

# Cerebot MX3cK™ Board Reference Manual

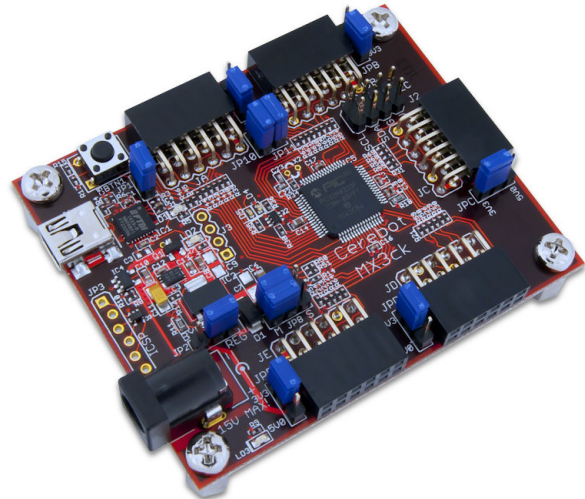
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## Overview

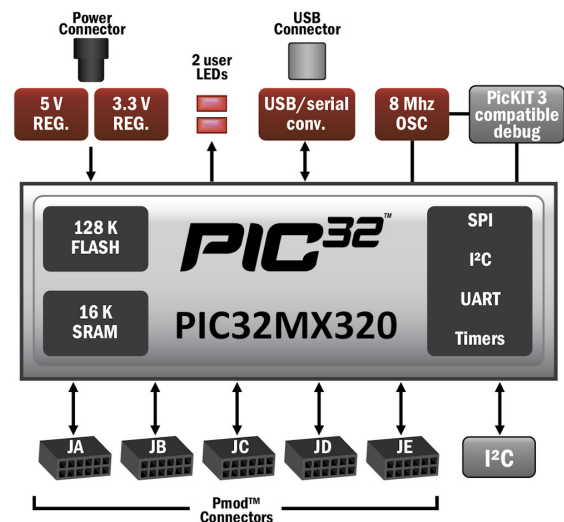
The Cerebot MX3cK is a microcontroller development board based on the Microchip PIC32MX320F128H, a member of the 32-bit PIC32 microcontroller family. It is compatible with Digiilent's line of Pmod™ peripheral modules, and is suitable for use with the Microchip MPLAB® IDE tools. The Cerebot MX3cK is also compatible for use with the chipKIT™ MPIDE development environment. ChipKIT and MPIDE is a PIC32 based system compatible with many existing Arduino™ code examples, reference materials and other resources.



The Cerebot MX3cK is designed to be easy to use and suitable for use by anyone from beginners to advanced users for experimenting with electronics and embedded control systems. It is intended to be used with either the Multi-Platform IDE, (modified Arduino IDE), MPIDE, or the Microchip MPLAB IDE. The kit contains everything needed to start developing embedded applications using the MPIDE. In order to use the MPLAB IDE, an additional programming/debugging device, such as a Microchip PICkit3 is required.

The Cerebot MX3cK provides 42 I/O pins that support a number of peripheral functions, such as UART, SPI and I<sup>2</sup>C™ ports as well as five pulse width modulated outputs and five external interrupt inputs. Eleven of the I/O pins can be used as analog inputs in addition to their use as digital inputs and outputs.

The Cerebot MX3cK can be powered via USB, or an external power supply that may be either an AC-DC power adapter, or batteries.



## Specifications

Microcontroller: PIC32MX320F128H  
Flash Memory: 128K  
RAM Memory: 16K  
Operating Voltage: 3.3V  
Max Operating Frequency: 80Mhz  
Typical operating current: 75mA  
Input Voltage (recommended): 7V to 15V  
Input Voltage (maximum): 20V  
I/O Pins: 42 total  
Analog Inputs: 12  
Analog input voltage range: 0V to 3.3V  
DC Current per pin: +/-18mA

## Programming Tools

The Cerebot MX3cK is designed to be used with either the Multi-Platform IDE (MPIDE), the development software environment used with the chipKIT™ system, or as a more traditional microcontroller development platform using the Microchip MPLAB® IDE and development tools. The Cerebot MX3cK is fully compatible with Microchip development tools that support the PIC32 family of microcontrollers.

The Cerebot MX3cK is immediately useable with the chipKIT MPIDE. Additional hardware is required to use the Microchip MPLAB tools.

### Using the Cerebot MX3cK with the chipKIT MPIDE

ChipKIT and the MPIDE is a PIC32 based hardware and software system compatible with many existing Arduino™ code examples, reference materials and other resources. The MPIDE development platform was produced by modifying the Arduino™ IDE and is fully backward compatible with the Arduino IDE. The Cerebot MX3cK board is designed to be fully compatible with the chipKIT MPIDE system, version 20111209 or later.

The MPIDE uses a serial communications port to communicate with a boot loader running in the target board. The serial port on the MX3cK board is implemented using an FTDI FT232R USB serial converter. Before attempting to use the MPIDE to communicate with the MX3cK, the appropriate USB device driver must be installed.

The Cerebot MX3cK board uses a standard mini-USB connector for connection to a USB port on the PC. Use a standard USB-A to mini-B cable (not provided) to connect the board to an available USB port on the PC.

In the MPIDE, use the “Tools.Board” command to select the Cerebot MX3cK from the list of available boards. Use the “Tools.Serial Port”

command to choose the appropriate serial port from the list of available serial ports on the PC.

When the MPIDE needs to communicate with the MX3cK board, the board is reset and starts running the boot loader. The MPIDE then establishes communications with the boot loader and downloads the program to the board.

When the MPIDE opens the serial communications connection on the PC, the DTR pin on the FT232R chip is driven low. This pin is coupled through a capacitor to the MCLR pin on the PIC32 microcontroller. Driving the MCLR line low resets the microcontroller, restarting execution with the boot loader.

Once the MPIDE has established communication with the boot loader, it transfers the user’s program to the boot loader, which programs it into the flash memory in the Microcontroller.

The automatic reset action when the serial communications connection is opened can be disabled. To disable this operation, remove the shorting block from jumper JP1. It is also possible that it will interfere with the operation of the MPLAB IDE and a Microchip hardware programmer/debugger. In this case, also, the shorting block should be removed from JP1. The shorting block is reinstalled on JP1 to restore operation with the MPIDE.

Two red LEDs (LD1 and LD2) will blink when data is being sent or received between the Cerebot MX3cK and the PC over the serial connection.

The header connector J3 provides access to the other serial handshaking signals provided by the FT232R. Connector J3 is not loaded at the factory but can be installed by the user to access these signals.

## Using the Cerebot MX3cK with Microchip Development Tools

In addition to being used with the MPIDE, the Cerebot MX3cK can be used as a more traditional microcontroller development board using Microchip Development Tools.

The Microchip MPLAB<sup>®</sup> IDE or the MPLAB<sup>®</sup> X IDE can be used to program and debug code running on the Cerebot MX3cK board. These programs can be downloaded from the Microchip web site. These software suites include a free evaluation copy of the Microchip C32 compiler for use with the PIC32 microcontroller family.

When creating a new project, use the “Configure.Select Device...” menu to specify the PIC32 device being used. Ensure that the device is set to PIC32MX320F128H.

Programming and debugging a program on the Cerebot MX3cK using the MPLAB IDE requires the use of external programming hardware. Typically, this will be a Microchip PICkit<sup>™</sup>3, but can be any other tool that supports the same connection interface as the PICkit3 and supports the PIC32MX3XX processor family.

Connector JP3 on the left side of the board is used to connect to the Microchip hardware development tool. This connector is not loaded at the factory, but can be installed by the user if desired. The holes for JP3 are staggered so that a standard, 100mil spaced, 6-pin header can be press fit to the board without the need to solder it in place. The connector at JP3 can be soldered in place if desired for a more reliable permanent connection.

