



<http://www.cubesatkit.com/>

CubeSat Kit™

Pluggable Processor Module (PPM) A2
Hardware Revision: B

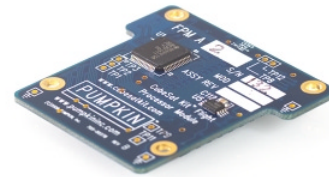
PPM with TI's MSP430F1611 for CubeSat Kit Motherboard

Applications

- CubeSat nanosatellite control, C&DH, TT&C
- General-purpose low-power computing for CubeSat Kit architecture
- Remote sensing for harsh environments

Features

- For CubeSat Kit Motherboard (MB)
- TI's MSP430F1611 16-bit microcontroller (MCU)
- 50KB program memory, 10KB on-chip SRAM
- Integrated peripherals:
 - 2 SCIs (UART0/SPI0/I2C & UART1/SPI1)
 - 8-channel 12-bit ADC
 - 2-channel 12-bit DAC
 - 16-bit Timer_A3
 - 16-bit Timer_B7
 - 3-channel DMA
 - On-chip comparator
 - SVS, BOR, WDT, JTAG, etc.
- 7.3728MHz & 32.768kHz clock crystals
- PCA9515A I2C isolator
- Ultra-low power operation
- Independent latchup (device overcurrent) protection
- Independent external reset supervisor (POR/BOR)
- Small-size PPM footprint
- 4-layer gold-plated blue-soldermask PCB
- Compatible with Pumpkin's Salvo™ RTOS and HCC-Embedded's EFFS-THIN SD Card file FAT file system for ease of programming



ORDERING INFORMATION

Pumpkin P/N 710-00486

| Option Code | PPM Connector Height |
|-------------------|----------------------|
| /00 (standard) | +3mm |

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



CAUTION

Electrostatic
Sensitive
Devices

Handle with
Care



CHANGELOG

| Rev. | Date | Author | Comments |
|------|----------|--------|--|
| A | 20090728 | AEK | Initial revision. |
| B | 20090808 | AEK | Added photo. |
| C | 20100113 | AEK | Revised I _{SLEEP} based on lot testing of PCA9515A. |

OPERATIONAL DESCRIPTION

PPM A2 enables CubeSat Kit customers to utilize TI's ultralow-power MSP430 processor on a CubeSat Kit Motherboard (MB). PPM A2 uses the 64-pin MSP430F1611IPM, with a wide selection of on-chip peripherals. Additionally, a PCA9515A I2C isolator is present to facilitate I2C interfacing.

ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Value | Units |
|--|----------------|--------------|-------|
| Operating temperature | T_A | -40 to +85 | °C |
| Voltage on +5V_USB bus | | -0.3 to +6.0 | V |
| Voltage on +5V_SYS bus | | | |
| Voltage on -FAULT_OC open-collector output | | | |
| Voltage on VCC bus | | -0.3 to +3.6 | V |
| Voltage on VCC_SD bus | | | |
| Voltage on any MSP430 I/O pin | | -0.3 to 3.6 | V |
| Diode current at any MSP430 pin | | -2 to +2 | mA |
| DC current through any pin of PPM connector H1 | I_{PIN_MAX} | 1.2 | A |
| MSP430 operating frequency | f_{OP_MAX} | 7.4 | MHz |

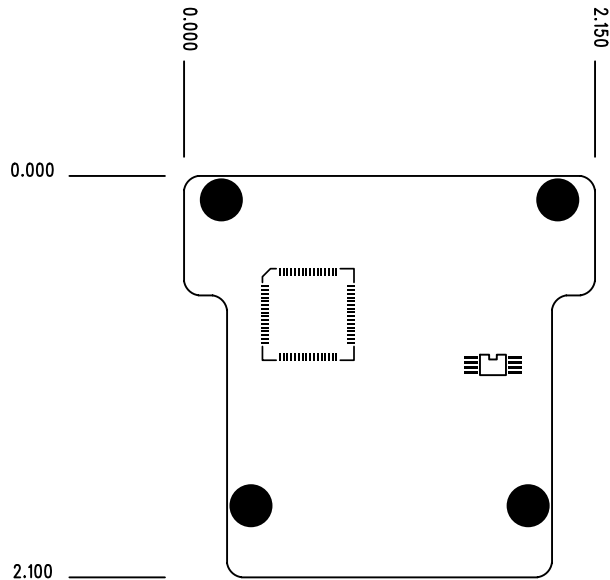
Refer to the MSP430x161x family datasheet for additional absolute maximum ratings associated with processor U1, especially per-pin current limits.

