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CubeSat Kit™
Payload Interface Module (PIM) 1
Hardware Revision: D

Payload Interface Module for Unified SUPERNOVA™ Architecture

Applications
- MISC 3™ nanosatellites
- SUPERNOVA™ nanosatellites

Features
- For use with 104-pin CubeSat Kit™ Bus
- SupMCU for commands & telemetry; with status LED and debug terminal
- Quad controllable high-side switches with multiple voltage sources and soft current limiting
- 4-port IEEE802.3 10BASE-T/100BASE-TX managed Ethernet switch
- Harness-free interconnect scheme for ADACS remote magnetometer
- Dual-connector MCX GPS antenna passthrough
- Topmost module in a 2U-size SUPERNOVA bus module stack
- Independent latchup (device overcurrent) protection on critical subsystems
- PC/104-size footprint
- Stackable 104-pin CubeSat Kit Bus connectors
- Wiring-free module interconnect scheme
- 4-layer gold-plated blue-soldermask PCB with ground plane for enhanced signal integrity
- Supervisor MCU programmed with Pumpkin's space-proven Salvo™ RTOS

ORDERING INFORMATION

Pumpkin P/N 710-01391

Option Code	CubeSat Kit Bus Connector
/00 (standard)	Non-stackthrough

Contact factory for availability of optional configurations.
Option code /00 shown.

CAUTION

Electrostatic Sensitive Devices

Handle with Care

CHANGELOG

Rev.	Date	Author	Comments
A	20180814	AEK	Created datasheet from Rev C datasheet.

OPERATIONAL DESCRIPTION

The Payload Interface Module (PIM) 1 is a CubeSat Kit (CSK)-compatible module for use in CSK nanosatellite bus stacks. PIM 1 is primarily responsible for high-side power switching of payload modules and payload connectivity via Ethernet. PIM 1 also implements several secondary features. A supervisor MCU controls power and interface to the CSK bus. The interface to the supervisor MCU is via I2C.

PIM 1 is built on Pumpkin PCB 705-01293.

COMMAND & TELEMETRY INTERFACE

A Pumpkin SupMCU provides a command and telemetry interface to the PIM 1, via SCPI over I2C. Commands and telemetry are both PIM 1-specific and general to SupMCUs.

The I2C address of the PIM 1 is configured in software.

DEBUGGING/PROGRAMMING INTERFACE

Three connectors are provided for SupMCU (re-)programming, a debug terminal to the SupMCU, and a CSK bus serial output. These are typically only used at the factory.

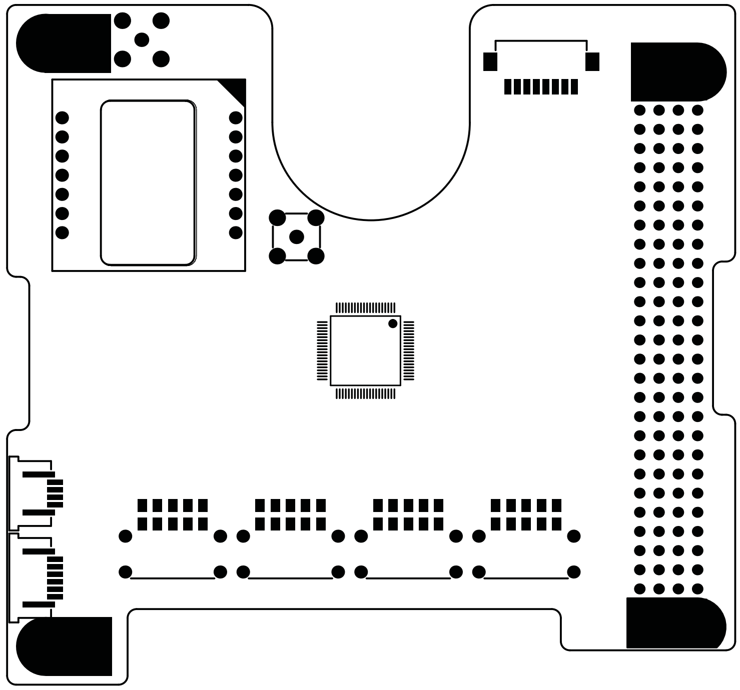
ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Value	Units
Operating temperature	T_A	-40 to +85	ºC
Voltage on **+5V_USB** bus		-0.3 to +6	V
Voltage on **+5V_SYS** bus			
Voltage on **VCC_SYS** bus		-0.3 to +3.6	V
Voltage on local **VCC** bus			
Voltage on power port output		-0.3 to +15.0	V