Typically, a right angle male connector will be used in JP3 so that a PICkit3 can be attached coplanar with the Cerebot MX3cK board. If the connector is loaded from the top, the PICkit3 will be upright (button and LEDs visible). Alternatively, the connector can be loaded from the bottom. In this case, the PICkit3 will be upside down.

If JP3 is loaded from the top, the PICkit3 will interfere with the USB connector and the external power connector. A short six-wire cable can be used between the PICkit3 and the Cerebot MX3cK. If JP3 is loaded from the bottom, the PICkit3 won't interfere with the USB and external power connectors.

Digilent has a kit available (PICkit3 Programming Cable Kit) that includes all necessary connectors and the cable for connecting a PICkit3 to the Cerebot MX3cK.

The MCLR pin on the PIC32 microcontroller is used by the hardware programming/debugging interface to reset the processor. This same pin is used by the USB serial converter to reset the processor when using the MPIDE. It is possible that the reset function from the USB serial interface can interfere with correct operation of the Microchip programming and debugging tools. If this happens, jumper JP1 can be used to disconnect the USB serial converter reset circuit. Remove the shorting block from JP1 to disable the reset circuit. If the shorting block has been removed, it is necessary to reinstall it on JP1 in order to use the Cerebot MX3cK board with the MPIDE again.

Using the Microchip development tools to program the Cerebot MX3cK will erase the boot loader. To use the board with the chipKIT MPIDE again, it is necessary to program the boot loader back onto the board. The programming file for the boot loader programmed into the board by Digilent at the factory is available for download from the product page for the Cerebot MX3cK on the Digilent web site. Additionally, the boot loader source code is available in the chipKIT project repository at [www.github.com/chipKIT32/pic32-Arduino-Bootloader](http://www.github.com/chipKIT32/pic32-Arduino-Bootloader).

To reprogram the boot loader using MPLAB, perform the following steps:

- Use the “Configure.Select Device ...” menu to select the PIC32MX320F128H

- Use the “Programmer.Select Programmer” menu to select the “PICkit3” or other hardware programming tool being used.
- Use the “File Import...” dialog box to navigate to and select the boot loader programming downloaded from the Digilent web site. The file name will be something like: chipKIT\_Bootloader\_MX3ck.hex
- Use the “Programmer.Program” command to program all memories on the device.

## Additional Reference Documentation

For additional information about the Cerebot MX3cK board and the use and operation of the PIC32MX320F128H microcontroller, refer to the following documents in addition to this reference manual.

The Cerebot MX3cK Schematic, available on the Cerebot MX3cK product page on the Digilent web site: [www.digilentinc.com](http://www.digilentinc.com)

The PIC32MX3XX/4XX Family Data Sheet and the PIC32MX Family Reference Manual available from the Microchip web site: [www.microchip.com](http://www.microchip.com)

Additional reference material for the chipKIT MPIDE system is included in the MPIDE software download, and on-line in the chipKIT wiki. Help with questions and problems using the board with the chipKIT MPIDE software can also be obtained in the chipKIT forums:

[www.github.com/chipKIT32](http://www.github.com/chipKIT32) (software download)

[www.chipKIT.org/wiki](http://www.chipKIT.org/wiki)  
[www.chipKIT.org/forum](http://www.chipKIT.org/forum)

## Board Hardware Description

The following describes the various features of the Cerebot MX3cK hardware and the PIC32XM320F128H microcontroller.

### Power Supply

The Cerebot MX3cK is designed to be powered either from USB or from an external power supply. There is an automatic switchover circuit that causes the external supply to be used if both supplies are present.

The power supply section uses two voltage regulators. The first regulates the external voltage to 5V to power the VCC5V0 bus. The second regulates the VCC5V0 bus to 3.3V to provide power to the VCC3V3 bus that powers the PIC32 microcontroller.

The 5V voltage regulator, IC2, is normally an NCP1117. The board is designed to be able to also use an LM1117, but the NCP1117 is the part normally used. The NCP1117 is rated for an output current of 1A (the LM1117 is rated for 800mA). The dropout voltage of the NCP1117 is a maximum of 1.2V at the rated output current (1.3V for the LM1117). There is a reverse polarity protection diode in the external power supply circuit. Considering the diode drop plus the forward drop across the regulator, the minimum input voltage to the regulator should be 7V to produce a reliable 5V output. The absolute maximum input voltage of both the NCP1117 and the LM1117 is 20V.

The recommended maximum operating voltage is 15V. For input voltages above 9V, the regulator will get extremely hot when drawing high currents. Both the NCP1117 and the LM1117 have output short circuit protection and internal thermal protection and will shut down automatically to prevent damage.

The 3.3V regulator, IC3, is a Microchip MCP1725. This regulator is rated for a maximum output current of 500mA. The absolute maximum input voltage for the MCP1725 is 6V. This regulator has internal short circuit protection and thermal protection.

It will get noticeably warm when the current consumed by the VCC3V3 bus is close to the 500mA maximum.

The 5V power bus, VCC5V0 can be powered from one of three sources: 1) The USB5V0 bus when the board is operating under USB power; 2) The output of the on-board 5V regulator when operating from an external 7V–15V supply; or 3) Directly from the external supply when operating from a regulated 5V external supply and jumper JP2 is in the BYP position.

Switchover from USB power to external power is done automatically and the external supply will be used if both are present.

Jumper JP2 is used to route the external power supply voltage through the on-board 5V regulator or directly to the VCC5V0 bus, bypassing the on-board 5V regulator. Normally, JP2 should be in the REG position. This routes the external supply through the 5V regulator. Operation from an externally regulated 5V supply is accomplished by placing the jumper in the BYP position.

The forward drop across the MCP1725 is typically 210mV (350mV max) at 500mA output. With JP2 in the BYP position, this will allow correct operation of the 3.3V power supply from an input voltage down to 3.5V. This allows powering the board from batteries and other lower voltage power sources. In this case, the VCC5V0 power bus will not be powered at 5V.

**NOTE: It is extremely important to observe the MCP1725 maximum input voltage rating of 6V when JP2 is in the BYP position. Applying more than 6V to the external power input with the jumper in the BYP position can damage the 3.3V regulator and possibly the PIC32 microcontroller as well.**

The PIC32 microcontroller is rated to use a maximum of 75mA of current when operating at 80Mhz. This allows up to 425mA from the VCC3V3 bus and up to 925mA from the VCC5V0 bus to power external devices. The

combined power used by the VCC5V0 bus and the VCC3V3 bus should not exceed 925mA.

The Cerebot MX3cK can provide power to any peripheral modules attached to the Pmod connectors, JA-JE, and to I<sup>2</sup>C devices connected to the I<sup>2</sup>C daisy chain connector, J2. Each Pmod connector provides power pins that can be powered from either the switched main power bus, VCC5V0, or the regulated voltage, VCC3V3, by setting the voltage jumper block to the desired position. The I<sup>2</sup>C power connector only provides 3.3V from the VCC3V3 bus.

It is also possible to power the Cerebot MX3cK from any one of the Pmod connectors or the I<sup>2</sup>C connector. When powering the board from a Pmod connector with the power select jumper in the 5V0 position, a voltage applied at the Pmod connector will power the VCC5V0 bus and be regulated to 3.3V for the VCC3V3 bus. When powering the board from the I<sup>2</sup>C connector or a Pmod connector with the power select jumper in the 3V3 position, only the VCC3V3 bus will be powered and the VCC5V0 bus will not be powered.

## Pmod™ Connectors

The Cerebot MX3cK has five connectors for connecting Digilent Pmod peripheral modules. The Pmod connectors, labeled JA-JF, are 2x8 right-angle, female pin header connectors. Each connector has an associated power select jumper block labeled JPA-JPF.

