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Eddie Control Board with Power Connector (#28993)
Eddie Control Board PCB (#550-28990)

The Eddie Control Board provides a complete single-board solution to control the Eddie Robot Platform (28992). Designed to be flexible and expandable, the Eddie Control Board is also well suited for other mobile robot platforms. While the board has a wide input voltage range, it is primarily targeted to 12 VDC battery-powered applications.

The heart of the Eddie Control Board is the Propeller P8X32A microcontroller. The Propeller chip's eight 32-bit cores provide incredible power and flexibility. The board includes high-current motor drivers, an eight-channel 10-bit ADC, and access to lots of digital I/O. Multiple regulated power supplies (12 V, 5 V, and 3.3 V) and three switchable auxiliary power ports support optional accessories for your robot.

This document provides details and specifications about the Eddie Control Board hardware only. For additional information and for details about the latest firmware, go to www.parallax.com/eddie.

Features

- Powered by the Propeller P8X32A with eight 32-bit cores
- Integrated high-current motor drivers
- Eight-channel 10-bit ADC
- Up to 16 general purpose digital I/O
- On-board regulated power supplies for 12 V, 5 V, and 3.3 V.
- Three auxiliary power ports provide switchable battery voltage for accessories
- 5 A auxiliary power fuse, and 20 A motor power fuse
- Four 0.125" diameter mounting holes for #4 screws, spaced at 4.60 x 3.35 in (11.68 x 8.51 cm)

Key Specifications

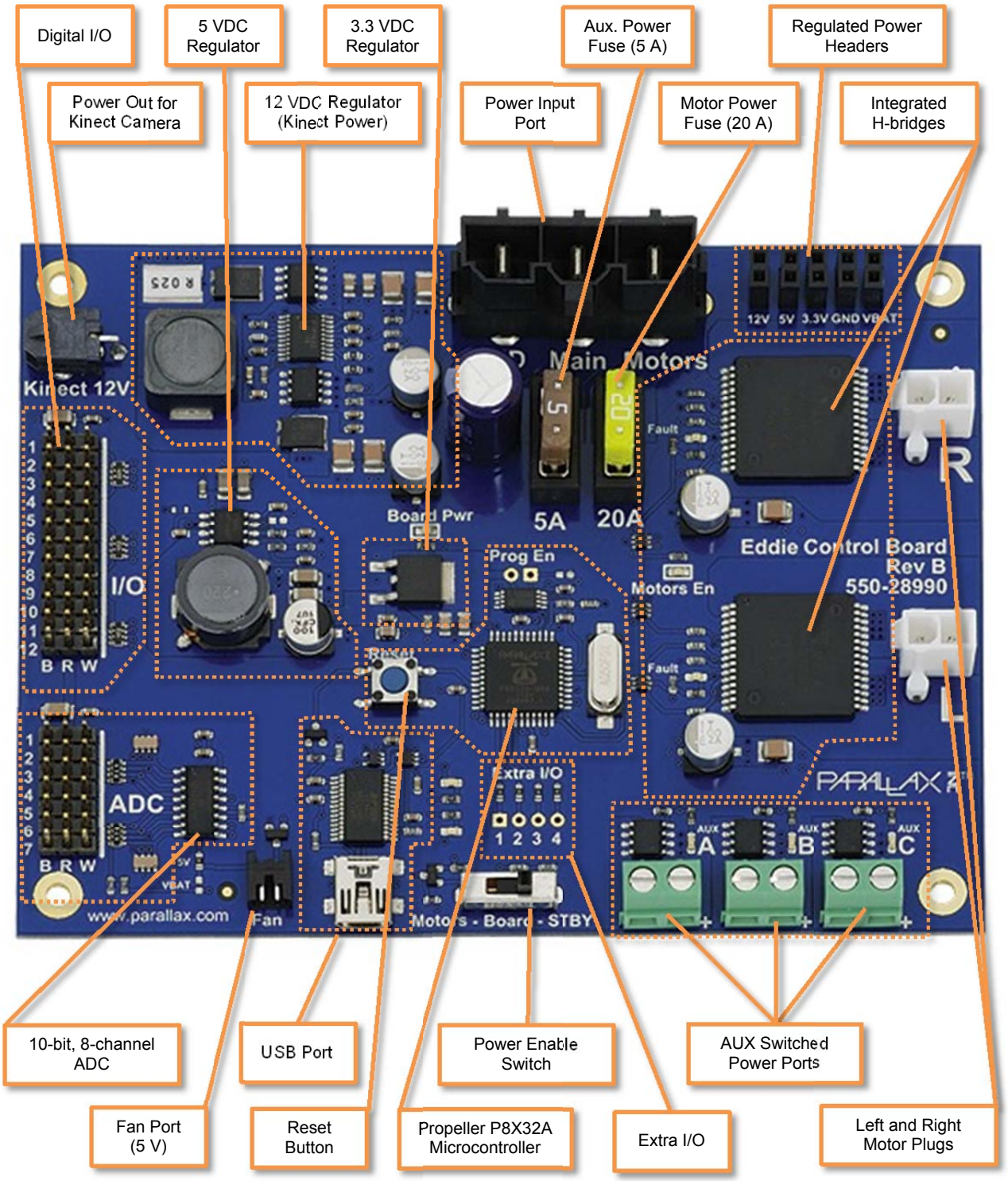
- Power requirements:
  Main board operating voltage (VCC_{MAIN}) 6.75 to 18 V;
  Motor driver operating voltage (VCC_{MOTORS}) 5.5 to 16 V
- Communication Interface: USB mini-B connector (enumerates as a serial COM port)
- Operating temperature: 32 to 158 °F (0 to 70 °C)
- Dimensions: 5.05 x 3.80 x 0.97 in (12.83 x 9.65 x 2.46 cm)