PHYSICAL CHARACTERISTICS

Parameter	Conditions / Notes	Symbol	Min	Typ	Max	Units
Mass				37		g
Height of components above PCB					11	mm
Height of components below PCB	Not including stacking H1/H2 connectors				2	mm
PCB width	Corner hole pattern matches PC/104			96		mm
PCB length				90		mm
PCB thickness				1.6		mm
CubeSat Kit Bus Connector terminal pitch	Horizontal or vertical distance to nearest terminal			2.54		mm

SIMPLIFIED MECHANICAL LAYOUT



ELECTRICAL CHARACTERISTICS

(T = 25ºC, +5V bus = +5V unless otherwise noted)

Parameter	Conditions / Notes	Symbol	Min	Typ	Max	Units
Operating power consumption				TBD		W

Parameter	Conditions / Notes	Min	Typ	Max	Units
I2C address			00x53		
I2C clock speed			400		kHz
I2C pull-up resistors			∞		Ω

IN-CIRCUIT DEBUGGING PIN DESCRIPTIONS

The Microchip® ICD®-compatible debugging/ programming connector **`J5`** is implemented with a standard 6-pin Pumpkin PIC24 FPC connector. It is designed to mate to a Pumpkin JFPC-PIC24 debugging adapter via a 6-terminal flexible printed circuit (cable). This in turn can be connected to various Microchip in-circuit debuggers and programmers.

Name	Pin	I/O	Description
	`J5.1`	–	Unused.
`PGEC`	**`J5.2`**	I/O	**`PGEC1`** – clock signal for in-circuit debugging.
`PGED`	**`J5.3`**	I/O	**`PGED1`** – data signal for in-circuit debugging.
`DGND`	**`J5.4`**	–	Digital ground.
`VCC`	**`J5.5`**	–	Supervisor MCU power.
`-MCLR`	**`J5.6`**	I	Supervisor MCU's reset.

