Fourth Generation 2 x 60A or 1 x 120A Brushless DC Motor Controller

CANopen EtherCAT

Roboteq's FBLG2360Txx is a features-packed, low-voltage, high-current, dual or single channel controller for brushless DC motors. It is a direct replacement for the company's popular FBL2360, using a 4th generation processor and implementing many performance, algorithmic, and other qualitative enhancements. The controller can be commanded via serial, USB, Analog or Pulse signals. Multiple controllers can be networked over a low-cost, twisted pair CANbus network. The controller can be ordered with Ethernet, EtherCAT for high speed robotics systems.

The FBLG2360Txx uses the latest motion control technology, such as field-oriented control (FOC), acceleration/velocity Feedforward, and fast loop frequency to deliver quick and precise motion control in speed, torque or position modes. Numerous safety features, including Safe Torque Off (STO) are incorporated into the controller to ensure reliable and safe operation. For mobile robot applications, the controller's two motor channels can either be operated independently or mixed to move and steer a vehicle

Numerous safety features are incorporated into the controller, including Safe Torque Off (STO). The controller's operation can be extensively automated and customized using Basic Language scripts. The controller can be configured, monitored and tuned in real-time using 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
- Multi-Axis Robot Arms
- Factory Automation
- Telepresence Systems

Key Features

- USB, Serial, 0-5V Analog, or Pulse (RC radio) command modes
- RS232 and RS485 serial ports
- MODBUS ASCII & RTU Support over RS232 or RS485 (Refer to Modbus Manual for the supported functions)
- MODBUS TCP Support over Ethernet (Refer to Modbus Manual for the supported functions)
- CAN bus up to 1 Mbit/s. Multi-Protocol support
  - CANOpen DS402
  - RoboCAN Meshed Network
  - RawCAN Customizable to Any Protocol
- Optional EtherCAT Interface CANOpen over EtherCAT (CoE)
- Auto switch between Serial, USB, CAN, fieldbus, Analog, or Pulse based on user-defined priority
- Built-in dual 3-phase high-power drivers for two brushless DC motors
- 2x60A Max, 2x40A continuous Current with I2T protection algorithm
- Output channels can be paralleled in order to drive a single motor at up to 120A (Requires special firmware)
- Programmable current limit up to 60A (120A on single channel version) per motor for protecting controller, motor, wiring and battery.
- Supports Surface Permanent Magnet (SPM) motors or Internal Permanent Magnet (IPM) motors
- 97% or better typical Efficiency
- Multiple Motor Operating mode
  - Trapezoidal with Hall Sensors
  - Sinusoidal with Hall+Encoder
  - Sinusoidal with Encoders
  - Sinusoidal with Hall Sensors
  - Sinusoidal with Absolute Encoder

- Support for absolute angle encoders
  - Sin/Cos analog
  - SSI (single-turn and multi-turn)
  - Resolver
- Field Oriented Control in Sinusoidal modes
- Automatic Field Weakening for maximizing motor speed and torque
- Full forward & reverse motor control. Four quadrant operation. Supports regeneration
- Operates from a single 14V-60V power source
- STO - Safe Torque Off
- Separate connector for Hall Sensors
- Accurate speed and Odometry measurement using Hall Sensor or Encoder data
- Up to 8 Analog Inputs for use as command and/or feedback
- Up to 8 Pulse Length, Duty Cycle or Frequency Inputs for use as command and/or feedback
- Up to 10 Digital Inputs for use as Deadman Switch, Limit Switch, Emergency stop or user inputs
- Inputs for up to 2 Quadrature Encoders
- 4 general purpose 24V, 1.5A open collector outputs for brake release or accessories
- Built-in Basic-like scripting language. Execution speed up to 100000 lines per second
- Selectable min, max, center and dead band in Pulse and Analog modes
- Selectable exponentiation factors for each command inputs
- Trigger action if Analog, Pulse or Hall counter capture are outside user selectable range (soft limit switches)
- Open loop speed control operation
- Closed loop speed, position and/or torque control
- Closed loop position control with encoder, hall sensors, analog or pulse/frequency feedback
- Cascaded Speed, Position, Torque PID loops
- High-Performance 16kHz Current Control loop
- Automatic Tuning of Torque, Speed and Position loops
- Automatic Motor Characterization
- Advanced performance optimization algorithms (Anti-cogging, notch filter, Decoupling control, ...)
- Support for NTC temperature sensors through analog inputs (requires an external pull-up resistor)
- 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
- Regulated 5V output for powering RC radio, RF Modem, sensors or microcomputer
- Separate Programmable acceleration and deceleration for each motor
- Ultra-efficient 2.5 mOhm ON resistance MOSFETs (1.25 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
- Efficient heat sinking. Operates without a fan in most applications.
- IP40 case protection rating
- Power wiring 0.25" Faston tabs
- 5.5" (139.7mm) L, 5.5" W (139.7mm), 1.0" (25mm) H
- -10°C to +70°C operating environment
- 1 lbs (500g)
- Easy configuration, tuning and monitory using provided PC utility
- Field upgradeable software for installing latest features via the Internet