PHYSICAL CHARACTERISTICS

| Parameter | Conditions / Notes | Symbol | Min | Typ | Max | Units |
|---|--------------------|--------|-----|------|-----|-------|
| Mass | | | | 11 | | g |
| Height of components above PCB | | | | | 2 | mm |
| Height of components below PCB ¹ | | | | | 4 | mm |
| PCB width | Small-size PPM | | | 54.6 | | mm |
| PCB length | | | | 53.4 | | mm |
| PCB thickness | | | | 1.6 | | mm |

SIMPLIFIED MECHANICAL LAYOUT ²

PPM A2 is implemented on a small-size PPM PCB, as shown below.



¹ Not including connector H1.

² Dimensions in inches.

ELECTRICAL CHARACTERISTICS

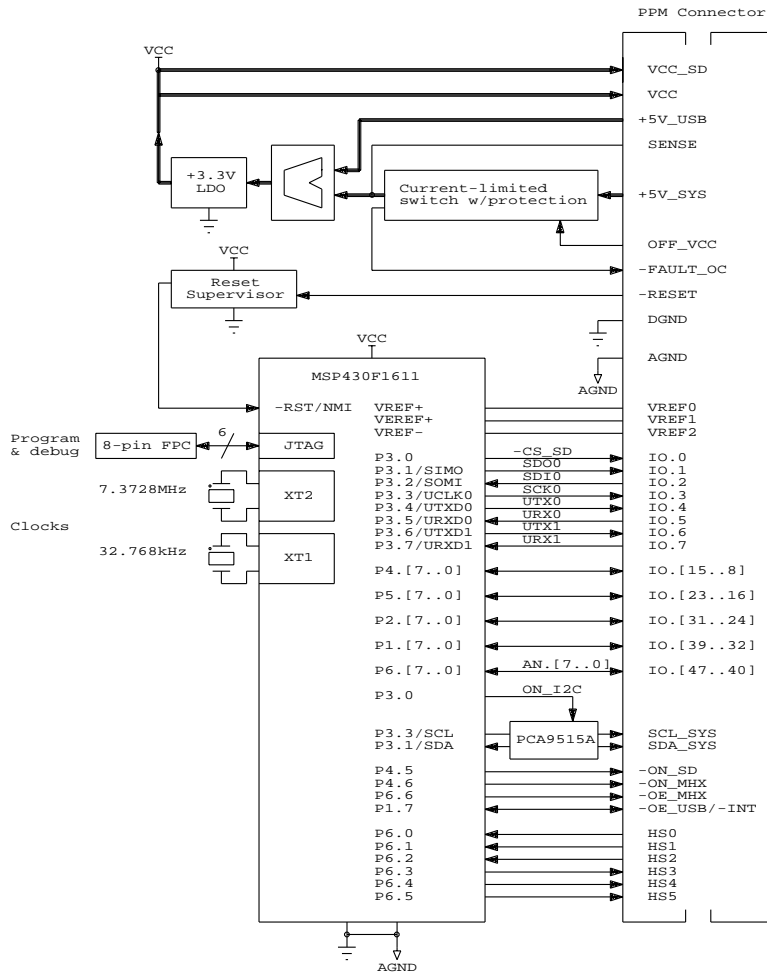
(T = 25°C, +5V bus = +5V unless otherwise noted)

| Parameter | Conditions / Notes | Symbol | Min | Typ | Max | Units |
|--|--|------------------------|-----------------|-----|------|-------|
| Reset voltage | +5V_SYS reduced until MCU resets | V _{RESET_MAX} | | | 3.1 | V |
| Operating Voltage | | V _{CC} | | 3.3 | | V |
| SD Card Voltage | | V _{CC_SD} | | 3.3 | | V |
| Operating current | LPM0, MCLK = DCO | I _{OP} | | 3 | | mA |
| | LMP4, all control outputs inactive, I2C isolator U5 fitted | I _{SLEEP} | 400 | | 1000 | µA |
| Low-frequency clock frequency | LFXTAL | f _{CLK_LF} | 32.768 ± 0.001 | | | kHz |
| DCO clock frequency | DCOCLK | f _{CLK_DCO} | 680 | 760 | 840 | kHz |
| High-frequency clock frequency | HFXTAL | f _{CLK_HF} | 7.3728 ± 0.0005 | | | MHz |
| Overcurrent trip point for VCC | Set by R3 | I _{TRIP_VCC} | | 220 | | mA |
| Time to switch between +5V_SYS and +5V_USB power sources | Automatic | | | | 1 | µs |

For more information on TI's MSP430 ultralow-power microcontrollers, refer to the TI datasheets.

