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CubeSat Kit™ Bus Interface Module (BIM) 1

Hardware Revision: B

Bus 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
- Three system serial port interfaces
- Six CSS & temperature sensor ports
- Pin puller driver
- Hardware windowed WDT subsystem
- Embedded 3-axis MEMS gyroscope and accelerometer
- Can host multi-port Ethernet switch
- Located directly above MBM 2 + BBB 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 710-01390

Option Code	CubeSat Kit Bus Connector
/00 (standard)	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	20151023	AEK	Initial release of hardware Rev B.
B	20170103	AEK	Updated image, fixed handshaking signals in block diagram, added second I2C port.

OPERATIONAL DESCRIPTION

The Bus Interface Module (BIM) 1 is a CubeSat Kit (CSK)-compatible module for use in CSK nanosatellite bus stacks. BIM 1 is primarily responsible for providing serial and Ethernet interfaces to bus subsystems and payload(s). BIM 1 has a pin puller driver for solar panel deployments. BIM 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.

BIM 1 is built on Pumpkin PCB 705-01272.

COMMAND & TELEMETRY INTERFACE

A Pumpkin SupMCU provides a command and telemetry interface to the BIM 2, via SCPI over I2C. Commands and telemetry are both BIM 2-specific and general to SupMCUs.

The I2C address of the BIM 2 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.

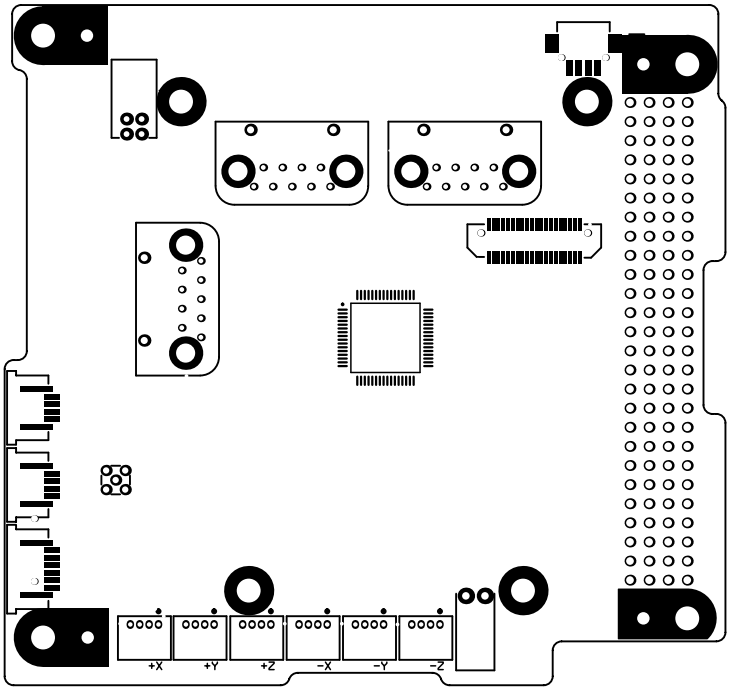
ABSOLUTE MAXIMUM RATINGS

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 pin puller driver output		-0.3 to +6.0	V

PHYSICAL CHARACTERISTICS

Parameter	Conditions / Notes	Symbol	Min	Typ	Max	Units
Mass				50		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		mW

Parameter	Conditions / Notes	Min	Typ	Max	Units
I2C address			0x52		
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

