2x150A or 1x300A High Performance Dual Channel Brushed DC Motor Controller with and CAN Interface

Roboteq's HDC2400 series controllers are designed to convert commands received from a RC radio, Analog Joystick, wireless modem, PC (via RS232 or USB) or microcomputer into high voltage and high current output for driving one or two DC motors. Designed for maximal ease-of-use, it is delivered with all necessary cables and hardware and is ready to use in minutes. Using CAN bus, up to 127 controllers can be networked at up to 1Mbit/s on a single twisted pair.

The controller features a high-performance 32-bit microcomputer and quadrature encoder inputs to perform advanced motion control algorithms in Open Loop or Close Loop (Speed or Position) modes. The HDC2400 series features a high number of Analog, Pulse and Digital I/Os which can be remapped as command or feedback inputs, limit switches, or many other functions. The controller's two motor channels can either be operated independently or mixed to set the direction and rotation of a vehicle by coordinating the motion of each motor.

Numerous safety features are incorporated into the controller to ensure reliable and safe operation. The controller's operation can be extensively automated and customized using Basic Language scripts. The controller can be reprogrammed in the field with the latest features by downloading new operating software from Roboteq.

Applications

- Industrial Automation
- Tracking, Pan & Tilt systems
- Terrestrial and Underwater Robotic Vehicles
- Automatic Guided Vehicles
- Police and Military Robots
- Flight simulators
- Telepresence Systems
- Animatronics

Features List

- USB, RS232, 0-5V Analog, or Pulse (RC radio) command modes
- RS485 Interface on selected models
- Available in version with CAN bus up to 1Mbit/s
- Auto switch between USB, RS232, CAN, Analog, or Pulse based on user-defined priority
- Built-in high-power power drivers for two brushed DC motors at up to 150A output per channel
- Orderable as single channel version up to 300A
- Full forward & reverse control on each channel. Four quadrant operation. Supports regeneration
- Built-in programming language for automation and customization
- Operates from a single power source
- Programmable current limit for each channel up to 2x150A or 1x300A for protecting controller, motors, wiring and battery.
- Up to 11 Analog Inputs for use as command and/or feedback
- Up to six Pulse Length, Duty Cycle or Frequency Inputs for use as command and/or feedback
- Up to 21 Digital Inputs for use as Deadman Switch, Limit Switch, Emergency stop or user inputs
- Dual Quadrature Encoder inputs with 32-bit counters
- Eight general purpose 24V, 1A output for brake release or accessories
- Custom scripting in Basic language. Execution speed 50,000+ lines per second
- Selectable min, max, center and deadband in Pulse and Analog modes
- Selectable exponentiation factors for each command inputs
- Trigger action if Analog, Pulse or Encoder capture are outside user selectable range (soft limit switches)
- Open loop or closed loop speed control operation

- Closed loop position control with analog or pulse/frequency feedback
- Precise speed and position control when Encoder feedback is used
- PID control loop with separate gains for each channel
- Multi-range PID gains changing on-the-fly according to motor speed
- Optional Mixed control (sum and difference) for tank-like steering
- Configurable Data Logging of operating parameters on RS232 Output for telemetry or analysis
- Built-in Battery Voltage and Temperature sensors
- Optional 12V backup power input for powering safely the controller if the main motor batteries are discharged
- Power Control wire for turning On or Off the controller from external microcomputer or switch
- No consumption by output stage when motors stopped
- Regulated 5V output for powering Encoders, RC radio, RF Modem or microcomputer
- Separate Programmable acceleration and deceleration for each motor
- Separate Programmable maximum forward and reverse power
- Support for CANopen and two simplified CAN protocols
- Ultra-efficient 1.5 mOhm ON resistance MOSFETs
- Stall detection and selectable triggered action if Amps is outside user-selected range
- Short circuit protection with selectable sensitivity levels
- Overvoltage and Undervoltage protection
- Programmable Watchdog for automatic motor shutdown in case of command loss
- Overtemperature protection
- Diagnostic LED
- Extruded aluminum, heat sinking enclosure for operation harsh shock and temperature environment
- Efficient heat sinking. Operates without a fan in most applications.
- Dustproof and weather resistant. IP51 NEMA rating
- Power wiring via heavy AWG8 cables
- Dimensions: 9" (228.5mm) L, 5.5" W (140mm), 1.6" (40mm) H
- -40° to +85° C operating environment
- Weight: 3 lbs (1,350g)
- Easy configuration, tuning and monitor using provided PC utility
- Field upgradeable software for installing latest features via the Internet

Orderable Product References

Reference	Number of Channels	Amps/Channel	Volts
HDC2460	2	150	60
HDC2460S	1	300	60
HDC2496 (Discontinued)	2	100	96
HDC2496S (Discontinued)	1	200	96

Important Safety Disclaimer

Dangerous uncontrolled motor runaway condition can occur for a number of reasons, including, but not limited to: command or feedback wiring failure, configuration error, faulty firmware, errors in user script or user program, or controller hardware failure.

