Cerebot 32MX4™ Board Reference Manual

Revision: August 26, 2011
Note: This document applies to REV C and REV D of the board.

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Overview

The Cerebot 32MX4 board is a useful tool for embedded control and robotics projects for both students and hobbyists.

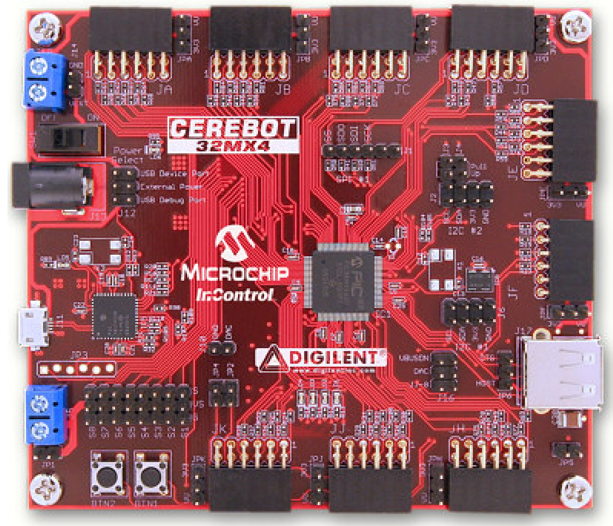
Its versatile design and programmable microcontroller lets you access numerous peripheral devices and program the board for multiple uses. The board has many I/O connectors and power supply options.

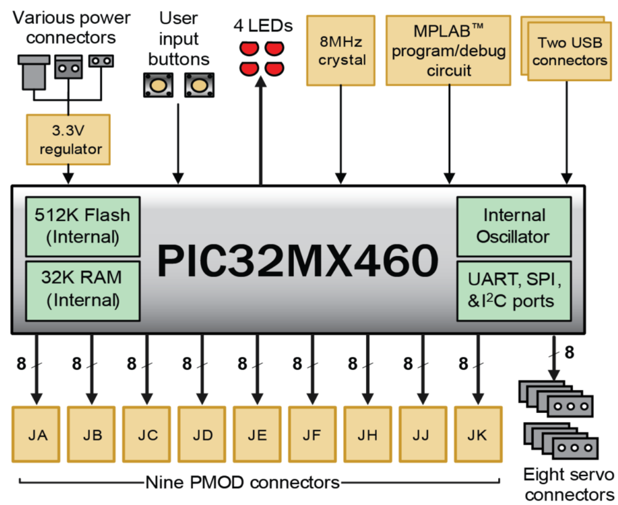
The Cerebot 32MX4 works with the Microchip MPLAB development environment and provides built in programming and debugging support under MPLAB.

The Cerebot 32MX4 provides a number of connections for peripheral devices. It has nine connectors for attaching Digilent Pmod™ peripheral modules. Digilent peripheral modules include H-bridges, analog-to-digital and digital-to-analog converters, speaker amplifier, switches, buttons, LEDs, as well as converters for easy connection to RS232, screw terminals, BNC jacks, servo motors, and more.

Features include:

- a PIC32MX460F512L microcontroller
- support for programming and debugging within the Microchip MPLAB development environment
- nine Pmod connectors for Digilent peripheral module boards
- eight hobby RC servo connectors
- USB 2.0 Device, Host, and OTG support
- two push buttons
- four LEDs
- multiple power supply options, including USB powered
- ESD protection and short circuit protection for all I/O pins.





Cerebot 32MX4 Circuit Diagram

Features of the PIC32MX460F512L include:

- 512KB internal program flash memory
- 32KB internal SRAM memory
- USB 2.0 compliant full-speed On-The-Go (OTG) controller with dedicated DMA channel
- two serial peripheral interfaces (SPI)
- two UART serial interfaces
- two I2C serial interfaces
- five 16-bit timer/counters
- five timer capture inputs
- five compare/PWM outputs
- sixteen 10-bit analog inputs
- two analog comparators

For more information on the PIC32MX460F512L microcontroller, refer to the PIC32MX3XX/4XX Family Data Sheet and the PIC32 Family Reference Manual available at www.microchip.com.

Functional Description

The Cerebot 32MX4 is designed for embedded control and robotic applications as well as microprocessor experimentation. Firmware suitable for many applications can be downloaded to the Cerebot 32MX4's programmable PIC32 microcontroller.

The board has a number of connection options, and is specially designed to work with the Digilent line of Pmod peripheral modules with various input and output functions. For more information, see www.digilentinc.com. In addition to the Pmod connectors, the board supports direct connection of up to 8 RC hobby servos, provides two on-board push buttons and four on-board LEDs for user i/o, as well as providing connections for two I2C busses. A serial EEPROM and a serial D/A converter are provided on one of the I2C busses.

The Cerebot 32MX4 can be used with the Microchip MPLAB development environment. In-system-programming and debug of firmware running on the PIC32 part is supported via USB within MPLAB. The in-system-programming and debug subsystem is implemented in IC5, a PIC18LF4550 microcontroller. Access to this subsystem is accomplished via USB connector J11. Normally, J11 will be connected to an available USB port on a PC while developing firmware to run on the PIC32 microcontroller.

