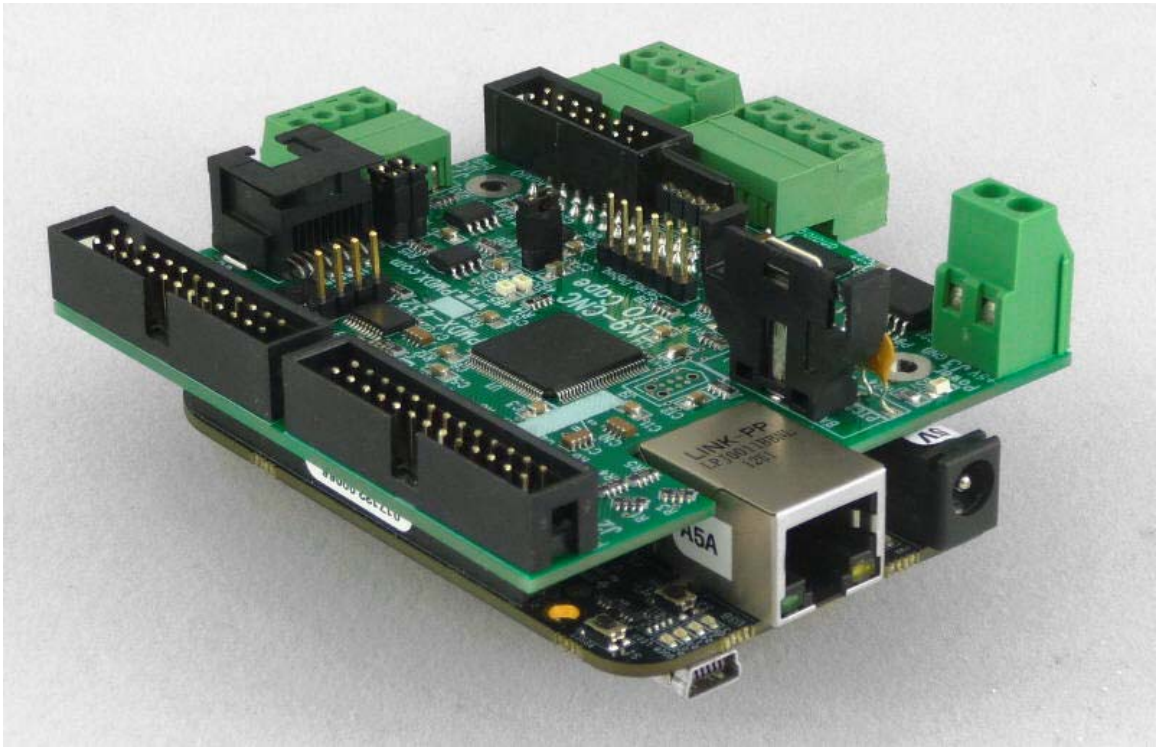
PMDX-432
K9-CNC I/O Cape
For the BeagleBoneBlack

Quick Start Guide



Document Revision: 0.5
Date: 31 August 2014

This document applies to units built on artwork revision PCB-513A.

This is a rough draft and users are cautioned that there may be errors in this document!! If you discover errors in this document, please report them to us.

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1.0 Overview

The PMDX-432 is an accessory cape to allow the BeagleBoneBlack to be used as a CNC controller using open source software such as the MachineKit offered at: ***www.machinekit.io*** Installing and configuring this software is beyond the scope of this document. Please join their mailing list and forums for help.

This document describes the connector pin-outs of the PMDX-432. The descriptions in this document assume the standard CPLD pattern is loaded. The actual functions of some pins including the parallel ports can be altered by loading a different pattern. The default pattern is configured for J1 to be a standard parallel port equivalent with the data bits used as outputs (or optionally bi-directional). J2 is configured with the data bits used as inputs.