The user must assume that such failures can occur and must make his/her system safe in all conditions. Roboteq will not be liable in case of damage or injury as a result of product misuse or failure.

Hardware Revisions

The HDC2400 family has undergone three major, 100% backwards compatible, updates since its introduction.

Hardware revision can be determined by the label located on the bottom side of the case, and are: RCB5, RCB53, H26.

Unless otherwise noted, information in this datasheet applies to all hardware versions.

Motor and Power Connections

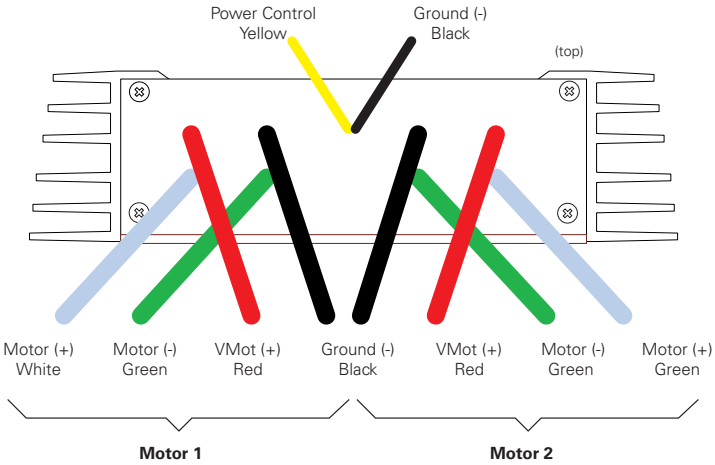

FIGURE 1. Rear Controller Layout

Figure 2, below, shows how to wire the controller and how to turn power On and Off.

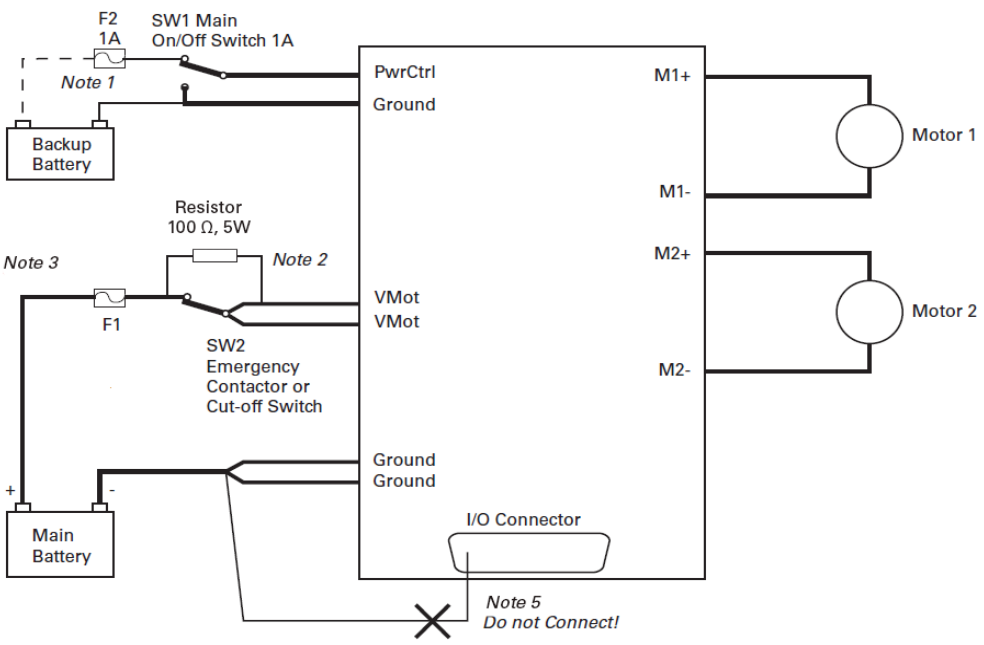

FIGURE 2. Powering the Controller. Thick lines identify MANDATORY connections

Important Warning

Carefully follow the wiring instructions provided in the Power Connection section of the User Manual.