The Cerebot 32MX4 features a flexible power supply routing system with a number of options for powering the board as well as powering peripheral modules connected to the board. It can be USB powered via either the debug USB port or the USB device port, or it can be powered from an external power supply or batteries.

Programming and In-System Debug Using MPLAB

The Cerebot 32MX4 board is intended to be use with the Microchip MPLAB IDE for firmware development, programming and in-system debug. The board is compatible with the Microchip PIC32 Starter Kit board, and appears to MPLAB as a PIC32 Starter Kit. When installing the MPLAB software, ensure that the PIC32MX Starter Kit support is installed.

After the MPLAB software is installed, the first time that the board is used, Windows will need to install the Microchip USB device driver to connect to the board. If the "Found New Hardware Wizard" asks for the installation CD and no CD is available, click OK anyway. In the "Files Needed" dialog box, use the browse button to navigate to the folder: "Program Files\Microchip\MPLAB IDE\PIC32MXSkit\Drivers" and select the file: mp32mxsk.sys and click on OK. The wizard should then complete installing the proper driver for the board. This process may need to be repeated if the board is later connected to a different USB port.

When creating a new project, ensure that the device is set to PIC32MX460F512L. On the Debugger.Select Tool menu, select the PIC32 Starter Kit as the debugger.

Board Power Supply

The Cerebot 32MX4 may be USB powered via either the USB debug port, or the USB device port. Alternatively, the board may be powered via dedicated, "external", power supply connectors.

There are three different power supply connectors on Cerebot 32MX4 for connecting an external power supply: J13, J14, and J18.

The barrel connector, J13, is useful for desktop development and testing where using USB or battery power is not suitable. J13 is the connector used by the AC supply adapter optionally available from Digilent, or other sources. J13 is a 2.5mm x 5.5mm coaxial connector wired with the center terminal as the positive voltage.

J14 is a two-pin male header that provides easy battery or battery-pack connection. Digilent has both two-cell and four-cell AA battery holders with two pin connectors available for connection to J14.

J18 is a screw terminal connector for an alternative power supply connection for use with higher current battery packs, bench supplies or other power sources where use of a hard wired power supply is desirable.

The Cerebot 32MX4 is rated for external power from 3.6 to 5 volts DC. Using voltage outside this range could damage the board and connected devices.

Connectors J13, J14, and J18 are wired in parallel and connect to the "External Power" position (center position) on the Power Select jumper block J12. A shorting block should be placed on the "External Power" position of J12 when using this option for board power. Only one of these three power connectors should be used at a time. If multiple power supplies are connected simultaneously, damage to the board or the power supplies may occur.

The output of power select jumper block J12 is wired to one terminal of the power switch, SW1. The other terminal of SW1 connects to the unregulated power bus DBG_VU. The DBG_VU bus provides the input to the voltage regulator powering the in-system-programming and debug subsystem.

The Cerebot 32MX4 has a second screw terminal connector, J5 that supplies power to the servo power bus, VS, to power the RC hobby servo connectors. This allows servos to be powered from a separate power supply than the one powering the electronics on the Cerebot 32MX4. This can be useful when using servos that draw large amounts of power.

Jumper JP1 can be used to connect the Cerebot 32MX4 unregulated power bus VU to the servo power bus, VS. When no shorting block is installed on JP1, the VU and VS busses are separate. When a shorting block is on JP1, the two busses are joined and the VU bus can be powered in any of the previously indicated ways, or from connector J5.

The Cerebot 32MX4 can provide power to any peripheral modules attached to the Pmod connectors and to I2C devices powered from the I2C daisy chain connectors, J2 and J6. Each Pmod connector provides power pins that can be powered by either unregulated voltage, VU, or regulated voltage, VCC, by setting the voltage jumper block to the desired position. The I2C power connectors only provide regulated voltage, VCC.

The PIC32 microcontroller and on-board I/O devices operate at a supply voltage of 3.3V provided by the VCC bus. The regulated voltage on the VCC bus is provided by an on-board voltage regulator. This regulator is capable of providing a maximum of 500mA of current. The PIC32 microcontroller will use approximately 55mA when running at 80MHz. The remaining current is available to provide power to attached Pmod and I2C devices. The regulator is on the bottom of the board, near the power connectors, and will get warm when the amount of current being used is close to its limit.

Power Supply Monitor Circuit

The Cerebot 32MX4 microcontroller can measure the power supply voltage on the VU and VS power busses using the provided power supply monitor circuits. This feature is especially useful when using batteries because it allows the microcontroller firmware to determine the charge state of the battery and potentially notify the user when a battery supply is low.

Each power supply monitor circuit is made up of a voltage divider that divides the power bus voltage by four, and a filter capacitor to stabilize the voltage. Jumper JP4 enables the supply monitor circuit for VU power, and jumper JP2 enables the supply monitor circuit for VS power. The analog to digital converter built into the PIC32 microcontroller is used to measure the power supply voltages. ADC channel 8 is used to measure VU and ADC channel 9 is used to measure VS.

USB Operation

The PIC32MX460 microcontroller contains a USB 2.0 Compliant, Full Speed Device and On-The-Go (OTG) controller. This controller provides the following features:

- USB full speed host and device support
- Low speed host support
- USB OTG support
- Endpoint buffering anywhere in system RAM
- Integrated DMA to access system RAM and Flash memory.

