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CubeSat Kit™

Pluggable Processor Module (PPM) A3

Hardware Revision: B

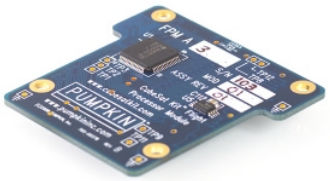
PPM with TI's MSP430F2618 for CubeSat Kit Motherboard

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 MSP430F2618 16-bit microcontroller (MCU)
- 116KB program memory, 8KB on-chip SRAM
- Integrated peripherals:
  - 2 USCI_A (UARTA0/SPIA0 & UARTA1/SPIA1)
  - 2 USCI_B (I2CB0/SPIB0 & I2CB1/SPIB1)
  - 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 on system I2C bus
- Multiple I2C configurations possible
- 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 710-00516

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.
D	20100913	AEK	Fixed block diagram MSP430F2618 port names for **`USCB0SCL`** and **`UCB0SDA`**, expanded on use of alternate or second I2C busses.

OPERATIONAL DESCRIPTION

PPM A3 enables CubeSat Kit customers to utilize TI's ultralow-power MSP430 processor on a CubeSat Kit Motherboard (MB). PPM A3 uses the 64-pin MSP430F2618TPM, with a wide selection of on-chip peripherals. Additionally, a PCA9515A I2C isolator is present to facilitate I2C interfacing and simple backwards compatibility with PPM A1 and PPM A2.

The MSP430F2618 employs the MSP430X core architecture – an extension of the 16-bit MSP430 architecture to 20 bits of address space. Tools capable of supporting the MSP430X architecture must be used to take advantage of the 20-bit address space.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Value	Units
Operating temperature	T_A	-40 to +85	ºC
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}	16	MHz

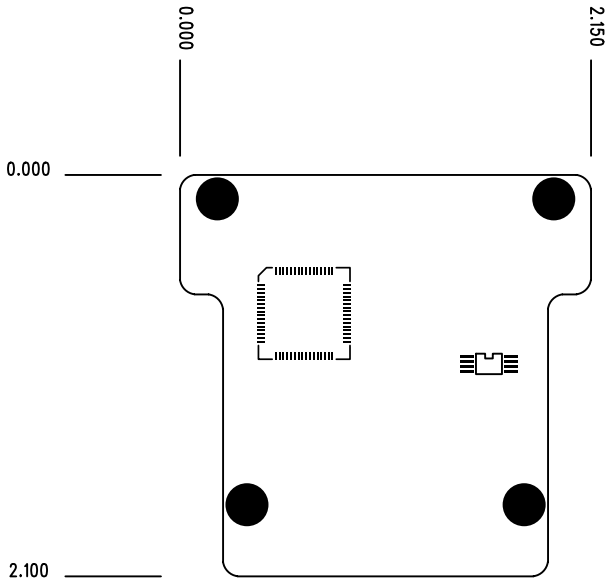
Refer to the MSP430x261x family datasheet for additional absolute maximum ratings associated with processor **U1**, especially per-pin current limits.

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 A3 is implemented on a small-size PPM PCB, as shown below.



[1] Not including connector H1.
[2] Dimensions in inches.

