High Power Brushless DC Motor Controller with USB and CAN

RoboteQ's HBLG2360 is a features-packed, high-current, dual or single channel controller for brushless DC motors. The controller can operate in one of several modes in order to sense the rotor position and sequence power on the motor's 3 windings in order to generate smooth continuous rotation. The controller can use several different sensors to compute speed and measure the traveled distance inside a 32 bit counter.The motors may be operated in open or closed loop speed mode, position mode or in torque mode.

The HBLG2360 features several Analog, Pulse and Digital I/Os which can be remapped as command or feedback inputs, limit switches, or many other functions. The HBLG2360 accepts commands received from an RC radio, Analog Joystick, wireless modem, or microcomputer. For mobile robot applications, the controller's two motor channels can either be operated independently or mixed to move and steer a vehicle. Using CAN bus, up to 127 controllers can be networked at up to 1Mbit/s on a single twisted pair.

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 MicroBasic Language scripts. The controller can be configured, monitored and tuned in real-time using the Roborun+ Utility, a RoboteQ's free PC utility. The controller can also be reprogrammed in the field with the latest features by downloading new operating software from Roboteq.

Applications

- Automatic Guided Vehicles
- Small Electric Vehicles, Electric Bikes
- Terrestrial and Underwater Robotic Vehicles
- Police and Military Robots
- Hazardous Material Handling Robots
- Balancing Robots
- Telepresence Systems
- Animatronics

Key Features

- USB, Serial, 0-5V Analog, or Pulse (RC radio) command modes
- MODBUS ASCII & RTU Support over RS232 or RS485
- CAN bus up to 1 Mbit/s. Multi-Protocol support
  - CANOpen DS402
  - RoboCAN Meshed Network
  - RawCAN Customizable to Any Protocol
- Auto switch between Serial, USB, CAN, Analog, or Pulse based on user-defined priority
- Built-in dual 3-phase high-power drivers for two brushless DC motor at up to 75A per channel
- Output channels can be paralleled in order to drive a single motor at up to 150A
- Multiple Motor Operating modes
  - Trapezoidal with Hall Sensors
  - Trapezoidal with Hall+Incremental Encoder
  - Sinusoidal with Incremental Encoder
  - Sinusoidal with SSI Encoder
  - Sinusoidal with Resolver
  - Sinusoidal with Hall Sensors
  - Sinusoidal with Sin/Cos Encoder
- Support for absolute angle encoders
- Sin/Cos Analog
- SSI
- Resolver
- Field Oriented Control in Sinusoidal modes
- Full forward & reverse motor control. Four quadrant operation. Supports regeneration
- Operates from a single 12V-60V power source
- STO - Safe Torque Off (Certification Pending)
- Design compliant/approval UL 61800-5-1 (Certification Pending)

- Programmable current limit up to 75A (150A on single channel version) per motor for protecting controller, motor, wiring and battery.
- Separate connector for Hall Sensors
- Accurate speed and Odometry measurement using Hall Sensor or Encoder data
- Up to 11 Analog Inputs for use as command and/or feedback
- Up to 6 Pulse Length, Duty Cycle or Frequency Inputs for use as command and/or feedback
- Up to 18 Digital Inputs for use as Deadman Switch, Limit Switch, Emergency stop or user inputs, up to 30V
- Inputs for up to 2 Quadrature Encoders
- 48 general purpose 40V, 1A output for brake release or accessories
- Selectable min, max, center and dead band in Pulse and Analog modes
- Selectable exponential, logarithmic or linear factors for each command input
- Trigger action if Analog, Pulse or Hall counter capture are outside user selectable range (soft limit switches)
- Open loop or closed loop speed control operation
- Closed loop position control with encoder, hall sensors, analog or pulse/frequency feedback
- Torque mode
- PID control loop
- Built-in Battery Voltage and Temperature sensors
- Optional 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 RC radio, RF Modem, sensors or microcomputer
- Separate Programmable acceleration and deceleration for each motor
- Ultra-efficient 2.8 mOhm ON resistance MOSFETs (1.4 mOhm on Single Channel)
- Stall detection and selectable triggered action if Amps is outside user-selected range
- Short circuit protection
- Overvoltage and Undervoltage protection
- Watchdog for automatic motor shutdown in case of command loss
- Overtemperature protection
- Diagnostic LED
- Extruded aluminum heat sinking enclosure for operating in harsh shock and temperature environments
- Efficient heat sinking. Operates without a fan in most applications.
- Dustproof and weather resistant. IP40 rating
- Power wiring via AWG8 battery cables and AWG10 motor cables
- Dimensions: 9" (228.5mm) L, 5.5" W (140mm), 1.6" (40mm) H
- -40o to + 85 °C operating environment
- Weight: 3 lbs (1,340g)
- Easy configuration, tuning and monitory using provided PC utility
- Field upgradeable software for installing latest features via the internet Orderable Product References

Specifications and Listings

Controller is designed and build to comply with UL and IEC specifications and standards, but is approved only under the mentioned standards on this datasheet.

Orderable Product References

Reference	Number of Channels	Amps/Channel	Volts
HBLG2360	2	75	60
HBLG2360S	1	150	60

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.