When operating as a USB device, the Cerebot 32MX4 can be used as a self powered device or as a bus powered device. To operate as a self powered device, an external power supply should be connected to any one of the three external power connectors (J13, J14, or J18) and a shorting block placed on the center, “External Power” position of J12. To operate as a bus powered device, the shorting block should be placed in the “USB Device Port” position on J12.

Connector J15, on the bottom of the board in the lower right corner is the Device/OTG connector. This is a standard USB micro-AB connector. Connect a cable with a micro-A plug (optionally available from Digilent) from this connector to an available USB port for device operation.

When operating as a USB host, the Cerebot 32MX4 must be externally powered. Connect a regulated 5V power supply to any one of the three external power connectors (J13, J14, or J18) and ensure that the shorting block is in the center, “External Power” position of J12. The power supply used must be a regulated 5V supply. The Cerebot 32MX4 board provides power to the attached USB device when operating as a host, and the USB specification requires the use of a 5V power supply.

Jumper JP6 is used to route power to the host connector being used. Place the shorting block in the “Host” position for use with the standard USB Host Connector, J17. Place the shorting block in the “OTG” position for use with the USB OTG connector, J15.

When operating as a USB host, the PIC32MX460 microcontroller controls application of power to the connected device via the VBUSON control pin. A shorting block must be placed in the “VBUSON” position of J16 to enable this connection. With the shorting block in place, bus power is applied to the device by driving the VBUSON pin high. Power is removed from the device by driving the VBUSON pin low. The VBUSON pin is accessed via bit 3 of the U1OTGCON register.

The VBUSON pin drives the enable input of a TPS2051B Current-Limited Power Distribution Switch to control the USB device power. This switch has over-current detection capability. The over-current output pin can be monitored via the INT2/RE9 pin on the PIC32MX460 microcontroller. Insert a shorting block on JP5 to enable this connection. Details about the operation of the TPS2051B can be obtained from the data sheet available at the Texas Instruments web site.

There are reference designs available on the Microchip web site demonstrating both device and host operation of PIC32 microcontrollers. These reference designs are suitable to use for developing USB firmware for the Cerebot 32MX4 board.

Pmod Connectors

The Cerebot 32MX4 has nine Pmod connectors for connecting Digilent Pmod peripheral modules. 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. 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. The power connection is switchable between the regulated 3.3V main board supply and the unregulated input supply.

Digilent Pmod peripheral modules can either be plugged directly into the connectors on the Cerebot 32MX4 or attached via cables. Digilent has a variety of Pmod interconnect cables available.

See the “Connector and Jumper Block Pinout Tables” section below for more information about connecting peripheral modules and other devices to the Cerebot 32MX4. These tables indicate the mapping between pins on the PIC32MX460 microcontroller and the pins on the various connectors.

RC Servo Connectors

The Cerebot 32MX4 provides eight 3-pin RC hobby servo connectors for direct control of servos in robotics and embedded hardware actuator applications. The connectors share I/O pins with Pmod connector JC. Individual I/O pins may be accessed through the JC connector if they're not in use by a servo. Refer to the PIC32 family data sheet for information on how to access the I/O pins.

RC Servos use a pulse width modulated signal, PWM, to control the servo position. The 16-bit timers in the PIC32 microcontroller have the ability to generate PWM signals using the output compare registers. However, it is also possible to use timer interrupts to accomplish this same thing. Using timer interrupts allows a single timer (ideally timer 0) to be used to control the signal timing for all eight servo connectors.

The servo connectors on the Cerebot 32MX4 board are intended to be driven using timer interrupts rather than directly by the pulse width modulators in the internal timers. This frees the pulse width modulators for other uses, such as DC motor speed control. Digilent has a reference design available that illustrates using timer interrupts to control signal timing for the PWM signals to control RC servos.

There are three power options for servo connections: a common power bus (VU) for the Cerebot 32MX4 and servos; separate on-board power busses for the Cerebot 32MX4 (VU) and the servos (VS); or an on-board power bus for the Cerebot 32MX4 (VU) an external power bus for servos.

For the first case above: Install the shorting block on JP1 to connect the VS servo power bus to the VU power bus. The servo power bus is then powered from the same source as the VU power bus. Powering a large number of servos from USB power is not recommended. USB power (J12 in the USB Device Port, or USB Debug Port positions) should only be used to power a couple of servos to avoid exceeding the 500mA that a USB device is allowed to use.

For the second case above: Remove the shorting block from jumper JP2 to make the VS servo power bus independent from the VU bus. In this case, the VS bus is powered from screw terminal connector J5.

Finally, for very high servo current applications, a separate power bus external to the Cerebot 32MX4 can be used to provide servo power. In this case, remove the shorting block on JP1, tie the external servo power bus ground to the Cerebot 32MX4 ground through the ground terminal on J10, and use pin 1 on the servo connectors to bring the servo control signals out to the servos. The servo power and ground connections are made off-board.

The on-board servo power bus can be used to provide a maximum of 2A to each servo connector and 5A total to all servo connectors.