Orderable Product References

Reference	Number of Channels	Amps/ Channel	Volts	Ethernet	STO
FBLG2360T	2	60	60	No	Yes
FBLG2360TS	1	120	60	No	Yes
FBLG2360TE	2	60	60	Yes	No
FBLG2360TES	1	120	60	Yes	No

Warning

A dangerous uncontrolled motor runaway condition can occur due to various reasons, including, but not limited to: command or feedback wiring failure, configuration errors, faulty firmware, errors in user scripts or programs, or controller hardware failure.

Users must be aware that such failures can occur and must ensure the safety of their system under all conditions. Roboteq will not be held liable for any damage or injury resulting from product misuse or failure.

Important Note

All products are not serviceable. If damage is suspected, the item must be replaced rather than repaired.

Attempting to service or repair the product voids any existing warranty and may pose safety risks.

Consult customer support for more information on replacements.

Power Terminals Identifications and Connection

Power connections are made by means of faston tabs located at the back of the controller.

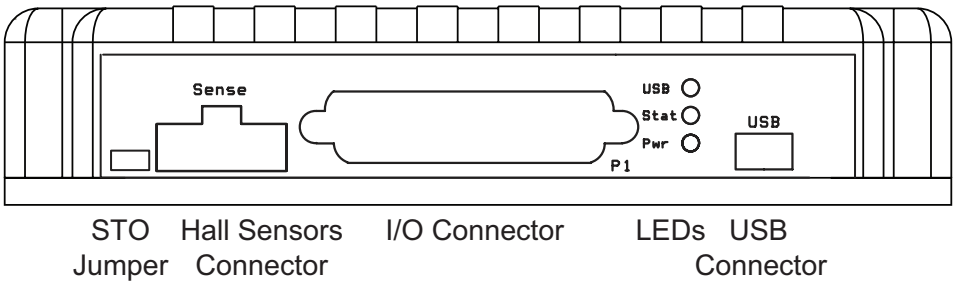


FIGURE 1. FBLG2360Txx front view

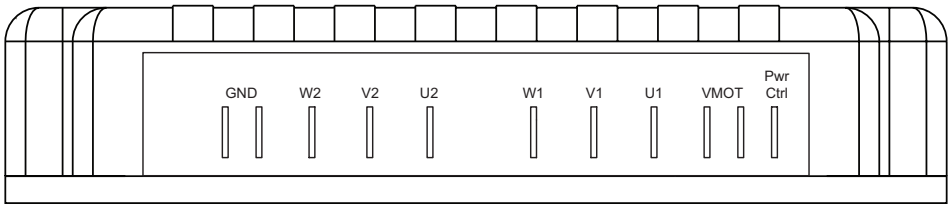


FIGURE 2. FBLG2360Txx rear view

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

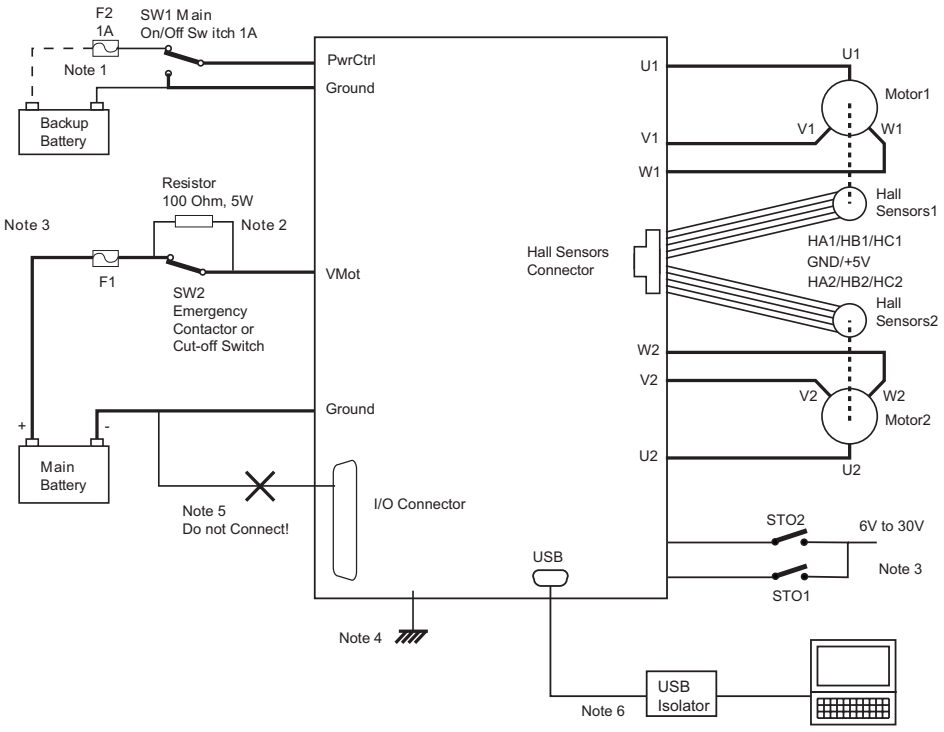


FIGURE 3. Powering the controller. Thick lines identify MANDATORY connections

Caution

Carefully follow the wiring instructions provided in the Power Connection section of the Roboteq Controllers User Manual. The information on this datasheet is only a summary.

Mandatory Connections

It is imperative that the controller is connected as shown Figure 3. 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.

Emergency Switch or Contactor

The battery must be connected Permanently to the controller's Vmot tabs via a high-power emergency switch or contactor SW2. The user must be able to deactivate the switch or contactor at any time, independently of the controller state. SW2 should be used only in emergency situations and not for normal operation. Opening SW2 while the motors are rotating can lead to permanent hardware damage.

Power On/Off Switch

The **controller must be powered On/Off using switch SW1** on the Power Control pin.

Note 1: To ensure motor operation with weak or discharged batteries, connect a second battery to the Power Control pin via the SW1 switch. This will keep the controller alive and responding even if no voltage is present on the Vmot terminal.

Precharge Resistor

The controller has 2350uF of internal capacitance which will cause a brief yet significant current inrush the moment power is applied.

Note 2: If there is a concern that this current can overload the power supply or the contactor, insert a precharge resistors as shown in figure 3. For precharging to take place, the controller must be turned off by grounding the Power Control pin.