Digilent Pmods are a line of small peripheral modules that provide various kinds of I/O interfaces. The Pmod product line includes such things as button, switch and LED modules, connector modules, LCD displays, high current output drivers, and many others.

There are two styles of Pmod connector: six-pin and twelve-pin. Both connectors use standard pin headers with 100mil spaced pins. The six-pin connectors have the pins in a 1x6 configuration, while the twelve-pin connectors use a 2x6 configuration. All of the Pmod

connectors on the Cerebot MX3cK are twelve pin connectors.

The six-pin connectors provide four I/O signals, ground and a switchable power connection. The twelve-pin connectors provide eight I/O signals, two power and two ground pins. The twelve-pin connectors have the signals arranged so that one twelve-pin connector is equivalent to two of the six-pin connectors. Pins 1-4 and 7-10 are the signal pins, pins 5 and 11 are the ground pins and pins 6 & 12 are the power supply pins.

The pin numbering that Digilent uses on the twelve-pin Pmod connectors is non-standard. The upper row of pins are numbered 1-6, left to right (when viewed from the top of the board), and the lower row of pins are numbered 7-12, left to right. This is in keeping with the convention that the upper and lower rows of pins can be considered to be two six-pin connectors stacked. When viewed from the end of the connector, pin 1 is the upper right pin and pin 7 is immediately below it (closer to the PCB).

Each Pmod connector has an associated power select jumper. These are used to select the power supply voltage supplied to the power supply pin on the Pmod connector. They are switchable between either the regulated 5V power supply or the 3.3V main board supply. Place the shorting block in the 3V3 position for regulated 3.3V and in the 5V0 position for regulated 5V. Note that the 5V0 position will supply the unregulated input supply if the regulator bypass jumper JP2 is in the BYP position.

Each signal pin on the Pmod connectors is connected to an input/output pin on the PIC32 microcontroller. Each pin has a 200 ohm series resistor and an ESD protection diode. The series resistor provides short circuit protection to prevent damaging the I/O block in the microcontroller if the pin is inadvertently shorted to VDD or GND, or two outputs are shorted together. The ESD protection diode

protects the I/O block from damage due to electro-static discharge.

Although ESD protection is provided between the connector pins and the microcontroller pins, ESD safe handling procedures should be followed when handling the circuit board. The pins on the microcontroller and other circuits on the board are exposed and can be damaged through ESD when handling the board.

Diligent Pmod peripheral modules can either be plugged directly into the connectors on the Cerebot MX3cK or attached via cables. Diligent has a variety of Pmod interconnect cables available.

See the Pinout Tables in Appendices B–D below for more information about connecting peripheral modules and other devices to the Cerebot MX3cK. These tables indicate the mapping between pins on the PIC32MX320 microcontroller and the pins on the various connectors.

The PIC32 microcontroller can source or sink a maximum of 18mA on all digital I/O pins. However, to keep the output voltage within the specified input/output voltage range ( $V_{OL}$  0.4V,  $V_{OH}$  2.4V) the pin current must be restricted to +/-12mA. The maximum current that can be sourced or sunk across all I/O pins simultaneously is +/-200mA. The maximum voltage that can be applied to any digital I/O pin is 5.5V. For more detailed specifications, refer to the PIC32MX3XX/4XX Data Sheet.

## Digital Inputs and Outputs

The Cerebot MX3cK board provides access to 40 of the I/O pins from the PIC32 microcontroller via the Pmod connectors. Two additional I/O pins can be accessed via the I<sup>2</sup>C connector, J2. Any of the pins on the Pmod or I<sup>2</sup>C connectors can be individually accessed for digital input or output. Note that when the I<sup>2</sup>C signals on J2 are being used for I<sup>2</sup>C communications, they are not available for general purpose I/O.

On PIC32 microcontrollers, the input/output pins are grouped into I/O Ports and are accessed via peripheral registers in the microcontroller. There are seven I/O Ports numbered A–G and each is 16 bits wide. Depending on the particular PIC32 microcontroller, some of the I/O Ports are not present, and not all 16 bits are present in all I/O Ports.

Each I/O Port has four control registers: TRIS, LAT, PORT, and ODC. The registers for I/O Port A are named TRISA, LATA, PORTA and ODCA. The registers for the other I/O Ports are named similarly.

The TRIS register is used to set the pin direction. Setting a TRIS bit to 0 makes the pin an output. Setting the TRIS bit to 1 makes the pin an input.

The LAT register is used to write to the I/O Port. Writing to the LAT register sets any pins configured as outputs. Reading from the LAT register returns the last value written.

The PORT register is used to read from the I/O Port. Reading from the PORT register returns the current state of all of the pins in the I/O Port. Writing to the PORT register is equivalent to writing to the LAT register.

PIC32 microcontrollers allow any pin set as an output to be configured as either a normal totem-pole output or as an open-drain output. The ODC register is used to control the output type. Setting an ODC bit to 0 makes the pin a normal output and setting it to 1 makes the pin an open drain output.

Refer to the PIC32MX3XX/4XX Family Data Sheet, and the PIC32 Family Reference Manual, Section 12, IO Ports, for more detailed information about the operation of the I/O Ports in the microcontroller.

The chipKIT MPIDE system uses logical pin numbers to identify digital I/O pins on the

connectors. These pin numbers start with pin 0 and are numbered up consecutively.

On the Cerebot MX3cK, pin numbers 0–39 are used to access the pins on the Pmod connectors and pin numbers 40 and 41 are used for the two signal pins on the I<sup>2</sup>C connector. The pin numbers are assigned so that connector JA pin 1 (JA-01) is digital pin 0, JA pin 2 (JA-02) is digital pin 1, and so on.

Pins 0-7 are on connector JA, pins 8-15 on JB, pins 16-23 on JC, pins 24-31 on JD, and pins 32-39 on JE. Refer to the tables in Appendices B–D for detailed information about the pin mapping between Pmod connector, logical pin number, and PIC32 microcontroller pin number and pin function.

When using the Cerebot MX3cK with the chipKIT MPIDE the functions `pinMode()`, `digitalRead()`, and `digitalWrite()` are used for digital pin I/O.

The `pinMode()` function is used to set the pin direction. Pin direction can be set to: `INPUT`, `OUTPUT`, or `OPEN`. `OPEN` is used for open-drain and implies output.

The `digitalRead()` and `digitalWrite()` functions are used to read or write the pins. `DigitalRead()` returns the current state of the specified pin, and `digitalWrite` is used to set the state of an output pin. The pin state can be either `HIGH` or `LOW`.

## User LEDs

Two LEDs are provided, LD4 and LD5, connected to I/O port F bits 0 and 1 (RF00 and RF01). LATF Bit 0 is connected to LD4 and bit 1 is connected to LD5. The LEDs are turned on or off by configuring these two pins as outputs and driving them high or low. Driving the pin high turns the LED on, driving it low turns it off. These I/O pins are dedicated to use with the LEDs and are not available at any connector.

When using the MPIDE and the chipKIT system, the LEDs are accessed as digital pins

42 (LD4) and 43 (LD5), or preferably, using the symbols `PIN_LED1` and `PIN_LED2`.

## 5V Signal Compatibility

The PIC32 microcontroller operates at 3.3V. And the I/O pins provide 3.3V logic levels. It is possible, in some circumstances, to use the Cerebot MX3cK to operate with 5V logic devices.

There are two issues to consider when dealing with 5V compatibility for 3.3V logic. The first is protection of 3.3V inputs from damage caused by 5V signals. The second is whether the 3.3V output is high enough to be recognized as a logic high value by a 5V input.

The digital I/O pins on the PIC32 microcontroller are 5V tolerant. It is safe to apply 5V logic signals directly to these pins without risk of damage to the microcontroller.