The information on this datasheet is only a summary.

Mandatory Connections

It is imperative that the controller is connected as shown in Figure 3, above, in order to ensure a safe and trouble-free operation. All connections shown as thick black lines line are mandatory. The controller must be powered On/Off using switch SW1on the Yellow wire. Use a suitable high-current fuse F1 as a safety measure to prevent damage to the wiring in case of major controller malfunction.

Emergency Switch or Contactor

The battery must be permanently connected to the controller's Red wires via a high-power emergency switch or contactor SW2 as additional safety measure. The user must be able to deactivate the switch or contactor at any time, independently of the controller state.

Electrostatic Discharge Protection

In accordance with IEC 61000-6-4, Roboteq Motor Controllers are designed to withstand ESD up to 4kV touch and 8kV air gap. This protection is implemented without any additional external connections required.

Some specifications, such as EN12895, require a higher level of protection. To maximize ESD protection, up to 8kV touch and 15kV air gap, you may connect the metallic heatsink of the controller to your battery negative terminal. See App Note 062918 for example connections.

Precautions and Optional Connections

Note 1: Backup battery to ensure motor operation with weak or discharged batteries, connect a second battery to the Power Control wire/terminal via the SW1 switch. For 96V version controllers, the maximum voltage that should be applied to Power Control (PwrCtrl) is 60V. Applying a voltage >60V to PwrCtrl will damage the controller
Note 2: Use precharge 100Ω, 5W Resistor to prevent switch arcing.
Note 3: The voltage generated by motors rotating while not powered by the controller can cause serious damage even if the controller is Off or disconnected.

- Use the main SW1 switch on the Power Control wire/terminal to turn Off and keep Off the controller. In this way the controller cannot be powered up under any unwanted circumstances.
- Countermeasures should be taken to deal with any regeneration power if the battery or BMS system does not support energy to return back to it.
- Disconnecting the controller from the battery while motors are rotating could lead to a serious damage. In this case a regeneration brake system is needed.

Note 4: Connect the controller's earth tab to a wire connected to the Earth while the charger is plugged in the AC main, or if the controller is powered by an AC power supply.
Note 5: Beware not to create a path from the ground pins on the I/O connector and the battery's minus terminal.

Single Channel Wiring

On the Single Channel HDC24xxS, each of the wires of the same color must be wired together.

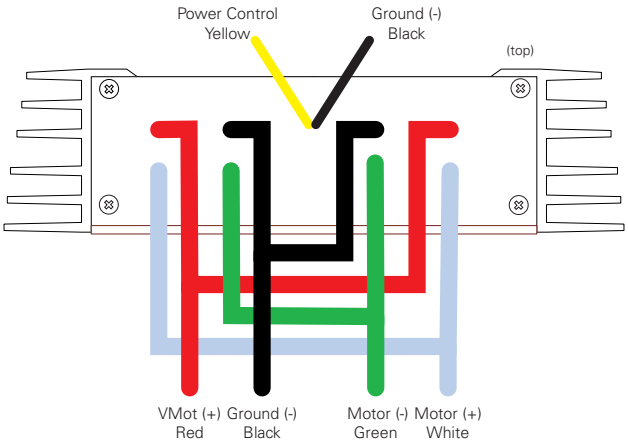

FIGURE 3. Controller wiring for single channel operation

Important Warning

This wiring must be done only on the single channel version of the controller. Paralleling the wires on a dual channel product will cause permanent damage. Verify that your controller is an HDC24xxS before you wire in this manner.

Use of Safety Contactor for Critical Applications

An external safety contactor must be used in any application where damage to property or injury to person can occur because of uncontrolled motor operation resulting from failure in the controller's power output stage.

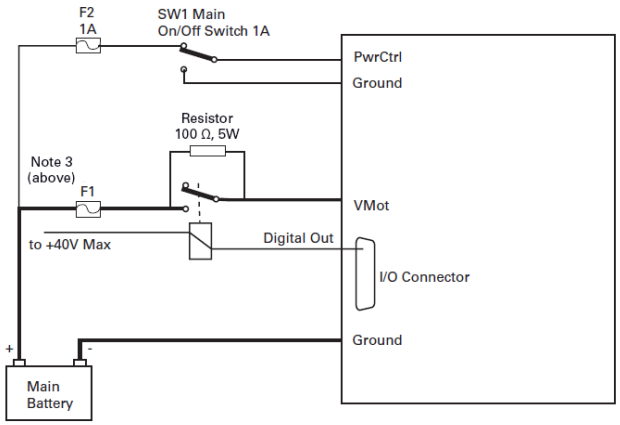

FIGURE 4. Contactor Wiring Diagram

Note: This wiring should not be used for 96V version controllers (HDC2496(S)). This would apply a voltage >60V to PwrCtrl and damage the controller. The wiring shown in FIGURE 2 is recommended for the HDC2496(S).

