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CubeSat Kit™

Pluggable Processor Module (PPM) D2

Hardware Revision: A

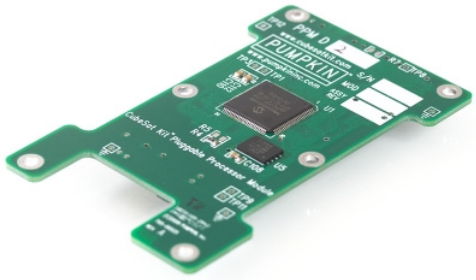
PPM with Microchip® dsPIC33 for CubeSat Kit Motherboard

Applications

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

Features

- For CubeSat Kit Motherboard (MB)
- Microchip® dsPIC33FJ256GP710 16-bit digital signal controller (DSC)
- CPU with MCU and DSP capabilities
- 256KB program memory, 30KB on-chip SRAM
- Up to 40MIPS @ 80MHz
- Integrated peripherals:
  - 2 UARTs, 2 SPIs, 2 I2Cs, 2 ECANs
  - Data Converter Interface (DCI) module with codec interface
  - 8-channel DMA
  - 32-channel 10/12-bit 1.1Msps/500ksps ADC
  - 9 16-bit timers
  - 8 capture inputs
  - 8 compare / PWM outputs
  - RTCC, WDT, ICD, JTAG, etc.
- 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 710-00528

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	20090729	AEK	Resolved minor formatting inconsistencies.
D	20090808	AEK	Added photo.
E	20091030	AEK	XT crystal now 20MHz.
F	20100302	AEK	HS5 description corrected (to RD1). XT crystal now 8.000MHz.
G	20100506	AEK	XT crystal in block diagram updated to 8MHz.
H	20101021	AEK	Added typical operating current.

OPERATIONAL DESCRIPTION

PPM D2 enables CubeSat Kit customers to utilize the dsPIC33 processor on a CubeSat Kit Motherboard (MB). PPM D2 uses the 100-pin dsPIC33FJ256GP710-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

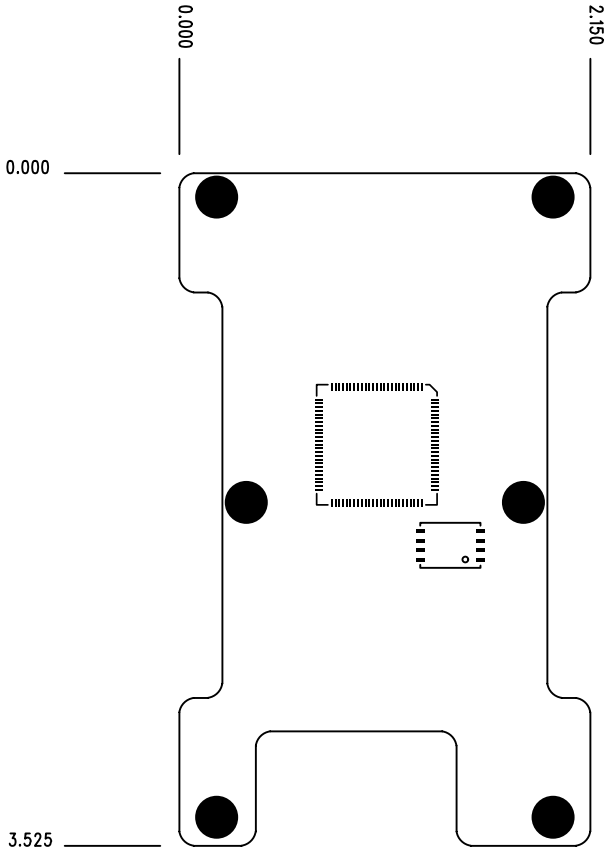
Refer to the dsPIC33FJxxxGPx10 family datasheet for additional absolute maximum ratings associated with processor **U1**, especially per-pin current limits.

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 D2 is implemented on a medium-size PPM PCB, as shown below.