The analog capable I/O pins on the PIC32 are not 5V tolerant. The absolute maximum voltage rating for the analog pins is 3.6V. Generally, the analog pins are the pins on I/O port B, however, there are other non-5V tolerant pins on the device.

Refer to the PIC32MX3XX/4XX Family Data Sheet for more information about which pins on the device are 5V tolerant before applying input signals higher than 3.3V to any pin on the Cerebot MX3cK board.

If a 5V signal is to be applied to a non-5V tolerant pin, some external means must be used to limit the applied voltage to 3.6V or less. The Cerebot MX3cK board provides 200 ohm series resistors between the microcontroller pins and the Pmod connector pins. These resistors are primarily intended to provide short circuit protection on the outputs, but will also provide limited protection if a 5V signal is inadvertently applied to a non-5V tolerant pin.

One technique that can be used to limit and input voltage to a safe level is to use a 200 ohm series resistor and a Schottky diode



connected to the 3.3V supply to clamp the voltage.

The minimum output high voltage of the PIC32 microcontroller is rated at 2.4V when sourcing 12mA of current. When driving a high impedance input (typical of CMOS logic) the output high voltage will be close to 3.3V. Some 5V devices will recognize this voltage as a logic high input, and some won't. Many 5V logic inputs will work reliably with 3.3V inputs.

If the 3.3V logic output is not sufficient for 5V logic input to be reliably seen as a logic high input signal, some external means must be used to raise the output level. In some cases, a pull-up resistor to 5V is sufficient. A pull-up resistor in the range of 2Kohm–10kOhm can be used. This technique should not be used with pins that are not 5V tolerant on the PIC32 microcontroller.

## RESET

A reset button is at the upper left corner of the board. Pressing this button will reset the PIC32 microcontroller.

## PIC32 Peripheral Devices

The following describes the peripheral devices available in the PIC32MX460F512L microcontroller and how they are accessed on the Cerebot MX4cK board.

### CPU Clock Source

The PIC32 microcontroller supports numerous clock source options for the main processor operating clock. The Cerebot MX3cK uses an 8Mhz external crystal for use with the XT oscillator option. Oscillator options are selected via the configuration settings specified using the `#pragma config` statement. Use `#pragma config POSCMOD=XT` to select the XT option.

Using the internal system clock phase-locked loop (PLL), it is possible to select numerous multiples or divisions of the 8Mhz oscillator to produce CPU operating frequencies up to 80Mhz. The clock circuit PLL provides an input divider, multiplier, and output divider. The external clock frequency (8Mhz) is first divided by the input divider value selected. This is multiplied by the selected multiplier value and then finally divided by the selected output divider. The result is the system clock, SYSCLK, frequency. The SYSCLK frequency is used by the CPU, DMA controller, interrupt controller and pre-fetch cache.

The values controlling the operating frequency are specified using the PIC32MX320 configuration variables. These are set using the `#pragma config` statement. Use `#pragma config FPLLIDIV` to set the input divider, `#pragma config FPLLMUL` to set the multiplication factor and `#pragma config FPLLODIV` to set the output divider. Refer to the PIC32MX3XX/4XX Family Data Sheet and the PIC32MX Family Reference Manual, Section 6. Oscillators, for information on how to choose the correct values, as not all combinations of multiplication and division factors will work.

In addition to configuring the SYSCLK frequency, the peripheral bus clock, PBCLK, frequency is also configurable. The peripheral bus clock is used for most peripheral devices, and in particular is the clock used by the timers, and serial controllers (UART, SPI, I2C). The PBLCK frequency is a division of the SYSCLK frequency selected using `#pragma config FPBDIV`. The PBCLK divider can be set to divide by 1, 2, 4, or 8.

The following example will set up the Cerebot MX3cK for operation with a SYSCLK frequency of 80Mhz and a PBCLK frequency of 10Mhz:

```
#pragma config FNOSC = PRIPLL
#pragma config POSCMOD = XT
#pragma config FPLLIDIV = DIV_2
#pragma config FPLLMUL = MUL_20
#pragma config FPLLODIV = DIV_1
#pragma config FPBDIV = DIV_8
```

Documentation for the available PIC32 configuration variables can be found in the PIC32MX Configuration Settings guide. This is found using the “Help.Topics...” in the MPLAB IDE. Refer to Appendix E for an example of setting the configuration variables.

When using the Cerebot MX3cK with the chipKIT MPIDE software, the clock source is automatically set by the boot loader and no action is required.

### UART Interface

The PIC32MX320 microcontroller provides two UART interfaces, UART1 and UART2. The UARTs can provide either a 2-wire or a 4-wire asynchronous serial interface. The 2-wire interface provides receive (RX) and transmit (TX) pins. The 4-wire interface includes request-to-send (RTS) and clear-to-send (CTS) in addition to receive and transmit.

UART1 can be accessed from Pmod connector JB and UART2 can be accessed from Pmod connector JC using the following pins:

- U1CTS JB-01
- U1TX JB-02
- U1RX JB-03
- U1RTS JB-04
  
- U2CTS JC-01
- U2TX JC-02
- U2RX JC-03
- U2RTS JC-04

Some of the pins on UART1 and SPI1 are shared on the PIC32 microcontroller. This means that UART1 and SPI1 can't both be used at the same time.

Detailed information about the operation of the UART peripherals can be found in the PIC32 Family Reference Manual, Section 21, UART.

The USB Serial converter is connected to UART1. The MPIDE uses this to communicate with the boot loader. This can also be used for a serial communications interface between the Cerebot MX3cK board and other software running on a PC. Resistors are used to decouple the USB serial interface and so UART 1 can also be used via Pmod connector JB.

Note that when using the MPIDE software, devices connected to JB can interfere with the operation of the serial interface and prevent the MPIDE from successfully downloading sketches to the board. If this happens, disconnect the external device from JB until the sketch has been downloaded and then reconnect it.

When using the Cerebot MX3cK with the MPIDE and the chipKIT system, the UARTs are accessed using the HardwareSerial facility built into the system. UART1, connector JB, is accessed using the `Serial` object and UART2, connector JC, is accessed using `Serial1`.

## Serial Peripheral Interface (SPI)

SPI is a four wire synchronous serial interface and devices can operate as either an SPI master device or as an SPI slave device. The four SPI signals are generally called Slave Select (SS), Master Out Slave In (MOSI), Master In Slave Out (MISO), and Serial Clock (SCK). The master device generates SS and SCK, and the slave device receives SS and SCK. The SS signal is used to enable the slave device, and this signal is only significant for slave devices. A master device can use any general purpose I/O pin to generate SS to enable the slave.

The PIC32 microcontroller labels the SPI signals as: Slave Select (SS), Serial Data Out (SDO), Serial Data In (SDI), and Serial Clock (SCK). When the PIC32 microcontroller is enabled as a master device SDO serves the purpose of MOSI and SDI serves the purpose of MISO. When the PIC32 microcontroller is operating as an SPI slave device, SDI serves the purpose of MOSI and SDO serves the purpose of MISO.

The PIC32 microcontroller provides two Serial Peripheral Interfaces, SPI1 and SPI2. SPI1 is accessed via Pmod connector JB and SPI2 is accessed via Pmod connector JE.

- RD9 JB-01 (used for SS output)
- SDO1 JB-02
- SDI1 JB-03
- SCK1 JB-04
  
- SS2 JE-01
- MOSI JE-02
- MISO JE-03
- SCK2 JE-04

SPI1 is only laid out to support use as an SPI master. To use SPI1 as a slave device, it is necessary to use external wiring to connect the signals appropriately. When using SPI1 as a slave device, the SS1 signal is obtained from Pmod connector JD, pin 1 (JD-01).