The contactor coil must be connected to a digital output configured to activate when "No MOSFET Failure". The controller will automatically deactivate the coil if the output is expected to be off and battery current of 2.5A or more is measured for more than 0.5s. This circuit will not protect against other sources of failure such as those described in the "Important Safety Disclaimer" on Page 3.

Measured and Calculated Amps

The controller includes Amps sensor in line with the battery ground wires. Battery Amps are therefore measured with precision. Motor Amps are estimated using the formula Motor Amps = Battery Amps / PWM. This formula produces accurate results from 20% PWM and above. No Motor Amps are reported at 0% PWM.

Controller Mounting

During motor operation, the controller will generate heat that must be evacuated. The published amps rating can only be fully achieved if adequate cooling is provided. Always operate the controller in a well ventilated space so that air can flow between the heat-sink fins. Additional conduction cooling can be achieved by having the bottom edges of the case making contact with a metallic surface (chassis, cabinet).

Sensor and Commands Connection

Connection to RC Radio, Microcomputer, Joystick and other low current sensors and actuators is done via the 25 and 9 pin connectors located in front of the connector. The functions of many pins vary depending on controller model and user configuration. Pin assignments are found in Table 2, below.

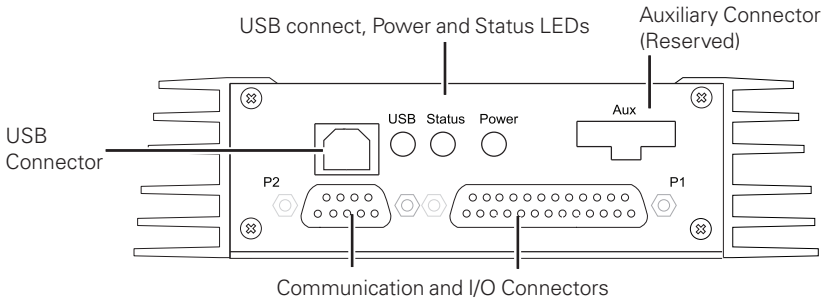

FIGURE 5. Front Controller Layout

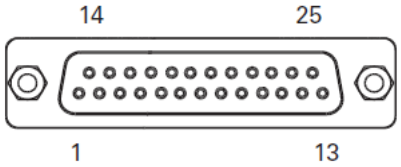

FIGURE 6. Main Connector Pin Locations

TABLE 1.

Connector Pin	Power	Dout	Com	Pulse	Ana	Dinput	Enc	Default Config
1	GND							
14	5VOut							
2			TxData					RS232Tx
15				PIN1	ANA1	DIN1		RCRadio1
3			RxData					RS232Rx
16				PIN2	ANA2	DIN2		RCRadio2
4				PIN3	ANA3	DIN3		AnaCmd1 (1)
17				PIN4	ANA4	DIN4		AnaCmd2 (1)
5	GND							
18		DOUT1				DIN12		Motor Brake 1
6		DOUT2				DIN13		Motor Brake 2
19		DOUT3				DIN14		Safety Contactor
7		DOUT4				DIN15		Unused
20		DOUT5				DIN16		Unused
8		DOUT6				DIN17		Unused
21					ANA5	DIN5		Unused
9	GND							
22				PIN6 (2)	ANA6	DIN6		Unused
10					ANA7	DIN7		Unused
23							ENC2B	Unused
11							ENC2A	Unused
24					ANA10	DIN10	ENC1B	Unused
12					ANA11	DIN11	ENC1A	Unused
25	5VOut							
13	GND							

Note 1: Analog command is disabled in factory default configuration.
Note 2: Present only in version labeled HR26 of the HDC24xx hardware

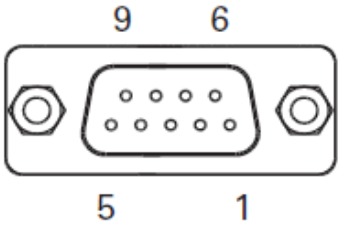

FIGURE 7. Secondary Connector Pin Locations

TABLE 2.