BLOCK DIAGRAM

PPM A2 provides regulated and current-limited +3.3V power, an external POR/BOR reset supervisor, a JTAG interface for programming and debugging, two clock sources, an external I2C isolator, connections to all 48 I/O pins of the PPM connector, shared MB control and radio handshaking signals, and a single-point analog/digital ground. All of the 64-pin MSP430's pin are used, some for multiple purposes.



PPM PIN DESCRIPTIONS

The PPM connector H1 connects the PPM to resources residing on the MB and to resources accessible via the CubeSat Kit Bus connector.³

Those signals that are connected directly to the PPM connector and to the CubeSat Kit Bus connectors are tagged under the CSKB label below.⁴ Signals marked with an ‘*’ are associated with dedicated peripherals on the MB. Some may also be used with off-board peripherals through the proper use of MB peripheral enables and MB power control.

The *potential* for a pin’s function is described by the I/O field. The *recommended usage* (as a digital or analog input or output, or as a power pin) is listed in the Description field. I/O pins can generally be configured as general-purpose I/O if the recommended usage is not desired.

Inputs are signals *from* the MB to the PPM’s processor U1 or other circuitry. *Outputs* are signals *from* the PPM’s processor U1 or other circuitry *to* the MB.

| | | H1 | | | |
|------------------|-------|-----------------|-------------|------|--|
| | | LSS-150-01-L-DV | | | |
| IO.23 | 2 | 1 | IO.47 | | |
| IO.22 | 4 | 3 | IO.46 | | |
| IO.21 | 6 | 5 | IO.45 | | |
| IO.20 | 8 | 7 | IO.44 | | |
| IO.19 | 10 | 9 | IO.43 | | |
| IO.18 | 12 | 11 | IO.42 | | |
| IO.17 | 14 | 13 | IO.41 | | |
| IO.16 | 16 | 15 | IO.40 | | |
| IO.15 | 18 | 17 | IO.39 | | |
| IO.14 | 20 | 19 | IO.38 | | |
| IO.13 | 22 | 21 | IO.37 | | |
| IO.12 | 24 | 23 | IO.36 | | |
| IO.11 | 26 | 25 | IO.35 | | |
| IO.10 | 28 | 27 | IO.34 | | |
| IO.9 | 30 | 29 | IO.33 | | |
| IO.8 | 32 | 31 | IO.32 | | |
| IO.7 | * 34 | 33 | IO.31 | | |
| IO.6 | * 36 | 35 | IO.30 | | |
| IO.5 | * 38 | 37 | IO.29 | | |
| IO.4 | * 40 | 39 | IO.28 | | |
| IO.3 | * 42 | 41 | IO.27 | | |
| IO.2 | * 44 | 43 | IO.26 | | |
| IO.1 | * 46 | 45 | IO.25 | | |
| IO.0 | * 48 | 47 | IO.24 | | |
| +5V_USB | 50 | 49 | +5V_USB | | |
| +5V_SYS | 52 | 51 | +5V_SYS | | |
| VCC_SD | 54 | 53 | VCC_SD | | |
| VCC | 56 | 55 | VCC | | |
| DGND | 58 | 57 | DGND | | |
| AGND | 60 | 59 | AGND | | |
| VBATT | 62 | 61 | VBATT | | |
| VBACKUP | 64 | 63 | VBACKUP | | |
| VREF0 | 66 | 65 | * -FAULT_OC | <-- | |
| VREF1 | 68 | 67 | SENSE | <-- | |
| VREF2 | 70 | 69 | -RESET | --> | |
| | X 72 | 71 | OFF_VCC | --> | |
| | X 74 | 73 | SDA_SYS | <--> | |
| | X 76 | 75 | SCL_SYS | <--> | |
| | X 78 | 77 | | | |
| | X 80 | 79 | X | | |
| --> -ON_SD | * 82 | 81 | X | | |
| --> -ON_MHX | * 84 | 83 | X | | |
| --> -OE_MHX | * 86 | 85 | X | | |
| --> -OE_USB/-INT | * 88 | 87 | X | | |
| <-- HS0 | * 90 | 89 | X | | |
| <-- HS1 | * 92 | 91 | X | | |
| <-- HS2 | * 94 | 93 | X | | |
| --> HS3 | * 96 | 95 | X | | |
| --> HS4 | * 98 | 97 | X | | |
| --> HS5 | * 100 | 99 | X | | |

³ Not included. MBs are purchased separately from PPMs.

⁴ The CubeSat Kit’s system peripherals are numbered from 0 onwards (e.g., U0, SPI0, etc.), and this nomenclature is used when referring to a PPM or CSK bus signal. The MSP430’s peripheral nomenclature begins with 0 (e.g., UART0, SPI0, etc.), and is used when referring to peripherals, signals and registers internal to the MSP430.

