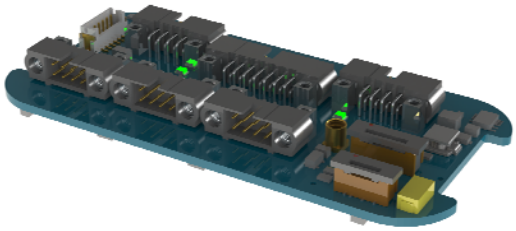
http://www.cubesatkit.com/

CubeSat Kit™
BSM 1 Battery Switch Module
Hardware Revision: A

Module for Switching Battery Power to Connected Loads



Applications

- CubeSats
- Nanosatellites
- Pumpkin MISC™ 3 3U CubeSats
- Pumpkin SUPERNOVA™ 6U/12U NanoSats

Features

- For use with Pumpkin battery modules or standalone
- 5 switchable high-current battery-voltage power ports w/LED indicators
- With dedicated nanopower supervisor MCU for:
  - Commands & telemetry
  - Power port control & status
  - Programmable overcurrent control
  - Additional user-defined functionality
  - CLK Out w/divider
- External control port:
  - Direct digital input control of each power port
- Flexible interface to CSK –RESET signal
- With 14-pin connector to Pumpkin battery modules
- Independent latchup (device overcurrent) protection on critical subsystems
- 4-layer gold-plated blue-soldermask PCB[1]
- Supervisor MCU programmed with Pumpkin's space-proven Salvo™ RTOS for easy user customization

ORDERING INFORMATION

Pumpkin P/N 710-01764

CAUTION

Electrostatic Sensitive Devices

Handle with Care

[1] Early / production versions may utilize green PCBs.

CHANGELOG

Rev.	Date	Author	Comments
A	20180819	DJW & AEK	Initial release of hardware Rev A.
B	20190725	AEK	Corrected I2C address.

OPERATIONAL DESCRIPTION

The BSM adds point-of-load power switching functionality to nanosatellites by integrating multiple intelligent MOSFET drivers and appropriate connectors in a small module. A built-in supervisor MCU provides commands and telemetry via SCPI over I2C via the CSK bus' I2C lines. The BSM receives its power, I2C, **-RESET** and **OFF_VCC** signals from a 14-pin harness connected to a BM 2 or compatible connector.

The BSM is typically integrated into a Pumpkin Battery Module 2 (BM 2). The BSM has a board shape that permits it to be mounted on the end of a BM 2 that is opposite to the BM 2's controller PCB.

One 14-pin Harwin M80 connector provides a power and signal interface between the BSM and a BM 2 battery module. Five 8-pin Harwin M80 connectors provide power interfaces between the BSM and connected loads.

A Hirose DF13 connector permits the use of external digital control signals to switch the BSM's power ports. Each power port is controlled by the logical ORing of the internal, commanded power port state and the external digital input for that port.

The BSM can only pass battery power (at unregulated battery voltage) to connected loads; it is not capable of any voltage regulation. The BSM has no energy storage capability of its own – it is simply a collection of switches that pass battery power to connected loads. The total power drawn by connected loads cannot exceed the power delivery capability of the battery.

The BSM has individual programmable soft current limits for each power port; when the current limit is exceeded, the power port will turn off and prevent the connected load from drawing power from the battery. Each power port has a green LED to indicate the power port's status (LED ON when power port is enabled).