Application Ideas

- Autonomous navigation robots
- Telepresence robots
- Two-wheeled balancing robots
- Robotic arm
- Manufacturing automation equipment

Note: #28993 includes the Eddie Control Board (#550-28990) and the Eddie Control Board Power Connector (#700-00230). When the Eddie Control Board is purchased as part of the Eddie Robot Platform kit (#28992) the Power Connector is not required; that kit includes the Eddie Wiring Harness.

Board Overview



WARNING! 	• After switching main board power off, wait at least 5 seconds before switching power back on. Rapid and repetitive power cycling of the board and motor power supplies causes significant stress on electronic components and may damage the board and/or connected electronic accessories. • After prolonged operation, use care when handling the board as some components may be hot to touch. • This board contains components which are sensitive to static electric discharge. Ensure proper grounding prior to operating on or around the board.

Absolute Maximum Ratings

Absolute Maximum Ratings are limits *beyond* which device damage may occur. Refer to Electrical Characteristics section (page 4) for *operating specifications*.

Symbol	Parameter	Value	Units
Main Board			
VCC_{MAIN}	Supply voltage for main board	24	V
T_A	Operating temperature	0 to 70	°C
T_{ST}	Storage Temperature	-55 to 150	°C
H-bridges			
VCC_{MOTORS}	Supply voltage for motor H-bridges	25	V
$I_{MOTORS(MAX)}$	Maximum H-bridge output current (surge)(1)	20	A
AUX Switched Power Ports			
$I_{D(AUX)}$	Open-drain MOSFET switch current(2)	5	A
ADC			
$V_{IH(ADC)}$	ADC input high voltage	$V_{OUT(5V)}$ + 0.6	V
$V_{IL(ADC)}$	ADC input low voltage	$V_{OUT(5V)}$ – 0.6	V
Digital I/O			
$I_{I/O(MAX)}$	I/O pin current (on any I/O pin)	40	mA
Fan Port			
$I_{D(FAN)}$	Open-drain MOSFET switch current	320	mA

Notes:

1. Each H-bridge has over-current and over-temperature protection; however, repeated stress will reduce life. Therefore the maximum current is limited by the protective 20 A fuse. Maximum current is the combined total for both channels.
2. Maximum current for AUX switched power ports is limited by protective 5 A fuse. Maximum current is the combined total for all channels.