SPI2 is laid out on the board for use either as an SPI master or as an SPI slave device. Jumpers JP6 & JP8 are used to select between master and slave. These jumpers switch the microcontroller signals SDO2 and SDI2 between the SPI signals MOSI and MISO at the Pmod connector. Place the shorting blocks on these jumpers in the M position when operating as an SPI master and in the S position when operating as an SPI slave device.

Detailed information about the operation of the SPI peripherals can be found in the PIC32 Family Reference Manual, Section 23, Serial Peripheral Interface.

When using the Cerebot MX3cK with the MPIDE and the chipKIT system, the SPI ports are accessed using either the standard chipKIT SPI library or using the Digilent DSPI library.

The standard SPI library supports access to a single SPI port, SPI2. This is accessed using the `SPI` object.

The DSPI library supports access to both SPI ports. The `DSPI0` object class is used to create an object used to access the default SPI port, SPI2, and the `DSPI1` object class is used to access SPI1.

## I<sup>2</sup>C™ Interface

The Inter-Integrated Circuit (I<sup>2</sup>C™) Interface provides a medium speed (100K or 400K bps) synchronous serial communications bus. The I<sup>2</sup>C interface provides master and slave operation using either 7 bit or 10 bit device addressing. Each device is given a unique address, and the protocol provides the ability to address packets to a specific device or to broadcast packets to all devices on the bus. Refer to the Microchip PIC32MX3XX/4XX Family Data Sheet and the PIC32 Family Reference Manual for detailed information on configuring and using the I<sup>2</sup>C interface.

The PIC32MX320 microcontroller provides for two independent I<sup>2</sup>C interfaces. The Cerebot MX3cK is designed to provide dedicated access to one of these interfaces, I2C1, using I<sup>2</sup>C daisy chain connector J2. The other I<sup>2</sup>C interface, I2C2, can be accessed at pins 2 & 3 on Pmod connector JC.

The I<sup>2</sup>C daisy chain connector provides two positions for connecting to the I<sup>2</sup>C signals, power and ground. By using two-wire or four-wire MTE cables (available separately from Digilent) a daisy chain of multiple Cerebot MX3cK boards or other I<sup>2</sup>C-capable boards can be created.

The I<sup>2</sup>C bus is an open-collector bus. Devices on the bus actively drive the signals low. The high state of the I<sup>2</sup>C signals is achieved by pull-up resistors when no device is driving the lines low. One device on the I<sup>2</sup>C bus must provide the pull-up resistors. On the Cerebot MX3cK, I2C1 provides selectable pull-up resistors that can be enabled or disabled via jumper blocks JP1 and JP10, near Pmod connector JA. The pull-ups are enabled by installing shorting blocks and are disabled by removing the shorting blocks. Generally, only one device on the bus will have the pull-ups enabled.

There are no pull-up resistors provided on the Cerebot MX3cK for I2C2. If I2C2 is to be used, external pull-up resistors must be provided. The operating voltage for the I<sup>2</sup>C busses on the Cerebot MX3cK is 3.3V. External pull-up resistors must be connected to a 3.3V source.

Detailed information about the operation of the I<sup>2</sup>C peripherals can be found in the PIC32 Family Reference Manual, Section 24, Inter-Integrated Circuit.

When using the Cerebot MX3cK with the MPIDE and the chipKIT system, the I<sup>2</sup>C interfaces are accessed using the standard chipKIT Wire library, or the Digilent DTWI library.

The Wire library supports a single I<sup>2</sup>C interface, I2C1 on J2. This is accessed using the `Wire` object.

The DTWI library supports both I<sup>2</sup>C interfaces. The `DTWI0` object class is used to create an object for access to I2C1 and the `DTWI1` object class is used to access I2C2.

The pinout of the I<sup>2</sup>C daisy chain connector is as follows:

Connector J2. I2C1

- J2-1 – SCL1
- J2-2 – SCL1
- J2-3 – SDA1
- J2-4 – SDA1
- J2-5 – GND
- J2-6 – GND
- J2-7 – BRD\_3V3
- J2-8 – BRD\_3V3

## Analog Inputs

The PIC32MX320 microcontroller provides a 10-bit analog to digital (A/D) converter that provides up to sixteen analog inputs. The Cerebot MX3cK board provides access to 11 of them on the Pmod connectors. The converted values produced by the A/D converter will be in the range 0–1023.

For detailed information on the operation and use of the A/D converter, refer to the PIC32 Family Reference Manual, Section 17, 10-bit AD Converter.

The analog inputs are accessed using the `analogRead()` function in the chipKIT MPIDE software. The analog input pin number is specified using the symbols A0–A10. The digital pin numbers for the pin or the numbers 0–10 can also be used, but using the symbols A0–A10 is recommended.

The following gives the Pmod connector position, digital pin number, and microcontroller I/O port and bit number for the analog inputs:

- A0 – JC-01, digital pin 16, RB8
- A1 – JC-04, digital pin 19, RB14
- A2 – JC-07, digital pin 20, RB0
- A3 – JC-08, digital pin 21, RB1
- A4 – JD-01, digital pin 24, RB2
- A5 – JD-04, digital pin 27, RB9
- A6 – JD-07, digital pin 28, RB12
- A7 – JD-10, digital pin 31, RB13
- A8 – JE-08, digital pin 37, RB5
- A9 – JE-09, digital pin 38, RB4
- A10 – JE-10, digital pin 39, RB3

## A/D Converter Reference

The PIC32 microcontroller provides two reference inputs to the analog to digital converter. `Vref-` is used set the lower reference level and `Vref+` is used to set the upper reference level. These references can be connected to internal references or external references using two of the analog input pins.

When the internal references are being used, `Vref-` is connected to `Vss` and `Vref+` is connected to `Vdd`. This means that the voltage input range at the analog input pins is 0V–3.3V. In this case, an input voltage of 0V will convert to ~0, an input voltage of 1.65V will convert to ~511, and an input voltage of 3.3V will convert to ~1023.

Either one, or both, of the references can be connected to external reference pins. When this is done, the references can be set to voltages other than 0V and 3.3V.

If, for example, both references were selected to use external references, with 1V applied to `Vref-` and 2V applied to `Vref+`, the input voltage range at the analog input pins would be from 1V to 2V. An applied voltage of 1V would have a converted value of ~0, 1.5V would have a converted value of ~511, and 2V would have a converted value of ~1023.

When both external references are being used, `Vref+` must have a higher voltage applied to it than `Vref-`.

The analog reference input pins are shared with two of the analog inputs. Vref- is shared with A3 (AN1/RB1), and Vref+ is shared with A2 (AN0/RB0). These pins are not available to be used as analog inputs when being used as an external reference.

When using the chipKIT MPIDE software, the use of external analog references is selected using the `analogReference()` function. The following values can be used with `analogReference()`:

- `DEFAULT` – Vref- = 0V, Vref+ = 3.3V
- `INTERNAL` – same as default
- `EXTERNAL` – Vref- = 0V, Vref+ = voltage at A2
- `EXTMINUS` – Vref- = voltage at A3, Vref+ = 3.3V
- `EXTPLUSMINUS` – Vref- = voltage at A3, Vref+ = voltage at A2

## Timers

The PIC32 microcontroller provides five timers that can be used for various timing functions. These timers are each 16 bits wide, although two pairs, `TIMER2/TIMER3` and `TIMER4/TIMER5` can be combined to produce 32 bit wide timers.

A timer consists of a control register, a counter register, and a period register. The control register is used to configure the timer for various modes of operation. The count register counts cycles of the clock source selected via the control register. This clock source can be the peripheral bus clock or a division of the peripheral bus clock via a pre-scaler divider. The period register can be used to generate an interrupt and/or reset the count register when a pre-determined value is reached.

