Cerebot™ Reference Manual

Revision: February 9, 2009
Note: This document applies to REV B-E of the board.

DIGILENT®
www.digilentinc.com
215 E Main Suite D | Pullman, WA 99163
(509) 334 6306 Voice and Fax

Overview

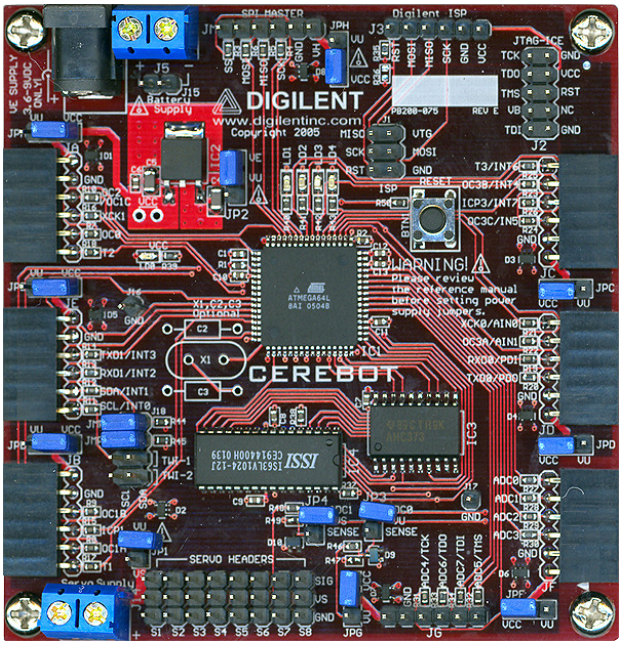
The Digilent Cerebot Board is a useful tool for embedded control and robotics projects for both students and hobbyists.

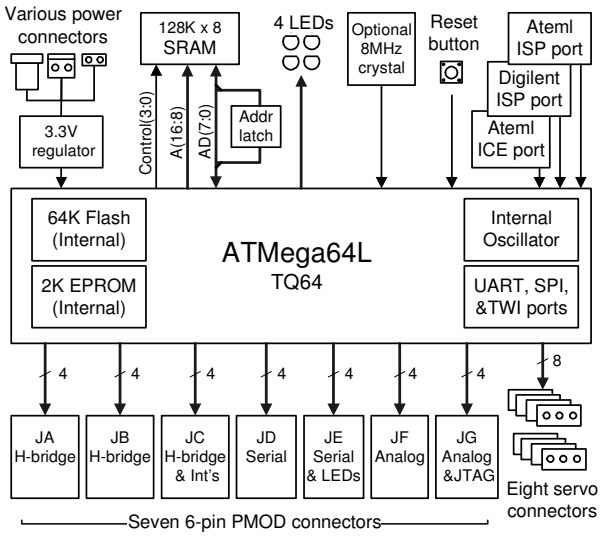
The Cerebot's versatile design and programmable embedded microcontroller lets you add different devices and program the board for multiple uses. The board has many I/O connectors and power supply options and supports a number of programming options including ATMEL AVR® STUDIO 4, and WINAVR.

The Cerebot has a number of connections for peripheral devices. Digilent peripheral modules include H-bridges, analog-to-digital and digital-to-analog converters, a speaker, 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
- 128KB expansion memory
- eight hobby RC servo connectors
- eight 6-pin connectors for Digilent peripheral module boards
- an on-board voltage regulator
- multiple flexible power supply and jumper options
- support for the Atmel AVRISP in-system programmer
- support for the Atmel AVR JTAGICE mkII
- support for the Digilent Parallel and USB AVR in-system programmers
- ESD protection for all I/O pins.





Cerebot 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.

Functional Description

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

The Cerebot has a number of connection options, and is specially designed to work with the Digilent line of peripheral modules (Pmods) with various input and output functions. For more information, see www.digilentinc.com.

The Cerebot has two programming interface options, the ATMEL in-system programmer (ISP) and the Digilent ISP, which can be accessed through the J3 connection on the Cerebot. The Cerebot also has a JTAG ICE interface for troubleshooting and a serial peripheral interface (SPI) for networking with other microcontroller and processor-based boards.

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

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

6-pin Pmod™ Headers

The Cerebot has seven 6-pin Pmod headers for connecting to digital I/O and specific functions such as analog-to-digital conversion on the Atmega64L.

See Table 1 for more information about connecting peripheral modules and other devices to the Cerebot. Table 1 shows 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 may be powered by external power connections, or it can be powered through any of the board's 6-pin headers. The Cerebot can also be powered through the servo power connector.

The Cerebot is rated for external power from 3.6 to 9 volts DC. Using voltage outside this range could damage the Cerebot and connected devices.

There are three different power supply connectors on Cerebot for board / processor power: J4, J15, and J5.