Power Wires Identifications and Connection

Power connections are made by means of heavy gauge wires located at the back of the controller, as shown in Figure 1.

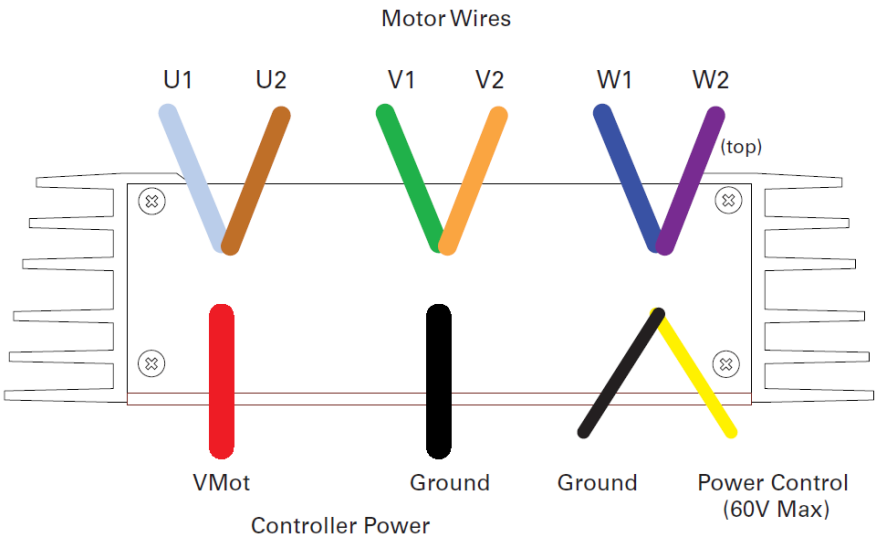


FIGURE 1. Rear Controller Layout

The diagram below shows how to wire the controller and how to turn power On and Off.

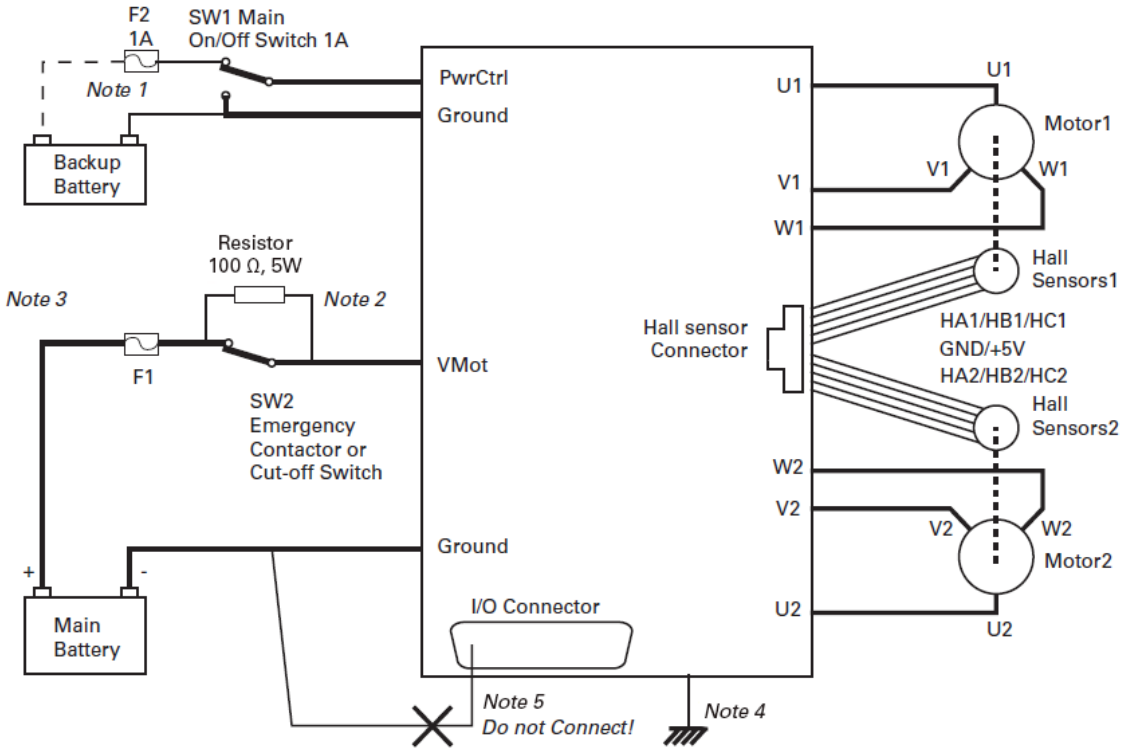


FIGURE 2. Powering the controller. Thick lines identify MANDATORY connections

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 the above diagram 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 PwrCtrl tab. Use a suitable high-current fuse F1 (check table 12) as a safety measure to prevent damage to the wiring in case of major controller malfunction.

Emergency Switch or Contactor

The battery must be connected in permanence to the controller's Vmot tabs 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.
Note 2: Use a precharge 100 Ω, 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 bottom plate 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 minus terminal.