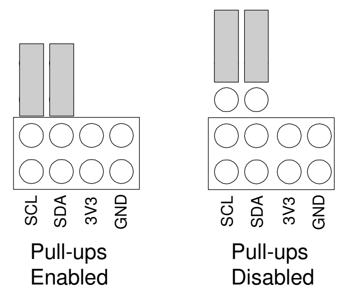
Inter-Integrated Circuit Interface

The Inter-Integrated Circuit (I2C™) Interface provides a medium speed (100K or 400K bps) synchronous serial communications bus. The I2C 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. See the Microchip documentation for detailed information on configuring and using the I2C interface.

The PIC32MX460 microcontroller used on the Cerebot 32MX4 provides two independent I2C interfaces. There are two sets of connectors on the board for access to the two I2C ports. Connector J6 provides access to I2C port #1 while connector J2 provides access to I2C port #2.

Each I2C connector provides two positions for connecting to the I2C signals, power and ground. By using two-wire or four-wire MTE cables (available separately from Digilent) a daisy chain of multiple Cerebot 32MX4 boards or other I2C-capable boards can be created.

The I2C bus is an open-collector bus. Devices on the bus actively drive the signals low. The high state on the I2C signals is achieved by pull-up resistors when no device is driving the lines low. One device on the I2C bus must provide the pull-up resistors. I2C bus #1 has permananely connected pull-up resistor. I2C bus #2 provides selectable pull-up resistors that can be enabled or disabled via jumper blocks on the 'pull-up' positions on connector J2. The pull-ups are enabled by installing shorting blocks and are disabled by removing the shorting blocks. The shorting blocks are placed so that they line up with the SCL and SDA labels on the board. Only one device on the bus should have the pull-ups enabled.



Jumper Settings for I2C Pull-Up Resistors

On-Board I2C Peripheral Devices

The Cerebot 32MX4 provides two on-board I2C peripheral devices, a 24LC256 serial EEPROM, and an MCP4725 Digital to Analog Converter. These devices are both connected to I2C port #1. The 24LC256 is a 256Kbit (32Kbyte) serial EEPROM device to provide non-volatile memory storage. The MCP4725 is a single channel, 12-bit, serial digital to analog converter that provides an analog output voltage for various uses. The device address for IC2, the 24LC256 is 1010000 (0x50). The device address for IC3, the MCP4725, is 1100000 (0x60).

Refer to the Microchip data sheets for detailed information on the operation of these devices.

The analog output voltage from IC3 is available at two places on the Cerebot 32MX4 board. The two pin header, J10, provides the DAC output voltage and ground for connection to off-board applications. The DAC output signal is also available at the center, DAC, position of J16. Placing a shorting block at this position connects the DAC output to the VBUSON/C1IN+/AN5/CN7/RB5 pin (pin 20) on the PIC32MX460 microcontroller. One of the functions for this pin is as one of the inputs to analog comparator #1 on the PIC32 part. This allows the output of the DAC to be used as a programmable reference voltage for the comparator.

User I/O Devices

The Cerebot 32MX4 board provides two push button switches for user input and four LEDs for output. The buttons, BTN1 and BTN2 are connected to I/O pins TRCLK/RA6 and TRD3/RA7 respectively. To read the buttons, bits 6 and 7 of PORTA must be set as inputs by setting the corresponding bits in the TRISA register and then reading the PORTA register. When a button is pressed, the corresponding bit will be high ('1').

The four LEDs are connected to bits 10-13 of PORTB. LED 1 is connected to bit 10, LED 2 is connected to bit 11, and so on. These four bits are also shared with pins 1-4 of Pmod connector JK. To use the LEDs, set the desired bits as outputs by clearing the corresponding bits in the TRISB register and set the bits to the desired value in the PORTB register. Setting a bit to 1 will illuminate the LED and setting the bit to 0 will turn it off.

CPU Clock Source

The PIC32 microcontroller supports numerous clock source options for the main processor operating clock. The Cerebot 32MX4 board is designed to support either a silicon resonator from Discera for use with the EC oscillator option, or an external crystal for use with the XT oscillator option. Standard production boards will have an 8Mhz Discera silicon resonator loaded and the EC oscillator option should be used.

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.