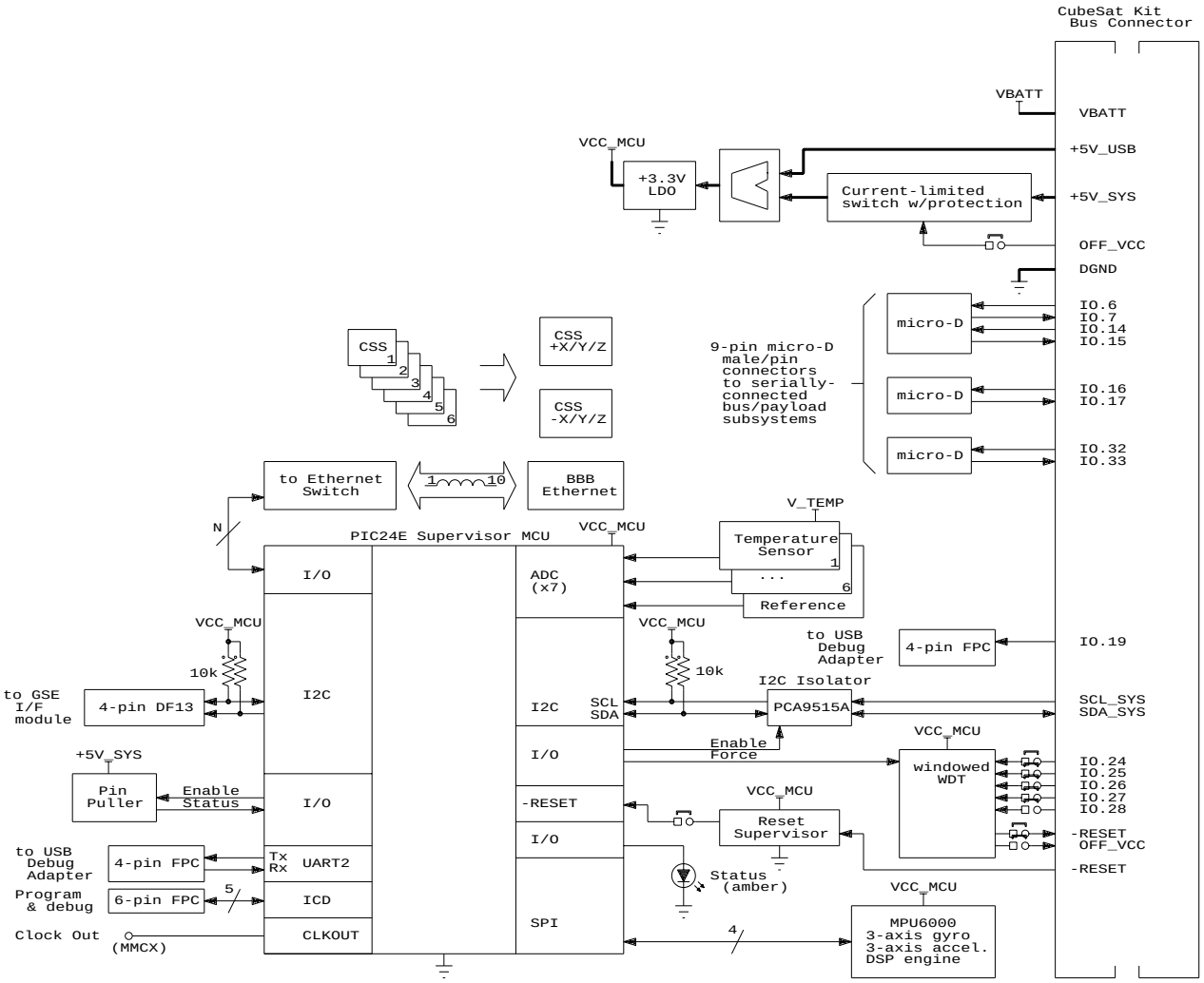
DEBUGGING ADAPTER PIN DESCRIPTIONS

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.