Electrical Characteristics

Unless otherwise noted, all parameters apply at VCC_{Main} = 12V, VCC_{Motors} = 12V, T_A = 0°C to +70°C.
Unless otherwise noted, typical values apply for VCC_{Main} = 12V, VCC_{Motors} = 12V, T_A = +25°C.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
Power Input Port						
VCC_{MAIN}	Supply voltage for main board		6.75		18	V
$I_{MAIN(SUPPLY)}$	Supply current	"OFF" state VCC_{MAIN} = 12V T_A = 25°C		345		µA
		"Board" state VCC_{MAIN} = 12V T_A = 25°C		20.6		mA
12 VDC Regulator						
$V_{OUT(12V)}$	Regulated output voltage		11.7	12.0	12.3	V
$I_{OUT(12V)}$	Maximum total output current		2.2			A
$V_{RIPPLE(12V)}$	Typical V_{OUT} ripple under load	I_{OUT} = 1.2A		200		mV_{P-P}
5 VDC Regulator						
$V_{OUT(5V)}$	Regulated output voltage		4.85	5.0	5.15	V
$I_{OUT(5V)}$	Maximum total output current		3.0			A
$V_{RIPPLE(12V)}$	Typical V_{OUT} ripple under load	I_{OUT} = 500mA		15		mV_{P-P}
3.3 VDC Regulator						
$V_{OUT(3.3V)}$	Regulated output voltage		3.23	3.3	3.37	V
$I_{OUT(3.3V)}$	Maximum total output current[1]	$T_A \leq 25°C$	1000			mA
		T_A = 70°C	625			mA
H-bridges[2]						
VCC_{MOTORS}	Supply voltage for motor H-bridges		5.5		16	V
$I_{MOTORS(SUPPLY)}$	Supply Current	"OFF" state VCC_{MOTORS} = 12V T_A = 25°C		22		µA
		"Motors" state VCC_{MOTORS} = 12V T_A = 25°C		4.5		mA
$I_{OUT(MOTOR)}$	Motor driver continuous output current				±10	A
R_{ONHS}	Static high-side resistance				28	mΩ
R_{ONLS}	Static low-side resistance				10	
f_{PWM}	PWM frequency		0		20	kHz
$t_{OFF(MIN)}$	PWM minimum off time[3]				6	µs

Symbol	Parameter	Conditions	Min	Typ	Max	Units
AUX Switched Power Ports[4]						
$V_{DSS(AUX)}$	Drain-source breakdown voltage		30			V
$I_{D(AUX)}$	Continuous drain current[5]				5	A
$R_{DS-ON(AUX)}$	Static drain-source on-resistance			22		mΩ
ADC[6]						
V_{RANGE}	Input voltage range for ADC1-7 pins		0		$V_{OUT(5V)}$	V
LSB	Least significant bit (resolution)			4.88		mV/bit
f_{CLK}	ADC clock frequency				3.6	MHz
t_{CONV}	ADC sample conversion time				10	clk cyc.
t_{SAMPLE}	ADC input sample time				1.5	clk cyc.
f_{SAMPLE}	ADC throughput rate				200	Ksps
Digital I/O[7]						
R_S	Protective series resistance			4.7		kΩ
Fan Port						
$I_{D(FAN)}$	Continuous drain current		250			mA

Notes:

1. The 3.3 V linear regulator can supply up to 1 A at 25 °C. Above 25 °C, maximum current is de-rated according to ambient temperature (T_A) based on the following equation: $I_{OUT(3.3V)} = (150\ °C - T_A)/(75°\ C/W * 1.7\ V)$.
2. For further details and specifications for the H-bridge drivers, please refer to the component datasheet for the STMicroelectronics VNH2SP30-E.
3. To avoid false Short to Battery detection during PWM operation, the PWM signal must be low for a time longer than 6 µs.
4. For further details and specifications for the low-side AUX power MOSFET switches, please refer to the component datasheet for the Diodes Inc. DMG4496SSS.
5. Maximum MOSFET open-drain output current is limited by protective 5 A fuse.
6. For further details and specifications for the ADC, please refer to the component datasheet for the Microchip MCP3008.
7. For further details and specifications for the Propeller microcontroller and its I/O pin capabilities please see the P8X32A component datasheet.

Operating Description

Power Input Port

Main board power and motor power are supplied to the board through a high-current 3-pin header. The header is part of the Molex Mini-Fit Sr. series of connectors. The pin functions are shown below.

