

Cerebot II™ Board Reference Manual

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Note: This document applies to REV B of the board.



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Overview

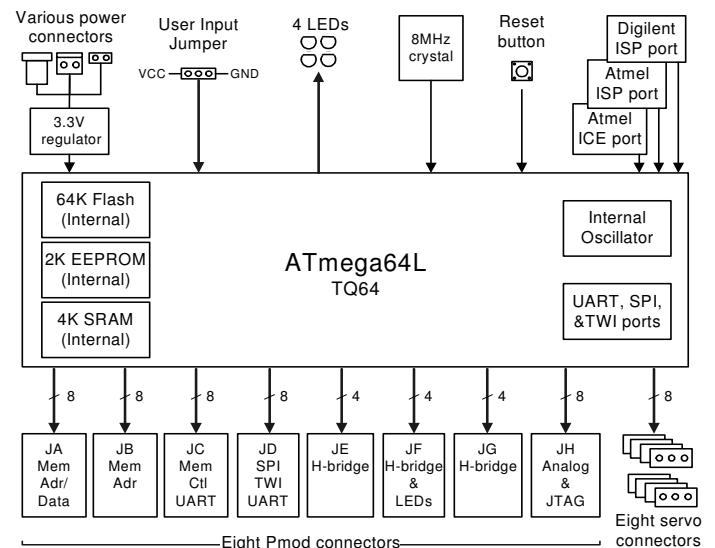
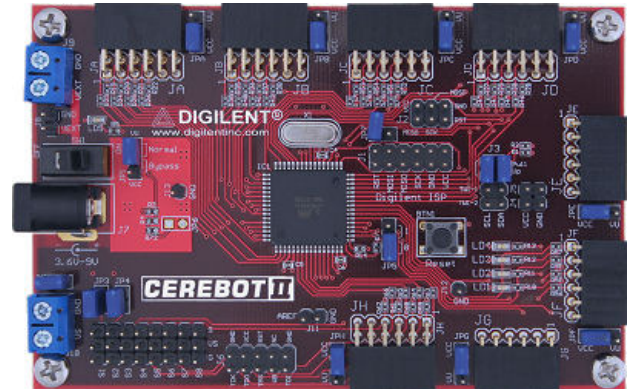
The Cerebot II board is a useful tool for embedded control and robotics projects for both students and hobbyists.

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 and supports a number of programming options including the free Atmel AVR® Studio 4, and WinAVR.

The Cerebot II has a number of connections for peripheral devices. It provides eight 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:

- an ATmega64L microcontroller
- eight hobby RC servo connectors
- eight Pmod connectors for Digilent peripheral module boards
- an on-board voltage regulator
- multiple flexible power supply jumper options
- support for the Digilent JTAG-3 Parallel and JTAG-USB programming cables
- support for the Atmel AVRISP in-system programmer
- support for the Atmel AVR JTAGICE mkII debugging tool
- ESD protection and short circuit protection for all I/O pins.



Cerebot II Circuit Diagram

Features of the ATmega64L include:

- a serial peripheral interface (SPI)
- two USART serial interfaces
- Atmel TWI serial interface
- eight 10-bit analog inputs
- two 8-bit timer counters
- two 16-bit timer counters
- 64KB program flash
- 2KB user EEPROM
- 4KB internal RAM
- an analog comparator.

For more information on the ATmega64L microcontroller, refer to the data sheet available at www.atmel.com.

Functional Description

The Cerebot II is designed for embedded control and robotic applications as well as microprocessor experimentation. Firmware suitable for many applications can be downloaded to the Cerebot II's programmable ATmega64L microcontroller.

The board has a number of connection options, and is specially designed to work with the Diligent line of Pmod peripheral modules with various input and output functions. For more information, see www.digilentinc.com.

The Cerebot II has two programming interface options: The Diligent in-system-programming option is accessed via connector J1. A Diligent USB or parallel programming cable can be attached to connector J1. The Diligent AVR Programmer application, available from the Diligent Web site, can be used to program the board via the Diligent programming cable. Alternatively, the Atmel AVRISP in-system programmer can be used. The AVRISP is connected to connector J2 and programming is done using the Atmel in-system-programming application built into the Atmel AVR Studio software. The Cerebot II also provides the ability to use the Atmel AVR JTAGICE mkII debugging tool for programming the board and debugging the user firmware.