ELECTRICAL CHARACTERISTICS

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

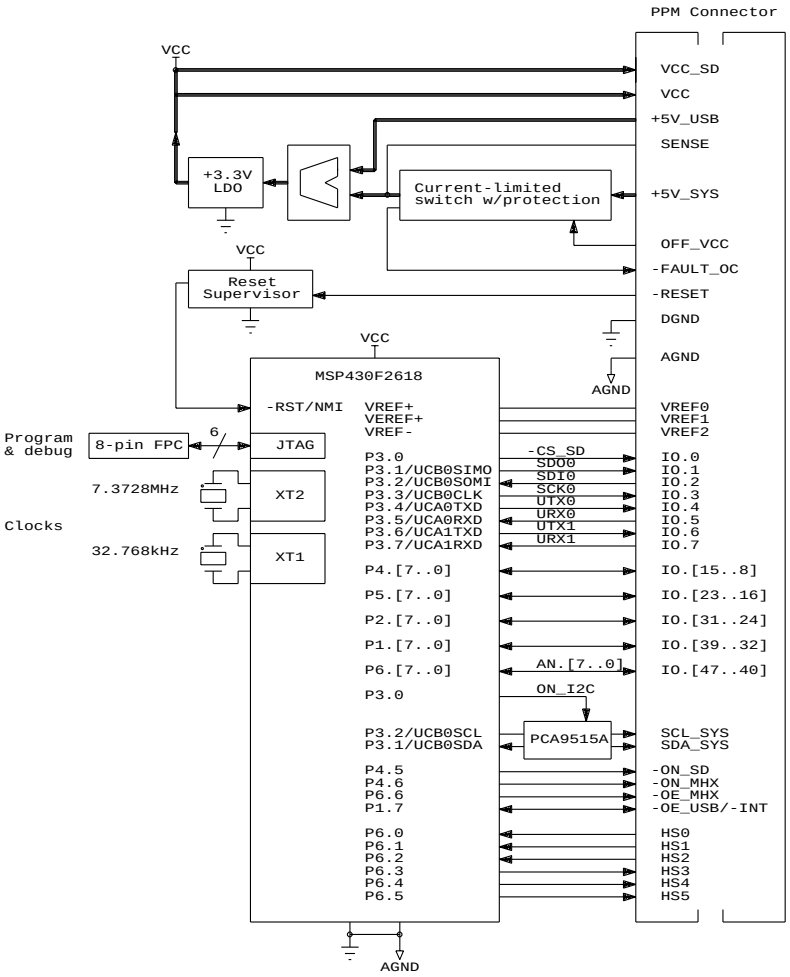
Parameter	Conditions / Notes	Symbol	Min	Typ	Max	Units
Reset voltage	**+5V_SYS** reduced until MCU resets	V_{RESET_MAX}			3.1	V
Operating Voltage		V_{CC}		3.3		V
SD Card Voltage		V_{CC_SD}		3.3		V
Operating current	LPM0, MCLK = DCO	I_{OP}		3		mA
	LMP4, all control outputs inactive, I2C isolator **U5** fitted	I_{SLEEP}	400		1000	µA
	LMP4, all control outputs inactive, I2C isolator **U5** not fitted			33	40	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[3]	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.

[3] See OSCILLATOR OPTIONS AND OPERATING SPEEDS, below.

BLOCK DIAGRAM

PPM A3 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.



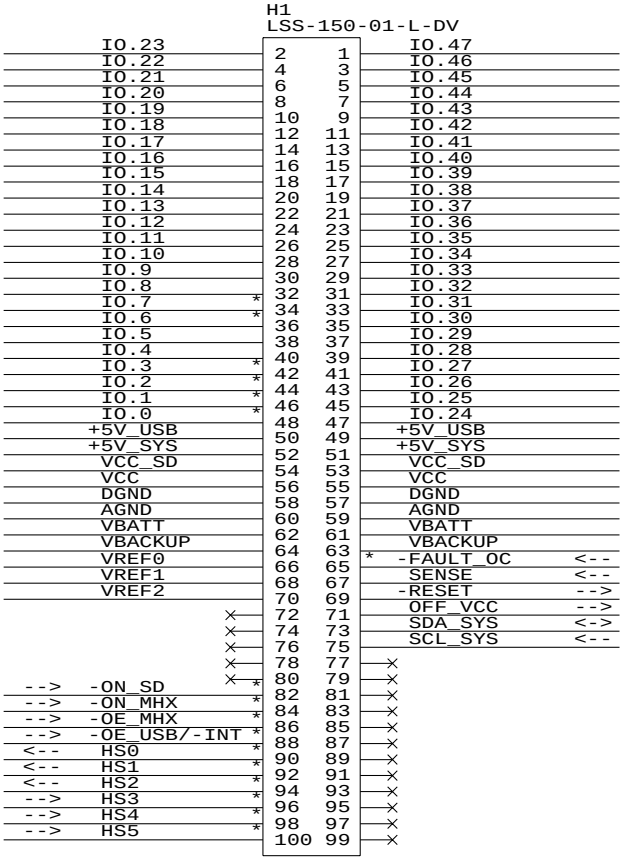
PPM PIN DESCRIPTIONS

The PPM connector **H1** connects the PPM to resources residing on the MB and to resources accessible via the CubeSat Kit Bus connector.[4]

Those signals that are connected directly to the PPM connector and to the CubeSat Kit Bus connectors are tagged under the CSKB label below.[5] 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.