Pin	Function
GND	Common ground for main board power and motor power
Main	Input supply for main board circuitry, power supplies, and AUX switched power ports.
Motors	Power supply for H-bridge drivers only. Power to this pin is routed through the 20 A fuse.

The isolation of the Motor power supply from the rest of the board and Main circuitry allows the motors to be fully disabled without affecting operation or power to any other part of the board.

12 VDC Regulator

The integrated 12 VDC buck-boost switching regulator provides a consistent stable output voltage across the entire operating input voltage range. For high values of VCC_{MAIN} the regulator operates entirely in buck mode, but as input voltage decreases the regulator gradually transitions into a buck-boost mode to seamlessly maintain the output voltage at 12 V.

The 12 VDC regulator circuit is designed to supply power to a Microsoft Kinect camera through the board-mounted Molex Micro-Fit 3.0 header. Supplied with each Eddie Robot Platform (28990 and 28992), the modified Kinect adapter cable uses the corresponding mating connector to allow easy assembly.

The Kinect camera requires a 12 V power supply rated up to 1.08 A capacity. The on-board 12 VDC regulator circuitry was intentionally designed to supply up to 2.2 A total output current to accommodate any extra user-added circuitry requiring regulated 12 V. The regulated power header marked "12V" provides convenient access to this 12 VDC regulated supply. Users may draw up to the full rated 2.2 A from this header; however when a Kinect camera is attached, no more than 1.12 A should be drawn from this header to remain below stated limits and ensure proper operation.

5 VDC Regulator

The integrated 5 VDC buck switching regulator provides up to 3 A total current to several on-board circuits as well as any attached 5 V sensors and accessories. The 5 VDC regulator also supplies power to the 3.3 V linear regulator. The center column of pins on the Digital I/O headers and ADC headers are connected directly to this 5 VDC regulated supply. The regulated power header marked "5 V" also provides convenient access to this power supply.

3.3 VDC Regulator

The 3.3 VDC linear regulator provides clean supply voltage to the Propeller microcontroller and other associated 3.3 V circuitry. Note: under certain conditions instantaneous high-current step transients may cause ringing in the output voltage.

At T_A = 25°C, the regulator can supply up to 1 A total output current, but at higher temperature the maximum current must be de-rated according to ambient temperature (T_A) based on the following equation:

$$I_{OUT(3.3V)} = \frac{150\,℃ - T_A}{75\,\frac{℃}{W} \times 1.7V}$$

Regulated Power Headers

For convenience, 2-pin female headers are installed to provide access to each regulated supply net. Power may be drawn from these headers to power additional user-circuitry as long as the total output current for each regulator does not exceed the specified ratings.

Power Enable Switch

The power enable switch controls the operating mode of the regulators and H-bridges according to the state table shown below.

Position	State of Operation	
	12 VDC and 5 VDC Regulators	H-bridge Drivers
STBY/OFF[(1)]*	Disabled	Disabled
Board	Enabled	Disabled
Motors	Enabled	Enabled

Notes:

1. Rev A boards show silkscreen text as "OFF", while Rev B and later boards show silkscreen text as "STBY". The circuits relating to this feature were not changed.

In the "STBY/OFF" state, *the switch does not actually break the electrical connection* to the entire board. All the circuits are disabled but battery power is still present and a very small amount of current is drawn (typically around 345 μA). The Eddie Robot Platform comes with large capacity sealed lead-acid batteries totaling 14.4 Ah, so this small current draw is insignificant. In fact, the batteries' own self-discharge rate is several times larger than the standby current of the Eddie Control Board. Additionally, sealed lead-acid batteries should be recharged at least every few months to maintain proper battery health regardless of whether the batteries were used or not.

In applications where battery capacity is in question, external high-current (25 A minimum recommended) power switches should be wired in series with the "Main" and/or "Motors" terminals on the power input port connector.

H-bridges

The board is equipped with two high-current integrated full H-bridge drivers. While each H-bridge IC is technically rated up to a maximum of 30 A output current (according to the device datasheet), design trade-offs and thermal limitations require each driver be de-rated to 10 A continuous per channel. This is more than adequate for the motors included in the Eddie Robot Platform as well as motors typically used in most small to mid-sized robotics applications.