The Cerebot II features a flexible power supply routing system with a number of options for powering the Cerebot II as well as peripheral modules connected to the board.

Pmod Connectors

The Cerebot II has eight Pmod connectors for connecting to Diligent Pmod peripheral modules. There are two styles of Pmod connector. The original Pmod connector standard uses a six-pin-header style of connectors providing four I/O signals, ground and a switchable power connection. The power connection is switchable between the regulated 3.3V main board supply and the unregulated input supply.

The newer Pmod connector standard uses a 12-pin (2x6) header connector and provides eight signal pins, two grounds, and two switchable power connections. The pin arrangement is such that the new connector is equivalent to two of the older connectors.

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

See the "Pmod Headers and SPI Connection" section below for more information about connecting peripheral modules and other devices to the Cerebot II. It lists the header connectors with their designed base function and a mapping to the Atmega64L I/O register ports. All pins can be used as general-purpose digital I/O ports.

Power Supply Connectors

The Cerebot II may be powered via dedicated power supply connectors, or it can be powered through any of the board's Pmod connectors. The Cerebot II can also be powered through the servo power connector.

The Cerebot II is rated for external power from 3.6 to 9 volts DC. Using voltage outside this

range could damage the Cerebot II and connected devices.

There are three different power supply connectors on Cerebot II for board/processor power: J7, J8, and J9.

The barrel connector, J7, is useful for desktop development and testing where use of batteries is cost- or time-prohibitive. J7 is the connector used by the AC supply adapter available from Digilent. J7 is a 2.5mm x 5.5mm coaxial connector wired with the center terminal as the positive voltage.

J8 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 J8.

J9 is a screw terminal connector for an alternative power supply connection.

Connectors J7, J8, and J9 are wired in parallel and connect to one terminal of the power switch, SW1. The other terminal of SW1 connects to the main unregulated power bus VU. The VU power bus connects to the center terminal of the voltage regulator input jumper JP1 and also connects to the VU terminal of the power select jumper associated with each Pmod connector.

Jumper JP1 is used to select the voltage for the main board power bus VCC. When JP1 is in the 'normal' position, the VCC power bus is powered by the output of the on-board 3.3V regulator. When JP1 is in the 'bypass' position, the on-board voltage regulator is bypassed and the VCC bus is connected directly to the VU bus. In this case, the microcontroller and other on-board electronics are powered directly from the voltage supply connected to VU. In this case, the input voltage must be in the range 2.7V – 5.5V. A supply voltage outside this range can permanently damage the board.

You can also power the Cerebot II from any Pmod header connector. Place the power select jumper associated with the Pmod

connector in the VU position to supply power to the VU bus, or the VCC position to supply power to the VCC bus. If power is being supplied to the VU bus, JP1 should be in the 'normal' position so that the on-board regulator will be able to regulate the supplied voltage to the 3.3V board operating voltage. If the Pmod connector power routing jumper is in the VCC position, the shorting block on JP1 should be placed in the 'bypass' position or removed.

The Cerebot II has a second screw terminal connector, J10 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 II. This can be useful when using servos that draw large amounts of power.

Jumper JP2 can be used to connect the Cerebot II unregulated power bus VU to the servo power bus, VS. When no shorting block is installed on JP2, the VU and VS busses are separate. When a shorting block is on JP2, the two busses are joined and the VU bus can be powered in any of the previously indicated ways, or from connector J10.

The Cerebot II can provide power to any peripheral modules attached to the Pmod connectors and to TWI devices powered from the TWI power daisy chain connectors, J4 and J5. 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 TWI power connectors only provide regulated voltage, VCC.

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 ATmega64L microcontroller will use approximately 15mA when running at 8MHz. The remaining current is available to provide power to attached Pmod and TWI 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 II 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 made up of a voltage divider that divides the power bus voltage by four, and a zener diode to clamp the resulting voltage to no greater than 3.3V. Jumper JP3 enables the supply monitor circuit for VU power, and jumper JP4 enables the supply monitor circuit for VS power. The analog to digital converter built into the ATmega64 is used to measure the power supply voltages. ADC channel 0 is used to measure VU and ADC channel 1 is used to measure VS.

When the power supply monitor circuit is enabled the maximum safe voltage on VU is 9V and the maximum safe voltage on VS is 12V.