Connector and Jumper Block Pinout Tables

MCU Port Bit to Pmod Connector Pin Mapping

MCU Port Bit	Signal	Connector Pin	Notes
RA00	TMS/RA0	N/A	Used by debug circuit
RA01	TCK/RA1	N/A	Used by debug circuit
RA02	SCL2/RA2	JF-01	Shared with I2C daisy chain #2, J6
RA03	SDA2/RA3	JF-02	Shared with I2C daisy chain #2, J6
RA04	TDI/RA4	N/A	Used by debug circuit
RA05	TDO/RA5	N/A	Used by debug circuit
RA06	TRCLK/RA6	JF-03	Shared with BTN1
RA07	TRD3/RA7	JF-04	Shared with BTN2
RA09	PMA7/Vref-/CVref-/RA9	JK-07	
RA10	PMA6/Vref+/CVref+/RA10	JK-08	
RA14	SCL1/INT3/RA14	N/A	I2C Bus #1, J2, not shared with Pmod connector
RA15	SDA1/INT4/RA15	N/A	I2C Bus #1, J2, not shared with Pmod connector
RB00	PGD1/EMUD1/AN0/CN2/RB0	JJ-01	
RB01	PGC1/EMUC1/AN1/CN3/RB1	JJ-02	
RB02	C2IN-/AN2/CN4/RB2	JJ-03	
RB03	C2IN+/AN3/CN5/RB3	JJ-04	
RB04	C1IN-/AN4/CN6/RB4	JJ-07	
RB05	VBUSON/C1IN+/AN5/CN7/RB5	JJ-08	Selected by J16
RB06	PGC2/EMUC2/AN6/OCFA/RB6	N/A	Used by debug circuit, PGC
RB07	PGD2/EMUD2/AN7/RB7	N/A	Used by debug circuit, PGD
RB08	C1OUT/AN8/RB8	JJ-09	
RB09	C2OUT/AN9/RB9	JJ-10	
RB10	CVrefout/PMA13/AN10/RB10	JK-01	Shared with LD1
RB11	PMA12/AN11/RB11	JK-02	Shared with LD2
RB12	PMA11/AN12/RB12	JK-03	Shared with LD3
RB13	PMA10/AN13/RB13	JK-04	Shared with LD4
RB14	PMALH/PMA1/AN14/RB14	JB-10	
RB15	PMALL/PMA0/AN15/OCFB/CN12/RB15	JB-07	
RC01	T2CK/RC1	JD-04	
RC02	T3CK/RC2	JD-10	
RC03	T4CK/RC3	JE-10	
RC04	SDI1/T5CK/RC4	JK-10	Shared with SPI Port 1 Connector, J1
RC12	OSC1/CLKI/RC12	N/A	Primary Oscillator Crystal
RC13	SOSCI/CN1/RC13	N/A	Secondary Oscillator Crystal
RC14	SOSCO/T1CK/CN0/RC14	N/A	Secondary Oscillator Crystal
RC15	OSC2/CLKO/RC15	N/A	Primary Oscillator Crystal
RD00	SDO1/OC1/INT0/RD0	JH-08	Shared with SPI Port 1 Connector, J1
RD01	OC2/RD1	JD-02	
RD02	OC3/RD2	JD-08	
RD03	OC4/RD3	JE-08	
RD04	PMWR/OC5/CN13/RD4	JB-09	

RD05	PMRD/CN14/RD5	JB-08	
RD06	PMD14/CN15/RD6	JD-07	
RD07	PMD15/CN16/RD7	JD-01	
RD08	IC1/RTCC/RD8	JH-09	
RD09	IC2/SS1/RD9	JD-03	Shared with SPI Port 1 Connector, J1
RD10	IC3/SCK1/PMCS2/PMA15/RD10	JD-09	Shared with SPI Port 1 Connector, J1
RD11	IC4/PMCS1/PMA14/RD11	JE-09	
RD12	PMD12/IC5/RD12	JK-09	
RD13	PMD13/CN19/RD13	JE-07	
RD14	CN20/U1CTS/RD14	JE-01	
RD15	U1RTS/BCLK1/CN21/RD15	JE-02	
RE00	PMD0/RE0	JA-01	
RE01	PMD1/RE1	JA-02	
RE02	PMD2/RE2	JA-03	
RE03	PMD3/RE3	JA-04	
RE04	PMD4/RE4	JA-07	
RE05	PMD5/RE5	JA-08	
RE06	PMD6/RE6	JA-09	
RE07	PMD7/RE7	JA-10	
RE08	INT1/RE8	JH-07	
RE09	INT2/RE9	JH-10	Shared with USB OC_SENSE via JP5
RF00	PMD11/RF0	JC-09	Shared with servo S7
RF01	PMD10/RF1	JC-10	Shared with servo S8
RF02	U1RX/RF2	JE-03	
RF03	USBID/RF3	N/A	USB-4
RF04	PMA9/U2RX/CN17/RF4	JH-03	
RF05	PMA8/U2TX/CN18/RF5	JH-04	
RF08	U1TX/RF8	JE-04	
RF12	U2CTS/RF12	JH-01	
RF13	U2RTS/BCLK2/RF13	JH-02	
RG00	PMD8/RG0	JC-07	Shared with servo S5
RG01	PMD9/RG1	JC-08	Shared with servo S6
RG02	D+/RG2	N/A	USB-3
RG03	D-/RG3	N/A	USB-2
RG06	PMA5/SCK2/CN8/RG6	JB-04	
RG07	PMA4/SDI2/CN9/RG7	JB-03	
RG08	PMA3/SDO2/CN10/RG8	JB-02	
RG09	PMA2/SS2/CN11/RG9	JB-01	
RG12	TRD1/RG12	JC-01	Shared with servo S1
RG13	TRD0/RG13	JC-02	Shared with servo S2
RG14	TRD2/RG14	JC-03	Shared with servo S3
RG15	RG15	JC-04	Shared with servo S4

