

Cerebot Nano™ Reference Manual

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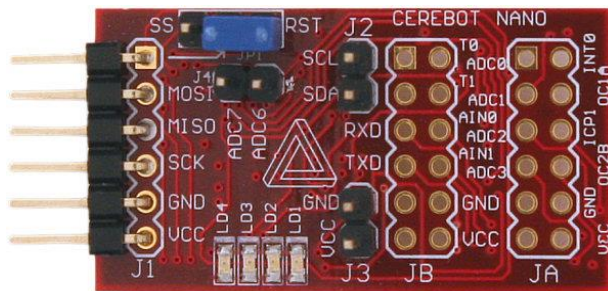
This manual applies to the Cerebot Nano rev. A

Overview

The Cerebot Nano is the smallest in the Cerebot line of boards offered by Digilent. The board's small size allows it to be used as either a peripheral that can be plugged directly into other Digilent boards or as a tiny stand-alone embedded control board. In spite of its small size, the Cerebot Nano is packed with features.

The Cerebot Nano's versatile design and programmable microcontroller allows you to control different external devices and program the board for multiple uses. The board has many I/O connectors and supports a number of programming tools including Atmel AVR Studio[®] 4 and WinAVR.

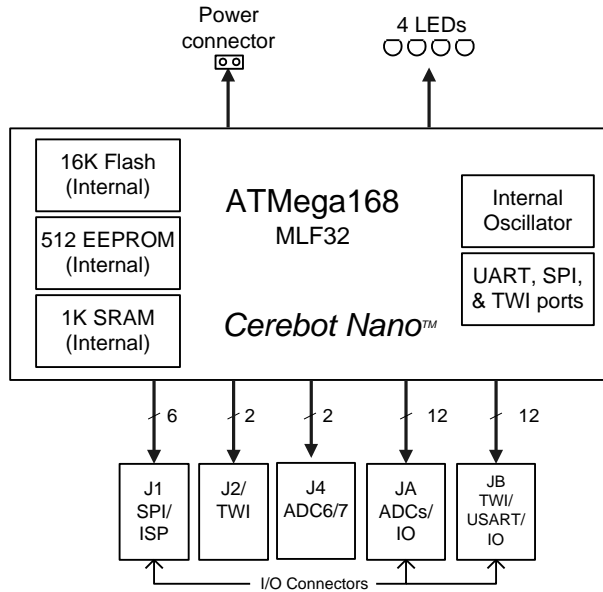
The Cerebot Nano has a number of connections for peripheral devices. Digilent peripheral modules (Pmods™) include H-bridges, analog-to-digital and digital-to-analog converters, a speaker, switches, buttons, LEDs, RS232 converters, screw terminal connectors, BNC connectors, servo motors, and more. For more information, visit www.digilentinc.com.



The Cerebot Nano.

Features include:

- ATmega168 microcontroller
- one 6-pin and two 12-pin ports for Digilent Pmod peripheral module boards
- up to eight analog-to-digital (ADC) input channels
- four LEDs
- ESD protection for all I/O pins
- In-system programming support using the Digilent parallel JTAG cable or the Digilent USB JTAG/SPI cable.



Cerebot Nano circuit diagram.

Features of the ATmega168 include:

- Master/slave serial peripheral interface (SPI)
- Programmable serial USART interface
- Atmel two wire serial interface (TWI)
- Eight channel, 10-bit ADC
- Two 8-bit timer/counters
- One 16-bit timer/counter
- 16KB program flash
- 512 byte EEPROM
- 1KB internal SRAM
- Analog comparator
- Built-in 8 MHz/1 MHz clock source.

For more information on the ATmega168 microcontroller, refer to the data sheet available at www.atmel.com.

1 Functional Description

The Cerebot Nano is designed for embedded control and robotic applications as well as microprocessor experimentation. Embedded firmware, suitable for many applications, can be programmed into the Cerebot Nano's ATmega168 microcontroller.

Although the Cerebot Nano can be used as a stand-alone microcontroller board, it is also designed to be part of a larger system using a distributed processing architecture. Connector J1 allows the Cerebot Nano to be plugged directly into other Digilent microcontroller boards, such as the Cerebot II or Cerebot Plus. The Cerebot Nano can be plugged directly into ports on many of Digilent's FPGA boards, although some boards may require the use of the Digilent Module Interface Board.

The Cerebot Nano can be programmed with firmware to perform local control functions. It can then be controlled by, and report back to, a higher level controller in the host controller board. For example, the Cerebot Nano could be programmed to perform closed-loop motor speed control. It could relieve extra work for the host processor, when performing the motor speed control, by processing commands from the host and controlling the motors itself.