Table 1: ICD connector pinout

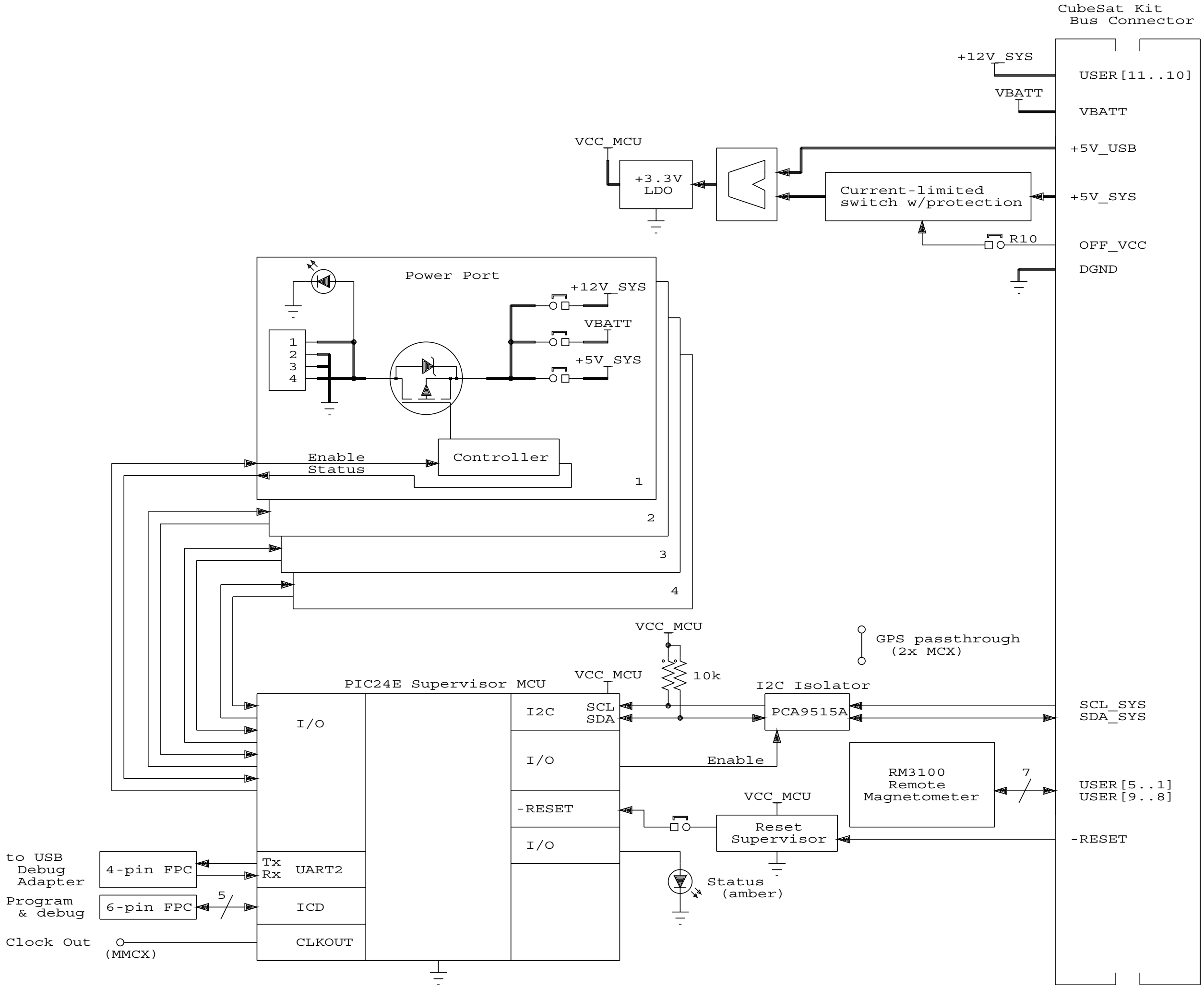
DEBUGGING ADAPTER PIN DESCRIPTIONS

The Pumpkin USB Debugging Adapter-compatible debugging connector **`J6`** is implemented with a standard 4-pin Pumpkin USB Debug FPC connector. It is designed to mate to a Pumpkin USB Debugging Adapter via a 4-terminal flexible printed circuit (cable). The serial interface is configured as 115200,N,8,1.

Name	Pin	I/O	Description
`VCC`	**`J6.1`**	–	Supervisor MCU power. When used with the BM 2, users must ensure that this voltage from the Pumpkin USB Debug Adapter is set to 3.3V, or disconnected (preferred).
`DGND`	**`J6.2`**	–	Digital ground.
`TXD`	**`J6.3`**	O	Asynchronous serial data out of the Supervisor MCU.
`RXD`	**`J6.4`**	I	Asynchronous serial data into the Supervisor MCU.