[4] Not included. MBs are purchased separately from PPMs.

[5] 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/UCB0SIMO** (**U1**.29). *Part of the MB's SD card interface.* ***P3.1/UCB0SIMO*** *is normally configured as a digital output as part of UCB0:SPI when the SPI peripheral is active.*[6]
IO.2	H1.44	I/O	•	**SDI0**. SPI0 (master) data in. To **P3.2/UCB0SOMI** (**U1**.30). *Part of the MB's SD card interface.* ***P3.2/UCB0SOMI*** *is normally configured as a digital input as part of UCB0:SPI when the SPI peripheral is active.*[6]
IO.3	H1.42	I/O	•	**SCK0**. SPI0 clock. From **P3.3/UCB0CLK** (**U1**.31). *Part of the MB's SD card interface.* ***P3.3/UCB0CLK*** *is normally configured as a digital output as part of UCB0:SPI when the SPI peripheral is active.*
IO.4	H1.40	I/O	•	**UTX0**. Tx0 data out. From **P3.4/UCA0TXD** (**U1**.32). ***P3.4/UCA0TXD*** *is normally configured as a digital output as part of UCA0:UART when the UART peripheral is active.*
IO.5	H1.38	I/O	•	**URX0**. Rx0 data in. To **P3.5/UCA0RXD** (**U1**.33). ***P3.5/UCA0RXD*** *is normally configured as a digital input as part of UCA0:UART when the UART peripheral is active.*
IO.6	H1.36	I/O	•	**UTX1.** Tx1 data out. From **P3.6/UCA1TXD** (**U1**.34). *Part of the MB's MHX/USB interface.* ***P3.6/UCA1TXD*** *is normally configured as a digital output as part of UCA1:UART when the UART peripheral is active.*
IO.7	H1.34	I/O	•	**URX1**. Rx1 data in. To **P3.7/UCA1RXD** (**U1**.35). *Part of the MB's MHX/USB interface.* ***P3.7/UCA1RXD*** *is normally configured as a digital input as part of UCA1: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). Can be used for a second I2C bus via **UCB1SDA**.
IO.18	H1.12	I/O	•	General-purpose I/O. To/from **P5.2** (**U1**.46). Can be used for a second I2C bus via **UCB1SCL**.
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).

[6] This pin is also active when the I2C peripheral in UCB0 is active. See PPM PIN DESCRIPTIONS – I2C Bus and I2C ISOLATOR & ALTERNATE I2C CONFIGURATIONS, below

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).
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	•	**-OE_USB/-INT**. 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* ***-OE_USB*** *and* ***-INT*** *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* ***-OE_MHX*** *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 **VEREF+** (**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**	H1.80	I		Not connected.
-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. *Normally configured as a digital output.*
-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. *Normally configured as a digital output.*
-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. *Normally configured as a digital output.*

-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. *Normally configured as a digital output.*
-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. *Normally configured as a digital input.*
HS0	H1.90	I		Handshake signal. -RTS (USB) or -CTS (MHX). To **P6.0** (**U1**.59). *Normally configured as a digital input. Requires that **R10** be fitted on the MB.*
HS1	H1.92	I		Handshake signal. -DTR (USB) or -DSR (MHX). To **P6.1** (**U1**.60). *Normally configured as a digital input. Requires that **R11** be fitted on the MB.*
HS2	H1.94	I		Handshake signal. -PWE (USB) or -DCD (MHX). To **P6.2** (**U1**.61). *Normally configured as a digital input. Requires that **R12** be fitted on the MB.*
HS3	H1.96	O		Handshake signal. -CTS (USB) or -RTS (MHX). From **P6.3** (**U1**.2). *Normally configured as a digital output. Requires that **R75** be fitted on the MB.*
HS4	H1.98	O		Handshake signal. -RI (USB) or -DTR (MHX). From **P6.4** (**U1**.3). *Normally configured as a digital output. Requires that **R76** be fitted on the MB.*
HS5	H1.100	O		Handshake (reset) signal. -RST (USB) or -RST (MHX). From **P6.5** (**U1**.4). *Normally configured as a digital output. Requires that **R77** be fitted on the MB.*