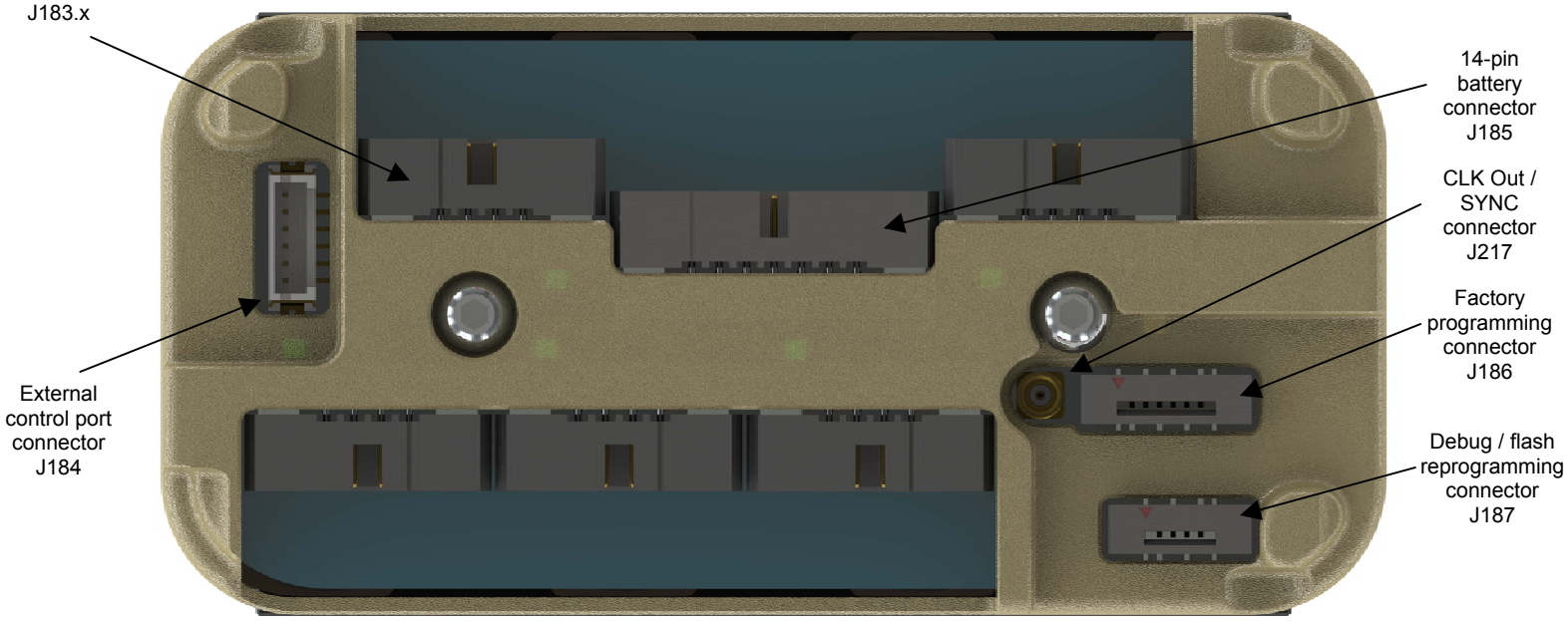


Figure 1: Top view of BSM installed in BM 2 battery module (not included)

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Value	Units
Operating temperature	T_A	-40 to +85	ºC
Voltage on local **VCC_MCU** bus		-0.3 to +4.0	Vdc
Voltage on **V+** relative to **V-**		+9	Vdc
Voltage **V-** relative to power port grounds		-0.3 to +0.3	Vdc
Voltage on **GPIO** control inputs		-0.3 to +6	Vdc
Current drawn from a single power port		8 [2]	A
Total current drawn with all power ports active		20 [3]	A

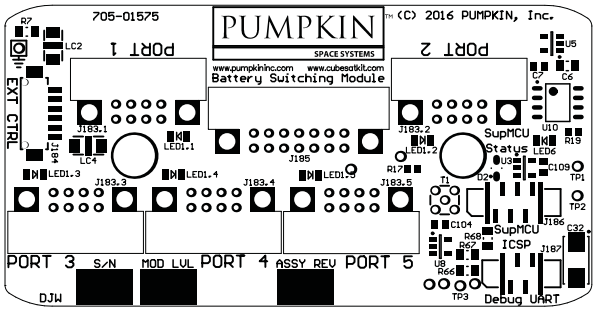
PHYSICAL CHARACTERISTICS

Parameter	Conditions / Notes	Symbol	Min	Typ	Max	Units
Mass				25.8		g
Height of components above PCB					6.2	mm
Height of components below PCB					2.3	mm
PCB width	Corner hole pattern matches PC/104			40.1		mm
PCB length				78.0		mm
PCB thickness				1.6		mm

[2] Connector heating will occur. See Harwin M80 datasheets for temperature/current derating.

[3] Dependent on battery source. BM 2 standard maximum discharge current is 10A. Higher currents are available with special programming.

SIMPLIFIED MECHANICAL LAYOUT



The BSM PCB's maximum dimensions are 1.58" x 3.07".