The J4 barrel connector is useful for desktop development and testing where use of batteries is cost or time prohibitive. J4 is the connector used by the AC supply adapter provided with the Cerebot.

J15 is a two pin male header that provides easy battery or battery-pack connection.

J5 is a screw terminal connector for an alternative battery supply connection.

You can also power the Cerebot from any 6-pin header connection.

The Cerebot also has a separate screw terminal connector J14 to supply power to the RC hobby servo connectors. This second screw terminal power option can be run

separately from the supply that is powering the Cerebot and can be used with servo motors that draw large amounts of power.

Jumper JP1 is used to separate the J14 power bus from the Cerebot's other power busses. The jumper must be inserted to connect J14 to the principal power supply, and when removed it separates J14 from the principal power supply.

Each 6-pin Pmod connector power pin can be powered by either unregulated voltage VU or regulated voltage VCC by setting the voltage jumper block to the desired position. When the jumper is on the VCC setting 3.3V must be used, otherwise the board will be damaged.

Any 6-pin header can be jumpered to provide either regulated or unregulated power to peripheral modules. There are labels on the Cerebot near the jumper pins. Place the jumper on the pins near the VCC label for regulated power, and on the pins near the VU label for unregulated power supply.

For information on how to set the jumper blocks for VU and VCC, see Table 2.

Power Supply Monitor Circuit

The Cerebot microcontroller can measure the power supply voltage on the VU and VS power busses using a power supply monitor circuit. Furthermore, the Cerebot's microcontroller can use this to monitor power supplies. This feature is especially useful when using batteries because it will notify when a battery supply is low.

Each power supply monitor circuit is a voltage divider that divides the power bus voltage by 4. The Jumper JP3 enables the supply monitor circuit for VU power, and jumper JP4 enables the supply monitor circuit for VS power. When a jumper is placed on JP3 or JP4, the ADC0 or ADC1 input is connected to the voltage divider.

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.

For more information about how to set the jumpers for the power supply monitor circuit see Table 2.

RC Servo Connectors

The Cerebot 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 6-pin headers JB (S1 through S4) and JE (S5 through S8) on the left lower side of the Cerebot. Individual I/O pins may be accessed through the JB or JE headers 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.

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

Install the shorting block on JP1 to connect the VS servo power bus to the VU power bus. The VU bus can be powered from the coax power connector J4, the screw terminal connector J5, or the 2-pin battery connector J15.

The VU bus can also be powered from any of the 6-pin 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 JP1 to make the VS servo power bus independent from the VU bus. In this case, the VS bus is powered from screw terminal connector J14.

Finally, for very high current applications, a separate power bus external to the Cerebot 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 ground through the ground terminal on J14, and use pin 1 on the servo connectors to

bring the servo control signals out to the servos.

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 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. The *ServoMini Reference Design* (available from www.digilentinc.com) illustrates using timer interrupts to control signal timing for the PWM signals to control RC servos.

Programming Options

The Cerebot provides two in-system programming connections, J1 and J3. J1 is a 6-pin (3x2) header for in-system programming using the Atmel AVRISP (P/N ATAVRISP) programmer. When connecting to the Cerebot, the red indicator line on the AVRISP connection plug must be aligned with the top pins MISO and VTG on J1. J3 is the Digilent ISP connector. This provides in-system programming using the Digilent parallel JTAG/SPI cable provided. A USB JTAG/SPI cable that can be used for programming the Cerebot via J3 is also available from Digilent. 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.

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 J2 on the Cerebot is provided for the Atmel JTAGICE mkII (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 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 128 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 interface.

The Cerebot provides two ways to connect to a TWI bus. The TWI signals (SCL and SDA) are available on 6-pin connector JE or on the TWI daisy chain connector J18.

Connector J18 provides two positions for connecting to the TWI signals. By using two-wire cables (available separately from Digilent) a daisy chain of multiple Cerebots 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 board provides pull-up resistors that can be enabled or disabled via jumper blocks on the JMP1 and JMP2 positions on J18. The pull-ups are enabled by installing jumper blocks on JMP1 and JMP2 and are disabled by removing the jumper blocks. Only one device on the bus should have the pull-ups enabled.

External SRAM

The ATmega64 microcontroller has 4KB of internal data memory and provision for up to 60KB of external expansion memory, providing 64KB of accessible data memory.

The Cerebot contains a 128KB external SRAM, providing two pages of 60KB each. Before this memory is accessible, the external memory interface must be enabled. See the ATmega64 data sheet for information on how to enable the external memory interface.

I/O pin PG3 (port G, bit 3) is connected to the high order address line on the external memory. To access both pages of the external memory, configure pin PG3 as an output and set this pin low to access the lower page and set this pin high to access the upper page. This line is pulled low on the board, so that the lower page will be accessed by default if PG3 is not used.

Although there are two pages of 64KB each in the external memory, the lower 4KB of memory addresses access the internal memory and so the lower 4KB of each external memory page are not accessible.