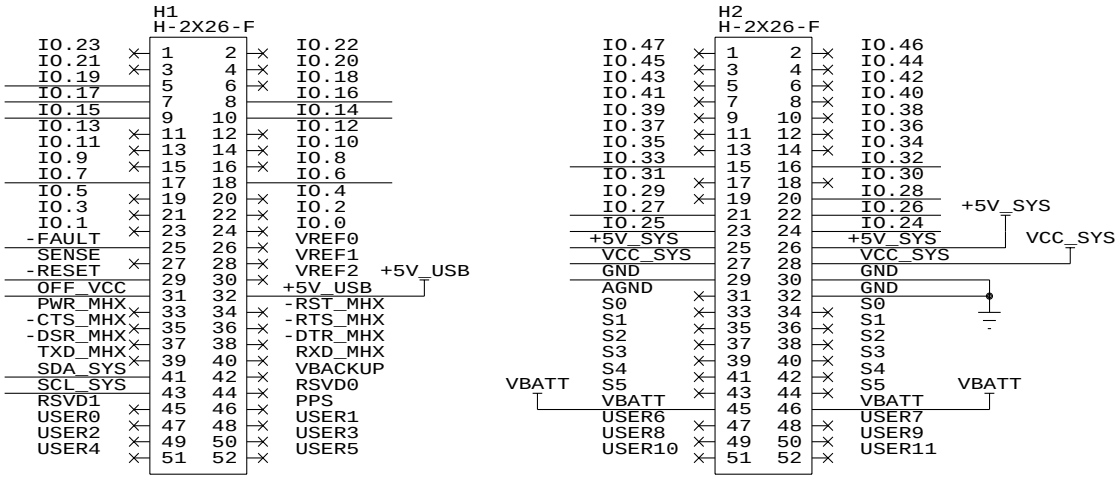
Name	Pin	I/O	Description
VCC	**J6.1**	–	Supervisor MCU power. When used with the BM 2, users must ensure that this voltage from the Pumpkin USB Debug Adapter is set to 3.3V, or disconnected (preferred).
DGND	**J6.2**	–	Digital ground.
TXD	**J6.3**	O	Asynchronous serial data out of the Supervisor MCU.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

Table 2: Debug terminal pinout

BLOCK DIAGRAM



CubeSat Kit Bus PIN DESCRIPTIONS



CubeSat 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	I	**UTX1.** Serial data out of port M9P-C-UB-1. Typically serial data from the PPM processor.
IO.7	H1.17	O	**URX1.** Serial data into port M9P-C-UB-1. Typically serial data to the PPM processor.
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	I	**-RTS1.** Flow control out of port M9P-A-UA-2. Typically flow control from the PPM processor. Can be paired with **URX1**.
IO.15	H1.9	O	**-CTS1.** Flow control into port M9P-A-UA-2. Typically flow control to the PPM processor. Can be paired with **UTX1**.
IO.16	H1.8	I	**UTX2.** Serial data out of port M9P-A-UA-2. Typically serial data from the PPM processor.
IO.17	H1.7	O	**URX2.** Serial data into port M9P-A-UA-2. Typically serial data to the PPM processor.
IO.18	H1.6		Not connected.
IO.19	H1.5	I	**UTX4.** Serial data out of USB debug port. Typically serial data from the PPM processor.
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		Input to WDT. A high-going pulse on this signal will reset/kick the WDT. Active when zero-ohm jumper **R52** is fitted.
IO.25	H2.23		Input to WDT. A high-going pulse on this signal will reset/kick the WDT. Active

			when zero-ohm jumper **R49** is fitted.
IO.26	H2.22		Input to WDT. A high-going pulse on this signal will reset/kick the WDT. Active when zero-ohm jumper **R51** is fitted.
IO.27	H2.21		Input to WDT. A high-going pulse on this signal will reset/kick the WDT. Active when zero-ohm jumper **R50** is fitted. *This is the factory default configuration.*
IO.28	H2.20		Input to WDT. A high-going pulse on this signal will reset/kick the WDT. Active when zero-ohm jumper **R54** is fitted.
IO.29	H2.19		Not connected.
IO.30	H2.18		Not connected.
IO.31	H2.17		Not connected.
IO.32	H2.16	I	**UTX3.** Serial data out of port M9P-A-UA-3. Typically serial data from the PPM processor. Passthrough can be disabled via SCPI command to the SupMCU.
IO.33	H2.15	O	**URX3.** Serial data into port M9P-A-UA-3. Typically serial data to the PPM processor. Passthrough can be disabled via SCPI command to the SupMCU.
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.
SENSE	H1.27	–	Not connected.
-RESET	H1.29	I/O	Input to reset supervisor. *An active signal (0Vdc) on this input will reset the BIM 1's SupMCU.*
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 BIM 1.*
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.
+5V_USB	H1.32	I/O	+5V USB power. From USB host. Powers the BIM 1 and local circuitry.
+5V_SYS	H2.25 H2.26	I	+5V system power. Powers the BIM 1 and local circuitry.
PWR_MHX	H1.33		Not connected.
VBACKUP	H1.42	I	Not connected.
VCC_SYS	H2.27 H2.28	I	Not connected.
AGND	H2.31	I	Not connected.
DGND	H2.29 H2.30 H2.32	–	Digital ground.

