http://www.cubesatkit.com/

CubeSat Kit™

Pluggable Processor Module (PPM) D1

Hardware Revision: A

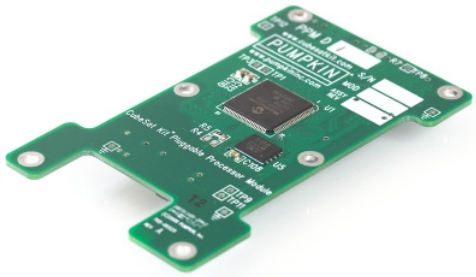
PPM with Microchip® PIC24 for CubeSat Kit Motherboard

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)
- Microchip® PIC24FJ256GA110 16-bit microcontroller (MCU)
- 256KB program memory, 16KB on-chip SRAM
- Up to 16MIPS @ 32MHz
- Integrated peripherals:
  - 4 UARTs, 3 SPIs, 3 I2Cs
  - 16-channel 10-bit 500ksps ADC
  - 5 16-bit timers
  - 9 capture inputs
  - 9 compare / PWM outputs
  - 3 analog comparators
  - RTCC, CTMU, WDT, ICD, JTAG, etc.
- Majority of Peripheral Pin Selects mapped to PPM connector
- 8.000MHz & 32.768kHz clock crystals
- AT25DF641 64Mbit SPI serial Flash memory
- Independent latchup (device overcurrent) protection
- Independent external reset supervisor (POR/BOR)
- Medium-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



Prototype shown.

ORDERING INFORMATION

Pumpkin P/N 710-00527

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	20090713	AEK	Initial revision.
B	20090728	AEK	Updated PPM pin descriptions and image, minor nomenclature changes, max heights of PCB, brought nomenclature inline with PPM A1/A2/A3, added additional signal information, other minor changes.
C	20090728	AEK	Fixed some incorrect PIC24 signal names, resolved minor formatting inconsistencies.
D	20090808	AEK	Added photo.
E	20091021	AEK	Added typical operating current.

OPERATIONAL DESCRIPTION

PPM D1 enables CubeSat Kit customers to utilize the PIC24 processor on a CubeSat Kit Motherboard (MB). PPM D1 uses the 100-pin PIC24FJ256GA110-I/PF, with a wide selection of on-chip peripherals. Additionally, a 64Mbit external serial Flash memory is present for off-chip storage.

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 mixed analog/digital processor I/O pin		-0.3 to (**VCC** + 0.3)	V
Voltage on any digital-only processor I/O pin		-0.3 to 6.0	
DC current through any pin of PPM connector **H1**	I_{PIN_MAX}	1.2	A

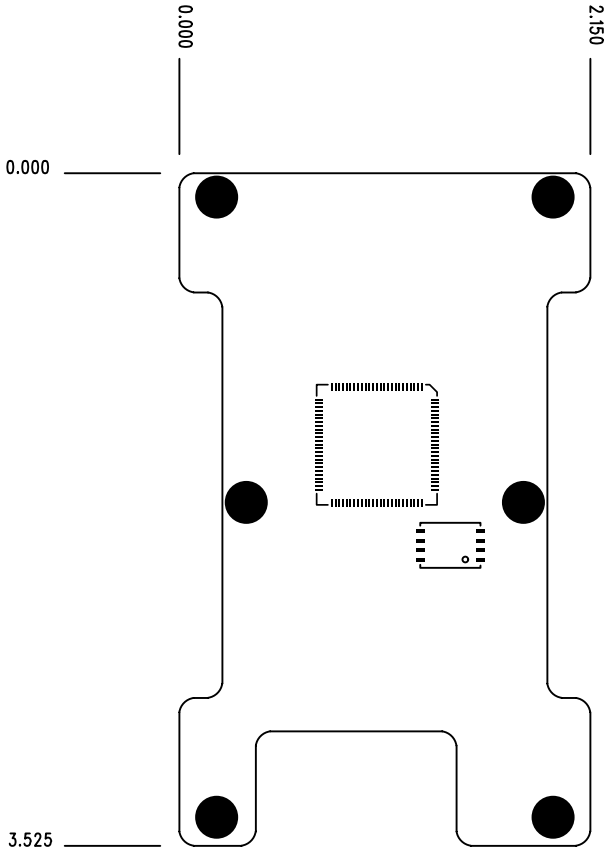
Refer to the PIC24FJxxxGAx10 family datasheet for additional absolute maximum ratings associated with processor **U1**, especially per-pin current limits.