Crystal Oscillator

The ATmega64 microcontroller 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.

Note: The RC oscillator's nominal frequency assumes operation at 5V. The Cerebot operates at 3.3V. See the oscillator frequency vs. supply voltage chart in the ATmega64 data sheet to determine the true nominal frequency at 3.3V. If a more precise operating frequency is required (such as for high speed asynchronous serial communications) an external crystal oscillator is provided. The Cerebot provides locations where a user-supplied crystal and load capacitors (X1, C1, C2) can be installed. If a crystal is required, refer to the ATmega64 data sheet for crystal and load capacitor selection. The provided crystal location is for a crystal in an HC49 or HC49US package.

For more information, see the *Cerebot II Reference Manual*. It's a similar board, and it's reference manual is more current and complete.

Table 1: 6-pin Pmod headers and SPI connection

Pin	Description *All Pmod headers can be used as general purpose IOs or for the following specific purposes.	Cerebot Pmod header pins to Atmega64L ports / bit		
		Pin	**Function**	**Port/ bit**
JA	**H-bridge connection** Designed for two H-bridge connections, one connection on pins 1 and 2 and another connection on pins 3 and 4. The JA pins are organized so H-bridge controlled motors can be easily connected to the Cerebot.	1	T2	PD 7
		2	OC0	PB 4
		3	XCK1	PD 5
		4	OC2/ OC1C	PB 7
		5	GND	
		6	VCC	
JB	**H-bridge connection with input capture** This port can be used to run two motors, just like JA, or it can be used to run a motor with input sensing for a shaft encoder or other sensor. JB shares pins with servo connectors S1-S4.	1	T1	PD 6
		2	OC1A	PB 5
		3	ICP1	PD 4
		4	OC1B	PB 6
		5	GND	
		6	VCC	
JC	**H-bridge connection, interrupts, and on board LEDs** Use this port to run two motors, like JA, 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. JC can be used as a motor controller or interrupt source. The onboard LEDs share pins with this header and can show visual status of 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	
JD	**Serial port communications** Use the RS232Pmod™ on this header to implement a serial interface to Cerebot. JD shares the RXD0 and TXD0 pins with the ISP ports. NO device can be connected to JD during in-system programming.	1	XCK0/ AIN0	PE 2
		2	OC3A/ AIN1	PE 3
		3	RXD0/ PDI	PE 0
		4	TXD0/ PDO	PE 1
		5	GND	
		6	VCC	
JE	**Serial port communications and interrupts** A second asynchronous serial port as well as the Atmel TWI interface can be accessed on JE. These pins can also be used as external interrupt sources. The pins on JE are shared with the servo connectors S5-S8.	1	SCL/ INT0	PD 0
		2	SDA/ INT1	PD 1
		3	RXD1/ INT2	PD 2
		4	TXD1/ INT3	PD 3
		5	GND	
		6	VCC	
JF	**Analog input** Inputs to the analog to digital converter of the Atmega64L. ADC0 and ADC1 are connected to the Cerebot'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.	1	ADC0	PF 0
		2	ADC1	PF 1
		3	ADC2	PF 2
		4	ADC3	PF 3
		5	GND	
		6	VCC	
JG	**Analog or JTAG input** The default fuse setting for the Cerebot 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 JG as a JTAG device input (e.g., to use the Atmel JTAGICE mkII).	1	ADC5/ TMS	PF 5
		2	ADC7/ TDI	PF 7
		3	ADC6/ TDO	PF 6
		4	ADC4/ TCK	PF 4
		5	GND	
		6	VCC	
JM	**SPI interface** The SPI interface on JM 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.	1	SS	PB 0
		2	MOSI	PB 2
		3	MISO	PB 3
		4	SCK	PB 1
		5	GND	
		6	VCC	

Table 2: Jumper Blocks

Jumper Label	Function
JP1	**Servo power bus** Connect the RC hobby servo power bus to the unregulated supply bus VU. When a connector block is in place on this jumper, servo power is supplied from VU on the Cerebot. If the jumper block is removed, the RC hobby servo power bus must be supplied with a source connected to the screw terminal block J14.
JP2	**Off-board regulated power supply selection** To connect external regulated power on a Rev E version board, a single wire jumper may be connected to the positive pin of J5 (the battery connecter) and the VCC pin of any of the JPA-JPH 6-pin header power selection jumpers. Alternatively, any of the JPA through JPH VCC pins can be connected to the positive screw terminal J5. Additionally, off-board regulated power can be brought onto the board via any of the 6-pin Pmod header connectors.
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 VS voltage monitor circuit is connected to ADC1. See page 3 of this reference manual for a description of the voltage monitor circuit.
JPA - JPH	**6-pin Pmod headers** Any of the seven 6-pin Pmod headers as well as the SPI header 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.