The "Motors" terminal on the power input port is connected to the supply voltage of each H-bridge through a 20 A mini-blade automotive fuse. For safety and circuit reliability, this fuse should only be replaced with an equivalent 20 A fast-blow mini-blade fuse.

AUX Switched Power Ports

The auxiliary (AUX) switched power ports provide unregulated power from the "Main" terminal on the power input port through a 5 A mini-blade automotive fuse to the '+' side (on the right) of each screw terminal. A power MOSFET switch then selectively switches the low side of the terminal (on the left) to ground, turning on whatever accessory is connected to the port. The MOSFET gates for switches A, B, and C are connected to Propeller pins P16, P17, and P18 respectively. These AUX switched power ports are very useful for powering LED light strips, auxiliary motors, and other electronic accessories and allows for these devices to be controlled in software.

Propeller Microcontroller

The Propeller P8X32A contains eight 32-bit microcontroller cores each operating at up to 80 MHz. An on-board 512 K-bit EEPROM provides storage for program memory as well as ample storage for additional non-volatile data. Application firmware can be loaded into RAM or automatically loaded from the external EEPROM on power-up.

In some applications it may be useful to lock the firmware into EEPROM so it cannot be overwritten either intentionally or unintentionally. For this purpose, through-hole pads were provided as an option to install a header or jumper wire to disable EEPROM write capability. By default, the pads are left unpopulated so reading, writing, and programming are fully enabled. When a jumper is installed to short the two pads together, then EEPROM programming/writing is disabled but reading will still be enabled.

A 5 MHz crystal oscillator and reset button complete the onboard Propeller circuitry.

Digital I/O and Extra I/O

Most of the Propeller's 32 general purpose I/O pins are used to interface with on-board peripherals, or connect to headers for sensor interfacing. While there are already 12 general purpose digital I/O pins brought out (including the Encoders section), each of these pins has a 4.7 kΩ series resistor for protection. This allows direct 3.3 V or 5 V sensor interfacing while preventing damage to the Propeller. However in situations where direct connection to Propeller I/O pins is necessary (or using a resistance other than 4.7 kΩ), four "Extra I/O" pins have been brought out to pads through 0 Ω resistors. If necessary, the 0 Ω resistors can be replaced with any other desired value.

The Digital I/O pins are brought out to twelve 3-pin headers near the edge of the board. The order of the pins from left to right is: Ground, 5 V, Signal. Some rules of thumb to remember this order is to keep the signal wire (typically colored white) close to the white silkscreen line located toward the center of the board (to the right of the header). Additionally, having the signal wires oriented toward the center of the board results in the shortest signal path back to the Propeller I/O pins.

ADC

For the analog to digital converter, the board is equipped with the Microchip MCP3008 which is an 8-channel, 10-bit ADC. For further device details about this ADC, please refer to the manufacturer's datasheet.

On this board, only seven of the eight ADC channels are brought out to 3-pin headers. The eighth channel is connected through a voltage divider to VCC_{MAIN}, the main supply voltage to the board. This allows convenient measurement and monitoring of the battery voltage level by application code.

Fan Port

During typical operation, the power dissipated by all the circuits will be minimal and a cooling fan is not necessary. However, when power dissipation becomes an issue due to continuously high motor output current or current draw from the regulators near the stated maximum limits, a cooling fan can be used to improve and extend circuit operation.

The fan port is populated with a 0 Ω resistor to the 5 VDC net (located near the fan port just below the ADC). Many 12 V fans still operate well at 5 V and are typically much quieter. If desired, the 0 Ω resistor can be de-soldered and repositioned directly below its current location to instead route VCC_{MAIN} to the fan port. Note that in this configuration, the low-side MOSFET switch will still turn off when the power enable switch is in the "STBY/OFF" state.

Additional Resources and Information

For additional information and resources go to www.parallax.com/eddie.

Revision History

Version 1.0

- Initial product documentation release.

Version 1.1

- In Power Enable Switch section (page 7), updated table and notes to mention silkscreen differences from Rev A to Rev B and later boards.
- Added further explanation in the Fan Port section (page 8) about voltage configurability option.

Version 1.2

- Updated images for Rev B of the board. Note added to the bottom of page 1.