Connector Pin	Power	Dout	Com	Pulse	Ana	Dinput	Default Config
5		DOUT7				DIN18	Unused
9	5VOut						
4			RS485+(1)				RS485+
8			RS485- (1)				RS485-
3	GND						
7			CANH				CAN High
2			CANL				CAN Low
6	GND						
1		DOUT8				DIN19	Unused
Note 1: RS485 is present only in version labeled HR26 of the HDC24xx hardware							

Default I/O Configuration

While the controller can be configured so that practically any Digital, Analog and RC pin can be used for any purpose, the controller's factory default configuration provides an assignment that is suitable for most applications. The figure below shows how to wire the controller to two analog potentiometers, an RC radio, and the RS232 port. It also shows how to connect two outputs to motor brake solenoids and another output to an external status LED. You may omit any connection that is not required in your application. The controller automatically arbitrates the command priorities depending on the presence of a valid command signal in the following order: 1-RS232, 2-RC Pulse, 3-None. If needed, use the Roborun+ PC Utility to change the pin assignments and the command priority order.

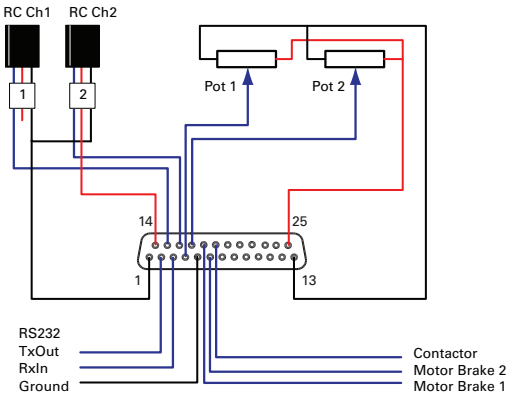

FIGURE 8. Factory Default Pin Assignment

Enabling Analog Commands

For safety reasons, the Analog command mode is disabled by default. To enable the Analog mode, use the PC utility and set Analog in Command Priority 2 or 3 (leave Serial as priority 1). Note that by default the additional securities are enabled and will prevent the motor from starting unless the potentiometer is centered, or if the voltage is below 0.25V or above 4.75V. The drawing shows suggested assignment of Pot 1 to ANA1 and Pot 2 to ANA4. Use the PC utility to enable and assign analog inputs.

Serial Communication

The controller has a full RS232 compatible serial interface. In versions labelled RCB53 and HR26 of the HDC24xx. the serial port can can also easily be connected to devices with TTL serial using a simple resistor and diodes circuit. See user manual for details.

CAN Bus Operation

The controller can interface to a standard CAN Bus network, using three possible protocols: Standard CANOpen, and three proprietary schemes (MiniCAN, RoboCAN and RawCAN). Please refer to the User Manual for details. Note that on old versions - labeled RCB5 - of the HDC24xx, USB and CAN cannot operate at the same time. The controller starts up with CAN available, but CAN will be disabled as soon as the controller is plugged into USB. To re-enable CAN, disconnect USB and restart the controller. On new versions - labeled RCB53 and H26 - USB and CAN can be operated simultaneously.

RS485 Communication

The latest HDC24xx hardware - labeled HR26 - has a half-duplex RS485 interface. Two signals are present on the 9-pin DSub connector for connecting to RS485 networks. Connecting these two wires with the correct polarity is all that is needed to establish a connection. The RS485+ is the positive signal and RS485- is the inverted signal. Once enabled, the RS485 can be used to communicate data under the Modbus protocol, or Roboteq's native serial commands.

USB communication

Use USB only for configuration, monitoring and troubleshooting. USB is not a reliable communication method when used in a electrically noisy environments and communication will not always recover after it is lost without unplugging and replugging the connector, or restarting the controller. RS232 is the preferred method of communication when interfacing to a computer.

Status LED Flashing Patterns

After the controller is powered on, the Power LED will tun on, indicating that the controller is On. The Status LED will be flashing at a two seconds interval. The flashing pattern and color provides operating or exception status information. Note that earlier versions of the HDC24xx hardware have a monochrome status LED.

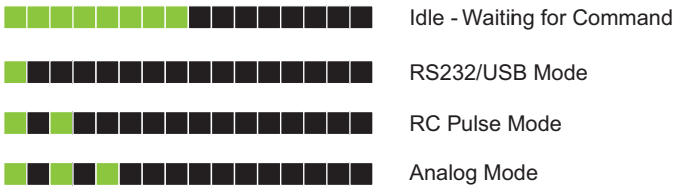

FIGURE 9. Normal Operation Flashing Patterns

FIGURE 10. Exception or Fault Flashing Patterns

Additional status information may be obtained by monitoring the controller with the PC utility.