PHYSICAL CHARACTERISTICS

Parameter	Conditions / Notes	Symbol	Min	Typ	Max	Units
Mass				17		g
Height of components above PCB					2	mm
Height of components below PCB[1]					4	mm
PCB width	Medium-size PPM			54.6		mm
PCB length				89.5		mm
PCB thickness				1.6		mm

SIMPLIFIED MECHANICAL LAYOUT [2]

PPM D1 is implemented on a medium-size PPM PCB, as shown below.



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

ELECTRICAL CHARACTERISTICS

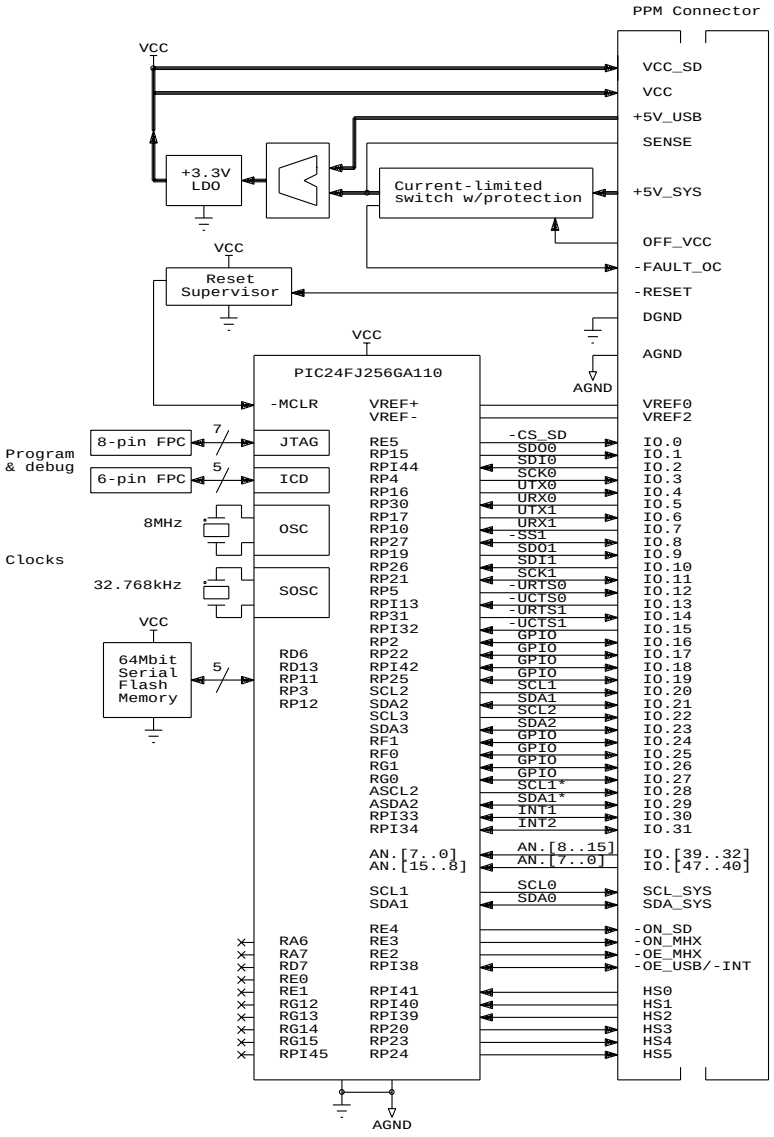
(T = 25ºC, +5V bus = +5V unless otherwise noted)

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	Typical operation[3]	I_{OP}		20		mA
	All control outputs inactive, PPM asleep	I_{SLEEP}		TBD	TBD	µA
Primary crystal frequency		f_{CLK_OSC}	8.00 ± 0.01			MHz
Secondary crystal frequency		f_{CLK_SOSC}	32.768 ± 0.001			kHz
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

[3] Running CubeSat Kit test\test1 application v1.2.2.

BLOCK DIAGRAM

PPM D1 provides regulated and current-limited +3.3V power, an external POR/BOR reset supervisor, JTAG and ICD interfaces for programming and debugging, two clock sources, an external high-speed 64Mbit serial Flash memory, connections to all 48 I/O pins of the PPM connector, dedicated MB control and radio handshaking signals, a single-point analog/digital ground, and a careful assignment of the mappable and non-mappable PIC24 peripherals to the PPM connector and CubeSat Kit bus. A few of the PIC24's 100 pins are not used.