RC Servo Connectors

The Cerebot II 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 JH on the left lower side of the Cerebot II. Individual I/O pins may be accessed through the JH header if they're not in use by a servo. Refer to the ATmega64 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 8-bit and 16-bit timers in the AVR 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 (preferably one of the 16-bit timers) to be used to control the signal timing for all eight servo connectors.

The servo connectors on the Cerebot II 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. Diligent has a reference design available (the *ServoMini Reference Design*) that illustrates using timer interrupts to control signal timing for the PWM signals to control RC servos.

The I/O pins shared between the servo connectors and connector JH are the analog to digital converter inputs on the ATmega64 microcontroller. If servos are being driven on some channels and analog voltages are being read on other pins simultaneously, it is possible for digital switching noise to reduce the accuracy of the analog to digital conversions. If this is an issue, perform the analog-to-digital conversions at times when the servo pins are not switching. In normal applications, there will be a great deal of dead time when the servo pins are not switching.

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

Install the shorting block on JP2 to connect the VS servo power bus to the VU power bus. The VU bus can be powered from the coax power connector, J7, the screw terminal connector, J9, or the 2-pin battery connector, J8.

The VU bus can also be powered from any of the Pmod header interface connectors by setting the corresponding power jumper block to the VU position. This option is not suitable for providing power for large numbers of servos or servos that have a high current demand.

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 J10.

Finally, for very high current applications, a separate power bus external to the Cerebot II can be used to provide servo power. In this case, remove the shorting block on JP2, tie the external servo power bus ground to the Cerebot II 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.

Programming Options

The Cerebot II provides two in-system programming connections, J1 and J2.

Connector J1 is the Digilent ISP connector. This provides for in-system programming using a Digilent parallel JTAG/SPI cable or a Digilent USB-JTAG/SPI cable. When connecting the Digilent JTAG/SPI cables, ensure that the VCC and GND pin labels from the cable match to the VCC and GND pins on the Cerebot II. When using a Digilent programming cable, use the Digilent AVR Programmer application available for download from the Digilent web site (www.digilentinc.com) to program the board.

Connector J2 is a 6-pin (3x2) header for in-system programming using the Atmel AVRISP (Atmel P/N ATAVRISP) programmer. When connecting to the Cerebot II, the red indicator line on the AVRISP connection plug must be aligned with the top pins MISO and VCC on J2.

Programming can be accomplished using several AVR programming applications including the Digilent AVR Programmer (AVRP), AVRDUDE from the WinAVR tool set, and Atmel's AVR Studio. Programming via AVR Studio requires use of the Atmel AVRISP programmer hardware. See the user's

documentation for each of these applications for more information on board programming.

Debugging with the Atmel JTAGICE mkII

Connector J6 on the Cerebot II is provided for the Atmel JTAGICE mkII (Atmel P/N ATJTAGICE2) in-circuit emulator for debugging purposes. The JTAGICE works with the debugger in Atmel's AVR Studio product.

The JTAG port on the ATmega64 must be enabled when using the JTAGICE. The Cerebot II is shipped with the JTAG port disabled. This port can be enabled or disabled using a fuse bit which can be set with any of the supported in-system programmers described above.

Two Wire Serial Interface

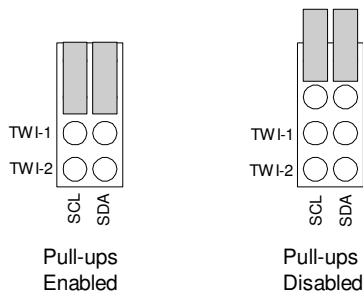
The Atmel Two Wire Serial Interface (TWI) provides a medium speed (400K bps) synchronous serial communications bus. The TWI interface provides master and slave operation with up to 127 devices on the bus. Each device is given a unique address, and the protocol provides the ability to address packets to a specific device or to broadcast packets to all devices on the bus. See the ATmega64 data sheet for detailed information on configuring and using the two wire serial interface.

The Cerebot II provides two ways to connect to a TWI bus. The TWI signals (SCL and SDA) are available on the connector JD (pins 7 and 8) or on the TWI daisy chain connector, J3.

Connector J3 provides two positions for connecting to the TWI signals. By using two-wire cables (available separately from Digilent) a daisy chain of multiple Cerebot II boards or other TWI-capable boards can be created.