The communication LED gives status information on the CAN and USB.

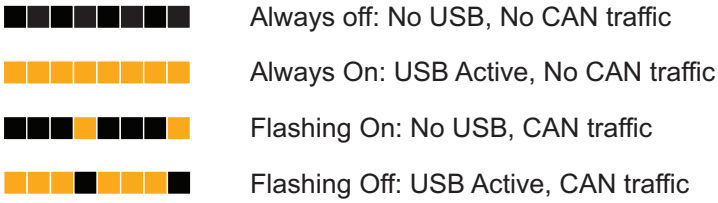

FIGURE 11. Com Led

Battery Backed Clock and RAM

The controller includes a real-time clock/calendar and Non-Volatile RAM storage for user variables. Both the clock and the RAM storage require a battery to continue running and for the stored data not to be lost while the controller is powered down. The battery is not installed by Roboteq. Users who wish to use the clock and/or battery backed RAM variables must install a battery themselves. The battery socket can be reached by removing the bottom cover to reach the board and insert a 3V, 12.5mm coin-style battery. Use battery type CR1225 or equivalent. Battery holder is present only in recent HDC24xx hardware versions. It is not present in version labeled RCB5.

Electrical Specifications

Absolute Maximum Values

The values in the table below should never be exceeded, Permanent damage to the controller may result.

TABLE 3.

Parameter	Measure point	Models	Min	Typical	Max	Units
		HDC2460(S)			60	Volts
		HDC2496(S)	36		100	Volts
Reverse Voltage on Battery Leads	Ground to VMot	All	-1			Volts
Power Control Voltage	Ground to Pwr Control wire	All			60	Volts
		HDC2460(S)			60 (1)	Volts
		HDC2496(S)	36		100 (1)	Volts
Digital Output Voltage	Ground to Output pins	All			30	Volts
Analog and Digital Inputs Voltage	Ground to any signal pin on 25 & 9-pin connectors	All			30	Volts
RS232 I/O pins Voltage	External voltage applied to Rx pin (2)	All			15	Volts
Case Temperature	Case	All	-40		85	ºC
Humidity	Case	All			100 (3)	%

Note 1: Maximum regeneration voltage in normal operation. Never inject a DC voltage from a battery or other fixed source
Note 2: No voltage must be supplied to the RS232 Tx pin
Note 3: Non-condensing Non-condensing

Power Stage Electrical Specifications (at 25 ºC ambient)

TABLE 4.

Parameter	Measure point	Models	Min	Typical	Max	Units
Battery Leads Voltage	Ground to VMot		0 (1)		50	Volts
		HDC2460(S)	0 (1)		60	Volts
		HDC2496(S)	36 (1)		100	Volts
Motor Leads Voltage	Ground to M1+, M1-, M2+, M2-		0 (1)		50 (2)	Volts
		HDC2460(S)	0 (1)		60 (2)	Volts
		HDC2496(S)	36 (1)		100 (2)	Volts
Power Control Voltage	Ground to Power Control wire	All	0 (1)		65	Volts
Minimum Operating Voltage	VMot or Pwr Ctrl wires	All	9 (3)			Volts
Over Voltage protection range	Ground to VMot		5	50 (4)	50	Volts
		HDC2460	5	60 (4)	60	Volts
		HDC2496(S)	5	96 (4)	100	Volts
Under Voltage protection range	Ground to VMot		0	5 (4)	50	Volts
		HDC2460	0	5 (4)	60	Volts
		HDC2496(S)	0	5 (4)	100	Volts

TABLE 4.