Pmod Connector Pin to MCU Port Bit Mapping

Connector Pin	Signal	MCU Port Bit	Notes
JA-01	PMD0/RE0	RE0	
JA-02	PMD1/RE1	RE1	
JA-03	PMD2/RE2	RE2	
JA-04	PMD3/RE3	RE3	
JA-07	PMD4/RE4	RE4	
JA-08	PMD5/RE5	RE5	
JA-09	PMD6/RE6	RE5	
JA-10	PMD7/RE7	RE7	
JB-01	PMA2/SS2/CN11/RG9	RG9	
JB-02	PMA3/SDO2/CN10/RG8	RG8	
JB-03	PMA4/SDI2/CN9/RG7	RG7	
JB-04	PMA5/SCK2/CN8/RG6	RG6	
JB-07	PMALL/PMA0/AN15/OCFB/CN12/RB15	RB15	
JB-08	PMRD/CN14/RD5	RD5	
JB-09	PMWR/OC5/CN13/RD4	RD4	
JB-10	PMALH/PMA1/AN14/RB14	RB14	
JC-01	TRD1/RG12	RG12	Shared with servo S1
JC-02	TRD0/RG13	RG13	Shared with servo S2
JC-03	TRD2/RG14	RG14	Shared with servo S3
JC-04	RG15	RG15	Shared with servo S4
JC-07	PMD8/RG0	RG0	Shared with servo S5
JC-08	PMD9/RG1	RG1	Shared with servo S6
JC-09	PMD11/RF0	RF0	Shared with servo S7
JC-10	PMD10/RF1	RF1	Shared with servo S8
JD-01	PMD15/CN16/RD7	RD7	
JD-02	OC2/RD1	RD1	
JD-03	IC2/SS1/RD9	RD9	Shared with SPI Port 1 Connector, J1
JD-04	T2CK/RC1	RC1	
JD-07	PMD14/CN15/RD6	RD6	
JD-08	OC3/RD2	RD2	
JD-09	IC3/SCK1/PMCS2/PMA15/RD10	RD10	Shared with SPI Port 1 Connector, J1
JD-10	T3CK/RC2	RC2	
JE-01	CN20/U1CTS/RD14	RD14	
JE-02	U1RTS/BCLK1/CN21/RD15	RD15	
JE-03	U1RX/RF2	RF2	
JE-04	U1TX/RF8	RF8	
JE-07	PMD13/CN19/RD13	RD13	
JE-08	OC4/RD3	RD3	
JE-09	IC4/PMCS1/PMA14/RD11	RD11	
JE-10	T4CK/RC3	RC3	
JF-01	SCL2/RA2	RA2	Shared with I2C daisy chain #2, J6
JF-02	SDA2/RA3	RA3	Shared with I2C daisy chain #2, J6
JF-03	TRCLK/RA6	RA6	Shared with BTN1

JF-04	TRD3/RA7	RA7	Shared with BTN2
JH-01	U2CTS/RF12	RF12	
JH-02	U2RTS/BCLK2/RF13	RF13	
JH-03	PMA9/U2RX/CN17/RF4	RF4	
JH-04	PMA8/U2TX/CN18/RF5	RF5	
JH-07	INT1/RE8	RE8	
JH-08	SDO1/OC1/INT0/RD0	RD0	Shared with SPI Port 1 Connector, J1
JH-09	IC1/RTCC/RD8	RD8	
JH-10	INT2/RE9	RE9	Shared with USB OC_SENSE via JP5
JJ-01	PGD1/EMUD1/AN0/CN2/RB0	RB0	
JJ-02	PGC1/EMUC1/AN1/CN3/RB1	RB1	
JJ-03	C2IN-/AN2/CN4/RB2	RB2	
JJ-04	C2IN+/AN3/CN5/RB3	RB3	
JJ-07	C1IN-/AN4/CN6/RB4	RB4	
JJ-08	VBUSON/C1IN+/AN5/CN7/RB5	RB5	Selected by J16
JJ-09	C1OUT/AN8/RB8	RB8	
JJ-10	C2OUT/AN9/RB9	RB9	
JK-01	CVrefout/PMA13/AN10/RB10	RB10	Shared with LD1
JK-02	PMA12/AN11/RB11	RB11	Shared with LD2
JK-03	PMA11/AN12/RB12	RB12	Shared with LD3
JK-04	PMA10/AN13/RB13	RB13	Shared with LD4
JK-07	PMA7/Vref-/CVref-/RA9	RA9	
JK-08	PMA6/Vref+/CVref+/RA10	RA10	
JK-09	PMD12/IC5/RD12	RD12	
JK-10	SDI1/T5CK/RC4	RC4	Shared with SPI Port 1 Connector, J1
N/A	TMS/RA0	RA0	Used by debug circuit
N/A	TCK/RA1	RA1	Used by debug circuit
N/A	TDI/RA4	RA4	Used by debug circuit
N/A	TDO/RA5	RA5	Used by debug circuit
N/A	SCL1/INT3/RA14	RA14	I2C Bus #1, J2, not shared with Pmod connector
N/A	SDA1/INT4/RA15	RA15	I2C Bus #1, J2, not shared with Pmod connector
N/A	PGC2/EMUC2/AN6/OCFA/RB6	RB6	Used by debug circuit, PGC
N/A	PGD2/EMUD2/AN7/RB7	RB7	Used by debug circuit, PGD
N/A	OSC1/CLKI/RC12	RC12	Primary Oscillator Crystal
N/A	SOSCI/CN1/RC13	RC13	Secondary Oscillator Crystal
N/A	SOSCO/T1CK/CN0/RC14	RC14	Secondary Oscillator Crystal
N/A	OSC2/CLKO/RC15	RC15	Primary Oscillator Crystal
N/A	USBID/RF3	RF3	USB-4
N/A	D+/RG2	RG2	USB-3
N/A	D-/RG3	RG3	USB-2

