	2
B22	25	$\overline{\text{PL2\_IFHard\_Reset}}$	N	O	B	2
B23	26	$\overline{\text{PL2\_IFSoft\_Reset}}$	P	O	B	2
B24	27	$\overline{\text{PL2\_IFSoft\_Reset}}$	N	O	B	2
B25	28	$\overline{\text{PL2\_IFTime\_Sync}}$	P	O	B	2
B26	29	$\overline{\text{PL2\_IFTime\_Sync}}$	N	O	B	2
B27	30	$\overline{\text{PL2\_Ready}}$	P	I	B	2
B28	31	$\overline{\text{PL2\_Ready}}$	N	I	B	2
B29	32	PL2_Fault	P	I	B	2

Subparagraph	Pin #	Signal Name	Differential Signal Polarity	CPM: In (I), Out (O)	To: Payload Interface Port Side	To: Suggested payload #
B30	33	PL2_Fault	N	I	B	2
B31	34	PL2_GeneralPurpose	P	I	B	2
B32	35	PL2_GeneralPurpose	N	I	B	2
B33	36	GND			B	
B34	39	GND			B	
B35	40	GND			B	
B36	41	PL3_IFPort_Select	P	O	B	3
B37	42	PL3_IFPort_Select	N	O	B	3
B38	43	PL3_IFHard_Reset	P	O	B	3
B39	44	PL3_IFHard_Reset	N	O	B	3
B40	45	PL3_IFSoft_Reset	P	O	B	3
B41	46	PL3_IFSoft_Reset	N	O	B	3
B42	47	PL3_IFTime_Sync	P	O	B	3
B43	48	PL3_IFTime_Sync	N	O	B	3
B44	49	PL3_Ready	P	I	B	3
B45	50	PL3_Ready	N	I	B	3
B46	51	PL3_Fault	P	I	B	3
B47	52	PL3_Fault	N	I	B	3
B48	53	PL3_GeneralPurpose	P	I	B	3
B49	54	PL3_GeneralPurpose	N	I	B	3

Subparagraph	Pin #	Signal Name	Differential Signal Polarity	CPM: In (I), Out (O)	To: Payload Interface Port Side	To: Suggested payload #
B50	55	GND			B	
B51	59	GND			B	
B52	60	GND			B	
B53	61	PL4_IFPort_Select	P	O	B	4
B54	62	PL4_IFPort_Select	N	O	B	4
B55	63	PL4_IFHard_Reset	P	O	B	4
B56	64	PL4_IFHard_Reset	N	O	B	4
B57	65	PL4_IFSoft_Reset	P	O	B	4
B58	66	PL4_IFSoft_Reset	N	O	B	4
B59	67	PL4_IFTime_Sync	P	O	B	4
B60	68	PL4_IFTime_Sync	N	O	B	4
B61	69	PL4_Ready	P	I	B	4
B62	70	PL4_Ready	N	I	B	4
B63	71	PL4_Fault	P	I	B	4
B64	72	PL4_Fault	N	I	B	4
B65	73	PL4_GeneralPurpose	P	I	B	4
B66	74	PL4_GeneralPurpose	N	I	B	4
B67	75	GND			B	
B68	78	GND			B	
B72	1	GND			B	

Subparagraph	Pin #	Signal Name	Differential Signal Polarity	CPM: In (I), Out (O)	To: Payload Interface Port Side	To: Suggested payload #
B73	2	PL5_IFPort_Select	P	O	B	5
B74	3	PL5_IFPort_Select	N	O	B	5
B75	4	PL5_IFHard_Reset	P	O	B	5
B76	5	PL5_IFHard_Reset	N	O	B	5
B77	6	PL5_IFSoft_Reset	P	O	B	5
B78	7	PL5_IFSoft_Reset	N	O	B	5
B79	8	PL5_IFTime_Sync	P	O	B	5
B80	9	PL5_IFTime_Sync	N	O	B	5
B81	10	PL5_Ready	P	I	B	5
B82	11	PL5_Ready	N	I	B	5
B83	12	PL5_Fault	P	I	B	5
B84	13	PL5_Fault	N	I	B	5
B85	14	PL5_GeneralPurpose	P	I	B	5
B86	15	PL5_GeneralPurpose	N	I	B	5
B87	16	GND			B	
B88	20	GND			B	
B89	21	GND			B	
B90	22	PL6_IFPort_Select	P	O	B	6
B91	23	PL6_IFPort_Select	N	O	B	6
B92	24	PL6_IFHard_Reset	P	O	B	6