Parameter	Measure point	Models	Min	Typical	Max	Units
Idle Current Consumption	VMot or Pwr Ctrl wires	All	50	100 (5)	150	mA
ON Resistance (Excluding wire resistance)	VMot to M+, plus M- to Ground at 100% power. Per channel	HDC2460/96		3		mOhm
		HDC2460S/96		1.5		mOhm
Max Current per channel for 30s	Ch1 or Ch2 Motor current	HDC2460			150 (6)	Amps
		HDC2496			100 (6)	Amps
		HDC2460S			300 (6)(7)	Amps
		HDC2496S			200 (6)(7)	Amps
Continuous Max Current per channel	Ch1 or Ch2 Motor current	HDC2460			80 (8)	Amps
		HDC2496			60 (8)	Amps
		HDC2460S			160 (7)(8)	Amps
		HDC2496S			120 (7)(8)	Amps
Current Limit range	Ch1 or Ch2 Motor current	HDC2460	10	100 (9)	150	Amps
		HDC2496	10	80 (9)	100	Amps
		HDC2496S	10	160 (9)	200 (7)	Amps
Stall Detection Amps range	Ch1 or Ch2 Motor current	HDC2460	10	100 (9)	150	Amps
		HDC2496	10	80 (9)	100	Amps
		HDC2460S	10	200 (9)	300 (7)	Amps
		HDC2496S	10	160 (9)	200 (7)	Amps
Stall Detection timeout range	Ch1 or Ch2 Motor current	All	1	65000 (10)	65000	ms
Short Circuit Detection threshold (11)	Between Motor wires or Between Motor wire and Ground	HDC2460			180	Amps
		HDC2496			120	Amps
		HDC2460S			360	Amps
		HDC2496S			240	Amps
Short Circuit Detection threshold	Between Motor wires and VMot	All	No Protection. Permanent damage will result			
Motor Acceleration/ Deceleration range	Ch1 or Ch2	All	100	500 (12)	65000	millisec-onds

Note 1: Negative voltage will cause a large surge current. Protection fuse needed if battery polarity inversion is possible
Note 2: Maximum regeneration voltage in normal operation. Never inject a DC voltage from a battery or other fixed source
Note 3: Minimum voltage must be present on VMot or Power Control wire
Note 4: Factory default value. Adjustable in 0.1V increments
Note 5: Current consumption is lower when higher voltage is applied to the controller's VMot or PwrCtrl wires
Note 6: Max value is determined by current limit setting. Duration is estimated and is dependent on ambient temperature cooling condition
Note 7: Current is sum of both synchronized channels. Current must be balanced between channel to obtain max current.
Note 8: Estimate. Limited by case temperature. Current may be higher with better cooling
Note 9: Factory default value. Adjustable in 0.1A increments
Note 10: Factory default value. Time in ms that Stall current must be exceeded for detection
Note 11: Controller will stop until zero command given in case of short circuit detection
Note 12: Factory default value. Time in ms for power to go from 0 to 100%

Command, I/O and Sensor Signals Specifications

TABLE 5.

Parameter	Measure point	Min	Typical	Max	Units
Main 5V Output Voltage	Ground to 5V pins on	4.6	4.75	5.1	Volts
5V Output Current	5V pins on DSub25 and DSub9			100 (1)	mA
Digital Output Voltage	Ground to Output pins			30	Volts
Digital Output Current	Output pins, sink current			1 (2)	Amps
Output On resistance	Output pin to ground		0.75	1.5	Ohm
Output Short circuit threshold	Output pin	1.05	1.4	1.75	Amps
Input Impedances	AIN/DIN Input to Ground		53		kOhm
Digital Input 0 Level	Ground to Input pins	-1		1	Volts
Digital Input 1 Level	Ground to Input pins	3		30	Volts
Analog Input Range	Ground to Input pins	0		5.1	Volts
Analog Input Precision	Ground to Input pins		0.5		%
Analog Input Resolution	Ground to Input pins		1		mV
Pulse durations	Pulse inputs	20000		10	us
Pulse repeat rate	Pulse inputs	50		250	Hz
Pulse Capture Resolution	Pulse inputs		1		us
Minimum Pulse on or Pulse off duration	Pulse inputs	25			us
Frequency Capture	Pulse inputs	100		2000	Hz
Encoder count	Internal	-2.147		2.15	10^9 Counts
Encoder frequency	Encoder input pins			500	kHz
Note 1: Sum of all 5VOut outputs Note 2: Total average current on all outputs not to exceed 4.5A					

Operating & Timing Specifications

TABLE 6.

Parameter	Measure Point	Min	Typical	Max	Units
Command Latency	Command to output change	1	0.5	1	ms
Maximum PWM Duty Cycle	Maximum PWM Duty Cycle			93.8	%
Closed Loop update rate	Internal		1000		Hz
USB Rate	USB pins			12	MBits/s
RS232 baud rate	Rx & Tx pins		115200 (1)		Bits/s
RS232 Watchdog timeout	Rx pin	1 (2)		65000	ms
Note 1: 115200, 8-bit, no parity, 1 stop bit, no flow control Note 2: May be disabled with value 0					

Scripting

TABLE 7.

Parameter	Measure Point	Min	Typical	Max	Units
Scripting Flash Memory	Internal		32000		Bytes
Integer Variables	Internal		4096		Words (1)
Boolean Variables	Internal		8192		Symbols
Execution Speed (2)	Internal	30,000		70,000	Lines/s
Note 1: 32-bit words Note 2: Execution Speed was calculated based on low communication load with the controller. In high communication workload, minimum time might be reduced drastically.					