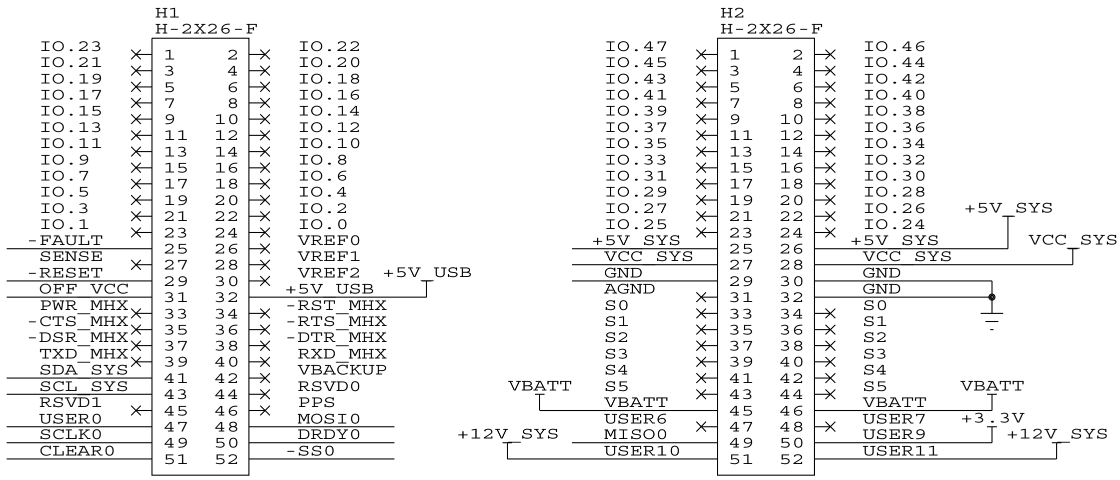
Table 2: Debug terminal pinout

BLOCK DIAGRAM



CubeSat Kit Bus PIN DESCRIPTIONS

CubeSat System Bus



CubeSat Kit Bus PIN DESCRIPTIONS – I/O

Name	Pin	I/O	Description
IO.0	H1.24		Not connected.
IO.1	H1.23		Not connected.
IO.2	H1.22		Not connected.
IO.3	H1.21		Not connected.
IO.4	H1.20		Not connected.
IO.5	H1.19		Not connected.
IO.6	H1.18		Not connected.
IO.7	H1.17		Not connected.
IO.8	H1.16		Not connected.
IO.9	H1.15		Not connected.
IO.10	H1.14		Not connected.
IO.11	H1.13		Not connected.
IO.12	H1.12		Not connected.
IO.13	H1.11		Not connected.
IO.14	H1.10		Not connected.
IO.15	H1.9		Not connected.
IO.16	H1.8		Not connected.
IO.17	H1.7		Not connected.
IO.18	H1.6		Not connected.
IO.19	H1.5		Not connected.
IO.20	H1.4		Not connected.
IO.21	H1.3		Not connected.
IO.22	H1.2		Not connected.
IO.23	H1.1		Not connected.
IO.24	H2.24		Not connected.
IO.25	H2.23		Not connected.
IO.26	H2.22		Not connected.
IO.27	H2.21		Not connected.
IO.28	H2.20		Not connected.
IO.29	H2.19		Not connected.
IO.30	H2.18		Not connected.
IO.31	H2.17		Not connected.
IO.32	H2.16		Not connected.
IO.33	H2.15		Not connected.
IO.34	H2.14		Not connected.

IO.35	H2.13		Not connected.
IO.36	H2.12		Not connected.
IO.37	H2.11		Not connected.
IO.38	H2.10		Not connected.
IO.39	H2.9		Not connected.
IO.40	H2.8		Not connected.
IO.41	H2.7		Not connected.
IO.42	H2.6		Not connected.
IO.43	H2.5		Not connected.
IO.44	H2.4		Not connected.
IO.45	H2.3		Not connected.
IO.46	H2.2		Not connected.
IO.47	H2.1		Not connected.

CubeSat Kit Bus PIN DESCRIPTIONS – Analog References

Name	Pin	I/O	Description
VREF0	H1.26		Not connected.
VREF1	H1.28		Not connected.
VREF2	H1.30		Not connected.

CubeSat Kit Bus PIN DESCRIPTIONS – Reserved

Name	Pin	I/O	Description
RSVD0	H1.44	–	Not connected.
RSVD1	H1.45	–	Not connected.

CubeSat Kit Bus PIN DESCRIPTIONS – I2C Bus

Name	Pin	I/O	Description
SDA_SYS	H1.41	I/O	I2C data. To/from supervisor MCU (an I2C slave device) via a PCA9515A I2C isolator. Typically from the PPM processor.
SCL_SYS	H1.43	I	I2C clock. To supervisor MCU (an I2C slave device) via a PCA9515A I2C isolator. Typically from the PPM processor.

CubeSat Kit Bus PIN DESCRIPTIONS – Control & Status

Name	Pin	I/O	Description
-FAULT	H1.25	O	Open-collector output from PIM 1's latchup-prevention overcurrent switch. Active LOW. Wire-ORed signal. On test point **TP45**.
SENSE	H1.27	–	Not connected.
-RESET	H1.29	I/O	Input to reset supervisor. *An active signal (0Vdc) on this input will reset the PIM 1's SupMCU.* On test point **TP51**.
OFF_VCC	H1.31	I	Input to latchup-prevention overcurrent switch. *An active signal (+5Vdc) on this input will disable* ***+5V_SYS*** *power to the PIM 1.* On test point **TP52**.
PPS	H1.46		Not connected.

CubeSat Kit Bus PIN DESCRIPTIONS – RBF and Separation Switches

Name	Pin	I/O	Description
S0	H2.33 H2.34		Not connected.
S1	H2.35 H2.36		Not connected.
S2	H2.37 H2.38		Not connected.
S3	H2.39 H2.40		Not connected.
S4	H2.41 H2.42		Not connected.

S5	H2.43 H2.44		Not connected.