ELECTRICAL CHARACTERISTICS

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

Parameter	Conditions / Notes	Symbol	Min	Typ	Max	Units
Operating power consumption	Supervisor MCU active, all power ports OFF	P_{OP_SUP}		25		mW
Supervisor MCU internal clock frequency	Base frequency, can be multiplied by onboard PLL	f_{CLK_MCU}		15.21		MHz
Current draw on external control inputs	5V external signal, per signal			4.3		mA

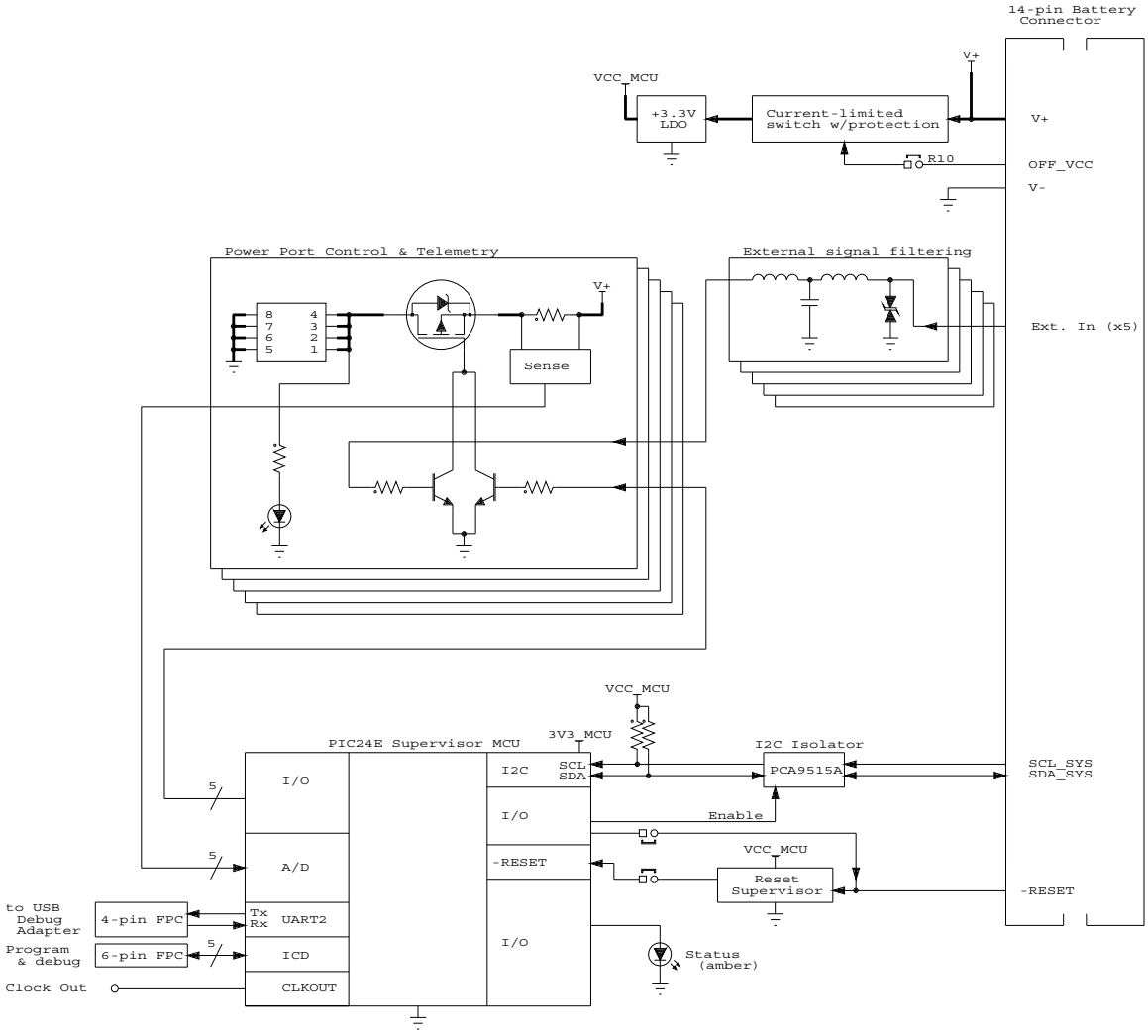
OPERATIONAL CHARACTERISTICS

Parameter	Conditions / Notes	Min	Typ	Max	Units
Bootloader delay time	Time during which the bootloader is enabled. Once the bootloader timeout expires, the SupMCU begins firmware execution		5		s
Bootloader speed		9,600		230,400	bps