1.1 Important Safety Information

- **Be careful out there! 8-)**

1.2 Updates to This Manual and Application Notes

Please see the PMDX web site for updates to this manual: ***http://www.pmdx.com/PMDX-432***

1.3 Pin numbering conventions

When referring to signals that emulate a parallel port, they are called by the names that would apply if the signals were presented on a DB-25 like an IBM-PC printer port. For example Port 1 pin 5 refers to the signal that would be present on pin 5 of the DB-25 connector, but its actual pin number on the ribbon header will be as required for use with a ribbon to DB-25 transition cable. Do not confuse signal names with physical pin numbers used on the ribbon connector where the cables connect to the PMDX-432.

1.4 Terminology

The remainder of this document will abbreviate the name BeagleBoneBlack as BBB.

2.0 LEDs

Ref #	LED Label	Description
DS1	Power	Located in the upper left corner of the board above the J3 power connector. On when +5 power is available from either J3 or the BBB
DS2	485-TX	Blinks when the BBB is transmitting data to the 485 bi-directional bus for the MODBUS serial port
DS3	485-RX	Blinks when the external MODBUS device sends data to the BeagleBoneBlack on the 485 bi-directional bus

3.0 Jumpers

JP1 EEPROM Write Protect (to the right of the words I/O Cape on the silkscreen) Install this jumper to inhibit writing to the Cape Personality EEPROM. EEPROM is shipped as all 0xFFs.

JP2 (to the left of the RJ-45 jack) Selects the Port 1 direction control options. Normally no jumper is installed.

- JP2 not installed will configure the 8 data bits of Port 1 as outputs. This is typical for step and direction signals.
- Pins 1-2 direction of 8 data bits comes from pin P8-18 of the BBB
- Pins 2-3 direction control of 8 data bits comes from Xilinx CPLD (possible future use?)
- Pins 3-4 direction of 8 data bits of Port 1 are configured as output, and the Xilinx reads the option setting as a logic Zero. Possible future use with new Xilinx patterns.

JP3 and JP4 (just below the RJ-45 jack)

- Install both these jumpers to enable low impedance pull-ups on the I2C bus. This is recommended for PMDX style I2C peripherals that support high drive current but may not be compatible with other I2C devices. Using this option reduces the probability of electrical noise interfering with the I2C bus.

4.0 R27 resistor pack

R27 (located above the J4 analog inputs terminal block) is a resistor pack network that provides pull-up resistors from the four analog inputs to +5 volts.

Install this resistor pack to use thermistor style sensors directly with the analog inputs. The most commonly used value is 4.7K ohms. Pin 1 of this resistor pack is the common pin tied to +5 volts. Pins 2 through 5 go to the four analog input pins.

Remove the R27 resistor pack when high impedance inputs are desired for reading voltages from the analog inputs.

5.0 Connectors

5.1 Parallel Port Connectors (J1, J2)

The PMDX-432 has two parallel port connectors. These are 26 pin ribbon headers with a pinout that matches the ribbon to DB-25 style transition cables. These headers can also be connected directly to most breakout boards that offer ribbon header connections for parallel port input using a ribbon header to ribbon header cable.

Port 1: Pins 1, 14, 16 and 17 are outputs from the BBB. Pins 10, 11, 12, 13 and 15 are inputs to the BBB. Pins 2-9 are usually outputs for step and direction signals, but may be otherwise configured. See the description for JP2 above.

Port 2: Pins 1, 14, 16, and 17 are outputs from the BBB. Pins 2-9, 10, 11, 12, 13 and 15 are inputs to the BBB. (note the standard CPLD pattern uses the data bits of this port as inputs)

Signals on these ports are buffered 5 volt logic signals. The outputs have sufficient drive current to directly connect to opto-isolator inputs of stepper and servo motor drivers. The inputs have pull-up resistors to +5 volts to allow operation with simple switches connected from the input signal to ground. The inputs are filtered and protected against overvoltage up to 25 volts. These inputs can also be driven by 5 volt logic signals such as MPGs or encoders.