Single Channel Wiring

On the Single Channel HBLG2360S, each of the motor wires must be connected to both wires of the same letter as shown in Figure 3 below. Use the sensors of Channel 1 for operation.

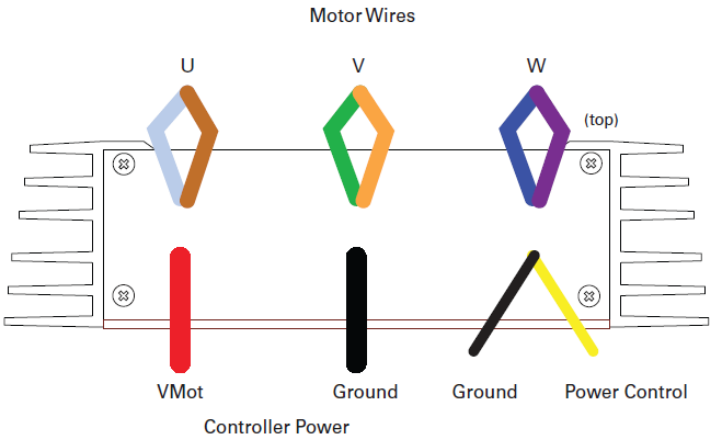


FIGURE 3. Single Channel wiring diagram

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 HBLG2360S 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.

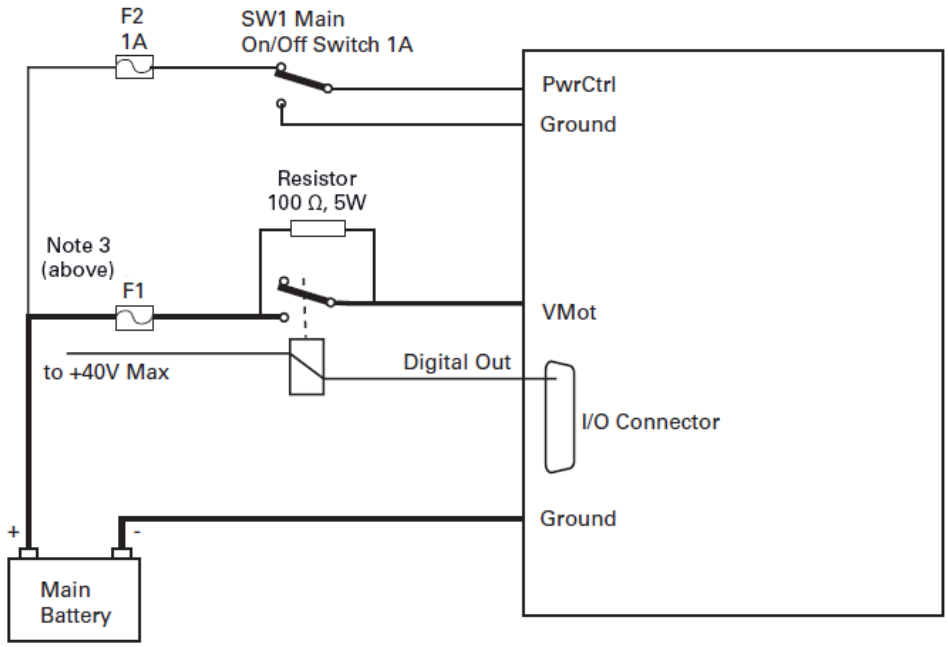


FIGURE 4. Contactor wiring diagram

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 1A 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.

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. Good conduction cooling can be achieved by having the bottom surface of the case making direct contact with a metallic surface (chassis, cabinet). The mounting has to be like that, so that the thermal-safety limits are not exceeded.

Hall Sensors Connection

Connection to the Hall Sensors is done using a special connector on the front side of the controller. The Hall sensor connector is a 10-pin Molex Microfit 3.0, ref. 43025-1000. Pin assignment is in the table below.

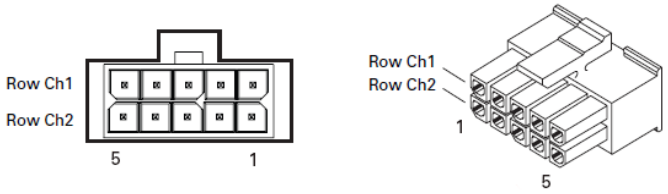


FIGURE 5. Hall Sensors connector

TABLE 1.

Pin Number	1	2	3	4	5
Row Ch1	GND	Hall 1 A	Hall1 B	Hall 1 C	5V
Row Ch2	GND	Hall 2 A	Hall2 B	Hall 2 C	5V

Hall Sensor vs Motor Output sequencing

The controller requires the Hall sensors inside the motor to be 120 degrees apart. The controller's 3-phase bridge will activate each of the motor winding according to the sequence shown in the figure below.