PPM PIN DESCRIPTIONS – I/O

| Name | Pin | I/O | CSKB | Description |
|-------|-------|-----|------|---|
| IO.0 | H1.48 | I/O | • | -CS_SD/ON_I2C. Controls SD Card interface and I2C isolator. From P3.0 (U1.28). Part of the MB's SD card interface and the PPM's I2C isolator. P3.0 is normally configured as a simple digital output. |
| IO.1 | H1.46 | I/O | • | SDO0. SPI0 (master) data out. From P3.1/SIMO0 (U1.29). Part of the MB's SD card interface. P3.1/SIMO0 is normally configured as a digital output as part of USART0:SPI when the SPI peripheral is active. |
| IO.2 | H1.44 | I/O | • | SDI0. SPI0 (master) data in. To P3.2/SOMI0 (U1.30). Part of the MB's SD card interface. P3.2/SOMI0 is normally configured as a digital input as part of USART0:SPI when the SPI peripheral is active. |
| IO.3 | H1.42 | I/O | • | SCK0. SPI0 clock. From P3.3/UCLK0 (U1.31). Part of the MB's SD card interface. P3.3/UCLK0 is normally configured as a digital output as part of USART0:SPI when the SPI peripheral is active. |
| IO.4 | H1.40 | I/O | • | UTX0. Tx0 data out. From P3.4/UTXD0 (U1.32). P3.4/UTXD0 is normally configured as a digital output as part of USART0:UART when the UART peripheral is active. |
| IO.5 | H1.38 | I/O | • | URX0. Rx0 data in. To P3.5/URXD0 (U1.33). P3.5/URXD0 is normally configured as a digital input as part of USART0:UART when the UART peripheral is active. |
| IO.6 | H1.36 | I/O | • | UTX1. Tx1 data out. From P3.6/UTXD1 (U1.34). Part of the MB's MHX/USB interface. P3.6/UTXD1 is normally configured as a digital output as part of USART1:UART when the UART peripheral is active. |
| IO.7 | H1.34 | I/O | • | URX1. Rx1 data in. To P3.7/URXD1 (U1.35). Part of the MB's MHX/USB interface. P3.7/URXD1 is normally configured as a digital input as part of USART1:UART when the UART peripheral is active. |
| IO.8 | H1.32 | I/O | • | General-purpose I/O. To/from P4.0 (U1.36). |
| IO.9 | H1.30 | I/O | • | General-purpose I/O. To/from P4.1 (U1.37). |
| IO.10 | H1.28 | I/O | • | General-purpose I/O. To/from P4.2 (U1.38). |
| IO.11 | H1.26 | I/O | • | General-purpose I/O. To/from P4.3 (U1.39). |
| IO.12 | H1.24 | I/O | • | General-purpose I/O. To/from P4.4 (U1.40). |
| IO.13 | H1.22 | I/O | • | -ON_SD. MB control signal. From P4.5 (U1.41). Part of the MB's SD card interface. P4.5 is normally configured as a digital output. See -ON_SD signal description, below. |
| IO.14 | H1.20 | I/O | • | -ON_MHX. MB control signal. From P4.6 (U1.42). Part of the MB's MHX interface. P4.6 is normally configured as a digital output. See -ON_MHX signal description, below. |
| IO.15 | H1.18 | I/O | • | General-purpose I/O. To/from P4.7 (U1.43). |
| IO.16 | H1.16 | I/O | • | General-purpose I/O. To/from P5.0 (U1.44). |
| IO.17 | H1.14 | I/O | • | General-purpose I/O. To/from P5.1 (U1.45). |
| IO.18 | H1.12 | I/O | • | General-purpose I/O. To/from P5.2 (U1.46). |
| IO.19 | H1.10 | I/O | • | General-purpose I/O. To/from P5.3 (U1.47). |
| IO.20 | H1.8 | I/O | • | General-purpose I/O. To/from P5.4 (U1.48). |
| IO.21 | H1.6 | I/O | • | General-purpose I/O. To/from P5.5 (U1.49). |
| IO.22 | H1.4 | I/O | • | General-purpose I/O. To/from P5.6 (U1.50). |
| IO.23 | H1.2 | I/O | • | General-purpose I/O. To/from P5.7 (U1.51). |
| IO.24 | H1.47 | I/O | • | General-purpose I/O. To/from P2.0 (U1.20). |
| IO.25 | H1.45 | I/O | • | General-purpose I/O. To/from P2.1 (U1.21). |
| IO.26 | H1.43 | I/O | • | General-purpose I/O. To/from P2.2 (U1.22). |