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		Not connected.
USER2	H1.49		Not connected.
USER3	H1.50		Not connected.
USER4	H1.51		Not connected.
USER5	H1.52		Not connected.
USER6	H2.47		Not connected.
USER7	H2.48		Not connected.
USER8	H2.49		Not connected.
USER9	H2.50		Not connected.
USER10	H2.51		Not connected.
USER11	H2.52		Not connected.

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.

System Serial Ports

The BIM 1 hosts up to three system serial ports. Serial ports are used – in conjunction with modules directly connected to the CSK bus and/or harnesses – to communicate between the C&DH host and serially-connected subsystems. Each serial port is mapped onto a 9-pin male/pin MIL-DTL-83513 micro-D ("MDM") connector. In effect, the connectors for these serial ports function as passthroughs for signals from the CSK bus.

In addition to carrying serial data, serial ports can also provide power and a choice of hardware flow control, **PPS** and/or **–RESET** signals. Power passes through a SupMCU-controlled MOSFET switch with overcurrent protection. The mappings and extra functionality of each serial port are listed below.

The serial port functions for pins 5 and 9 are set via zero-Ohm resistor jumpers on the BIM 1 PCB.

Port	CSK Signals	Power	Pin 5	Pin 9	Applications
M9P-C-UB-1	UTX1/IO.6 & URX1/IO.7	+5V_SYS	-CTS1/IO.15 or PPS	-RTS1/IO.14 or -RESET	Serially-connected payload powered from +5V. Full hardware flow control is possible.
M9P-A-UA-2	UTX2/IO.16 & URX2/IO.17	VBATT	-CTS1/IO.15 or PPS	-RESET	GlobalStar® simplex modem powered from 2-cell Li battery.
M9P-A-UA-3	UTX3/IO.32 & URX3/IO.33	VBATT	PPS	-RESET	Serially-connected payload powered from 2-cell Li battery.

Table 3: Serial port configurations

The complete pinout for the three BIM serial ports is listed below. For configurable pins, see Table 3.

Port	Pins 1, 2 &3	Pin 4	Pin 5	Pins 6 & 7	Pin 8	Pin 9
M9P-C-UB-1	GND	UTX1	-CTS1 or PPS	+5V_SYS	URX1	-RTS1 or -RESET
M9P-A-UA-2	GND	UTX2	-CTS1 or PPS	VBATT	URX2	-RESET
M9P-A-UA-3	GND	UTX3	PPS	VBATT	URX3	-RESET

Table 4: Serial port pinouts

Additionally, serial port 3 has a pair of serial isolators under SupMCU control. When disabled, there is no passthrough of the TX3/RX3 signals from the CSK bus to the 9-pin connector, and the UTX3/URX3 serial signal pair can be used on the CSK bus without interference from the BIM and any connected serial devices.

Watchdog Timer (WDT)

The BIM 1 incorporates a windowed watchdog timer for system WDT functionality. One of five CSK bus signals **IO.[28..24]** can be chosen to kick the WDT. To kick the WDT, apply a high-going pulse of at least 100us duration every 1.25s. The WDT's output can drive the CSK **–RESET** and/or **OFF_VCC** signals. The SupMCU can also force the WDT system on command.

The zero-ohm jumpers required to route the WDT kick signal from the CSK bus to the BIM are listed below. Only one resistor should be fitted.

CSK Signal	0 Ohm Jumper / Resistor	Notes
IO.24	R52	
IO.25	R49	
IO.26	R51	
IO.27	R50	Default
IO.28	R54	

Table 5: Jumper selectors for WDT kick signal

Coarse Sun Sensor (CSS) Interface & Remote Temperature Sensors

The BIM 1 supports up to six photodiode-based remote coarse sun sensors (CSS) for applications that utilize the Pumpkin Solar Interface Module (SIM) and require CSS inputs to an ADACS. Each CSS has its own harness connector (shared with the remote temperature sensors, see below). The six CSSes are re-routed into two groups of three (+X/+Y/+Z and –X/-Y/-Z) on the BIM 1 to simplify harness routing.

