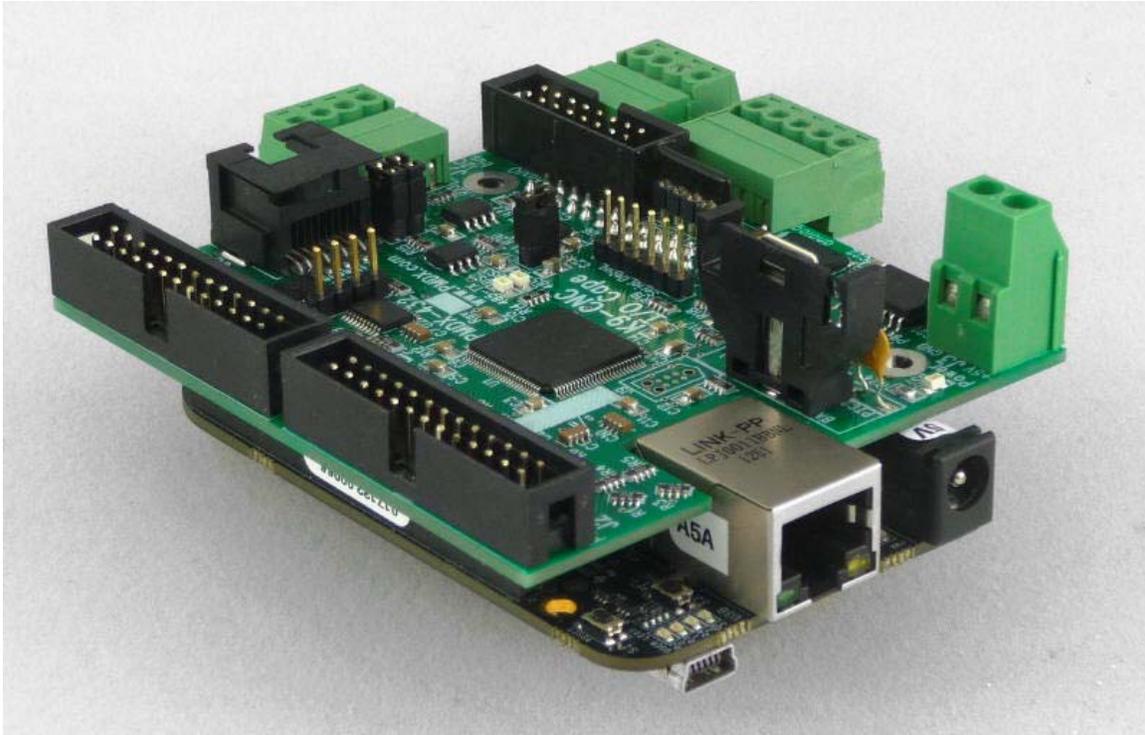


# *PMDX-432*

## *K9-CNC I/O Cape*

### *For the BeagleBoneBlack*

#### *Quick Start Guide*



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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](http://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 (to the right of the words I/O Cape on the silkscreen) Install this jumper to inhibit writing to the Cape Personality EEPROM

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        output from BBB pin P8-17
- Pin 2        output from BBB pin P9-31
- Pin 3        output from BBB pin P9-29
- Pin 4        output from BBB pin P9-30
- Pin 5        output from BBB pin P9-28
- Pin 6        output from BBB pin P9-42
- Pin 7        output from BBB pin P9-27
- Pin 8        output from BBB pin P9-41
- Pin 9        output from BBB pin P9-25
- Pin 10       input to BBB pin P8-9
- Pin 11       input to BBB pin P8-7

- Pin 12 input to BBB pin P8-8
- Pin 13 input to BBB pin P8-10
- Pin 14 output from BBB pin P8-14
- Pin 15 input to BBB pin P8-15
- Pin 16 output from BBB pin P8-13
- Pin 17 output from BBB pin P8-19
- Pin 18-25 ground

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

- Pin 1 output from BBB pin P9-13
- Pin 2 input to BBB pin P9-11
- Pin 3 input to BBB pin P8-11
- Pin 4 input to BBB pin P8-12
- Pin 5 input to BBB pin P9-26
- Pin 6 input to BBB pin P8-16
- Pin 7 input to BBB pin P9-12
- Pin 8 input to BBB pin P9-14
- Pin 9 input to BBB pin P9-15
- Pin 10 input to BBB pin P9-16
- Pin 11 input to BBB pin P9-23
- Pin 12 input to BBB pin P9-24
- Pin 13 input to BBB pin P8-26
- Pin 14 output from BBB pin P9-21
- Pin 15 input to BBB pin P9-22
- Pin 16 output from BBB pin P9-17
- Pin 17 output from BBB pin P9-18
- Pin 18-25 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     | I2C1_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.
- The RTC is a Microchip (Dallas) DS3231. It will appear at address 0xD0 and there is no way to disable it or change its address.

## 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.