CubeSat Kit Bus PIN DESCRIPTIONS – Power

Name	Pin	I/O	Description
VBATT	H2.45 H2.46		System battery voltage. One of three selectable power sources for on-board power switches. On test point **TP35**.
+5V_USB	H1.32	I/O	+5V USB power. From USB host. Powers the PIM 1 and local circuitry. On test point **TP11**.
+5V_SYS	H2.25 H2.26	I	+5V system power. Powers the PIM 1 and local circuitry. One of three selectable power sources for on-board power switches.On test point **TP9**.
PWR_MHX	H1.33		Not connected.
VBACKUP	H1.42	I	Connected only to test point **TP49**.
VCC_SYS	H2.27 H2.28	I	Connected only to test point **TP44**.
AGND	H2.31	I	Not connected.
DGND	H2.29 H2.30 H2.32	–	Digital ground. On test points **T100**-**T102** and others.

CubeSat Kit Bus PIN DESCRIPTIONS – Transceiver Interface

Name	Pin	I/O	Description
-RST_MHX	H1.34		Not connected.
-CTS_MHX	H1.35		Not connected.
-RTS_MHX	H1.36		Not connected.
-DSR_MHX	H1.37		Not connected.
-DTR_MHX	H1.38		Not connected.
TXD_MHX	H1.39		Not connected.
RXD_MHX	H1.40		Not connected.

CubeSat Kit Bus PIN DESCRIPTIONS – User-defined

Name	Pin	I/O	Description
USER0	H1.47		Not connected.
USER1	H1.48	I	**MOSI0**. SPI data from remote ADACS to RM3100 magnetometer.
USER2	H1.49	I	**SCLK0**. SPI clock from remote ADACS to RM3100 magnetometer.
USER3	H1.50	O	**DRDY0**. Ready signal from RM3100 to remote ADACS.
USER4	H1.51	I	**CLEAR0**. Clear signal from remote ADACS to RM3100 magnetometer.
USER5	H1.52	I	**-SS0**. SPI clock from remote ADACS to RM3100 magnetometer.
USER6	H2.47		Not connected.
USER7	H2.48		Not connected.
USER8	H2.49	O	**MISO0**. SPI data from RM3100 magnetometer to remote ADACS.
USER9	H2.50	I	**3V3**. +3.3V power to RM3100 from remote ADACS. On test point **TP12**.
USER10 **USER11**	H2.51 H2.52	I	**+12V_SYS**. +12V power from EPS (when fitted/available). One of three selectable power sources for on-board power switches. On test point **TP12**.

Power

The PIM 1 draws its power from the CSK's **+5V_SYS** and/or **+5V_USB**, and uses the resultant +5Vdc power to generate a local 3.3V (**VCC_MCU**) for its SupMCU. +5Vdc power drawn from **+5V_SYS** for **VCC_MCU** is current-limited and will automatically trip and reset if the setpoint is exceeded.

+12V_SYS, **VBATT** and **+5V_SYS** are the three selectable power sources for the PIM's power ports. The PIM 1 does not use **VCC_SYS** or **VBACKUP**.

Power Ports

The PIM 1 has four controllable high-side switches (HSS) named PORT[4..1]. At power-on, each port is disabled. Each power port is under SupMCU control and is enabled or disabled via SCPI commands. Each port has an associated LED that lights when the port is enabled.

For each port, one three zero-Ohm resistors is fitted to select **+12V_SYS**, **VBATT** or **+5V_SYS** as the power source for the given port. Each power port's source of power is fixed by the corresponding zero-Ohm resistor and cannot be changed on-the-fly. Each power port can deliver up to 4A to the connected load. Each power port also implements a programmable soft current limit, with a resolution of ca. 6.3mA.

The header for each power port is a Harwin M80-6661042; the mating harness connector is a Harwin M80-6911098. These are latching connectors. The pinout is shown below, where **n** is 1, 2, 3 or 4 for power ports 1 through 4.

Connector	Pins 1, 3, 5, 7 & 9	Pins 2, 4, 6, 8 & 10	Notes
J1.n	Selected **Port n** power	**GND**	Power is selected via one of three resistors for the desired voltage: **R12.n** **+12V_SYS** **R13.n** **VBATT** **R14.n** **+5V_SYS**

Table 3: Power port pinouts

The PIM 1's power ports are typically used to power-up or power-down payloads. For example, since wired Ethernet is an AC-coupled interface, payloads that communicate over Ethernet are well-served via a payload power connection via the PIM 1, and a separate twisted-pair Ethernet connection.