1.1 Communication Options

Connector J1 provides access to the master/slave SPI. SPI is a high-speed, synchronous, serial interface used by many serial peripheral devices like ADCs and DACs. The SPI interface is used for programming the ATmega168 and as a user-accessible SPI port. The Digilent PmodAD1 and PmodDA1 modules use the SPI interface.

Connectors JB and J2 provide access to the Atmel two-wire interface (TWI). The TWI is a medium speed (200-400 Kbps) serial bus that allows up to 128 devices to be connected. Connector J2 can be used to daisy chain other devices to the TWI bus. Atmel's TWI interface is directly compatible with Phillips' I²C protocol.

The ATmega168 microcontroller provides a USART that can be used for asynchronous or synchronous serial communications. However, the Cerebot Nano doesn't provide for a crystal oscillator, and the internal RC oscillator isn't accurate enough for reliable asynchronous communications. It is sometimes possible to tune the oscillator using the calibration register to allow asynchronous communications to work.

1.2 6-pin Pmod Ports

The Cerebot Nano has five 6-pin header ports for connecting to general-purpose, off-board digital I/O or to specific ATmega168 features like analog-to-digital converters or pulse-width modulators. Each 6-pin port provides four signals, power, and ground. These ports are specifically designed to work with the Digiilent Pmod line of peripheral boards, but can be used to connect to virtually any off-board I/O device.

See Table 1 for more information on connecting peripheral modules and other devices to the Cerebot Nano. Table 1 shows the ports with their designed base function and a map to the ATmega168 I/O ports. All I/O port signal pins can be used for general-purpose digital I/Os.

1.3 Power Supply

The Cerebot Nano is rated for external power ranging from 2.7 to 5.5 volts DC. The Cerebot Nano does not feature a voltage regulator, so care should be exercised when selecting a power source. Using voltage outside this range could damage the Cerebot Nano and connected devices.

The Cerebot Nano can be powered through any of the board's 6-pin Pmod headers or the J3 connector.

Each of these connectors provides a VCC and a ground pin. A power supply providing between 2.7 and 5.5 volts can be connected to the VCC pin on any one of these connectors.

When the Cerebot Nano is plugged into another Digiilent microcontroller or FPGA board, that board can power the Cerebot Nano through the Pmod port. The host board should be jumpered to provide 3.3V on the VCC pin of the Pmod port being used. The Cerebot Nano will then be powered by the host board's power supply, and will in turn provide power from the host board to any peripheral boards connected to the Cerebot Nano's other Pmod ports.

For standalone applications, the Digiilent PmodREG1 voltage regulator module can be used to supply 3.3 volts to the board.

1.4 Device Programming

The Cerebot Nano has one in-system-programming (ISP) connector, J1. A Digiilent programming cable is connected to J1. Either a parallel JTAG or USB JTAG/SPI cable can be used. When connecting the programming cable, ensure that the VCC and GND pin labels from the cable match to the VCC and GND pins on the Cerebot Nano.

A power supply must be provided to the Cerebot Nano when programming. The Digilent programming cable does not supply power to the board; the board that it is plugged into powers the programming cable. The Digilent PmodREG1 voltage regulator module can be used, or any appropriately regulated power supply can be connected to J3. If the Cerebot Nano is being used in conjunction with another Digilent board, such as the Cerebot II or Minicon, these boards have connectors that can be used to supply power to the J3 connector on the Cerebot Nano using a two-wire cable.

Programming can be accomplished using the Digilent AVR application, available by free download from the Digilent web site. It is also possible to configure the AVRDUDE programmer in the WinAVR release for in-system-programming using the Digilent parallel JTAG cable. See the documentation for these applications for more information on board programming.

Connector J1 is used both for in-system-programming and for user access to the SPI controller. The jumper block JP1 is used to select between the two functions. The shorting block is placed in the RST position for in-system-programming, and in the SS position for user access to the SPI port.

1.5 AVR Clock Fuse Settings

AVR microcontrollers use control bits called fuses to set basic operating parameters for the device. The SPI controller uses the clock source set by the fuses for its clock. If the clock source fuses are set to select a clock source that doesn't exist on the board, the SPI controller won't work and it will no longer be possible to program the microcontroller via the in-system programming protocol. The Cerebot Nano can only use the internal RC oscillator as the clock source.

If the external oscillator, or one of the crystal/resonator clock sources is selected, it may be possible to recover the board by applying a suitable clock signal to pin 1 of connector JB. There is an applications note on the Digilent web site illustrating this technique for the Cerebot board.