CubeSat Kit PPM A2 Rev. A

| | | | | |
|-------|-------|-----|---|---|
| IO.27 | H1.41 | I/O | • | General-purpose I/O. To/from P2.3 (U1.23). |
| IO.28 | H1.39 | I/O | • | General-purpose I/O. To/from P2.4 (U1.24). |
| IO.29 | H1.37 | I/O | • | General-purpose I/O. To/from P2.5 (U1.25). |
| IO.30 | H1.35 | I/O | • | General-purpose I/O. To/from P2.6 (U1.26). |
| IO.31 | H1.33 | I/O | • | General-purpose I/O. To/from P2.7 (U1.27). |
| IO.32 | H1.31 | I/O | • | General-purpose I/O. To/from P1.0 (U1.12). |
| IO.33 | H1.29 | I/O | • | General-purpose I/O. To/from P1.1 (U1.13). |
| IO.34 | H1.27 | I/O | • | General-purpose I/O. To/from P1.2 (U1.14). |
| IO.35 | H1.25 | I/O | • | General-purpose I/O. To/from P1.3 (U1.15). |
| IO.36 | H1.23 | I/O | • | General-purpose I/O. To/from P1.4 (U1.16). |
| IO.37 | H1.21 | I/O | • | General-purpose I/O. To/from P1.5 (U1.17). |
| IO.38 | H1.19 | I/O | • | General-purpose I/O. To/from P1.6 (U1.18). |
| IO.39 | H1.17 | I/O | • | <i>-OE_USB/-INT</i> . MB control/status signal. To/from P1.7 (U1.19). Part of the MB's USB and RTC interfaces. P1.7 is normally configured as a digital output. See <i>-OE_USB</i> and <i>-INT</i> signal descriptions, below. |
| IO.40 | H1.15 | I/O | • | AN.0/HS0 . Analog input or MB handshake signal. To/from P6.0 (U1.59). Part of the MB's MHX interface. P6.0 is normally configured as a digital input. See HS0 signal description, below. Can also be used as a general-purpose I/O or an analog input. |
| IO.41 | H1.13 | I/O | • | AN.1/HS1 . Analog input or MB handshake signal. To/from P6.1 (U1.60). Part of the MB's MHX interface. P6.1 is normally configured as a digital input. See HS1 signal description, below. Can also be used as a general-purpose I/O or an analog input. |
| IO.42 | H1.11 | I/O | • | AN.2/HS2 . Analog input or MB handshake signal. To/from P6.2 (U1.61). Part of the MB's MHX interface. P6.2 is normally configured as a digital input. See HS2 signal description, below. Can also be used as a general-purpose I/O or an analog input. |
| IO.43 | H1.9 | I/O | • | AN.3/HS3 . Analog input or MB handshake signal. To/from P6.3 (U1.2). Part of the MB's MHX interface. P6.3 is normally configured as a digital output. See HS3 signal description, below. Can also be used as a general-purpose I/O or an analog input. |
| IO.44 | H1.7 | I/O | • | AN.4/HS4 . Analog input or MB handshake signal. To/from P6.4 (U1.3). Part of the MB's MHX interface. P6.4 is normally configured as a digital output. See HS4 signal description, below. Can also be used as a general-purpose I/O or an analog input. |
| IO.45 | H1.5 | I/O | • | AN.5/HS5 . Analog input or MB handshake signal. To/from P6.5 (U1.4). Part of the MB's MHX interface. P6.5 is normally configured as a digital output. See HS5 signal description, below. Can also be used as a general-purpose I/O or analog input. |
| IO.46 | H1.3 | I/O | • | AN.6/-OE_MHX . Analog input or MB control signal. To/from P6.6 (U1.5). Part of the MB's MHX interface. P6.6 is normally configured as a digital output. See <i>-OE_MHX</i> signal description, below. Can also be used as general-purpose I/O or an analog output. |
| IO.47 | H1.1 | I/O | • | AN.7 . Analog input. To/from P6.7 (U1.6). Can also be used as a general-purpose I/O or an analog output. |

PPM PIN DESCRIPTIONS – Power

| Name | Pin | I/O | CSKB | Description |
|---------|----------------|-----|------|--|
| +5V_USB | H1.49 H1.50 | – | • | +5V USB power. From USB host. Powers PPM. |
| +5V_SYS | H1.51 H1.52 | – | • | +5V system power. From EPS or external +5V connector. Powers PPM. |
| VCC_SD | H1.53 H1.54 | – | | +3.3V SD Card power. From PPM's vcc. |
| VCC | H1.55 H1.56 | – | | +3.3V PPM power, MB power and I/O level. From PPM LDO U4 using +5V_SYS and/or +5V_USB. |
| DGND | H1.57 H1.58 | – | • | Digital ground. |
| AGND | H1.59 H1.60 | – | • | Analog ground. |
| VBATT | H1.61 H1.62 | – | • | Not connected. |
| VBACKUP | H1.63 H1.64 | – | • | Not connected. |