I2C CHARACTERISTICS

Parameter	Conditions / Notes	Min	Typ	Max	Units
I2C address	7-bit I2C address		0x58		
I2C clock speed				400	kHz
I2C pull-up resistors	No pull-up resistors are fitted to **SCL_SYS** or **SDA_SYS**		∞		Ω

BLOCK DIAGRAM



CONNECTOR PIN DESCRIPTIONS

J183 PIN DESCRIPTIONS – Switched Power Port

Name	Pin	I/O	Description
V+_SW	1		Switched unregulated battery source to load. A connected load sinks current from these pins. Power is available on all four **V+_SW** pins when the corresponding power port is enabled, unless the programmable soft current limit has been exceeded.
	2		
	3		
	4		
V-	5		Unregulated battery return. From load; load current returns to the battery through all four of these pins in the corresponding port.
	6		
	7		
	8		

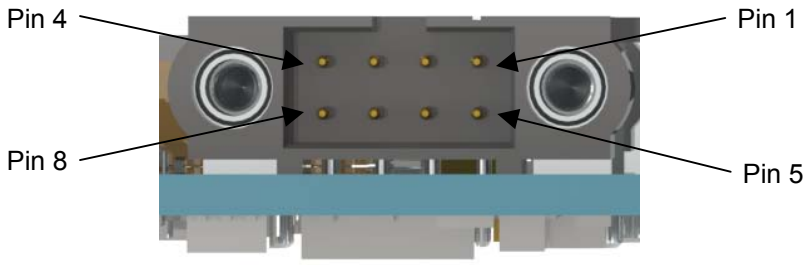


Figure 2: BSM Power Port Connector J183 (1 of 5)

The mating connector for J183 is a Harwin Datamate J-Tek double-row 8-pin female connector M80-4800805. Pumpkin recommends M22759-class 22AWG or 24AWG wiring (with the appropriate Harwin crimp pins and tooling) when creating mating harnesses.

J184 PIN DESCRIPTIONS – External Control Signals

Name	Pin	I/O	Description
EXT_EN_1	1	I	Logic control signal for switched battery ports. A logical high on any pin will enable the corresponding power port.
EXT_EN_2	2		
EXT_EN_3	3		
EXT_EN_4	4		
EXT_EN_5	5		
DGND	6		System ground / unregulated battery return. To battery. Connected internal to **V-**.

The mating connector for J184 is a Hirose DF13 single-row 6-pin socket housing DF13-6S-1.25C. Pumpkin recommends M22759-class 26-30AWG wiring (with the appropriate Hirose crimp pins and tooling) when creating mating harnesses.

J185 PIN DESCRIPTIONS – Battery

Name	Pin	I/O	Description
V+	1		Unregulated battery source. From battery.
	2		
	3		
	4		
	5		
OFF_VCC	6	I	An active signal on this pin will disable **VCC_MCU** power to the supervisor MCU.

SDA_SYS	7	I/O	I2C data. To/from supervisor MCU (an I2C slave device) via a PCA9515A I2C isolator. Typically from the I2C master processor (host).
V-	8		Unregulated battery return. To battery.
	9		
	10		
	11		
	12		
-RESET	13	I	Input to reset supervisor. An active signal on this pin will reset the supervisor MCU.
SCL_SYS	14	I	I2C clock. To supervisor MCU (an I2C slave device) via a PCA9515A I2C isolator. Typically from the I2C master processor (host).

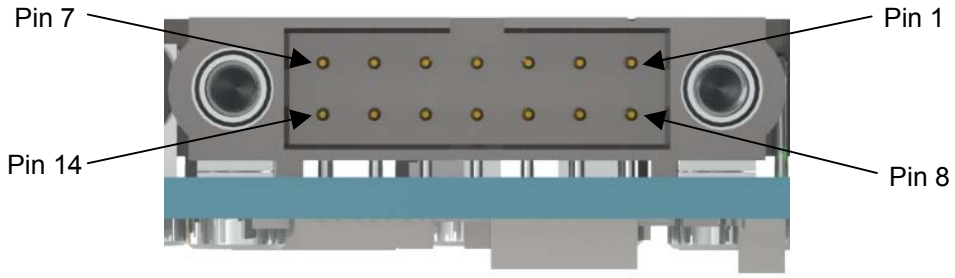


Figure 3: BSM Power Port Connector J185

The mating connector for J183 is a Harwin Datamate J-Tek double-row 14-pin female connector M80-4801405. Pumpkin recommends M22759-class 22AWG or 24AWG wiring (with the appropriate Harwin crimp pins and tooling) when creating mating harnesses.