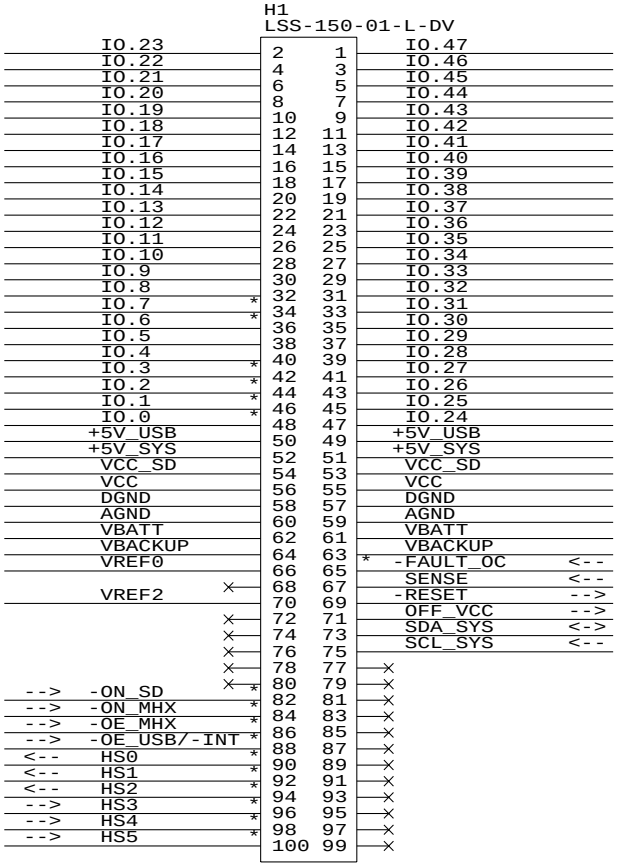
PPM PIN DESCRIPTIONS

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. They 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., UART0, SPI0, etc.), and this nomenclature is used when referring to a PPM or CSK bus signal. The PIC24's peripheral nomenclature begins with 1 (e.g., U1, SPI1, etc.), and is used when referring to peripherals, signals and registers internal to the PIC24.

PPM PIN DESCRIPTIONS – I/O

Name	Pin	I/O	CSKB	Description
IO.0	H1.48	I/O	•	**-CS_SD**. Controls SD Card interface. From **RE5** (**U1**.3). *Part of the MB's SD card interface. **RE5** is normally configured as a simple output.*
IO.1	H1.46	I/O	•	**SDO0**. SPI0 (master) data out. From **RP15** (**U1**.53). *Part of the MB's SD card interface. **RP15** is normally configured as output function SDO1.*
IO.2	H1.44	I/O	•	**SDI0**. SPI0 (master) data in. To **RPI44** (**U1**.54). *Part of the MB's SD card interface. **RPI44** is normally configured as input function SDI1.*
IO.3	H1.42	I/O	•	**SCK0**. SPI0 clock. From **RP4** (**U1**.69). *Part of the MB's SD card interface. **RP4** is normally configured as output function SCK1OUT.*
IO.4	H1.40	I/O	•	**UTX0**. Tx0 data out. From **RP16** (**U1**.51). ***RP16** is normally configured as output function U1TX.*
IO.5	H1.38	I/O	•	**URX0**. Rx0 data in. To **RP30** (**U1**.52). ***RP30** is normally configured as input function U1RX.*
IO.6	H1.36	I/O	•	**UTX1**. Tx1 data out. From **RP17** (**U1**.50). *Part of the MB's MHX/USB interface. **RP17** is normally configured as output function U2TX.*
IO.7	H1.34	I/O	•	**URX1**. Rx1 data in. To **RP10** (**U1**.49). *Part of the MB's MHX/USB interface. **RP10** is normally configured as input function U2RX.*
IO.8	H1.32	I/O	•	**-SS1**. SPI1 slave select. From **RP27** (**U1**.14). *Part of the second SPI interface. **RP27** is normally configured as output function SS2OUT. Can also be used as general-purpose I/O.*
IO.9	H1.30	I/O	•	**SDO1**. SPI1 (master) data out. From **RP19** (**U1**.12). *Part of the second SPI interface. **RP19** is normally configured as output function SDO2. Can also be used as general-purpose I/O.*
IO.10	H1.28	I/O	•	**SDI1**. SPI1 (master) data in. To **RP26** (**U1**.11). *Part of the second SPI interface. **RP26** is normally configured as input function SDI2. Can also be used as general-purpose I/O.*
IO.11	H1.26	I/O	•	**SCK1**. SPI1 clock. From **RP21** (**U1**.10). *Part of the second SPI interface. **RP21** is normally configured as output function SCK2OUT. Can also be used as general-purpose I/O.*
IO.12	H1.24	I/O	•	**-URTS0**. UART0 request-to-send. From **RP5** (**U1**.48). *Part of the first UART interface. **RP5** is normally configured as output function -U1RTS. Can also be used as general-purpose I/O.*
IO.13	H1.22	I/O	•	**-UCTS0**. UART0 clear-to-send. To **RPI43** (**U1**.47). *Part of the first UART interface. **RPI43** is normally configured as input function –U1CTS. Can also be used as general-purpose I/O.*
IO.14	H1.20	I/O	•	**-URTS1**. UART1 request-to-send. From **RP31** (**U1**.39). *Part of the second UART interface. **RP31** is normally configured as output function –U2RTS. Can also be used as general-purpose I/O.*
IO.15	H1.18	I/O	•	**-UCTS1**. UART1 clear-to-send. To **RPI31** (**U1**.40). *Part of the second UART interface. **RPI31** is normally configured as input function –U2CTS. Can also be used as general-purpose I/O.*
IO.16	H1.16	I/O	•	General-purpose I/O. To/from **RP2** (**U1**.68).
IO.17	H1.14	I/O	•	General-purpose I/O. To/from **RP22** (**U1**.78).
IO.18	H1.12	I/O	•	General-purpose I/O. To/from **RPI42** (**U1**.79).
IO.19	H1.10	I/O	•	General-purpose I/O. To/from **RP25** (**U1**.81).