PPM PIN DESCRIPTIONS – Analog References

| Name | Pin | I/O | CSKB | Description |
|-------|-------|-----|------|---|
| VREF0 | H1.66 | – | • | Positive analog voltage reference. To/from VREF+ (U1.7). |
| VREF1 | H1.68 | – | • | Positive analog voltage reference. To/from VREF+ (U1.10). |
| VREF2 | H1.70 | – | • | Negative analog voltage reference. To/from VREF- (U1.11). |

PPM PIN DESCRIPTIONS – Reserved

| Name | Pin | I/O | CSKB | Description |
|-------|-------|-----|------|---|
| RSVD0 | H1.72 | – | • | Not connected. Reserved for future use. |
| RSVA1 | H1.74 | – | • | Not connected. Reserved for future use. |
| RSVD2 | H1.76 | – | • | Not connected. Reserved for future use. |

PPM PIN DESCRIPTIONS – MB-Specific

| Name | Pin | I/O | CSKB | Description |
|--------------|-------|-----|------|---|
| CB4 USBDP | H1.78 | I | | Not connected. |
| CB2 USBDM | | | | |
| -ON_SD | H1.82 | O | | Control signal for SD Card power. From P4.5 (U1.41). Active LOW, pulled high on the MB. When active, enables VCC_CARD on the MB, thereby powering SC Card socket and SD Card level translators / isolators. <i>Normally configured as a digital output.</i> |
| -ON_MHX | H1.84 | O | | Control signal for MHX socket power. From P4.6 (U1.42). Active LOW, pulled high on the MB. When active, enables PWR_MHX on the MB, thereby powering MHX socket and MHX level translators / isolators. <i>Normally configured as a digital output.</i> |
| -OE_MHX | H1.86 | O | | Control signal for MHX interface. From P6.6 (U1.5). Active LOW, pulled high on the MB. When active, enables signals to pass through MHX level translators / isolators. <i>Normally configured as a digital output.</i> |
| -OE_USB | H1.88 | O | | Control signal for USB interface. From P1.7 (U1.19). Active LOW, pulled high on the MB. When active, enables signals to pass through USB level translators / isolators. <i>Normally configured as a digital output.</i> |

| | | | | |
|-------------|--------|---|--|---|
| -INT | | I | | Output from RTC's -IRQ open-collector output. To P1.7 (U1.19). When properly configured, can be used to interrupt processor U1 via MB RTC. <i>Normally configured as a digital input.</i> |
| HS0 | H1.90 | I | | Handshake signal. -RTS (USB) or -CTS (MHX). To P6.0 (U1.59). <i>Normally configured as a digital input. Requires that R10 be fitted on the MB.</i> |
| HS1 | H1.92 | I | | Handshake signal. -DTR (USB) or -DSR (MHX). To P6.1 (U1.60). <i>Normally configured as a digital input. Requires that R11 be fitted on the MB.</i> |
| HS2 | H1.94 | I | | Handshake signal. -PWE (USB) or -DCD (MHX). To P6.2 (U1.61). <i>Normally configured as a digital input. Requires that R12 be fitted on the MB.</i> |
| HS3 | H1.96 | O | | Handshake signal. -CTS (USB) or -RTS (MHX). From P6.3 (U1.2). <i>Normally configured as a digital output. Requires that R75 be fitted on the MB.</i> |
| HS4 | H1.98 | O | | Handshake signal. -RI (USB) or -DTR (MHX). From P6.4 (U1.3). <i>Normally configured as a digital output. Requires that R76 be fitted on the MB.</i> |
| HS5 | H1.100 | O | | Handshake (reset) signal. -RST (USB) or -RST (MHX). From P6.5 (U1.4). <i>Normally configured as a digital output. Requires that R77 be fitted on the MB.</i> |

PPM PIN DESCRIPTIONS – Control & Status

| Name | Pin | I/O | CSKB | Description |
|------------------|-------|-----|------|---|
| -FAULT_OC | H1.65 | O | | Open-collector output from PPM's latchup prevention overcurrent switch. Active LOW. Wire-ORed to -FAULT_OC on the MB. |
| SENSE | H1.67 | - | • | Can be used to measure PPM's current consumption. The current used by the PPM from a single source is (source – SENSE) / 75mΩ. Depends on PPM implementation. |
| -RESET | H1.69 | I | • | Reset signal to PPM's reset supervisor. Active LOW. |
| OFF_VCC | H1.71 | I | • | Control signal to PPM's power circuit(s). Active HIGH. |