For detailed information on the operation of the PIC32 timers, refer to the PIC32 Family Reference Manual, Section 14, Timers.

Control and operation of the timers is not explicitly provided in the current version of the

chipKIT MPIDE software. This capability will be added in a future version of the software. Timers are used implicitly by various core functions and libraries, however.

## Output Compare

The PIC32 microcontroller provides five output compare units that can be used to control the timing of state changes on certain output pins or to generate pulse width modulated (PWM) outputs.

Each output compare unit works with a particular output pin (OC1-OC5). It can be programmed to control the pin in any of the following ways:

- PWM output
- Generate continuous pulses
- Generate a single pulse
- Toggle the output pin
- Generate falling edge
- Generate rising edge

The output compare units work in conjunction with a timer. Either `Timer2` or `Timer3` can be used with any of the five output compare units.

Refer to the PIC32 Family Reference Manual, Section 16, Output Compare for detailed information on the use of the output compares units.

When using the chipKIT MPIDE software, these are accessed using the `analogWrite()` function. The digital pin number, or preferably, the symbols `PIN_OC1` through `PIN_OC5` are used to specify the pin. The chipKIT MPIDE software currently only supports using the output compare units to generate PWM outputs. It uses `Timer2` to control the output compares.

The following gives Pmod connector position, chipKIT pin number, and microcontroller I/O port and bit number for the output compare unit's output pins:

- OC1 – JC-09, digital pin 23, RD0
- OC2 – JC-10, digital pin 24, RD1
- OC3 – JD-02, digital pin 25, RD2
- OC4 – JD-08, digital pin 29, RD3
- OC5 – JB-09, digital pin 14, RD4

## Input Capture

The PIC32 microcontroller provides five input capture units. An input capture unit works in conjunction with a timer and monitors the state of an associated pin. When the pin changes state, the current value of the timer is captured. The input capture units can be used with either Timer2 or Timer3.

The input capture unit can be programmed to be sensitive to either a rising edge, a falling edge, or both edges on the input pin. An interrupt can also be signaled when an input capture is triggered. Each input capture has a four level deep fifo that can buffer up to four capture events.

For detailed information on the operation and use of the input capture units, refer to the PIC32 Family Reference Manual, Section 15, Input Capture.

The following gives the Pmod connector position, chipKIT pin number, and microcontroller port and bit number for the input capture units input pins:

- IC1 – JE-07, digital pin 32, RD08
- IC2 – JB-01, digital pin 8, RD09
- IC3 – JD-03, digital pin 26, RD10
- IC4 – JD-09, digital pin 30, RD11
- IC5 – JB-09, digital pin 14, RD04

Use of the input capture units is not currently supported in the chipKIT MPIDE software. This will be added in a future version.

## External Interrupts

The PIC32 microcontroller provides five external interrupt inputs. An external interrupt input can be used to generate an interrupt to

the microprocessor CPU when the pin changes state. They can be programmed to interrupt on a rising edge or a falling edge on the pin.

Refer to the PIC32 Family Reference Manual, Section 8, Interrupts for more information on the operation of the external interrupts.

These are accessed using the `attachInterrupt()` and `detachInterrupt()` functions when using the chipKIT MPIDE software. The interrupt number is specified using the numbers 0-4, or preferably, the symbols `EXT_INT0` through `EXT_INT4`.

The following gives Pmod connector position, chipKIT pin number, and microcontroller I/O port and bit number:

- INT0 – JB-04, digital pin 11, RF6
- INT1 – JE-07, digital pin 36, RD8
- INT2 – JB-01, digital pin 8, RD9
- INT3 – JD-03, digital pin 26, RD10
- INT4 – JD-09, digital pin 30, RD11

## RTCC

The PIC32 microcontroller contains a low frequency oscillator and Real Time Clock/Calendar, RTCC, circuit that can be used to maintain time and date information. The operation of the RTCC requires a 32.768Khz frequency source. The crystal X2 position, just above and on the left of the PIC32 microcontroller, IC5, is provided for the user to solder in a 32Khz watch crystal. The Citizen CFS206-32.768KDZF-UB is a crystal part that can be used in this location.

## Appendix A: Connector Description and Jumper Settings

Label	Description
JA–JE	<i>Pmod I/O Connectors</i> These are used to access the I/O pins on the PIC32 microcontroller.
JPA–JPE	<i>Pmod Connector Power Select Jumpers</i> These are used to select the power supply voltage applied to the Pmod connector. Place the shorting block in the 3V3 position (away from the board edge) to provide power from the VCC3V3 bus to the Pmod connector. Place the shorting block in the 5V0 position (nearer the board edge) to provide power from the VCC5V0 bus.
J1	<i>USB Connector</i> This is a USB-mini B connector used to access the USB serial converter connected to UART1.
J2	<i>I2C Daisy Chain Connector</i> This connector provides access to the I <sup>2</sup> C data signals and board power signals. Multiple I <sup>2</sup> C devices can be daisy chained from this connector to create an I <sup>2</sup> C bus.
J3	<i>Auxiliary USB Serial Converter I/O</i> This connector provides access to the additional signals: CTS#, DSR#, DCD#, and RI# provided by the FT232R serial converter. These signals are not used on the Cerebot MX3cK board. This connector is not loaded at the factory.
J4	<i>External Power Connector</i> This is a 5.5x2.5mm coaxial power connector used to provide external power to the board. It is wired as center positive. The maximum recommended operating voltage is 15V DC.
JP1	<i>USB Serial converter reset disconnect</i> This jumper is used to disconnect the USB serial converter from the MCLR pin used to reset the PIC32 microcontroller. The shorting block on this jumper can be removed if the USB serial converter reset is interfering when using a Microchip development tool such as a PICkit3™ when debugging under the MPLAB® IDE. The shorting block must be installed to use the board with the chipKIT MPIDE.
JP2	<i>5V Regulator Bypass</i> This jumper is used to bypass the on-board 5V regulator. With the jumper in the REG position, the external voltage applied at J4 is routed through the 5V regulator. If the jumper is in the BYP position, the on-board 5V regulator is bypassed and the voltage from J4 is applied directly to the VCC5V0 bus.
JP3	<i>Microchip Development Tool Connector</i> Install a 6-pin header in this connector to enable use of Microchip hardware debugging and programming tools.
JP6, JP8	<i>Pmod connector JE, SPI2 Master/Slave Select</i> Place shorting blocks in the M position for when operating SPI2 as an SPI master, place shorting blocks in the S position for operation as an SPI slave.
JP10, JP11	<i>I2C Pullup Resistor Enable</i> Install shorting blocks on these to enable use of the on-board I <sup>2</sup> C pullup resistors. Remove the shorting blocks the disable the on-board pull-up resistors.