Subparagraph	Pin #	Signal Name	Differential Signal Polarity	CPM: In (I), Out (O)	To: Payload Interface Port Side	To: Suggested payload #
B93	25	PL6_IFHard_Reset	N	O	B	6
B94	26	PL6_IFSoft_Reset	P	O	B	6
B95	27	PL6_IFSoft_Reset	N	O	B	6
B96	28	PL6_IFTime_Sync	P	O	B	6
B97	29	PL6_IFTime_Sync	N	O	B	6
B98	30	PL6_Ready	P	I	B	6
B99	31	PL6_Ready	N	I	B	6
B100	32	PL6_Fault	P	I	B	6
B101	33	PL6_Fault	N	I	B	6
B102	34	PL6_GeneralPurpose	P	I	B	6
B103	35	PL6_GeneralPurpose	N	I	B	6
B104	36	GND			B	
B105	39	GND			B	
B106	40	GND			B	
B107	41	PL7_IFPort_Select	P	O	B	7
B108	42	PL7_IFPort_Select	N	O	B	7
B109	43	PL7_IFHard_Reset	P	O	B	7
B110	44	PL7_IFHard_Reset	N	O	B	7
B111	45	PL7_IFSoft_Reset	P	O	B	7
B112	46	PL7_IFSoft_Reset	N	O	B	7

Subparagraph	Pin #	Signal Name	Differential Signal Polarity	CPM: In (I), Out (O)	To: Payload Interface Port Side	To: Suggested payload #
B113	47	PL7_IFTime_Sync	P	O	B	7
B114	48	PL7_IFTime_Sync	N	O	B	7
B115	49	PL7_Ready	P	I	B	7
B116	50	PL7_Ready	N	I	B	7
B117	51	PL7_Fault	P	I	B	7
B118	52	PL7_Fault	N	I	B	7
B119	53	PL7_GeneralPurpose	P	I	B	7
B120	54	PL7_GeneralPurpose	N	I	B	7
B121	55	GND			B	
B122	59	GND			B	
B123	60	GND			B	
B124	61	PL8_IFPort_Select	P	O	B	8
B125	62	PL8_IFPort_Select	N	O	B	8
B126	63	PL8_IFHard_Reset	P	O	B	8
B127	64	PL8_IFHard_Reset	N	O	B	8
B128	65	PL8_IFSoft_Reset	P	O	B	8
B129	66	PL8_IFSoft_Reset	N	O	B	8
B130	67	PL8_IFTime_Sync	P	O	B	8
B131	68	PL8_IFTime_Sync	N	O	B	8
B132	69	PL8_Ready	P	I	B	8

Subparagraph	Pin #	Signal Name	Differential Signal Polarity	CPM: In (I), Out (O)	To: Payload Interface Port Side	To: Suggested payload #
B133	70	PL8_Ready	N	I	B	8
B134	71	PL8_Fault	P	I	B	8
B135	72	PL8_Fault	N	I	B	8
B136	73	PL8_GeneralPurpose	P	I	B	8
B137	74	PL8_GeneralPurpose	N	I	B	8
B138	75	GND			B	
B139	78	GND			B	
B142	1	GND				
B143	2	PL9_IFPort_Select	P	O	B	9
B144	3	PL9_IFPort_Select	N	O	B	9
B145	4	PL9_IFHard_Reset	P	O	B	9
B146	5	PL9_IFHard_Reset	N	O	B	9
B147	6	PL9_IFSoft_Reset	P	O	B	9
B148	7	PL9_IFSoft_Reset	N	O	B	9
B149	8	PL9_IFTime_Sync	P	O	B	9
B150	9	PL9_IFTime_Sync	N	O	B	9
B151	10	PL9_Ready	P	I	B	9
B152	11	PL9_Ready	N	I	B	9
B153	12	PL9_Fault	P	I	B	9
B154	13	PL9_Fault	N	I	B	9