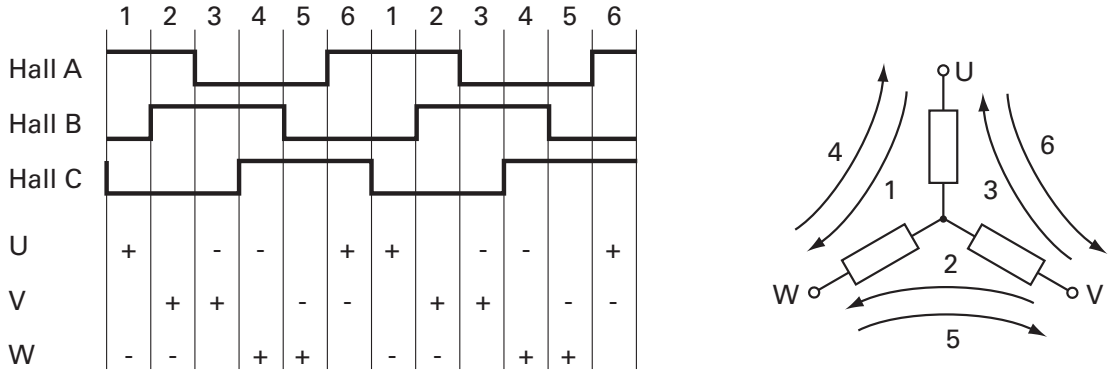


FIGURE 6. Hall Sensors sequence

Connection to SSI Absolute Encoder

In Sinusoidal Mode, the controller can use motors equipped with absolute angle sensors with SSI interface. When enabled, the SSI signals are found on the 10-pin Molex connector that is otherwise used for the Hall Sensors. The controller issues a differential clock signal and expects a 16-bit differential data signal from the encoder. When two motors are used, these signals must be connected to both sensors. Serial data from each sensor is captured on separate input pins.

TABLE 2.

Pin Number	1	2	3	4	5
Row 1	GND	Data 1 –	Data 2 –	CLK –	5V
Row 2	GND	Data 1 +	Data 2 +	CLK +	5V

Connection to Analog Sin/Cos Absolute Encoder

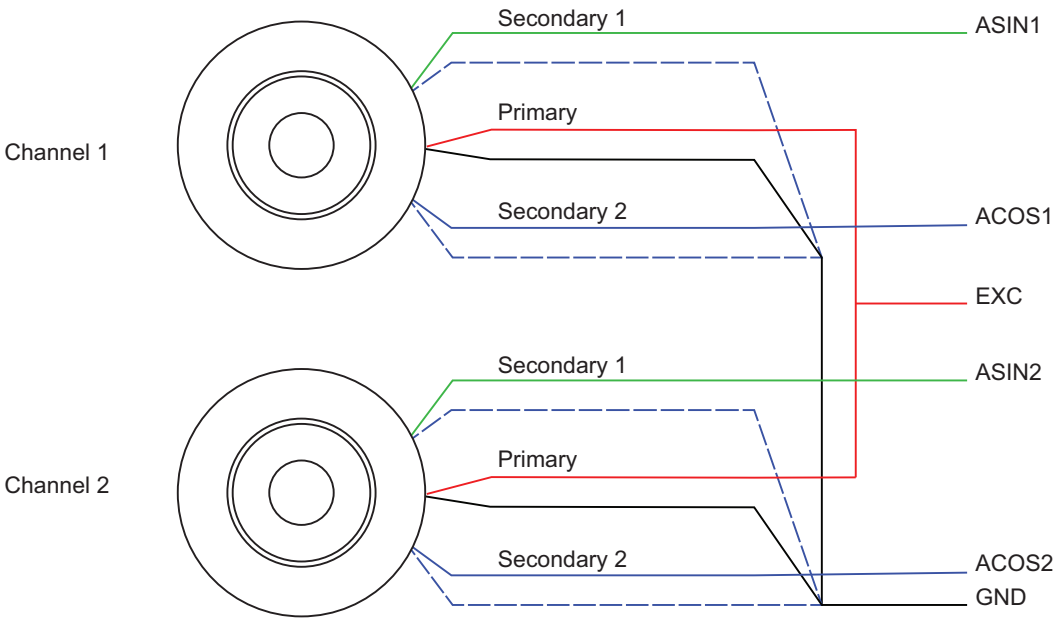
The HBLG2360 has 4 high-speed analog inputs that can be used to capture absolute angle position from resolvers or magnetic sensors with sin/cos voltage outputs. The signal must be 0-5V max with the 0 at 2.500V. The table below shows the signals assignment on the 25-pin connector.

TABLE 3.

Signal	Pin Number	Pin Name
Sin1	9	ASIN1
Cos1	10	ACOS1
Sin2	24	ANA7/ASIN2
Cos2	12	ANA8/ACOS2

Connecting Resolver

Resolver wiring is similar to a Sin/Cos sensor with the addition of an excitation signal. Diagram below shows the necessary connections.



The table below shows the signals assignment on the 25-pin connector.

TABLE 4.

Signal	Pin Number	Pin Name
Sin1	12	ANA11/ASIN1
Cos1	24	ANA10/ACOS1
Sin2	11	ANA7/ASIN2
Cos2	23	ANA8/ACOS2
Exc	23	ANA4/EXC
GND	1, 5, 9, 13	GND

Commands and I/O Connections

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. Pin assignments are found in Tables 6 & 7, below.