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/USB0SDA** (**U1**.29) through I2C isolator **U5** when **ON_I2C** is active. *Part of the I2C interface. **UCB0SDA** is normally configured as an I2C data input/output as part of UCB0:I2C when the I2C peripheral is active.*
SCL_SYS	H1.75	O	•	I2C clock. From **P3.2/UCB0SCL** (**U1**.30) through I2C isolator **U5** when **ON_I2C** is active. *Part of the I2C interface. **UCB0SCL** is normally configured as an I2C clock output as part of UCB0:I2C when the I2C peripheral is active.*

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 **U1**'s I/O pins are connected directly to the CubeSat Kit Bus. Due to the relatively low pincount of the MSP430F2618 used on PPM A3, some of the general-purpose I/O pins are also connected to other signals on PPM connector **H1**. 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 100kΩ to **VCC** on the MB. Can be isolated from RTC by removal of **R73** on the MB. Can be used as simple I/O if VCC_IO is not present on the MB[7] 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 100kΩ to **VCC** on the MB. Arbitration with **U1** 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 100kΩ to **VCC** on the MB. Arbitration with **U1** 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 *not* 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 *not* 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 *not* 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 *not* 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 *not* fitted, to be used as analog input or digital I/O.

[7] I.e., if USB is not connected.

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 *not* fitted, to be used as analog input or digital I/O.
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]**.[8] This is true regardless of the state of the resistors **R10-R12** and **R75-R77** on the MB. For further information, consult the PPM A3 and MB schematics.

I2C ISOLATOR & ALTERNATE I2C CONFIGURATIONS

On PPM A3, **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.

PPM A3 is configured at the factory to be a drop-in replacement for PPM A1 or A2 in terms of electrical connectivity. This is done by fitting **R5** instead of **R4** for proper sourcing of the **UCB0SCL** signal to **SCL_SYS** and by using the MSP430F2618's UCB0:I2C peripheral instead of the MSP430F161x's USART0:I2C peripheral for I2C communications. Different firmware is required for PPM A3, because of its use of the different peripherals involved.

Alternatively, users can employ the UCB1:I2C peripheral instead of the UCB0:I2C peripheral for I2C communications on **SCL_SYS** and **SDA_SYS**. This has the advantage of no longer requiring an I2C isolator, since the UCB1:I2C peripheral is mapped directly to **IO.17** & **I0.18** via **P5.1/UCB1SDA** & **P5.2/UCB1SCL**, respectively. As long as the user has no SPI devices using the UCB1:SPI peripheral, no I2C isolator is required. To make use of this option, a qualified electronics assembler can remove **U5** and **R4-R7**, and fit **R8-R9**.

Lastly, users wishing to implement two I2C busses can do so. Due to the presence of four enhanced Universal Serial Communications Interfaces (USCIs) on the '2618, it is possible to have two independent I2C busses via PPM A3, whereas that is not possible with PPMs A1 and A2. The first I2C bus (on **P3.1/UCB0SDA** & **P3.2/UCB0SCL**) passes through the PCA9515 isolator to **SCL_SYS** and **SDA_SYS**, whereas the second I2C bus is available on **P5.1/UCB1SDA** & **P5.2/UCB1SCL** and thereby on **IO.17** and **IO.18**, respectively.

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, wishing to implement an I2C isolator elsewhere in the system, or implementing I2C via UCB1 can remove **U5**, thereby reducing I_{SLEEP} to under 40µA.[9]

OSCILLATOR OPTIONS AND OPERATING SPEEDS

The MSP430F261x family is rated for 16MHz operating speeds at **VCC** = +3.3V. For maximum backwards compatibility with PPM A1 and A2, a 7.3728MHz crystal is fitted to PPM A3. Users can replace crystal **X3** with a faster crystal[10] using a qualified electronics assembler.

[8] 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.

[9] I_{SLEEP} of 40µA is representative of the quiescent current of the previous-generation FM430 flight module, of which the MB + PPM A3 combination is a superset.

[10] E.g., ECS P/N ECS-160-20-5PXDN.

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 A3 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 A3 via an 8-conductor FPC cable.

NOTES

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

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