J1 detailed pinout (pin numbers are DB-25 presentation, not actual ribbon header pin number)

- Pin 1 on DB-25 (pin 1 on ribbon header) output from BBB pin P8-17
- Pin 2 on DB-25 (pin 3 on ribbon header) output from BBB pin P9-31
- Pin 3 on DB-25 (pin 5 on ribbon header) output from BBB pin P9-29
- Pin 4 on DB-25 (pin 7 on ribbon header) output from BBB pin P9-30
- Pin 5 on DB-25 (pin 9 on ribbon header) output from BBB pin P9-28
- Pin 6 on DB-25 (pin 11 on ribbon header) output from BBB pin P9-42
- Pin 7 on DB-25 (pin 13 on ribbon header) output from BBB pin P9-27
- Pin 8 on DB-25 (pin 15 on ribbon header) output from BBB pin P9-41
- Pin 9 on DB-25 (pin 17 on ribbon header) output from BBB pin P9-25
- Pin 10 on DB-25 (pin 19 on ribbon header) input to BBB pin P8-9
- Pin 11 on DB-25 (pin 21 on ribbon header) input to BBB pin P8-7

- Pin 12 on DB-25 (pin 23 on ribbon header) input to BBB pin P8-8
- Pin 13 on DB-25 (pin 25 on ribbon header) input to BBB pin P8-10
- Pin 14 on DB-25 (pin 2 on ribbon header) output from BBB pin P8-14
- Pin 15 on DB-25 (pin 4 on ribbon header) input to BBB pin P8-15
- Pin 16 on DB-25 (pin 6 on ribbon header) output from BBB pin P8-13
- Pin 17 on DB-25 (pin 8 on ribbon header) output from BBB pin P8-19
- Pin 18-25 on DB-25 (pins 10,12,14,16,18,20,22,24 on ribbon header) ground

J2 detailed pinout (pin numbers are DB-25 presentation, not actual ribbon header pin number)

- Pin 1 on DB-25 (pin 1 on ribbon header) output from BBB pin P9-13
- Pin 2 on DB-25 (pin 3 on ribbon header) input to BBB pin P9-11
- Pin 3 on DB-25 (pin 5 on ribbon header) input to BBB pin P8-11
- Pin 4 on DB-25 (pin 7 on ribbon header) input to BBB pin P8-12
- Pin 5 on DB-25 (pin 9 on ribbon header input to BBB pin P9-26
- Pin 6 on DB-25 (pin 11 on ribbon header) input to BBB pin P8-16
- Pin 7 on DB-25 (pin 13 on ribbon header) input to BBB pin P9-12
- Pin 8 on DB-25 (pin 15 on ribbon header) input to BBB pin P9-14
- Pin 9 on DB-25 (pin 17 on ribbon header) input to BBB pin P9-15
- Pin 10 on DB-25 (pin 19 on ribbon header) input to BBB pin P9-16
- Pin 11 on DB-25 (pin 21 on ribbon header) input to BBB pin P9-23
- Pin 12 on DB-25 (pin 23 on ribbon header) input to BBB pin P9-24
- Pin 13 on DB-25 (pin 25 on ribbon header) input to BBB pin P8-26
- Pin 14 on DB-25 (pin 2 on ribbon header) output from BBB pin P9-21
- Pin 15 on DB-25 (pin 4 on ribbon header) input to BBB pin P9-22
- Pin 16 on DB-25 (pin 6 on ribbon header) output from BBB pin P9-17
- Pin 17 on DB-25 (pin 8 on ribbon header) output from BBB pin P9-18
- Pin 18-25 on DB-25 (pins 10,12,14,16,18,20,22,24 on ribbon header) ground

5.2 +5V Power Input (J3)

J3 is a 2-position screw terminal connector. Power may also be supplied from the BBB when it is powered from its coaxial power jack, or the BBB can be powered from the cape when power is applied to J3 of the cape. Do not attempt to power the cape from the BBB when the BBB is being powered by its USB cable. There is a 1.6 ampere solid state “PolyFuse” between the +5 volt systems of the cape and the BBB in order to try to prevent damage due to excessive current being drawn either way.