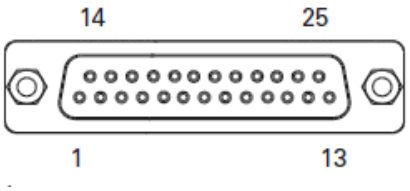


FIGURE 7. Main Connector pin locations

TABLE 5.

Connector Pin	Power	Dout	Com	Pulse	Ana	Dinput	Enc	Default Config
1	GND							
14	5VOut							
2			Tx Data					RS232Tx
15				RC1/ PIN1	ANA1	DIN1		RCRadio1 (2)
3			Rx Data					RS232Rx
16				RC2/ PIN2	ANA2	DIN2		RCRadio2 (2)
4				RC3/ PIN3	ANA3	DIN3		AnaCmd1 (1)
17				RC4/ PIN4	ANA4	DIN4		AnaCmd2 (1)
5	GND							
18		DOUT1				DIN12		Motor Brake 1
6		DOUT2				DIN13		Motor Brake 2
19		DOUT3				DIN14		Contactor
7		DOUT4				DIN15		Unused
20		DOUT5				DIN16		Unused
8		DOUT6				DIN17		Unused
21				RC5/ PIN5	ANA5	DIN5/ STO1 (2)		Unused
9	GND							

TABLE 5.

Connector Pin	Power	Dout	Com	Pulse	Ana	Dinput	Enc	Default Config
22				RC6/ PIN6	ANA6	DIN6/ STO2 (2)		Unused
10					ANA7/ EXC	DIN7		Unused
23					ANA8/ ASIN2	DIN8	ENC2B	
11					ANA9/ ASIN2	DIN9	ENC2A	
24					ANA10/ ACOS1	DIN10	ENC1B	Unused
12					ANA11/ ASIN1	DIN11	ENC1A	Unused
25	5VOut							
13	GND							

Note 1: Analog command is disabled in factory default configuration.

Note 2: Pulse input enable by default on firmware version prior to v2.0

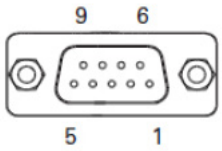


FIGURE 8. Secondary Connector Pin Locations

TABLE 6.

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

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.

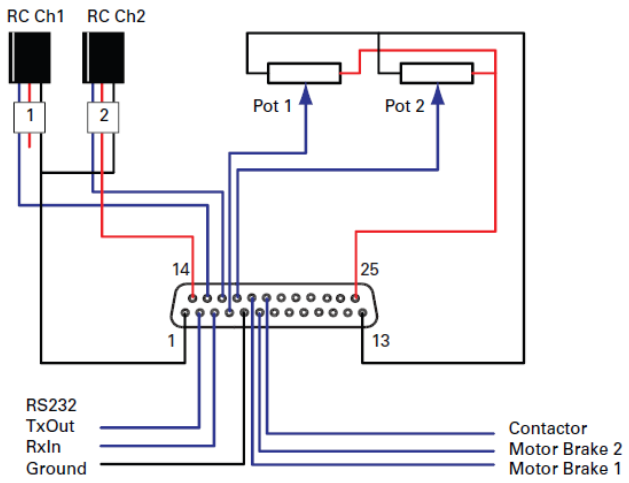


FIGURE 9. Factory default pins assignment

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.

USB Communication

Use USB only for configuration, monitoring and troubleshooting. USB is not a reliable communication method when used in an electrically noisy environments and communication will not always recover after it is lost without unplugging and replugging the connector, or restarting the controller. Always prefer RS232 communication when interfacing to a computer. USB and CAN can operate at the same time on the HBLG2360. Plugging USB to a computer will not disable CAN interface.

RS485 Communication

RS485 is an industry standard for defining serial communication. Due to its balanced signalling, RS485 is effective over distances, even if other electrical signals are present. Its stability makes it well suited to connect multiple receivers to a single network.
You can operate RS485 in half-duplex mode and it is well suited for use with the Modbus protocol. On the 9-pin connector, RS485+ and RS485- pins are present.

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 second interval. The flashing pattern and colour provides operating or exception status information.

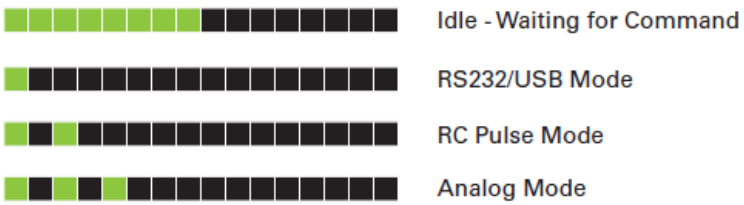


FIGURE 10. Normal Operation Flashing Patterns

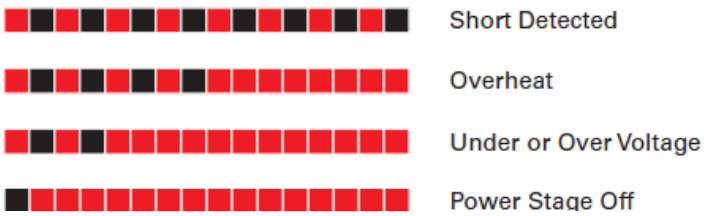


FIGURE 11. Exception or Fault Flashing Patterns

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.