Subparagraph	Pin #	Signal Name	Differential Signal Polarity	CPM: In (I), Out (O)	To: Payload Interface Port Side	To: Suggested payload #
B155	14	$\overline{\text{PL9\_GeneralPurpose}}$	P	I	B	9
B156	15	$\overline{\text{PL9\_GeneralPurpose}}$	N	I	B	9
B157	16	GND				
B158	20	GND				
B159	21	GND				
B160	22	$\overline{\text{PL10\_IFPort\_Select}}$	P	O	B	10
B161	23	$\overline{\text{PL10\_IFPort\_Select}}$	N	O	B	10
B162	24	$\overline{\text{PL10\_IFHard\_Reset}}$	P	O	B	10
B163	25	$\overline{\text{PL10\_IFHard\_Reset}}$	N	O	B	10
B164	26	$\overline{\text{PL10\_IFSoft\_Reset}}$	P	O	B	10
B165	27	$\overline{\text{PL10\_IFSoft\_Reset}}$	N	O	B	10
B166	28	$\overline{\text{PL10\_IFTime\_Sync}}$	P	O	B	10
B167	29	$\overline{\text{PL10\_IFTime\_Sync}}$	N	O	B	10
B168	30	$\overline{\text{PL10\_Ready}}$	P	I	B	10
B169	31	$\overline{\text{PL10\_Ready}}$	N	I	B	10
B170	32	PL10_Fault	P	I	B	10
B171	33	PL10_Fault	N	I	B	10
B172	34	$\overline{\text{PL10\_GeneralPurpose}}$	P	I	B	10
B173	35	$\overline{\text{PL10\_GeneralPurpose}}$	N	I	B	10
B174	36	GND				

Subparagraph	Pin #	Signal Name	Differential Signal Polarity	CPM: In (I), Out (O)	To: Payload Interface Port Side	To: Suggested payload #
B175	39	GND				
B176	40	GND				
B177	41	PL11_IFPort_Select	P	O	B	11
B178	42	PL11_IFPort_Select	N	O	B	11
B179	43	PL11_IFHard_Reset	P	O	B	11
B180	44	PL11_IFHard_Reset	N	O	B	11
B181	45	PL11_IFSoft_Reset	P	O	B	11
B182	46	PL11_IFSoft_Reset	N	O	B	11
B183	47	PL11_IFTime_Sync	P	O	B	11
B184	48	PL11_IFTime_Sync	N	O	B	11
B185	49	PL11_Ready	P	I	B	11
B186	50	PL11_Ready	N	I	B	11
B187	51	PL11_Fault	P	I	B	11
B188	52	PL11_Fault	N	I	B	11
B189	53	PL11_GeneralPurpose	P	I	B	11
B190	54	PL11_GeneralPurpose	N	I	B	11
B191	55	GND				
B192	59	GND				
B193	60	GND				
B194	61	PL12_IFPort_Select	P	O	B	12

Subparagraph	Pin #	Signal Name	Differential Signal Polarity	CPM: In (I), Out (O)	To: Payload Interface Port Side	To: Suggested payload #
B195	62	$\overline{\text{PL12\_IFPort\_Select}}$	N	O	B	12
B196	63	$\overline{\text{PL12\_IFHard\_Reset}}$	P	O	B	12
B197	64	$\overline{\text{PL12\_IFHard\_Reset}}$	N	O	B	12
B198	65	$\overline{\text{PL12\_IFSoft\_Reset}}$	P	O	B	12
B199	66	$\overline{\text{PL12\_IFSoft\_Reset}}$	N	O	B	12
B200	67	$\overline{\text{PL12\_IFTime\_Sync}}$	P	O	B	12
B201	68	$\overline{\text{PL12\_IFTime\_Sync}}$	N	O	B	12
B202	69	$\overline{\text{PL12\_Ready}}$	P	I	B	12
B203	70	$\overline{\text{PL12\_Ready}}$	N	I	B	12
B204	71	PL12_Fault	P	I	B	12
B205	72	PL12_Fault	N	I	B	12
B206	73	$\overline{\text{PL12\_GeneralPurpose}}$	P	I	B	12
B207	74	$\overline{\text{PL12\_GeneralPurpose}}$	N	I	B	12
B208	75	GND				
B209	78	GND				