N.B. There is no keying associated with the power port connectors; any compatible harness can be plugged into any of the four power ports. Therefore it is recommended that the user color-code each port connector on the PIM and the intended mating harness connector to avoid accidentally connecting a lower-voltage payload to a power port that is configured for a higher voltage.

Ethernet Switch

The PIM 1 has a four-port IEEE 802.3 10BASE-T/100BASE-TX high-performance managed Ethernet switch for use with twisted-pair Ethernet cabling at up to 100Mbps speeds. The switch's four ports are named PORT[4..1]. This switch is intended to connect the C&DH processor and the Ground Service Equipment port to each other and to up to two attached Ethernet-connected payloads. There is an activity LED for each port which lights when a port is active, and blinks when there is activity / traffic on the port. The switch is fitted with a dedicated heatsink.

By default, the Ethernet port is enabled at power-on. Power to the Ethernet Switch is under SupMCU control via SCPI commands. The switch will not be damaged if it is off and there are active connections to it.

The switch has HP Auto MDI/MDI-X crossover support; therefore it is unnecessary to differentiate between straight or crossover cables when connecting to it.

Port 1 utilizes an 8-pin pinout that is compatible with Gigabit Ethernet harnessing; however, only 100Mbps speeds are supported. Ports 2-4 use just four signals, as only four are required for 100BASE-TX and slower Ethernet speeds. Cables to the PIM Ethernet switch should observe standard twisted-pair Ethernet cabling twist rates for best performance. The headers for the Ethernet connectors are Hirose DF13-8P-1.25H and DF13-4P-1.25H; the mating harness connectors are Hirose DF13-8S-1.25C and DF13-4S-1.25C. The mapping of the Ethernet switch's ports to the PIM Ethernet switch connectors and the pinout of the PIM's Ethernet switch connectors are shown below.

Native Port	PIM Port	Connector	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8
3	1	J3	TX1_P	TX1_N	RX1_P	loop 1		RX1_N	loop 2	
1	2	H5.1	TX2_P	TX2_N	RX2_P	RX2_N	n/a			
2	3	H5.2	TX3_P	TX3_N	RX3_P	RX3_N				
4	4	H5.3	TX4_P	TX4_N	RX4_P	RX4_N				

Table 4: Ethernet ports and pinouts

Harness-free Interface to Remote Magnetometer

The PIM 1 supports a harness-free means of connecting the PNI RM3100 remote magnetometer to the MAI-400 ADACS (where fitted / applicable). The PIM 1 routes all of the remote magnetometer's signals to a selection of the **USER** signals on the CSK Bus (see **CubeSat Kit Bus PIN DESCRIPTIONS – User-defined**, above). These signals are directly connected to the remote magnetometer inputs and outputs of the MAI-400 ADACS. To utilize them, an RM3100 remote magnetometer must be soldered in place on the PIM 1 in the correct orientation; a cutout is provided in the PIM 1's PCB for clearance for the taller components on the RM3100.

The +3.3V supply for the remote magnetometer is provided by the MAI-400 ADACS. Therefore, when using this interconnect scheme, the remote magnetometer will be automatically powered down whenever the MAI-400 ADACS is powered down. The SupMCU on the PIM has no interface to the RM3100 remote magnetometer.

The MAI-400 has requirements regarding how close the remote magnetometer can be placed to the MAI-400 ADACS. Locating the RM3100 on the PIM 1 in a standard Pumpkin SUPERNOVA bus stack satisfies these requirements.

In applications where an MAI-400 ADACS is not part of the bus stack, the RM3100 can be omitted, and the related **USER** pins freed for other purposes.

GPS Antenna Passthrough

The pair of interconnected upright MCX jacks are provided; one on top and one on the bottom of the PCB, interconnected with a 50Ω characteristic impedance. When a GPS receiver is used, its antenna input is routed from the lower MCX jack; the upper MCX jack is used to connect to the GPS antenna. This permits easy removal and re-installation of the GPS antenna when servicing the volume around the PIM.

Test Points

The PIM 1 PCB is fitted with a variety of system-level test points. These test points are user accessible in a 6U SUPERNOVA nanosatellite once the +Z-face bus-side cover and GPS antenna are removed. These test points enable a technician to verify nominal values for various important system-level voltages (e.g. **+5V_SYS**, **VBATT**, etc.).

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