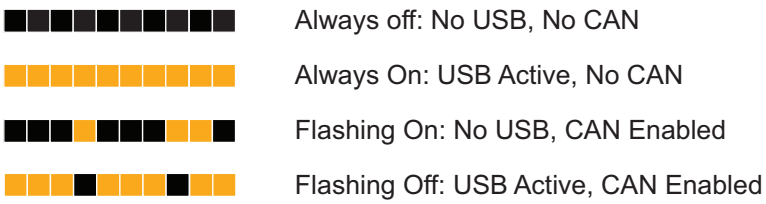


FIGURE 12. Communication LED Flashing Patterns

Battery Backed Clock and Variables

The battery backed clock and variables feature allows accurate time/date stamping of information such as status and error reports. It is important to note that the only Roboteq products that include this feature are ones that specifically say that battery backed clock is a product feature. If your Roboteq product has displayed time/date information but the product does not specifically list the battery backed clock as a feature, then the information displayed is random and not accurate.

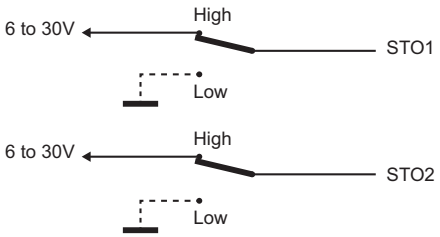
The location of the battery is dependent on the product. However, any Roboteq product with this feature will run it on a 3V, 12.5mm coin style battery. The clock is accessible via the ^BEE commands and user input variables will remain even if the unit is powered off.

Please Note: Customers will be required to install the battery for the clock (type BR-1225), themselves. Units do not ship with the battery for the Battery Backed Clock, installed.

Safe Torque Off - STO (Certification Pending)

Safe Torque Off is a safe method for switching controller in a state where no torque is generated, regardless whether the controller is operating normally or is faulty. When STO is enabled, two digital inputs, DIN5 and DIN6 are remapped as STO1 and STO2. The inputs are redundant and both must have a 6V to 30V signal present at the same time in order for the Power MOSFETs to be energized. The controller will perform a self-check of the STO circuit at every power on and every time the STO inputs go from any state to both high. Once the STO hardware is verified to work, the controller will safely allow the motors to be energized. If either input is below 1V, the controller's outputs will be disabled. The STO circuit is verified and validated and can therefore be trusted instead of external relays. See STO Manual for more information and maintenance instructions.

By factory default STO functionality is disabled. It must be enabled by removing the jumper located on the controller's PCB. STO functionality is only available in the T version of the controller.



STO1	STO2	Motors Output
Low	Low	Disabled
High	Low	Disabled/Fault
Low	High	Disabled/Fault
High	High	Enabled

FIGURE 13. STO input levels effects on controller output

The STO function is compliant to:

- IEC 61800-5-2:2007, SIL 3
- IEC 61508:2010, SIL 3
- IEC 62061:2005, SIL 3
- ISO 13849-1:2015, Category 3 Performance Level e

Important Warning

Activating STO does lead to no more torque generation on the motor. The motor will not be actively stopped but run out. In case of a multiple fault in the power stage a rotation might occur.

Electrical Specifications

Absolute Maximum Values

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

TABLE 7.

Parameter	Measure Point	Models	Min	Typical	Max	Units
Voltage on Battery Leads	GND to Vmot	All			60	Volts
Reverse Voltage on Battery Leads	GND to Vmot	All	-1			Volts
Power Control Voltage	GND to PWR CTRL wire	All			60	Volts
Motor Leads Voltage	GND to U, V, W wires	All			60 (1)	Volts
Digital Output Voltage	GND to DOUT pins	All			40	Volts
Analog & Digital Inputs Voltage	GND to any signal pin on the 25 & 9-pin connectors	All			30	Volts
RS232 I/O pins Voltage	External Voltage Applied to Rx pin	All			30 (2)	Volts
Case Temperature	Case	All	-40		85	°C
Humidity	Case	All			100 (3)	%

Note: Only PELV/SELV voltages shall be used.
Note 1: Maximum regeneration voltage in normal operation. Never inject a DC voltage from a battery or other fixed sources.
Note 2: No voltage must be applied to the RS232 Tx pin.
Note 3: Non-condensing.

Power Stage Electrical Specifications (at 25ºC ambient)

TABLE 8.