## Appendix B: Example of Configuration Values

The following example illustrates setting the configuration values in the PIC32 microcontroller on the Cerebot MX3cK. The microcontroller configuration should be done in a single source file in the project, and is typically done in the 'main' project source file. This example sets all configuration values to valid values for the Cerebot MX3cK board. It sets the system clock for processor operation at 80Mhz, and the peripheral bus at 10Mhz. This example is for use with MPLAB. Configuration variables are set by the boot loader in the chipKIT MPIDE system.

```

/* ----- */
/*          PIC32 Configuration Settings          */
/* ----- */

/* Oscillator Settings
*/
#pragma config FNOSC    = PRIPLL    // Oscillator selection
#pragma config POSCMOD = XT        // Primary oscillator mode
#pragma config FPLLIDIV = DIV_2    // PLL input divider
#pragma config FPLLMUL  = MUL_20   // PLL multiplier
#pragma config FPLLODIV = DIV_1    // PLL output divider
#pragma config FPBDIV   = DIV_8    // Peripheral bus clock divider
#pragma config FSOCSEN  = OFF      // Secondary oscillator enable

/* Clock control settings
*/
#pragma config IESO     = OFF       // Internal/external clock switchover
#pragma config FCKSM    = CSDCMD   // Clock switching (CSx)/Clock monitor (CMx)
#pragma config OSCIOFNC = OFF      // Clock output on OSCO pin enable

/* Other Peripheral Device settings
*/
#pragma config FWDTEN   = OFF       // Watchdog timer enable
#pragma config WDTPS    = PS1024   // Watchdog timer post-scaler

/* Code Protection settings
*/
#pragma config CP       = OFF       // Code protection
#pragma config BWP      = OFF       // Boot flash write protect
#pragma config PWP      = OFF       // Program flash write protect

/* Debug settings
*/
// #pragma config ICESEL = ICS_PGx2 // ICE pin selection

```

## Appendix C: Connector Pinout Tables

### Arranged by Microcontroller Pin Number

PIC32 Pin #	Connector Pin #	Digital Pin #	MCU Port Bit	PIC32 Signal Name	Notes
1	JA-08	5	RE05	PMD5/RE5	
2	JA-09	6	RE06	PMD6/RE6	
3	JA-10	7	RE07	PMD7/RE7	
4	JE-04	35	RG06	SCK2/PMA5/CN8/RG6	
5	JE-03	34	RG07	SDI2/PMA5/CN9/RG7	JP6 in M position
6	JE-02	33	RG08	SDO2/PMA3/CN10/RG8	JP8 in M position
7	N/A	N/A		MCLR	
8	JE-01	32	RG09	SS2/PMA2/CN11/RG9	
9	N/A	N/A		VSS	
10	N/A	N/A		VDD	
11	JE-08	37	RB05	C1IN+/AN5/CN7/RB5	A8
12	JE-09	38	RB04	C1IN-/AN4/CN6/RB4	A9
13	JE-10	39	RB03	C2IN+/AN3/CN5/RB3	A10
14	JD-01	24	RB02	C2IN-/AN2/SS1/CN4/RB2	A4
15	JC-08	21	RB01	PGC1/AN1/VREF-/CVREF-/CN3/RB1	A3
16	JC-07	20	RB00	PGED1/PMA6/AN0/VREF+/CVREF+/CN2/RB0	A2
17	N/A	N/A	RB06	PGEC2/AN8/OCFA/RB6	
18	N/A	N/A	RB07	PGED2/AN7/RB7	
19	N/A	N/A		AVDD	
20	N/A	N/A		AVSS	
21	JC-01	16	RB08	U2CTS/C1OUT/AN8/RB8	A0
22	JD-04	27	RB09	PMA7/C2OUT/AN9/RB9	A5
23	N/C	N/C	RB10	TMS/CVREFOUT/PMA13/AN10/RB10	
24	N/C	N/C	RB11	TDO/PMA12/AN11/RB11	
25	N/A	N/A		VSS	
26	N/A	N/A		VDD	
27	JD-07	28	RB12	TCK/PMA11/AN12/RB12	A6
28	JD-10	31	RB13	TDI/PMA10/AN13/RB13	A7
29	JC-04	19	RB14	PMALH/PMA1/U2RTS/AN14/RB14	A1
30	N/C	N/C	RB15	PMALL/PMA0/AN15/OCFB/CN12/RB15	
31	JC-03	18	RF04	PMA9/U2RX/SDA2/CN17/RF4	
32	JC-02	17	RF05	PMA8/U2TX/SCL2/CN18/RF5	
33	JB-02	9	RF03	U1TX/SDO1/RF3	
34	JB-03	10	RF02	U1RX/SDI1/RF2	
35	JB-04	11	RF06	U1RTS/BCLK1/SCK1/INT0/RF6	
36	J2-3,J2-4	40	RG03	SDA1/RG3	
37	J2-1,J2-2	41	RG02	SCL1/RG2	

38	N/A	N/A		VDD	
39	N/A	N/A	RC12	OSC1/CLKI/RC12	X1, system clock oscillator
40	N/A	N/A	RC15	OSC2/CLKO/RC15	X1, system clock oscillator
41	N/A	N/A		VSS	
42	JE-07	36	RD08	IC1/RTCC/INT1/RD8	
43	JB-01	8	RD09	IC2/U1CTS/INT2/RD9	
44	JD-03	26	RD10	IC3/PMCS2/PMA15/INT3/RD10	
45	JD-09	30	RD11	IC4/PMCS1/PMA14/INT4/RD11	
46	JC-09	22	RD00	OC1/RD0	PIN_OC1
47	N/A	N/A	RC13	SOSCI/CN1/RC13	X2, secondary oscillator
48	N/A	N/A	RC14	SOSCO/T1CK/CN0/RC14	X2, secondary oscillator
49	JC-10	23	RD01	OC2/RD1	PIN_OC2
50	JD-02	25	RD02	OC3/RD2	PIN_OC3
51	JD-08	29	RD03	OC4/RD3	PIN_OC4
52	JB-09	14	RD04	PMWR/OC5/IC5/CN13/RD4	PIN_OC5
53	JB-08	13	RD05	PMRD/CN14/RD5	
54	JB-07	12	RD06	CN15/RD6	
55	JB-10	15	RD07	CN16/RD7	
56	N/A	N/A		VCAP/VDDcore	
57	N/A	N/A		ENVREG	
58	N/A	42	RF00	RF0	PIN_LED1, (LD4)
59	N/A	43	RF01	RF1	PIN_LED2, (LD5)
60	JA-01	0	RE00	PMD0/RE0	
61	JA-02	1	RE01	PMD1/RE1	
62	JA-03	2	RE02	PMD2/RE2	
63	JA-04	3	RE03	PMD3/RE3	
64	JA-07	4	RE04	PMD4/RE4	

## Arranged by Connector Pin Number and Digital Pin Number

PIC32 Pin #	Connector Pin #	Digital Pin #	MCU Port Bit	PIC32 Signal Name	Notes
60	JA-01	0	RE00	PMD0/RE0	
61	JA-02	1	RE01	PMD1/RE1	
62	JA-03	2	RE02	PMD2/RE2	
63	JA-04	3	RE03	PMD3/RE3	
64	JA-07	4	RE04	PMD4/RE4	
1	JA-08	5	RE05	PMD5/RE5	
2	JA-09	6	RE06	PMD6/RE6	
3	JA-10	7	RE07	PMD7/RE7	
43	JB-01	8	RD09	IC2/U1CTS/INT2/RD9	
33	JB-02	9	RF03	U1TX/SDO1/RF3	
34	JB-03	10	RF02	U1RX/SDI1/RF2	
35	JB-04	11	RF06	U1RTS/BCLK1/SCK1/INT0/RF6	
54	JB-07	12	RD06	CN15/RD6	
53	JB-08	13	RD05	PMRD/CN14/RD5	
52	JB-09	14	RD04	PMWR/OC5/IC5/CN13/RD4	PIN_OC5
55	JB-10	15	RD07	CN16/RD7	
21	JC-01	16	RB08	U2CTS/C1OUT/AN8/RB8	A0
32	JC-02	17	RF05	PMA8/U2TX/SCL2/CN18/RF5	
31	JC-03	18	RF04	PMA9/U2RX/SDA2/CN17/RF4	
29	JC-04	19	RB14	PMALH/PMA1/U2RTS/AN14/RB14	A1
16	JC-07	20	RB00	PGED1/PMA6/AN0/VREF+/CVREF+/CN2/RB0	A2
15	JC-08	21	RB01	PGC1/AN1/VREF-/CVREF-/CN3/RB1	A3
46	JC-09	22	RD00	OC1/RD0	PIN_OC1
49	JC-10	23	RD01	OC2/RD1	PIN_OC2
14	JD-01	24	RB02	C2IN-/AN2/SS1/CN4/RB2	A4
50	JD-02	25	RD02	OC3/RD2	PIN_OC3
44	JD-03	26	RD10	IC3/PMCS2/PMA15/INT3/RD10	
22	JD-04	27	RB09	PMA7/C2OUT/AN9/RB9	A5
27	JD-07	28	RB12	TCK/PMA11/AN12/RB12	A6
51	JD-08	29	RD03	OC4/RD3	PIN_OC4
45	JD-09	30	RD11	IC4/PMCS1/PMA14/INT4/RD11	
28	JD-10	31	RB13	TDI/PMA10/AN13/RB13	A7
8	JE-01	32	RG09	SS2/PMA2/CN11/RG9	
6	JE-02	33	RG08	SDO2/PMA3/CN10/RG8	JP8 in M position
5	JE-03	34	RG07	SDI2/PMA5/CN9/RG7	JP6 in M position
4	JE-04	35	RG06	SCK2/PMA5/CN8/RG6	
42	JE-07	36	RD08	IC1/RTCC/INT1/RD8	
11	JE-08	37	RB05	C1IN+/AN5/CN7/RB5	A8
12	JE-09	38	RB04	C1IN-/AN4/CN6/RB4	A9