The TWI bus is an open-collector bus. Devices on the bus actively drive the signals low. The high state on the TWI lines is achieved by pull-

up resistors when no device is driving the lines low. One device on the TWI bus must provide the pull-up resistors. The Cerebot II board provides pull-up resistors that can be enabled or disabled via jumper blocks on the 'pull-up' positions on J3. The pull-ups are enabled by installing jumper blocks on J3 and are disabled by removing the jumper 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 TWI Pull-Up Resistors

Connectors J4 and J5 are provided for daisy-chaining power along with the TWI signals. These can be used to pass power from the Cerebot II to other devices on the TWI bus. Either of these connectors could also be used to provide power to the Cerebot II from some other board on the TWI bus.

Crystal Oscillator

The ATmega64 microcontroller supports numerous clock source options for the main processor operating clock. The Cerebot II has an 8MHz oscillator crystal for use with the crystal oscillator option. The Cerebot II comes from the factory with the external crystal oscillator source selected.

The ATmega64 microcontroller also provides an internal RC oscillator that can operate at nominal frequencies of either 1MHz, 2MHz, 4MHz, or 8MHz. This internal oscillator has a frequency variability of approximately 2-3%, which is suitable for many applications.

The RC oscillator's nominal frequency assumes operation at 5V. The Cerebot II normally operates at 3.3V. See the oscillator frequency vs. supply voltage chart in the ATmega64 data sheet to determine the nominal frequency at 3.3V.

Although the Cerebot II will normally be operated using the 8MHz crystal oscillator, the internal oscillator can be selected to operate the board at a lower frequency if desired. The clock source to be used by the board is chosen using the fuse settings in the in-system programmer.

When changing the clock source fuse settings, it is extremely important to ensure that the clock source chosen actually exists on the board (i.e., only choose the crystal oscillator or internal oscillator). The ATmega64 internal in-system-programming state machine operates from the selected clock source and if an unavailable clock source is selected, the board may no longer be programmable.

In some cases, it is possible to recover the board if an improper clock source is chosen, but not always. There is an applications note "Cerebot Clock Source Fix" (available from www.digilentinc.com) that explains the procedure for recovering a board that has had an improper clock source programmed.

User I/O Devices

The Cerebot II board has a two-position jumper for user input and four LEDs for output. The user input jumper, JP5, is connected to I/O port G, bit 4. To read this jumper, bit 4 of port G must be set as an input by clearing bit 4 in the port G data direction register (DDRG) and reading the pin register for port G (PING). When the shorting block is in the '0' position, bit 4 in the pin register will be 0. When the shorting block is in the '1' position, bit 4 will be 1.

The four LEDs are connected to bits 4-7 of I/O port E. LED 1 is connected to bit 4, LED 2 is connected to bit 5, and so on. These four bits are also shared with the four I/O signals on

Pmod connector JF. To use the LEDs, set the desired bits as outputs by setting the corresponding bits in the port E data direction register (DDRE) and set the bits to the desired level in the port E output register (PORTE). Setting a bit to 1 will illuminate the LED and setting the bit to 0 will turn it off.

Pmod Headers and SPI Connection

Note: All Pmod headers can be used as general purpose I/Os or for the following specific purposes.

Pin	Description	Cerebot II Pmod Header Pins to ATmega64L Ports / Bit		
JA	External memory bus These pins connect to the multiplexed Address/Data line of the ATmega64 external memory bus interface.	Pin	Function	Port / Bit
		1	AD0	PA0
		2	AD1	PA1
		3	AD2	PA2
		4	AD3	PA3
		5	GND	
		6	VCC	
		7	AD4	PA4
		8	AD5	PA5
		9	AD6	PA6
		10	AD7	PA7
		11	GND	
		12	VCC	
JB	External memory bus These pins connect to the higher order address pins of the ATmega64 external memory bus interface.	1	A8	PC0
		2	A9	PC1
		3	A10	PC2
		4	A11	PC3
		5	GND	
		6	VCC	
		7	A12	PC4
		8	A13	PC5
		9	A14	PC6
		10	A15	PC7
		11	GND	
		12	VCC	
JC	Serial port communications Connection to UART0. A PmodRS232™ can be used on this connector for an RS232 serial interface. JC shares the RXD0 and TXD0 pins with the ISP ports. No device can be connected to JC during in-system programming. External memory bus Pins 7-9 connect to the control signals of the ATmega64 external memory bus interface.	1	XCK0/ AIN0	PE2
		2	OC3A/ AIN1	PE3
		3	RXD0/ PDI	PE0
		4	TXD0/ PDO	PE1
		5	GND	
		6	VCC	
		7	WR	PG0
		8	RD	PG1
		9	ALE	PG2
		10	TOSC2	PG3
		11	GND	
		12	VCC	