In addition, the maximum SPI clock frequency is the selected clock frequency divided by four. If the 128KHz internal oscillator is selected as the clock source, the SPI clock would need to be set to a frequency of 32KHz or less. The Digilent programming cables do not support frequencies that low, so if the 128KHz internal oscillator is selected for the clock source, the board will no longer be programmable using the Digilent programming cable.

1.6 Two-wire Serial Interface

The Atmel TWI interface is a medium speed (400 Kbps), synchronous, serial, communications bus. The TWI interface supports master or slave operation with up to 128 devices on the bus. Each device is given a unique address, and the protocol has the ability to address packets to a specific device or to broadcast packets to all devices on the bus. For detailed information on configuring and using the two-wire interface see the ATmega168 data sheet at www.atmel.com.

The Cerebot Nano has two ways to connect to a TWI bus. The TWI signals, SCL and SDA, are available on 6-pin connector JB or on the 2-pin connector J2.

Pins one and two of connector JB and connector J2 provide two positions for connecting to the TWI signals. By using two-wire cables (available separately from Digilent), a daisy chain of Cerebot Nanos 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. When no device is driving the lines low, pull-up resistors achieve the high state on the TWI lines. A single device on the TWI bus must provide the pull-up resistors.

The Cerebot Nano provides pull-up resistors that are controlled by software.

I/O port B, bits 6 and 7 (PB6 and PB7), are connected to the pull-up resistors. To enable the pull-ups, configure these pins as outputs and set the I/O port output bits to “1”. To disable the pull-ups, configure these pins as inputs with the internal pull-ups disabled. Both TWI pull-ups should be enabled or disabled together. Only one device on the TWI bus should have pull-ups enabled.

A port bit is configured as an input or an output by setting the corresponding bit in the DDR register. The pin becomes an output by writing a “1” and an input by writing a “0”. When a pin is configured as an input, an internal pull-up resistor is enabled by writing the corresponding output port bit to “1” and disabled by writing it to “0”. See the Atmel Atmega168 data sheet for more information.

1.7 On-board User I/O

The Cerebot Nano provides four on-board LEDs for user output. The LEDs are connected to I/O Port D, bits 2-5 (PD2-PD5). An LED is turned on by writing the corresponding DDRD and PORTD register bits to logic 1 and turned off by writing the corresponding PORTD bit to logic 0.

The LED connections are shared with ports JA and JB as follows:

LED1	JB8	PD5
LED2	JA10	PD3
LED3	JB7	PD4
LED4	JA7	PD2

All Pmod port pins can be used for general purpose I/Os. The following table describes how the Cerebot Nano header pins connect to ATmega168 ports/bits.

	Description	Pin	Function	Port/Bit
JA	Analog Input and PmodHB5 Connections JA1 through JA4 can be used as analog inputs in applications and pins JA7 through JA10 are ideally suited for connection with a Digiilent PmodHB5 motor control board.	1	ADC0/PCINT8	PC0
		2	ADC1/PCINT9	PC1
		3	ADC2/PCINT10	PC2
		4	ADC3/PCINT11	PC3
		5	GND	
		6	VCC	
		7	INT0/PCINT18	PD2
		8	OC1A/PCINT1	PB1
		9	ICP1/PCINT0	PB0
		10	INT1/PCINT19	PD3

		11	GND	
		12	VCC	
JB	Serial Communication and General I/O Pins JB1 through JB4 provide access to the TWI and USART communication interfaces. Pins JB7 and JB10 are limited to general I/O and JB8 and JB9 provide access to the output compare pins of Timer/Counter 0.	1	ADC5/SCL/PCINT13	PC5
		2	ADC4/SDA/PCINT12	PC4
		3	RXD/PCINT16	PD0
		4	TXD/PCINT17	PD1
		5	GND	
		6	VCC	
		7	XCK/T0/PCINT20	PD4
		8	T1/OC0B/PCINT21	PD5
		9	AIN0/OC0A/PCINT22	PD6
		10	AIN1/PCINT23	PD7
		11	GND	
		12	VCC	
J1	SPI Interface and In-System Programming When the shorting block on JP1 is in the SS position, J1 is used for the SPI port. When the shorting block on JP1 is in the RST position, J1 is used for in-system programming.	1	PCINT2/SS/OC1B	PB2
		2	PCINT3/OC2A/MOSI	PB3
		3	PCINT4/MISO	PB4
		4	SCK/PCINT5	PB5
		5	GND	
		6	VCC	
J2	TWI Connectors The Atmel TWI interface can be accessed on this connector.	1	ADC5/SCL/PCINT13	PC5
		2	ADC4/SDA/PCINT12	PC4
J4	ADC Input Only Analog to digital input channels 6 and 7 are input-only and have digital I/O capabilities.	1	ADC6	
		2	ADC7	