13	JE-10	39	RB03	C2IN+/AN3/CN5/RB3	A10
36	J2-3,J2-4	40	RG03	SDA1/RG3	
37	J2-1,J2-2	41	RG02	SCL1/RG2	
58	N/A	42	RF00	RF0	PIN_LED1, (LD4)
59	N/A	43	RF01	RF1	PIN_LED2, (LD5)
7	N/A	N/A		MCLR	
9	N/A	N/A		VSS	
10	N/A	N/A		VDD	
17	N/A	N/A	RB06	PGEC2/AN8/OCFA/RB6	
18	N/A	N/A	RB07	PGED2/AN7/RB7	
19	N/A	N/A		AVDD	
20	N/A	N/A		AVSS	
25	N/A	N/A		VSS	
26	N/A	N/A		VDD	
38	N/A	N/A		VDD	
39	N/A	N/A	RC12	OSC1/CLKI/RC12	X1, system clock oscillator
40	N/A	N/A	RC15	OSC2/CLKO/RC15	X1, system clock oscillator
41	N/A	N/A		VSS	
47	N/A	N/A	RC13	SOSCI/CN1/RC13	X2, secondary oscillator
48	N/A	N/A	RC14	SOSCO/T1CK/CN0/RC14	X2, secondary oscillator
56	N/A	N/A		VCAP/VDDcore	
57	N/A	N/A		ENVREG	
23	N/C	N/C	RB10	TMS/CVREFOUT/PMA13/AN10/RB10	
24	N/C	N/C	RB11	TDO/PMA12/AN11/RB11	
30	N/C	N/C	RB15	PMALL/PMA0/AN15/OCFB/CN12/RB15	

## Arranged by Microcontroller I/O Port Name and Bit Number

PIC32 Pin #	Connector Pin #	Digital Pin #	MCU Port Bit	PIC32 Signal Name	Notes
16	JC-07	20	RB00	PGED1/PMA6/AN0/VREF+/CVREF+/CN2/RB0	A2
15	JC-08	21	RB01	PGC1/AN1/VREF-/CVREF-/CN3/RB1	A3
14	JD-01	24	RB02	C2IN-/AN2/SS1/CN4/RB2	A4
13	JE-10	39	RB03	C2IN+/AN3/CN5/RB3	A10
12	JE-09	38	RB04	C1IN-/AN4/CN6/RB4	A9
11	JE-08	37	RB05	C1IN+/AN5/CN7/RB5	A8
17	N/A	N/A	RB06	PGEC2/AN8/OCFA/RB6	
18	N/A	N/A	RB07	PGED2/AN7/RB7	
21	JC-01	16	RB08	U2CTS/C1OUT/AN8/RB8	A0
22	JD-04	27	RB09	PMA7/C2OUT/AN9/RB9	A5
23	N/C	N/C	RB10	TMS/CVREFOUT/PMA13/AN10/RB10	
24	N/C	N/C	RB11	TDO/PMA12/AN11/RB11	
27	JD-07	28	RB12	TCK/PMA11/AN12/RB12	A6
28	JD-10	31	RB13	TDI/PMA10/AN13/RB13	A7
29	JC-04	19	RB14	PMALH/PMA1/U2RTS/AN14/RB14	A1
30	N/C	N/C	RB15	PMALL/PMA0/AN15/OCFB/CN12/RB15	
39	N/A	N/A	RC12	OSC1/CLKI/RC12	X1, system clock oscillator
47	N/A	N/A	RC13	SOSCI/CN1/RC13	X2, secondary oscillator
48	N/A	N/A	RC14	SOSCO/T1CK/CN0/RC14	X2, secondary oscillator
40	N/A	N/A	RC15	OSC2/CLKO/RC15	X1, system clock oscillator
46	JC-09	22	RD00	OC1/RD0	PIN_OC1
49	JC-10	23	RD01	OC2/RD1	PIN_OC2
50	JD-02	25	RD02	OC3/RD2	PIN_OC3
51	JD-08	29	RD03	OC4/RD3	PIN_OC4
52	JB-09	14	RD04	PMWR/OC5/IC5/CN13/RD4	PIN_OC5
53	JB-08	13	RD05	PMRD/CN14/RD5	
54	JB-07	12	RD06	CN15/RD6	
55	JB-10	15	RD07	CN16/RD7	
42	JE-07	36	RD08	IC1/RTCC/INT1/RD8	
43	JB-01	8	RD09	IC2/U1CTS/INT2/RD9	
44	JD-03	26	RD10	IC3/PMCS2/PMA15/INT3/RD10	
45	JD-09	30	RD11	IC4/PMCS1/PMA14/INT4/RD11	
60	JA-01	0	RE00	PMD0/RE0	
61	JA-02	1	RE01	PMD1/RE1	
62	JA-03	2	RE02	PMD2/RE2	
63	JA-04	3	RE03	PMD3/RE3	
64	JA-07	4	RE04	PMD4/RE4	

1	JA-08	5	RE05	PMD5/RE5	
2	JA-09	6	RE06	PMD6/RE6	
3	JA-10	7	RE07	PMD7/RE7	
58	N/A	42	RF00	RF0	PIN_LED1, (LD4)
59	N/A	43	RF01	RF1	PIN_LED2, (LD5)
34	JB-03	10	RF02	U1RX/SDI1/RF2	
33	JB-02	9	RF03	U1TX/SDO1/RF3	
31	JC-03	18	RF04	PMA9/U2RX/SDA2/CN17/RF4	
32	JC-02	17	RF05	PMA8/U2TX/SCL2/CN18/RF5	
35	JB-04	11	RF06	U1RTS/BCLK1/SCK1/INT0/RF6	
37	J2-1,J2-2	41	RG02	SCL1/RG2	
36	J2-3,J2-4	40	RG03	SDA1/RG3	
4	JE-04	35	RG06	SCK2/PMA5/CN8/RG6	
5	JE-03	34	RG07	SDI2/PMA5/CN8/RG7	JP6 in M position
6	JE-02	33	RG08	SDO2/PMA3/CN10/RG8	JP8 in M position
8	JE-01	32	RG09	SS2/PMA2/CN11/RG9	
7	N/A	N/A		MCLR	
9	N/A	N/A		VSS	
10	N/A	N/A		VDD	
19	N/A	N/A		AVDD	
20	N/A	N/A		AVSS	
25	N/A	N/A		VSS	
26	N/A	N/A		VDD	
38	N/A	N/A		VDD	
41	N/A	N/A		VSS	
56	N/A	N/A		VCAP/VDDcore	
57	N/A	N/A		ENVREG	