MCU Pin to Pmod Connector Pin Mapping

MCU Pin	MCU Port Bit	Signal	Connector Pin	Notes
1	RG15	RG15	JC-04	Shared with servo S4
3	RE5	PMD5/RE5	JA-08	
4	RE5	PMD6/RE6	JA-09	
5	RE7	PMD7/RE7	JA-10	
6	RC1	T2CK/RC1	JD-04	
7	RC2	T3CK/RC2	JD-10	
8	RC3	T4CK/RC3	JE-10	
9	RC4	SDI1/T5CK/RC4	JK-10	Shared with SPI Port 1 Connector, J1
10	RG6	PMA5/SCK2/CN8/RG6	JB-04	
11	RG7	PMA4/SDI2/CN9/RG7	JB-03	
12	RG8	PMA3/SDO2/CN10/RG8	JB-02	
14	RG9	PMA2/SS2/CN11/RG9	JB-01	
17	RA0	TMS/RA0	N/A	Used by debug circuit
18	RE8	INT1/RE8	JH-07	
19	RE9	INT2/RE9	JH-10	Shared with USB OC_SENSE via JP5
20	RB5	VBUSON/C1IN+/AN5/CN7/RB5	JJ-08	Selected by J16
21	RB4	C1IN-/AN4/CN6/RB4	JJ-07	
22	RB3	C2IN+/AN3/CN5/RB3	JJ-04	
23	RB2	C2IN-/AN2/CN4/RB2	JJ-03	
24	RB1	PGC1/EMUC1/AN1/CN3/RB1	JJ-02	
25	RB0	PGD1/EMUD1/AN0/CN2/RB0	JJ-01	
26	RB6	PGC2/EMUC2/AN6/OCFA/RB6	N/A	Used by debug circuit, PGC
27	RB7	PGD2/EMUD2/AN7/RB7	N/A	Used by debug circuit, PGD
28	RA9	PMA7/Vref-/CVref-/RA9	JK-07	
29	RA10	PMA6/Vref+/CVref+/RA10	JK-08	
32	RB8	C1OUT/AN8/RB8	JJ-09	
33	RB9	C2OUT/AN9/RB9	JJ-10	
34	RB10	CVrefout/PMA13/AN10/RB10	JK-01	Shared with LD1
35	RB11	PMA12/AN11/RB11	JK-02	Shared with LD2
38	RA1	TCK/RA1	N/A	Used by debug circuit
39	RF13	U2RTS/BCLK2/RF13	JH-02	
40	RF12	U2CTS/RF12	JH-01	
41	RB12	PMA11/AN12/RB12	JK-03	Shared with LD3
42	RB13	PMA10/AN13/RB13	JK-04	Shared with LD4
43	RB14	PMALH/PMA1/AN14/RB14	JB-10	
44	RB15	PMALL/PMA0/AN15/OCFB/CN12/RB15	JB-07	
47	RD14	CN20/U1CTS/RD14	JE-01	
48	RD15	U1RTS/BCLK1/CN21/RD15	JE-02	
49	RF4	PMA9/U2RX/CN17/RF4	JH-03	
50	RF5	PMA8/U2TX/CN18/RF5	JH-04	
51	RF3	USBID/RF3	N/A	USB-4
52	RF2	U1RX/RF2	JE-03	
53	RF8	U1TX/RF8	JE-04	

56	RG3	D-/RG3	N/A	USB-2
57	RG2	D+/RG2	N/A	USB-3
58	RA2	SCL2/RA2	JF-01	Shared with I2C daisy chain #2, J6
59	RA3	SDA2/RA3	JF-02	Shared with I2C daisy chain #2, J6
60	RA4	TDI/RA4	N/A	Used by debug circuit
61	RA5	TDO/RA5	N/A	Used by debug circuit
63	RC12	OSC1/CLKI/RC12	N/A	Primary Oscillator Crystal
64	RC15	OSC2/CLKO/RC15	N/A	Primary Oscillator Crystal
66	RA14	SCL1/INT3/RA14	N/A	I2C Bus #1, not shared with Pmod connector
67	RA15	SDA1/INT4/RA15	N/A	I2C Bus #1, not shared with Pmod connector
68	RD8	IC1/RTCC/RD8	JH-09	
69	RD9	IC2/SS1/RD9	JD-03	Shared with SPI Port 1 Connector, J1
70	RD10	IC3/SCK1/PMCS2/PMA15/RD10	JD-09	Shared with SPI Port 1 Connector, J1
71	RD11	IC4/PMCS1/PMA14/RD11	JE-09	
72	RD0	SDO1/OC1/INT0/RD0	JH-08	Shared with SPI Port 1 Connector, J1
73	RC13	SOSCI/CN1/RC13	N/A	Secondary Oscillator Crystal
74	RC14	SOSCO/T1CK/CN0/RC14	N/A	Secondary Oscillator Crystal
76	RD1	OC2/RD1	JD-02	
77	RD2	OC3/RD2	JD-08	
78	RD3	OC4/RD3	JE-08	
79	RD12	PMD12/IC5/RD12	JK-09	
80	RD13	PMD13/CN19/RD13	JE-07	
81	RD4	PMWR/OC5/CN13/RD4	JB-09	
82	RD5	PMRD/CN14/RD5	JB-08	
83	RD6	PMD14/CN15/RD6	JD-07	
84	RD7	PMD15/CN16/RD7	JD-01	
87	RF0	PMD11/RF0	JC-09	Shared with servo S7
88	RF1	PMD10/RF1	JC-10	Shared with servo S8
89	RG1	PMD9/RG1	JC-08	Shared with servo S6
90	RG0	PMD8/RG0	JC-07	Shared with servo S5
91	RA6	TRCLK/RA6	JF-03	Shared with BTN1
92	RA7	TRD3/RA7	JF-04	Shared with BTN2
93	RE0	PMD0/RE0	JA-01	
94	RE1	PMD1/RE1	JA-02	
95	RG14	TRD2/RG14	JC-03	Shared with servo S3
96	RG12	TRD1/RG12	JC-01	Shared with servo S1
97	RG13	TRD0/RG13	JC-02	Shared with servo S2
98	RE2	PMD2/RE2	JA-03	
99	RE3	PMD3/RE3	JA-04	
100	RE4	PMD4/RE4	JA-07	