Parameter	Measure Point	Models	Min	Typical	Max	Units
Battery Leads Voltage	GND to Vmot	All	0 (1)		60	Volts
Motor Leads Voltage	GND to U, V, W wires	All	0 (1)		60 (2)	Volts
Power Control Voltage	GND to PWR CTRL wire	All	0 (1)		60	Volts
Minimum Operating Voltage	Vmot or PWR CTRL wires	All	12 (3)			Volts
Overvoltage Protection Range	GND to Vmot	All	5	60 (4)	60	Volts
Undervoltage Protection Range	GND to Vmot	All	12	5 (4)		Volts
Idle Current Consumption	Vmot or PWR CTRL wires	All	50	100 (5)	150	mAmps
ON Resistance (Excluding wire resistance)	Vmot to U, V or W	HBLG2360		2.8		mOhms
	GND to U, V, or W	HBLG2360S		1.4		mOhms
Max Current for 30s	Motor Current	HBLG2360			75 (6)	Amps
		HBLG2360S			150 (6)	Amps
Continuous Max Current per channel	Motor Current	HBLG2360			50 (7)	Amps
		HBLG2360S			100 (7)	Amps
Current Limit Range	Motor Current	HBLG2360	10	50 (8)	75	Amps
		HBLG2360S	10	100 (8)	150 (7)	Amps
Stall Detection Current Range	Motor Current	HBLG2360	10	75 (8)	50 (7)	Amps
		HBLG2360S	10	150 (8)	100 (7)	Amps

TABLE 8.

Parameter	Measure Point	Models	Min	Typical	Max	Units
Stall Detection Timeout Range	Motor Range	All	1	500 (9)	65000	milliseconds
Short Circuit Detection Threshold (10)	Between Motor Wires or Between Motor Wires and GND	HBLG2360	127			Amps
		HBLG2360S	254			Amps
Short Circuit Detection Threshold	Between Motor Wires and Vmot	All	No protection. Permanent damage will result.			
Motor Acceleration / Deceleration Range	Motor Output	All	100	500 (12)	6500	Milliseconds

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 PWR CTRL 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 PWR CTRL wires.

Note 6: Max value is determined by current limit setting. Duration is estimated and is dependent on ambient temperature cooling condition.

Note 7: Estimate. Limited by case temperature. Current may be higher with better cooling.

Note 8: Factory default value. Adjustable in 0.1A increments.

Note 9: Factory default value. Time in ms that Stall current must be exceeded for detection.

Note 10: Controller will stop in case of Short Circuit Detection, until motor command becomes idle.

Note 11: Factory default value. Time in ms for power to go from 0 to 100%.

Command, I/O and Sensor Signals Specifications

TABLE 9.

Parameter	Measure Point	Min	Typical	Max	Units
Main 5V Output Voltage	Ground to 5V pins on 25-pin or 9-pin connector	4.6	4.75	5.1	Volts
5V Output Current	5V pins on RJ45 and 15-pin connector			100 (1)	mAmps
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 GND		0.75	1.5	Ohms
Output Short Circuit Threshold	Output pin	1.05	1.4	1.75	Amps
Input Impedances	AIN/DIN Inputs to GND		53		kOhms
Digital Input 0 Level	GND to Input Pins	-1		1	Volts
Digital Input 1 Level	GND to Input Pins	3		30	Volts
Analog Input Range	GND to Input Pins	0		5.1	Volts
Analog Input Precision	GND to Input Pins		0.5		%
Analog Input Resolution	GND to Input Pins		1		mVolts
Pulse Durations	Pulse Inputs	2000		10	us
Pulse Repeat Rate	Pulse Inputs	50		250	Hz
Pulse Capture Resolution	Pulse Inputs		1		us

TABLE 9.

Parameter	Measure Point	Min	Typical	Max	Units
Minimum Pulse On or Pulse Off Duration	Pulse Inputs	25			us
Frequency Capture	Pulse Inputs	100		2000	Hz
Encoder Count	Internal	-2.147		2.147	109 Counts
Encoder Frequency	Encoder Input Pins			1	MHz
Note 1: Sum of all 5V Outputs.					
Note 2: Total average current on all outputs, not to exceed 4.5A.					

Operating & Timing Specifications

TABLE 10.

Parameter	Measure Point	Min	Typical	Max	Units
Command Latency	Command to Output change	0	0.5	1	ms
Maximum PWM Duty Cycle	Motor Output			93.8	%
Closed Loop Update Rate	Internal		1000		Hz
Current Loop Update Rate	Internal		16		kHz
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 a value of 0.					

Motor Characteristics Requirement for FOC current control

For proper FOC current control and motor operation under sinusoidal commutation, it is necessary for the motor to meet a minimum load inductance, minimum load L/R and maximum electric operating speed requirements. The minimum required inductance is necessary in order to ensure low Total Harmonic Distortion (THD) of the motor current. Furthermore, to achieve proper current response and stability, the controller's current loop sampling rate will limit the minimum permissible motor time constant τ=L/R and the maximum operating electric speed.

TABLE 11.

Parameter	Input DC Voltage (V)	Value	Units
Minimum load phase inductance (1)	12	25	uH
	24	40	uH
	48	60	uH
	60	80	uH
Minimum load inductance/resistance ratio (1)	0 - 60	0.063	msec
Maximum operating electric speed (2)	0 - 60	96000	RPM
Note 1: Star connected three phase load considered. In case the motor phase inductance does not fulfill the above requirements (minimum phase inductance and inductance/resistance ratio) an external AC inductor with proper inductance value is recommended to be added.			
Note 2: Maximum rotor speed is calculated from the maximum operating electric speed and pole pairs. For example, in a motor with 4 pole pairs the maximum operating rotor speed is 96000/4 = 24000 rpm			

Scripting

TABLE 12.