Pin	Description	Cerebot II Pmod Header Pins to ATmega64L Ports / Bit		
JD	SPI interface The SPI interface on JD is used for synchronous serial communication of host processor and peripherals or for a connection of two processors. Master or slave modes are selected as part of the software. Serial port communications and interrupts Asynchronous serial port, UART1, as well as the Atmel TWI interface can be accessed on JD. These pins can also be used as external interrupt sources.	Pin	Function	Port / Bit
		1	SS	PB 0
		2	MOSI	PB 2
		3	MISO	PB 3
		4	SCK	PB 1
		5	GND	
		6	VCC	
		7	SCL/ INT0	PD 0
		8	SDA/ INT1	PD 1
		9	RXD1/ INT2	PD 2
		10	TXD1/ INT3	PD 3
		11	GND	
		12	VCC	
JE	H-bridge connection with input capture This port can be used to provide two pulse width modulated outputs to run two motors, or it can be used to run a single motor with input sensing for a shaft encoder or other sensor. The PmodHB3 or PmodHB5 can be used for this application.	1	T1	PD 6
		2	OC1A	PB 5
		3	ICP1	PD 4
		4	OC1B	PB 6
		5	GND	
		6	VCC	
JF	H-bridge connection, interrupts, and on-board LEDs Use this port to run two motors, like JE, or a motor with input sensing for a shaft encoder or other sensor. All of the pins on this header give access to interrupt inputs, providing flexibility for application development. JF can be used as a motor controller or interrupt source. The onboard LEDs share pins with this header and can display information.	1	T3/ INT6	PE 6
		2	OC3B/ INT4	PE 4
		3	ICP3/ INT7	PE 7
		4	OC3C/ INT5	PE 5
		5	GND	
		6	VCC	
JG	H-bridge connection This port can be used to provide two pulse width modulated outputs to run two motors, or it can be used to run a single motor with input sensing for a shaft encoder or other sensor. The PmodHB3 or PmodHB5 can be used for this application.	1	T2	PD 7
		2	OC0	PB 4
		3	XCK1	PD 5
		4	OC2/ OC1C	PB 7
		5	GND	
		6	VCC	
JH	Analog input Inputs to the analog to digital converter of the ATmega64L. ADC0 and ADC1 are connected to the Cerebot II's voltage monitoring circuits. ADC0 is the input for monitoring VU board power and ADC1 is connected to VS for monitoring the independent servo power. The default fuse setting for the Cerebot II is to disable the JTAG input and provide analog inputs. The ATmega64L fuse settings have to be changed to enable the JTAG interface to use JH as a JTAG device input (e.g., to use the Atmel JTAGICE mkII). The pins on JH are shared with the servo connectors S1-S8.	1	ADC0	PF 0
		2	ADC1	PF 1
		3	ADC2	PF 2
		4	ADC3	PF 3
		5	GND	
		6	VCC	
		7	ADC5/ TMS	PF 5
		8	ADC7/ TDI	PF 7
		9	ADC6/ TDO	PF 6
		10	ADC4/ TCK	PF 4
		11	GND	
		12	VCC	

Jumper Blocks

Jumper Label	Function
JP1	Voltage regulator bypass This jumper is used to select the voltage source to power the main board-regulated power bus, VCC. Place the shorting block in the 'normal' position to power the board from the on-board 3.3V regulator. Place the shorting block in the 'bypass' position to power the board from an externally regulated supply. This connects the unregulated power bus, VU, to the main regulated power bus, VCC.
JP2	Servo power bus Connect the RC hobby servo power bus to the unregulated supply bus, VU. When a shorting block is in place on this jumper, servo power is supplied from VU on the Cerebot II. If the jumper block is removed, the RC hobby servo power bus must be supplied with a source connected to the screw terminal block, J10.
JP3	VU voltage sense circuit enable When JP3 is installed, the VU voltage monitor circuit is connected to ADC0. See page 3 of this reference manual for a description of the voltage monitor circuit.
JP4	VS voltage sense circuit enable When JP4 is installed, the VU voltage monitor circuit is connected to ADC1. See page 3 of this reference manual for a description of the voltage monitor circuit.
JPA - JPH	Pmod headers Any of the eight 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.