IO.20	H1.8	I/O	•	**SCL1**. I2C1 clock. From **SCL2** (**U1**.58). *Part of the second I2C interface.* **SCL2** *is normally configured as an I2C clock output. Can also be used as general-purpose I/O.*
IO.21	H1.6	I/O	•	**SDA1**. I2C1 data. To/from **SDA2** (**U1**.59). *Part of the second I2C interface.* **SDA2** *is normally configured as an I2C data input/output. Can also be used as general-purpose I/O.*
IO.22	H1.4	I/O	•	**SCL2**. I2C2 clock. To/from **SCL3** (**U1**.4). *Part of the third I2C interface.* **SCL3** *is normally configured as an I2C clock output. Can also be used as general-purpose I/O.*
IO.23	H1.2	I/O	•	**SDA2**. I2C2 data. To/from **SDA3** (**U1**.5). *Part of the third I2C interface.* **SDA3** *is normally configured as an I2C data input/output. Can also be used as general-purpose I/O.*
IO.24	H1.47	I/O	•	General-purpose I/O. To/from **RF1** (**U1**.88).
IO.25	H1.45	I/O	•	General-purpose I/O. To/from **RF0** (**U1**.87).
IO.26	H1.43	I/O	•	General-purpose I/O. To/from **RG1** (**U1**.89).
IO.27	H1.41	I/O	•	General-purpose I/O. To/from **RG0** (**U1**.90).
IO.28	H1.39	I/O	•	**SCL1***. I2C1 clock (alternate). To/from **ASCL2** (**U1**.66). *Provides an alternate location for the second I2C interface. If used,* **ASCL2** *is normally configured as an I2C clock output. Can also be used as general-purpose I/O.*
IO.29	H1.37	I/O	•	**SDA1***. I2C1 data (alternate). To/from **ASDA2** (**U1**.67). *Provides an alternate location for the second I2C interface. If used,* **ASCL3** *is normally configured as an I2C data input/output. Can also be used as general-purpose I/O.*
IO.30	H1.35	I/O	•	**INT1**. External interrupt. To **RPI33** (**U1**.18). ***RPI33*** *is normally configured as input function INT1. Can also be used as general-purpose I/O.*
IO.31	H1.33	I/O	•	**INT2**. External interrupt. To **RPI34** (**U1**.19). ***RPI34*** *is normally configured as input function INT2. Can also be used as general-purpose I/O.*
IO.32	H1.31	I/O	•	**AN8**. Analog input 8. To **AN5** (**U1**.20). *Can also be used as general-purpose I/O.*
IO.33	H1.29	I/O	•	**AN9**. Analog input 9. To **AN4** (**U1**.21). *Can also be used as general-purpose I/O.*
IO.34	H1.27	I/O	•	**AN10**. Analog input 10. To **AN3** (**U1**.22). *Can also be used as general-purpose I/O.*
IO.35	H1.25	I/O	•	**AN11**. Analog input 11. To **AN2** (**U1**.23). *Can also be used as general-purpose I/O.*
IO.36	H1.23	I/O	•	**AN12**. Analog input 12. To **AN1** (**U1**.24). Also used for **PGEC** (ICD clock). *Can also be used as general-purpose I/O.*
IO.37	H1.21	I/O	•	**AN13**. Analog input 13. To **AN0** (**U1**.25). Also used for **PGED** (ICD data). *Can also be used as general-purpose I/O.*
IO.38	H1.19	I/O	•	**AN14**. Analog input 14. To **AN6** (**U1**.26). *Can also be used as general-purpose I/O.*
IO.39	H1.17	I/O	•	**AN15**. Analog input 15. To **AN7** (**U1**.27). *Can also be used as general-purpose I/O.*
IO.40	H1.15	I/O	•	**AN0**. Analog input 0. To **AN8** (**U1**.32). *Can also be used as general-purpose I/O.*
IO.41	H1.13	I/O	•	**AN1**. Analog input 1. To **AN9** (**U1**.33). *Can also be used as general-purpose I/O.*
IO.42	H1.11	I/O	•	**AN2**. Analog input 2. To **AN10** (**U1**.34). *Can also be used as general-purpose I/O.*
IO.43	H1.9	I/O	•	**AN3**. Analog input 3. To **AN11** (**U1**.35). *Can also be used as general-purpose I/O.*
IO.44	H1.7	I/O	•	**AN4**. Analog input 4. To **AN12** (**U1**.41). *Can also be used as general-purpose I/O.*