PPM PIN DESCRIPTIONS – I2C Bus

| Name | Pin | I/O | CSKB | Description |
|----------------|-------|-----|------|---|
| SDA_SYS | H1.73 | I/O | • | I2C data. To/from P3.1 / SDA (U1.29) through I2C isolator U5 when ON_I2C is active. <i>Part of the I2C interface. SDA is normally configured as an I2C data input/output as part of USART0:I2C when the I2C peripheral is active.</i> |
| SCL_SYS | H1.75 | O | • | I2C clock. From P3.3 / SCL (U1.31) through I2C isolator U5 when ON_I2C is active. <i>Part of the I2C interface. SCL is normally configured as an I2C clock output as part of USART0:I2C when the I2C peripheral is active.</i> |

PPM PIN DESCRIPTIONS – User-defined

| Name | Pin | I/O | CSKB | Description |
|--------------|-------|-----|------|----------------|
| USER0 | H1.77 | I/O | • | Not connected. |
| USER1 | H1.79 | I/O | • | Not connected. |
| USER2 | H1.81 | I/O | • | Not connected. |
| USER3 | H1.83 | I/O | • | Not connected. |
| USER4 | H1.85 | I/O | • | Not connected. |
| USER5 | H1.87 | I/O | • | Not connected. |
| USER6 | H1.89 | I/O | • | Not connected. |
| USER7 | H1.91 | I/O | • | Not connected. |

| | | | | |
|---------------|-------|-----|---|----------------|
| USER8 | H1.93 | I/O | • | Not connected. |
| USER9 | H1.95 | I/O | • | Not connected. |
| USER10 | H1.97 | I/O | • | Not connected. |
| USER11 | H1.99 | I/O | • | Not connected. |

SHARED I/O PINS

All of $\mu 1$'s I/O pins are connected directly to the CubeSat Kit Bus. Due to the relatively low pincount of the MSP430F1611 used on PPM A2, some of the general-purpose I/O pins are also connected to other signals on PPM connector $\mu 1$. Generally speaking, these shared I/O pins are dedicated to ancillary functions and should not be used by modules on the CubeSat Kit Bus. Provisions are in place to "free" some of these shared I/O pins from their ancillary functions, as outlined below.

| Pin | Signal | Standalone Function | Ancillary Function | Notes |
|------|--------------|---------------------|-------------------------|---|
| P1.7 | -OE_USB/-INT | -OE_USB, -INT | I/O | Always connected to USB interface. Pulled up via 100k Ω to v_{CC} on the MB. Can be isolated from RTC by removal of R73 on the MB. Can be used as simple I/O if V_{CC_IO} is not present on the MB ⁵ and RTC on the MB is configured to ignore -OE_USB/-INT. |
| P4.5 | -ON_SD | -ON_SD | none | Always connected to SD Card interface. Pulled up via 100k Ω to v_{CC} on the MB. Arbitration with $\mu 1$ can permit other devices to control the MB's SD Card interface. |
| P4.6 | -ON_MHX | -ON_MHX | I/O | Always connected to MHX power switching. Pulled up via 100k Ω to v_{CC} on the MB. Arbitration with $\mu 1$ can permit other devices to power an MHX transceiver on the MB. Can be used as I/O if no source of power is available on the MB to power MHX socket. |
| P6.0 | HS0 | HS0 | I/O, analog input | When R10 on the MB is fitted, to be used as a handshake line to USB or MHX. When R10 on the MB is <i>not</i> fitted, to be used as analog input or digital I/O. |
| P6.1 | HS1 | HS1 | I/O, analog input | When R11 on the MB is fitted, to be used as a handshake line to USB or MHX. When R11 on the MB is <i>not</i> fitted, to be used as analog input or digital I/O. |
| P6.2 | HS2 | HS2 | I/O, analog input | When R12 on the MB is fitted, to be used as a handshake line to USB or MHX. When R12 on the MB is <i>not</i> fitted, to be used as analog input or digital I/O. |
| P6.3 | HS3 | HS3 | I/O, analog input | When R75 on the MB is fitted, to be used as a handshake line to USB or MHX. When R75 on the MB is <i>not</i> fitted, to be used as analog input or digital I/O. |
| P6.4 | HS4 | HS4 | I/O, analog input | When R76 on the MB is fitted, to be used as a handshake line to USB or MHX. When R76 on the MB is <i>not</i> fitted, to be used as analog input or digital I/O. |
| P6.5 | HS5 | HS5 | I/O, analog input | When R77 on the MB is fitted, to be used as a handshake line to USB or MHX. When R77 on the MB is <i>not</i> fitted, to be used as analog input or digital I/O. |