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

ELECTRICAL CHARACTERISTICS

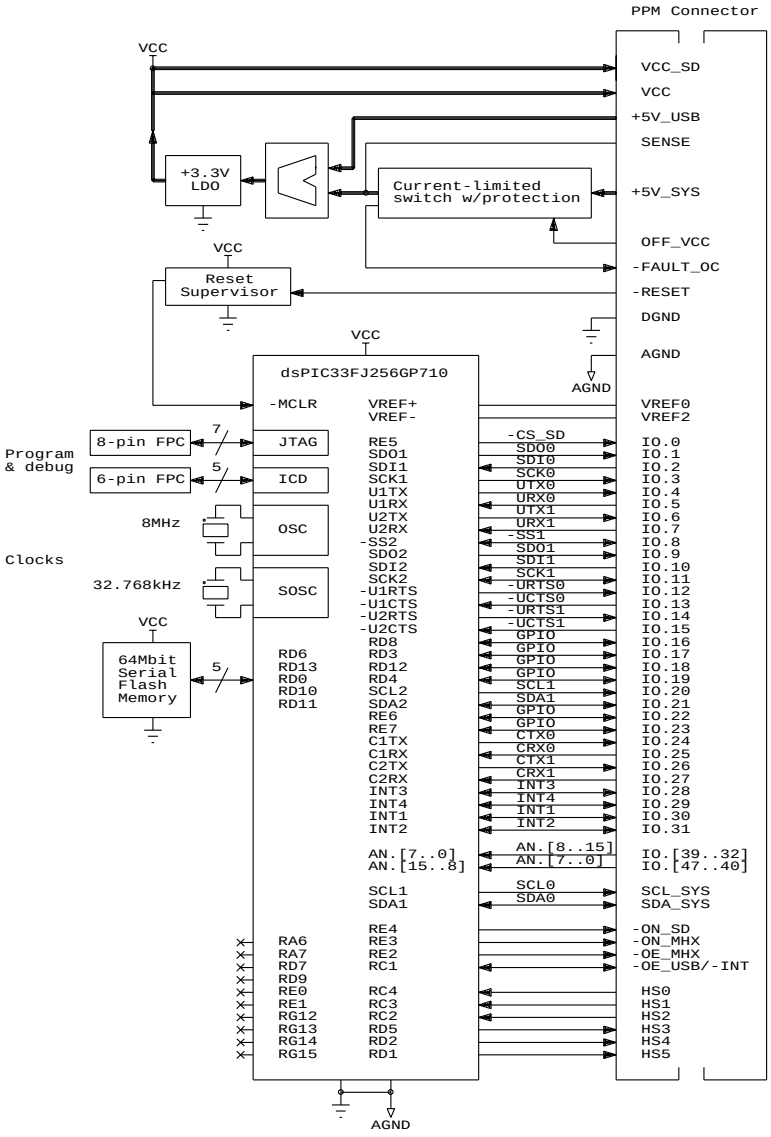
(T = 25ºC, +5V bus = +5V unless otherwise noted)

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}	8.000 ± 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 D2 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 dsPIC33 peripherals to the PPM connector and CubeSat Kit bus. A few of the dsPIC33's 100 pins are not used.



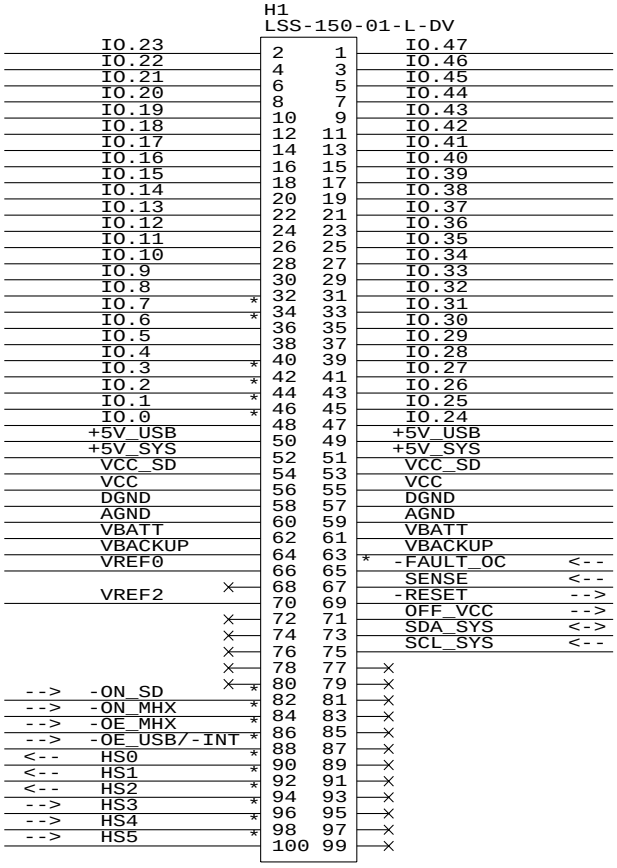
PPM PIN DESCRIPTIONS

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 dsPIC33's peripheral nomenclature begins with 1 (e.g., U1, SPI1, etc.), and is used when referring to peripherals, signals and registers internal to the dsPIC33.