IO.45	H1.5	I/O	•	**AN5**. Analog input 5. To **AN13** (**U1**.42). *Can also be used as general-purpose I/O.*
IO.46	H1.3	I/O	•	**AN6**. Analog input 6. To **AN14** (**U1**.43). *Can also be used as general-purpose I/O.*
IO.47	H1.1	I/O	•	**AN7**. Analog input 7. To **AN15** (**U1**.44). *Can also be used as general-purpose I/O.*

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**.29).
VREF1	H1.68	–	•	Not connected.
VREF2	H1.70	–	•	Negative analog voltage reference. To/from **VREF-** (**U1**.28).

PPM PIN DESCRIPTIONS – Reserved

Name	Pin	I/O	CSKB	Description
RSVD0	H1.72	–	•	Not connected. Reserved for future use.
RSVD1	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 **RE4** (**U1**.100). 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 **RE3** (**U1**.99). 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 **RE2** (**U1**.98). 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 **RC1** (**U1**.6). 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 **RPI38** (**U1**.6). When properly configured, can be used to interrupt Processor via MB RTC. *Normally configured as a digital input with change-on input interrupt capability.*
HS0	H1.90	I		Handshake signal. -RTS (USB) or -CTS (MHX). To **RPI41** (**U1**.9). *Can be configured as an external interrupt to **U1** or input handshake signal via its Peripheral Pin Select. Requires that **R10** be fitted on the MB.*
HS1	H1.92	I		Handshake signal. -DTR (USB) or -DSR (MHX). To **RPI40** (**U1**.8). *Can be configured as an external interrupt to **U1** or input handshake signal via its Peripheral Pin Select. Requires that **R11** be fitted on the MB.*
HS2	H1.94	I		Handshake signal. -PWE (USB) or -DCD (MHX). To **RPI39** (**U1**.7). *Can be configured as an external interrupt to **U1** or input handshake signal via its Peripheral Pin Select. Requires that **R12** be fitted on the MB.*
HS3	H1.96	O		Handshake signal. -CTS (USB) or -RTS (MHX). From **RP20**/**RD5** (**U1**.82). *Can be configured as an output handshake signal via its Peripheral Pin Select. Requires that **R75** be fitted on the MB.*
HS4	H1.98	O		Handshake signal. -RI (USB) or -DTR (MHX). From **RP23**/**RD2** (**U1**.77). *Can be configured as an output handshake signal via its Peripheral Pin Select. Requires that **R76** be fitted on the MB.*
HS5	H1.100	O		Handshake (reset) signal. -RST (USB) or -RST (MHX). From **RP24**/**RD1** (**U1**.76). *Can be configured as an output handshake signal via its Peripheral Pin Select. 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 **SDA1** (**U1**.56). *Part of the first I2C interface. **SDA1** is normally configured as an I2C data input/output. Can also be used as general-purpose I/O.*
SCL_SYS	H1.75	O	•	I2C clock. From **SCL1** (**U1**.57). *Part of the first I2C interface. **SCL1** is normally configured as an I2C clock output. Can also be used as general-purpose I/O.*

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.