- Pin 1 is the +5V terminal. (towards the corner of the board, marked “+5V”)
- Pin 2 is the ground terminal. (towards the center of the board, marked “Gnd”)

5.3 Analog Inputs (J4)

J4 is the pluggable connector for analog inputs. These inputs accept 0 to +5 volt signals and scale them to the proper 1.8 volt range used by the BBB analog inputs. The BBB inputs are protected against overvoltage applied to J4. Note that the pin number sequence does ***NOT*** match the analog signal number sequence.

- Pin 1 is the AIN_1 input to the BBB. (towards the left edge of the connector)
- Pin 2 is the AIN_0 input to the BBB.
- Pin 3 is the AIN_3 input to the BBB.
- Pin 4 is the AIN_2 input to the BBB.
- Pin 5 is the AIN ground reference

5.4 Aux I/O signals (J5)

J5 is a 16-pin ribbon header with duplicates of signals useful for connecting 3D heater controls. These pin numbers follow the IDC ribbon header standard numbering scheme.

- Pin 1 is ground
- Pin 2 is AIN_2
- Pin 3 is ground
- Pin 4 is AIN_3
- Pin 5 is ground
- Pin 6 is AIN_0
- Pin 7 is +5 volts
- Pin 8 is AIN_1
- Pin 9 is Port 1 pin 11
- Pin 10 is Port 1 pin 15
- Pin 11 is Port 1 pin 13
- Pin 12 is Port 1 pin 12
- Pin 13 is Port 2 pin 14
- Pin 14 is Port 2 pin 1
- Pin 15 is Port 2 pin 16
- Pin 16 is Port 2 pin 17

5.5 RS-485 MODBUS serial (J6)

J6 is a 4-pin pluggable connector for MODBUS bi-directional RS-485 serial communications.

- Pin 1 (on left side of connector) is +5 volts
- Pin 2 is the +TX/RX side of the balanced RS-485 bus
- Pin 3 is the -TX/RX side of the balanced RS-485 bus
- Pin 4 is the ground reference for the RS-485 bus

5.6 I2C bus (J7)

J7 is a 4-pin pluggable connector for the I2C expansion bus. The signals on this bus are 5 volt signals and may be high drive/low impedance signals depending on the setting of jumpers JP3 and JP4. Low current expansion devices may be powered directly from the +5 volts on this connector.

- Pin 1 (on left side of connector) is +5 volts
- Pin 2 is the SDA signal for the I2C bus
- Pin 3 is the SCL signal for the I2C bus
- Pin 4 ground

5.7 Alternate I2C bus connector (J8)

J8 is an RJ-45 connector for PMDX style I2C peripherals. It includes the same signals as J7, but with duplicates of ground and +5 for higher current through the RJ-45 connector and cable. Signals are assigned to twisted pairs in a manner to help shield signals and prevent crosstalk.

- J8 pins 1, 2, 3, and 5 are ground
- J8 pin 4 is SCL
- J8 pin 6 is SDA
- J8 pins 7 and 8 are +5 volts

5.8 Factory programming connector (J9)

J9 is a proprietary connector for programming the Xilinx CPLD chip.

5.9 Serial Debug port (J10)

J10 is a 6-pin bare header containing the serial debug console signals from the BBB. It directly mates with a USB to 3.3 volt logic level serial port cable from FTDI. This item is available as part number 768-1015-ND from Digikey.

5.10 BBB pin mapping and functions

Many BBB header pins on P8 and P9 are direct connections to the processor on the BBB and their functions are set by the processor configuration. The MachineKit software reconfigures many of the default settings. The pinout used by the PMDX-432 is organized for best function of the available features of the BBB and the BBB port mapping must be configured to utilize the PMDX-432 features. The BBB function column in the charts below shows the default configuration name of the pins used in the BBB user's manual. Many of these pins will need to be used for different functions than the defaults, with most being remapped by the MachineKit software to be GPIO pins.