Connector Descriptions and Jumper Settings

Label	Function
J1	**SPI port #1 connector** Because of multiple uses for the pins, the signals for SPI port #1 are scattered across multiple Pmod connectors. This connector provides all of the SPI port #1 signals on a single connector. All of the signal pins on this connector are shared with pins on various Pmod connectors.
J2	**I2C port #2 daisy chain connector** This connector provides access to the I2C signals, power and ground for I2C port #2.
J3 & J4	**Pull-up enable for I2C port #2** These two jumpers are used to enable/disable the pull-up resistors on I2C port #2. Insert shorting blocks on these two jumpers for enable the pull-up resistors. Remove the shorting blocks to disable the pull-up resistors. Only a single device on the I2C bus should have the pull-up resistors enabled.
J5	**Servo bus power connector** This connector is used to provide power to the servo power bus, VS.
J6	**I2C port #1 daisy chain connector** This connector provides access to the I2C signals, power and ground for I2C port #1.
J10	**DAC output** The analog output voltage of IC3, the MCP4725 Digital to Analog converter, is available at this connector.
J12	**Power supply source select** This jumper is used to select the source of main board power. Place a shorting block in the upper, “USB Device Port” position to have the board powered from the USB device connector, J15. Place a shorting block in the center, “External Power” position to have the board powered from one of the external power connectors, J13, J14, or J18. Place a shorting block in the lower, “USB Debug Port” position to have the board powered from the debug USB connector, J11.
J16	**PIC32 pin 20 function select** Pin 20 on the PIC32MX460 microcontroller has multiple functions. It functions as the VBUSON control pin when acting as a USB host. It can be used as an analog input for the A/D converter or one of the analog comparators. It can also be used as a pin change interrupt input or as a general digital i/o. This jumper is used to route pin 20 to one of three places on the board: Place a shorting block in the upper, VBUSON, position when acting as a USB host to control the USB power supplied to the connected device.

	Place a shorting block in the middle, DAC, position to connect the output of the MCP4725 digital to analog converter to pin 20. This allows the use of the DAC output as an input to analog comparator #1. Place a shorting block in the lower, JJ, position to connect pin 20 to Pmod connector JJ, pin 8. This allows access to pin 20 from this Pmod connector.
JP1	**Connect VS bus to VU bus** This jumper is used to connect the VS bus to the VU bus. The VS bus provides power to the servo connectors, S1-S8. The VU bus is the main board power bus. Install a shorting block on this jumper to have the servo power bus powered from the main power bus. Remove the shorting block from this jumper to separate the two power busses. When using a separate servo power bus, the VS bus is powered from screw terminal connector J5.
JP2	**VS bus voltage monitor** This jumper is used to enable monitoring of the VS bus voltage. When a shorting block is installed on this jumper, the VS bus is connected via a voltage divider to analog input AN9. This can be used, for example, to monitor the state of a battery supply being used to power servos.
JP4	**VU bus voltage monitor** This jumper is used to enable monitoring of the VU bus voltage. When a shorting block is installed on this jumper, the VU bus is connected via a voltage divider to analog input AN8. This can be used, for example, to monitor the state of a battery supply being used to power the board.
JP5	**USB over-current detect** This jumper is used to enable monitoring of the over-current detect capability of the USB bus power switch, IC6. When a shorting block is installed on this jumper, the over-current output pin of IC6 is connected to the INT2/RE9 pin of the PIC32MX460 microcontroller.
JP6	**USB host power select** This jumper is used to select which host connector is powered when host power is enabled. Place the shorting block in the "OTG" position to supply power to the USB OTG Connector, J15. Place the shorting block in the "HOST" position to supply power to the USB Host Connector, J17.
S1-S8	**Servo connectors** These provide connection for up to 8 RC hobby servos. Each of these connectors provides a control signal: labeled S; servo power: labeled VS, and a ground connection: labeled G. The signal pins on these connectors are shared with the signal pins on Pmod connector JC.
JPA – JPF & JPH-JPK	**Pmod header power select** Any of the Pmod headers can be connected to use either regulated or unregulated power. To use regulated power, place the jumper block over the center pin and the pin marked VCC. To use unregulated power, place the jumper block over the center pin and the pin marked VU.