⁵ I.e., if USB is not connected.

| | | | | |
|-------------|----------------|----------------|-----|---|
| P6.6 | -OE_MHX | -OE_MHX | I/O | Always connected to MHX interface. Pulled up via 100kΩ to VCC on the MB. Can be used as an analog input, analog output or simple I/O when DPWR_MHX on the MB is off. |
|-------------|----------------|----------------|-----|---|

For example, if **-ON_MHX** is kept inactive, **DPWR_MHX** on the MB is off. Therefore MB MHX isolators **U2** and **U3** are left in a high-impedance state, and **P6.[7..0]** can all be used as analog inputs, getting their signals from the CubeSat Kit Bus via **IO.[47..40]**.⁶ This is true regardless of the state of the resistors **R10-R12** and **R75-R77** on the MB. For further information, consult the PPM A2 and MB schematics.

I2C ISOLATOR

On PPM A2, **U5** is an I2C bus isolator implemented via a PCA9515A. The purpose of **U5** is to ensure that the I2C peripherals attached to the I2C bus via **SCL_SYS** and **SDA_SYS** do not see spurious clock and/or data signals when SPI activity is present on **SPI0**, which might cause problems with the I2C bus. I2C signals to/from **U1** can only reach the I2C bus when **ON_I2C** is active. Therefore, when **ON_I2C** is inactive, **U1** can perform SPI activity on **SPI0** (e.g., read from and write to the SD Card on the MB) without fear of I2C bus problems.

U5 has a quiescent current consumption I_{SLEEP} of around 500μA, regardless of the state of **ON_I2C**. This sets the floor for I_{SLEEP} . Users not requiring I2C connectivity, or wishing to implement an I2C isolator elsewhere in the system, can remove **U5**, thereby reducing I_{SLEEP} to under 40μA.⁷

CONNECTORS

| Item | Description | Source | Part Number | Application |
|------|-------------------------|--------|-----------------|--------------------------------|
| 1 | 100-pin, hermaphroditic | Samtec | LSS-150-01-L-DV | PPM connector (standard, +3mm) |

This connector information is provided for reference only.

PROGRAMMING & DEBUGGING

PPM A2 provides one interface for programming and debugging – the popular and low-cost Flash Emulation Tool (FET) interface, a type of JTAG interface. It is implemented via Flexible Printed Circuit (FPC) connector on the PPM.

8-pin FPC connector **J1** is for the FET. Via Pumpkin's JFPC-MSP430 adapter, customers can connect either a traditional TI USB or parallel FET, or an aftermarket FET, all with 14-pin 2x7 0.100" pitch dual-inline headers. The JFPC-MSP430 connects to PPM A2 via an 8-conductor FPC cable.

NOTES

PPM A2 (MSP430F1611) is built on the same Pumpkin PCB (705-00378) as PPM A1 (MSP430F1612) and PPM A3 (MSP430F2618), with minor differences in the components placed at assembly time.

⁶ Even if an analog signal drives **P6.6** (**-OE_MHX**) below the input threshold of **U1** or **U2**, the isolators remain in their high-impedance state because **DPWR_MHX** (enabled via **-ON_MHX**) is off.

⁷ I_{SLEEP} of 40μA is representative of the quiescent current of the previous-generation FM430 flight module, of which the MB + PPM A2 combination is a superset.

TRADEMARKS

The following are Pumpkin trademarks. All other names are the property of their respective owners.

- Pumpkin™ and the Pumpkin logo
- Salvo™ and the Salvo logo
- CubeSat Kit™ and the CubeSat Kit logo
- MISC™ and the MISC logo

DISCLAIMER

PUMPKIN RESERVES THE RIGHT TO MAKE ANY CHANGES WITHOUT FURTHER NOTICE TO ANY PRODUCTS HEREIN TO CORRECT ERRORS AND IMPROVE RELIABILITY, FUNCTION, APPEARANCE OR DESIGN. PUMPKIN DOES NOT ASSUME ANY LIABILITY ARISING OUT OF THE APPLICATION OR USE OF ANY PRODUCT OR CIRCUIT DESCRIBED HEREIN; NEITHER DOES IT CONVEY ANY LICENSE UNDER ITS PATENT RIGHTS, NOR THE RIGHTS OF OTHERS.



744 Naples Street
San Francisco, CA 94112 USA
tel: (415) 584-6360
fax: (415) 585-7948

web: <http://www.pumpkininc.com/>
email: info@pumpkininc.com

web: <http://www.cubesatkit.com/>
email: info@cubesatkit.com