5.11 BBB connector P8

P8 pin	BBB function	K9 function	Dir	Typical usage on K9 for CNC control
1	GND	GND		
2	GND	GND		
3-6	eMMC	no connect		
7	timer4	J1-11	in	limit/home
8	timer7	J1-12	in	limit/home
9	timer5	J1-10	in	eStop
10	timer6	J1-13	in	limit/home
11	GPIO1_13	J2-3	in	misc in
12	GPIO1_12	J2-4	in	misc in
13	EHRPWMM2B	J1-16	out	PWM spindle speed
14	GPIO1_26	J1-14	out	dir spindle
15	GPIO1_15	J1-15	in	limit/home
16	GPIO1_14	J2-6	in	misc in
17	GPIO1_27	J1-1	out	misc out
18	GPIO2_1	J1 data bits dir	out	pins 2-9 dir if JP2 is jumper is on 1-2
19	EHRPWMM2A	J1-17	out	charge pump
20-25	eMMC	no connect		
26	GPIO1_29	J2-13 in	in	misc in
27-46	HDMI	no connect		

5.12 BBB connector P9

P9 pin	BBB function	K9 function	Dir	Typical usage on K9 for CNC control	
1,2	GND	GND			
3,4	DC_3.3V	DC_3.3			
5,6	VDD_5V	VDD_5V			
7,8	SYS_5V	SYS_5V			
9	PWR_BUT	no connect			
10	SYS_RESETn	SYS_RESETn	bi-directional		
11	UART4_RXD	J2-2	in	misc in	
12	GPIO1_28	J2-7	in	misc in	
13	UART4_TXD	J2-1	out	misc out	
14	EHRPWM1A	J2-8	in	misc in	
15	GPIO1_16	J2-9	in	misc in	
16	EHRPWM1B	J2-10	in	misc in	
17	12C1_SCL	J2-16	out	misc out	
18	I2C1_SDA	J2-17	out	misc out	
19	I2C2_SCL	I2C2_SCL	bus	dedicated eeprom/I2C bus	
20	I2C2_SDA	I2C2_SDA	bus	dedicated eeprom/I2C bus	
21	UART2_TXD	J2-14	out	misc out/alt. modbus	
22	UART2_RXD	J2-15	in	misc in/alt. modbus	
23	GPIO1_17	J2-11	in	misc in	
24	UART1_TXD	J2-12	in	misc in	
25	GPIO3_21	J1-9	out	s/d	
26	UART1_RXD	J2-5	in	misc in	
27	GPIO3_19	J1-7	out	s/d	
28	SPI1_CS0	J1-5	out	s/d	
29	SPI1_D0	J1-3	out	s/d	
30	SPI1_D1	J1-4	out	s/d	
31	SPI1_SCLK	J1-2	out	s/d	
32	VADC	no connect		V ref from ADC on BBB	
33	AIN4	no connect			
34	AGND	AGND		gnd for ADC	
35	AIN6	no connect			
36	AIN5	no connect			
37	AIN2	AIN_2	in		
38	AIN3	AIN_3	in		
39	AIN0	AIN_0	in		
40	AIN1	AIN_1	in		
41	CLK2OUT/SPI1_SCLK	J1-8	out	s/d	see SRM, dual pinout
42	GPIO0_7/GPIO3_18	J1-6	out	s/d	see SRM, dual pinout
43-46	GND				

6.0 I2C Device Addresses

The K9 CNC I/O cape contains two I2C devices. They share the same I2C bus as the expansion bus, so it is essential that expansion bus devices not cause address conflicts.

- The cape personality EEPROM will appear at address 0x54 and there is no way to disable it or change its address. JP1 can be installed for write protection.

- The RTC is a Microchip (Dallas) DS3231. It will appear at address 0x68 and there is no way to disable it or change its address. The RTC chip cannot generate interrupts to the BBB.

7.0 Firmware upgrades

The PMDX-432 uses a small Xilinx CPLD to map pinouts and provide a few minor functions. If it should prove necessary to alter the way the PMDX-432 works, it is possible to make corrections to this firmware by sending the board back to PMDX for re-programming.