J186 PIN DESCRIPTIONS – In-Circuit Serial Programming

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

The mating cable for J186 is a 6-conductor 1mm pitch flat flex cable. This connector is typically used only at Pumpkin, for initial programming of the SupMCU.

J187 PIN DESCRIPTIONS – Debug Terminal

Name	Pin	I/O	Description
VCC	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	2	–	Digital ground.
TXD	3	O	Asynchronous serial data out of the Supervisor MCU.
RXD	4	I	Asynchronous serial data into the Supervisor MCU.

The mating cable for J186 is a 4-conductor 1mm pitch flat flex cable. This connector is typically used to reflash the SupMCU firmware via Pumpkin's USB Debug Adapter and bootloader GUI.

CLK Out Output

The BSM provides an additional clock input/output – **`CLK Out`** – that can be configured to be either:

1. The CPU clock of the BSM's Supervisor MCU, with a selectable postscaling divider of 1 to 2^15 in sixteen steps. This clock is generated on the Supervisor MCU via an internal high-accuracy RC oscillator and is presented on one of the Supervisor MCU's output pins. The nominal value of this oscillator is 15.21MHz at room temperature.
2. A synchronization clock input to the SupMCU.

The BSM provides the Supervisor MCU's **`CLK Out`** on connector **`J217`**. **`CLK Out`** is controlled via commands to the BSM's Supervisor MCU, and is off by default. Apart from some additional power consumption and possible noise associated with driving the **`CLK Out`** output pin, there is no discernable effect on the Supervisor MCU when **`CLK Out`** is active.

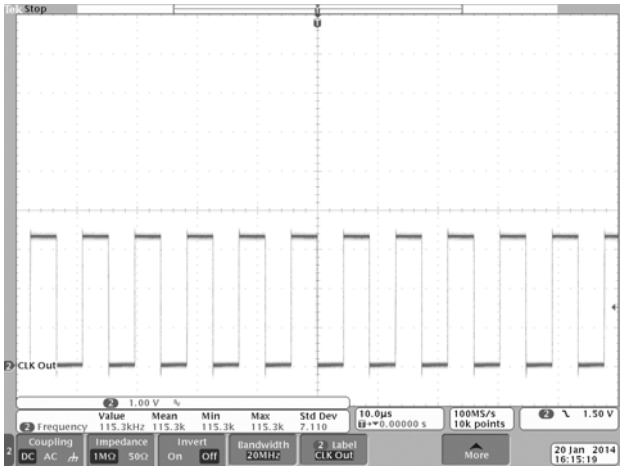


Figure 4: **`CLK Out`** output on **`J217`** when Supervisor MCU is commanded to output MCU clock with the divider set to 64.

I2C Interface

The BSM functions as an I2C Slave device.

The BSM's I2C interface is compatible with 100kHz and 400kHz I2C clock speeds.

When being written to or being read from by an I2C Master device, the BSM (as a clock-stretching I2C Slave device) may stretch the I2C clock (**SCL_SYS**) as a means of avoiding overruns. This is part of the I2C protocol.

No pull-up resistors are present on the BSM. Pull-up resistors must be implemented elsewhere in the system; typically, they are on or close to the system's I2C Master device.

Command & Telemetry Interface

The SupMCU on the BSM responds to various general SupMCU and BSM-specific commands via its SCPI interface over I2C, and provides preformatted telemetry with timestamps in response to telemetry requests. Please refer to Pumpkin's SUPERNOVA™ Firmware Reference Manual for more information.

Bootloader and Firmware Reflashing

The SupMCU on the BSM incorporates a bootloader to permit in-the-field reflashing of the BSM's operating firmware. Reflashing is done through connector J187 and via Pumpkin's USB Debug Adapter and bootloader GUI.

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