The BIM 1 supports up to six LM335-class absolute Kelvin temperature sensors. Each one has a dedicated connector. In a typical implementation, remote LM335s would be distributed throughout a nanosatellite, and the BIM 1 can be queried for temperature telemetry. The voltage source for the remote temperature sensors is compensated for error, adjusted to enable the reporting of temperatures well above 330K, and can be disabled to save power.

The headers on the BIM PCB are Hirose DF13-4P-1.25V; the mating harness connectors are Hirose DF13-4S-1.25C. Their pinouts are shown below.

Connector	Pin 1	Pin 2	Pin 3	Pin 4
J6	+X CSS cathode	+X CSS anode	LM335 output	-1.8v to LM335 ground
J7	+Y CSS cathode	+Y CSS anode	LM335 output	-1.8v to LM335 ground
J8	+Z CSS cathode	+Z CSS anode	LM335 output	-1.8v to LM335 ground
J9	-X CSS cathode	-X CSS anode	LM335 output	-1.8v to LM335 ground
J10	-Y CSS cathode	-Y CSS anode	LM335 output	-1.8v to LM335 ground
J11	-Z CSS cathode	-Z CSS anode	LM335 output	-1.8v to LM335 ground

Table 6: CSS & temperature sensor pinouts

Pin Puller Driver

The BIM 1 is fitted with a SupMCU-controlled MOSFET switch with overcurrent protection that is used to drive the pin puller to release the solar panels. The BIM 1 accepts SCPI commands to safe, arm and fire (i.e., energize) the pin puller and thereby release the solar panels. The pin puller driver will not be damaged if +5Vdc is applied to its pins 1 and 4 it from an external source, even when the BIM is unpowered.

The header on the BIM PCB is a Hirose DF11-4DP-2DS; the mating connector is a Hirose DF11-4DS-2C. The pinout is shown below.

Connector	Pin 1	Pin 2	Pin 3	Pin 4
J12	+5Vdc	GND	GND	+5Vdc

Table 7: Pin puller driver pinout

Ethernet Switch Interface

The BIM 1 can be expanded with a 5-port Ethernet switch in the form of a mezzanine module that mounts on top of the BIM. A single 40-pin connector carries power, control signals and the Ethernet signals from a BBB mounted below the BIM 1.

Ground Service Equipment Interface

The BIM 1 SupMCU's secondary I2C peripheral is used to control a multi-color LED of a connected GSE Interface Module, over SCPI.

The header on the BIM PCB is a Hirose DF13-4P-1.25V; the mating harness connector is a Hirose DF13-4S-1.25C. The pinout is shown below.

Connector	Pin 1	Pin 2	Pin 3	Pin 4
H7	+3.3Vdc	GND	SDA	SCL

Table 8: GSE LED driver (remote I2C) pinout

External Oscillator into SupMCU[1]

The BIM 1's SupMCU operates with an internal 7.37MHz oscillator. For applications that wish to synchronize the SupMCU's clock with an external source, the SupMCU can be configured to run from an externally-provided oscillator applied to its **T1** MMCX connector.

If the external oscillator signal fails, the SupMCU will automatically switchover to its internal 7.37MHz oscillator.

If/when providing an external oscillator at a frequency other than 7.37MHz, the SupMCU must be commanded with the new operating frequency, so that it can reconfigure peripherals that are dependent on particular clock speeds (e.g., UARTs).

The external oscillator in function is disabled when the oscillator out function is selected.

External Oscillator out of SupMCU[2]

The BIM 1 can output an oscillator signal on its **T1** MMCX connector. This signal can be used to synchronize to other SupMCUs, or to derive information re the BIM 1's SupMCU operation.

The oscillator output is the SupMCU's internal clock, divided by a commandable power-of-2. This oscillator output can be enabled, disabled and the resultant frequency changed via SCPI commands.

The oscillator out function is disabled when the external oscillator in function is selected.

[1] Future software enhancement.
[2] Future software enhancement.

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