SERIAL FLASH MEMORY INTERFACE

PPM D1 has an external 64Mbit serial flash memory (SFM) peripheral implemented via an SPI interface to an Atmel AT25DF641 (**U5**). The preferred method of interfacing to **U5** is by using **U1**'s third SPI interface (SPI3) — this will permit a very high-speed interface to **U5**. The pin assignments associated with this interface are listed below.

If the user desires to map SPI3 to the PPM connector instead, the SFM interface pins can be configured as simple I/O, using a software SPI driver to read and write from/to the SFM.

PIN DESCRIPTIONS – Serial Flash Memory Interface

Name	Pin	I/O	Description
-WP	U5.3	I/O	**-WP_SFM**. SFM write-protect function. From **RD6** (**U1**.83). *Part of the third SPI interface.* ***RD6*** *is normally configured as a simple output.*
-CS	U5.1	I/O	**-CS_SFM**. SFM chip select. From **RD13** (**U1**.80). *Part of the third SPI interface.* ***RD13*** *is normally configured as a simple output.*
SDI	U5.5	I/O	**SDO_SFM**. SPI2 (master) data out. From **RP11** (**U1**.72). *Part of the third SPI interface.* ***RP11*** *is normally configured as output function SDO3.*
SDO	U5.2	I/O	**SDI_SFM**. SPI2 (master) data in. From **RP3** (**U1**.70). *Part of the third SPI interface.* ***RP3*** *is normally configured as input function SDI3.*
SCK	U5.6	I/O	**SCK_SFM**. SPI2 clock. From **RP12** (**U1**.71). *Part of the third SPI interface.* ***RP12*** *is normally configured as output function SCK3OUT.*

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 D1 provides two interfaces for programming and debugging – the popular and low-cost In-Circuit Debugging (ICD) interface, and a JTAG interface. Both are implemented via Flexible Printed Circuit (FPC) connectors on the PPM.

6-pin FPC connector **J1** is for the ICD. Via Pumpkin's JFPC-PIC24 adapter, customers can connect either a traditional Microchip® ICD like the ICD2, with its 6-pin RJ11 6P6C connector[6], or a Microchip PICKit, with its 6-pin 0.100" pitch in-line header. The JFPC-PIC24 connects to PPM D1 via a 6-conductor

[6] Also called RJ25.

FPC cable. **PGEC** (**U1**.24) and **PGED** (**U1**.25) are used as the clock/data pair for the ICD. No isolation from these signals to the CSK bus is provided – therefore care should be taken in connecting circuitry to **IO.36** and **IO.37** of the CSK bus.

8-pin FPC connector **J2** is for JTAG, and is compatible with 8-conductor FPC cables. Customers who wish to use the JTAG port must fabricate their own adapter.

NOTES

The PIC24's Peripheral Pin Select system enables the user to place digital peripherals at the selected I/O pins of choice. On PPM D1, the peripheral functions (e.g., second and third I2C interfaces, second SPI interface, third and fourth UART interfaces) beyond those that interact with peripheral hardware on the MB have been arranged in a logical manner on the PPM connector, and will correspond to the same arrangement on other PPMs where such additional peripherals present in the processor utilized on that PPM.

Additionally, some mappable peripherals (e.g., the third and fourth UARTs) are not assigned pins on the PPM connector. The user can bring them to the CubeSat Kit bus – and thereby to any CubeSat Kit-compatible modules – by mapping them to unused **RP**/**RPI** pins (e.g., those on **IO.16** through **IO.19**), or to other **RP**/**RPI** pins of choice. In all cases, **IO.0** through **IO.7** should remain with the peripheral assignments outlined above, as they correspond to resources on the CSK MB.

PPM D1 (PIC24) is built on the same Pumpkin PCB (705-00525) as PPM D2 (dsPIC33), with minor differences in the components placed at assembly time.

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