Thermal Specifications

TABLE 8.

Parameter	Measure Point	Model	Min	Typical	Max	Units
Case Temperature	Case	All	-40		85 (1)	°C
Thermal Protection range	Case	All	80		90 (2)	°C
Power Dissipation	Case	All			70	Watts
Thermal resistance	Power MOSFETs to case	All			0.6	°C/W
Note 1: Thermal protection will protect the controller power Note 2: Max allowed power out starts lowering at minimum of range, down to 0 at max of range						

Mechanical Specifications

TABLE 9.

Parameter	Measure Point	Min	Typical	Max	Units
Weight	Case		1.0 (2.0)		kg (lbs)
Wire Length	Case	17 (43)			inches (cm)
Power Wire Gauge	Wire		8		AWG
Power Wire Diameter	Outside diameter		0.26 (6.6)		inches (mm)

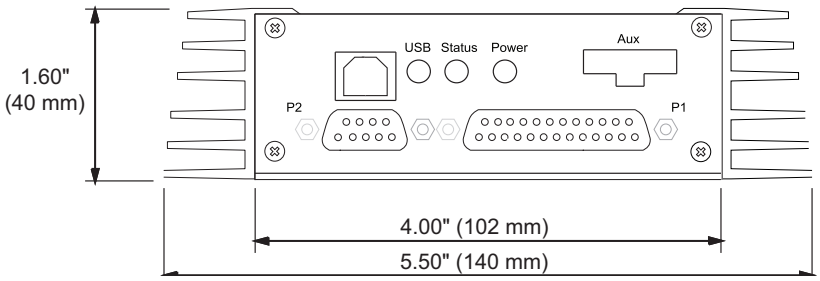

FIGURE 12. HDC24xx Front View and Dimensions

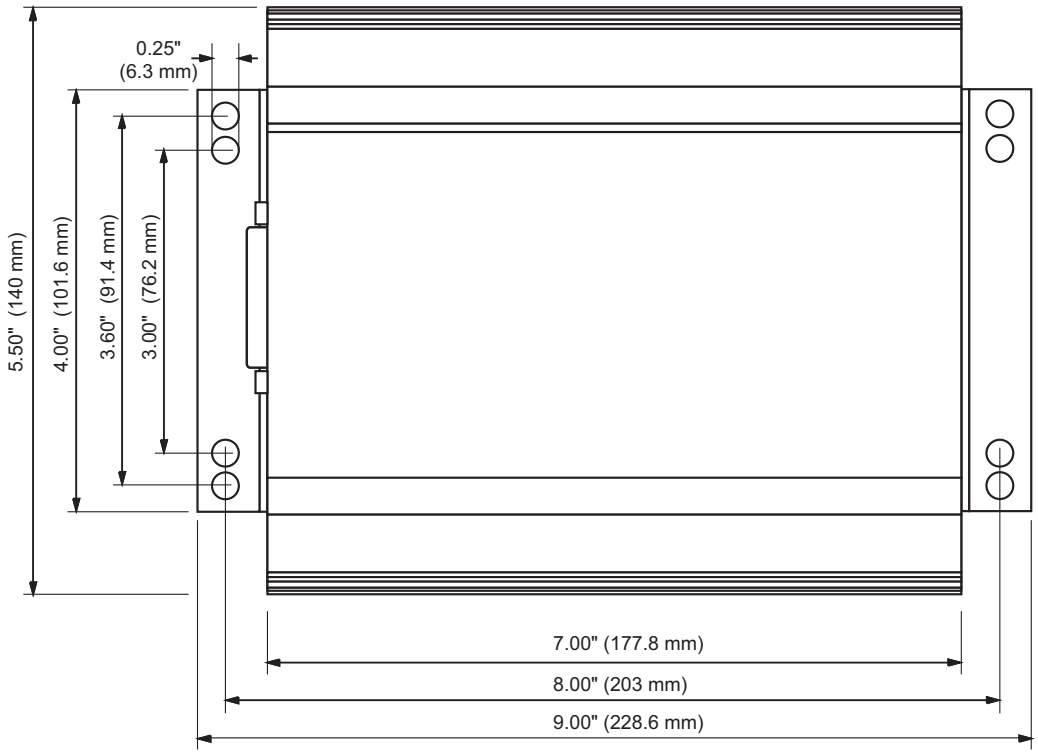

FIGURE 13. HDC24xx Top View and Dimensions