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 **SDO1** (**U1**.53). *Part of the MB's SD card interface. **SDO1** is normally configured as output function SDO1.*
IO.2	H1.44	I/O	•	**SDI0**. SPI0 (master) data in. To **SDI1** (**U1**.54). *Part of the MB's SD card interface. **SDI1** is normally configured as input function SDI1.*
IO.3	H1.42	I/O	•	**SCK0**. SPI0 clock. From **SCK1** (**U1**.55). *Part of the MB's SD card interface. **SCK1** is normally configured as output function SCK1.*
IO.4	H1.40	I/O	•	**UTX0**. Tx0 data out. From **U1TX** (**U1**.51). ***RP16** is normally configured as output function U1TX.*
IO.5	H1.38	I/O	•	**URX0**. Rx0 data in. To **U1RX** (**U1**.52). ***RP30** is normally configured as input function U1RX.*
IO.6	H1.36	I/O	•	**UTX1**. Tx1 data out. From **U2TX** (**U1**.50). *Part of the MB's MHX/USB interface. **U2TX** is normally configured as output function U2TX.*
IO.7	H1.34	I/O	•	**URX1**. Rx1 data in. To **U2RX** (**U1**.49). *Part of the MB's MHX/USB interface. **U2RX** is normally configured as input function U2RX.*
IO.8	H1.32	I/O	•	**-SS1**. SPI1 slave select. From **–SS2** (**U1**.14). *Part of the second SPI interface. **–SS2** is normally configured as output function –SS2. Can also be used as general-purpose I/O.*
IO.9	H1.30	I/O	•	**SDO1**. SPI1 (master) data out. From **SDO2** (**U1**.12). *Part of the second SPI interface. **SDO2** 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 **SDI2** (**U1**.11). *Part of the second SPI interface. **SDI2** 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 **SCK2** (**U1**.10). *Part of the second SPI interface. **SCK2** is normally configured as output function SCK2. Can also be used as general-purpose I/O.*
IO.12	H1.24	I/O	•	**-URTS0**. UART0 request-to-send. From -**U1RTS** (**U1**.48). *Part of the first UART interface. **–U1RTS** 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 **–U1CTS** (**U1**.47). *Part of the first UART interface. **–U1CTS** 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 **–U2RTS** (**U1**.39). *Part of the second UART interface. **–U2RTS** 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 **–U2CTS** (**U1**.40). *Part of the second UART interface. **–U2CTS** 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 **RD8** (**U1**.68).
IO.17	H1.14	I/O	•	General-purpose I/O. To/from **RD3** (**U1**.78).
IO.18	H1.12	I/O	•	General-purpose I/O. To/from **RD12** (**U1**.79).

IO.19	H1.10	I/O	•	General-purpose I/O. To/from **RD4** (**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	•	General-purpose I/O. To/from **RE6** (**U1**.4).
IO.23	H1.2	I/O	•	General-purpose I/O. To/from **RE7** (**U1**.5).
IO.24	H1.47	I/O	•	**C0TX**. CANbus 0 transmit data. From **C1TX** (**U1**.88). *Part of the first CAN interface.* **C1TX** *is normally configured as a CAN output. Can also be used as general-purpose I/O.*
IO.25	H1.45	I/O	•	**C0RX**. CANbus 0 receive data. From **C1RX** (**U1**.87). *Part of the first CAN interface.* **C1RX** *is normally configured as a CAN input. Can also be used as general-purpose I/O.*
IO.26	H1.43	I/O	•	**C1TX**. CANbus 1 transmit data. From **C2TX** (**U1**.89). *Part of the second CAN interface.* **C2TX** *is normally configured as a CAN output. Can also be used as general-purpose I/O.*
IO.27	H1.41	I/O	•	**C1RX**. CANbus 1 receive data. From **C2RX** (**U1**.90). *Part of the second CAN interface.* **C2RX** *is normally configured as a CAN input. Can also be used as general-purpose I/O.*
IO.28	H1.39	I/O	•	**INT3**. External interrupt. To **INT3** (**U1**.66). ***INT3*** *is normally configured as input function INT3. Can also be used as general-purpose I/O.*
IO.29	H1.37	I/O	•	**INT4**. External interrupt. To **INT4** (**U1**.67). ***INT4*** *is normally configured as input function INT4. Can also be used as general-purpose I/O.*
IO.30	H1.35	I/O	•	**INT1**. External interrupt. To **INT1** (**U1**.18). ***INT1*** *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 **INT2** (**U1**.19). ***INT2*** *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.
RSVD2	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 MB. When active, enables **VCC_CARD** on 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 MB. When active, enables **PWR_MHX** on 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 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 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 **RC1** (**U1**.6). *Normally configured as a digital input.*
HS0	H1.90	I		Handshake signal. -RTS (USB) or -CTS (MHX). To **RC4** (**U1**.9). *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 **RC3** (**U1**.8). *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 **RC2** (**U1**.7). *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 **RD5** (**U1**.82). *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 **RD2** (**U1**.77). *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 **RD1** (**U1**.76). *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 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 D2 has an external 64Mbit serial flash memory (SFM) peripheral implemented via an SPI interface to an Atmel AT25DF641 (**U5**). A software SPI driver is required to read and write from/to the SFM via this interface. The pin assignments associated with this interface are listed below.

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 a software SPI interface. **RD6** is normally configured as a simple output.*
-CS	U5.1	I/O	**-CS_SFM**. SFM chip select. From **RD23** (**U1**.80). *Part of a software SPI interface. **RD23** is normally configured as a simple output.*
SDI	U5.5	I/O	**SDO_SFM**. SPI2 (master) data out. From **RD0** (**U1**.72). *Part of a software SPI interface. **RD0** is normally configured as a simple output.*
SDO	U5.2	I/O	**SDI_SFM**. SPI2 (master) data in. From **RD10** (**U1**.70). *Part of a software SPI interface. **RD10** is normally configured as a simple input.*
SCK	U5.6	I/O	**SCK_SFM**. SPI2 clock. From **RD11** (**U1**.71). *Part of a software SPI interface. **RD11** is normally configured as a simple output.*

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 D2 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 D2 via a 6-conductor 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

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

[6] Also called RJ25.

TRADEMARKS

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