Parameter	Measure Point	Min	Typical	Max	Units
Scripting Flash Memory	Internal			6400	Bytes
Integer Variables	Internal		4096		Words (1)
Boolean Variables	Internal		8192		Symbols
Execution Speed (2)	Internal	40,000		200,000	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 13.

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
Humidity	Case	All			95	%
Ambient Temperature	Ambient	All			55	°C
Pollution Degree	-		-			
Fast Fuse to install (3)	-	HBLG2360 (4)	1 x 150	2 x 150	2 x 150	Amps
		HBLG2360S (4)		2 x 150		Amps
Overload Motor Protection	-	Check Note 5.				
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 the range. Note 3: There are two power cables. The fuse should be installed in both for safety. Note 4: In dual channel controller, for operating only one channel, install a single fuse based on the current rating. For operating both channels, install 2 fuses based on the ratings. The power source must be capable of blowing the fuse instantly in case of a short circuit. Note 5: Current limiting mechanism is available through firmware. External overload motor protection can be used if required (provided by the user).						

Mechanical Specifications

TABLE 14.

Parameter	Measure Point	Min	Typ	Max	Units
Weight	Case		1340 (2.95)		g (lbs)
Wire Length	Case	17 (43)			Inches (cm)
Power Wires Gauge	Wire		8		AWG
Motor Wires Gauge	Wire		10		AWG

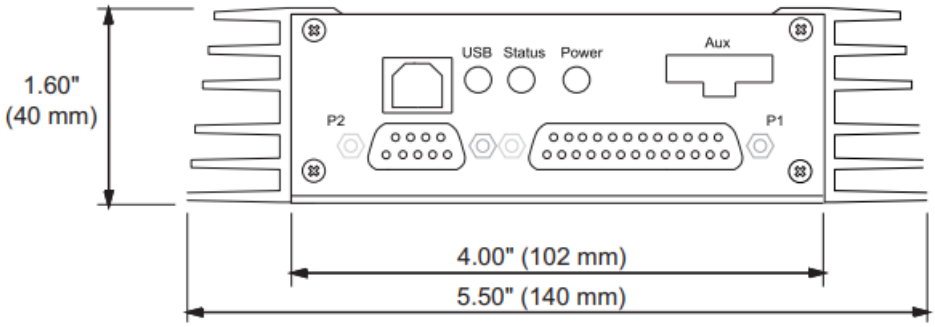


FIGURE 14. HBLG2360 front view and dimensions

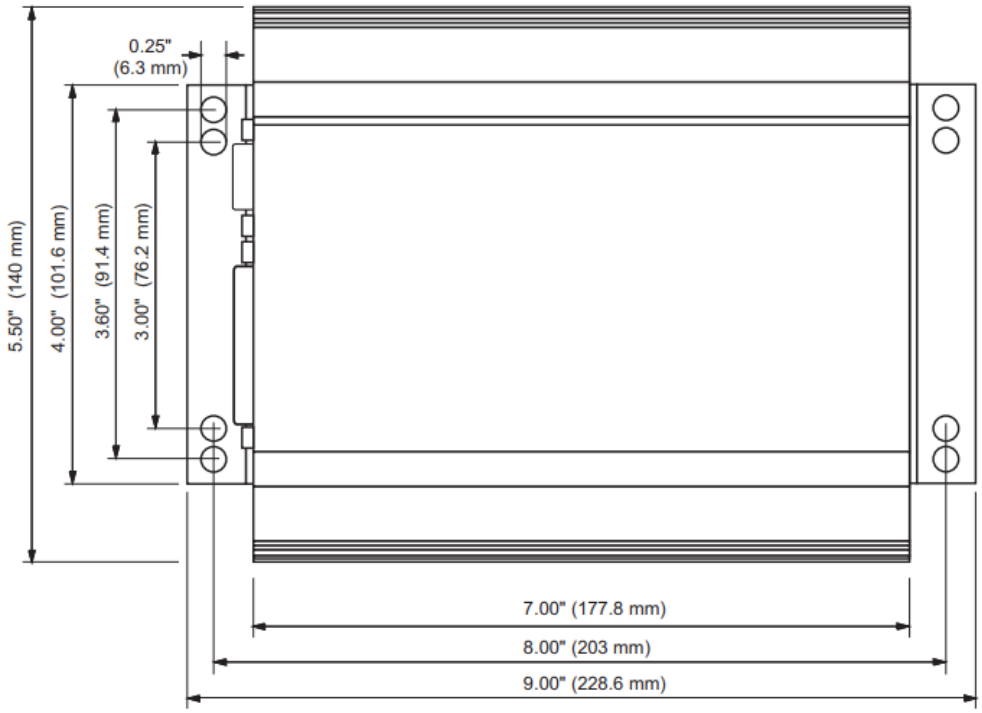


FIGURE 15. HBLG2360 top view and dimensions