Enable Safe Torque Off

Note 3: When STO is enabled (STO jumper removed), the motor will be prevented from running until both of its STO inputs are connected to a voltage of 6V or higher. If one or both STO lines are left floating or grounded, the drive will be ON and able to communicate, but the motor will not be driven. For more details, refer to the STO chapter further down in this document and consult the Roboteq Controllers User Manual.

Regeneration Protection and Braking

During rapid deceleration, the kinetic energy will cause regenerative current to flow out of the motor and back to the power source. When using a battery, this current will recharge the battery and create a dynamic braking effect. When a power supply is used, the current will not be able to flow back to the source. Without a return path, the regenerative current can cause the voltage to rise to a dangerous level for the electronics.

Connection to Chassis

Note 4: For improved EMI immunity and reduced emissions, it is recommended to connect the controller's bottom plate to the system's chassis. Note that the integrated controller's ground is not DC-electrically connected to the plate. However, there is a capacitor between the controller's ground and the bottom plate, providing AC conductivity.

Avoid Alternate Ground Paths

Note 5: Be cautious not to create a path between the ground pins on the I/O connector and the battery's negative terminal. An internal connection already exists between the battery's negative pole and the control ground. Avoiding an additional external connection is highly recommended, as this could allow current to circulate in the signal ground, potentially introducing noise into low-power signals. If the main power ground terminal becomes loose or disconnected, very high current from the motor may flow through the signal ground wire, causing damage.

Precautions When Connecting PC via USB

Note 6: Always use a USB isolator to protect both the drive and the PC against potential electrical damage. When using a portable PC, operate it on battery power to avoid creating an accidental return ground path via the charger.

Controller Mounting

The drive should be mounted in such a way that its bottom surface makes direct contact with a metallic surface, such as the system chassis or cabinet. This will assist in dissipating the heat generated during the operation of the controller. It's important to note that the nominal and peak ampere values documented in the datasheet can only be fully achieved with adequate cooling.

Electrostatic Discharge Protection

In accordance to IEC 61800-5-2, Roboteq Motor Controllers are designed to withstand ESD up to 6kV contact and 8kV air gap.

Single Channel Wiring

On the Single Channel FBLG2360TS, each of the motor wires must be connected to both output tabs labeled with the same letter, as shown in figure 4. The sensors connected to Channel One will be used for the motor's operation.

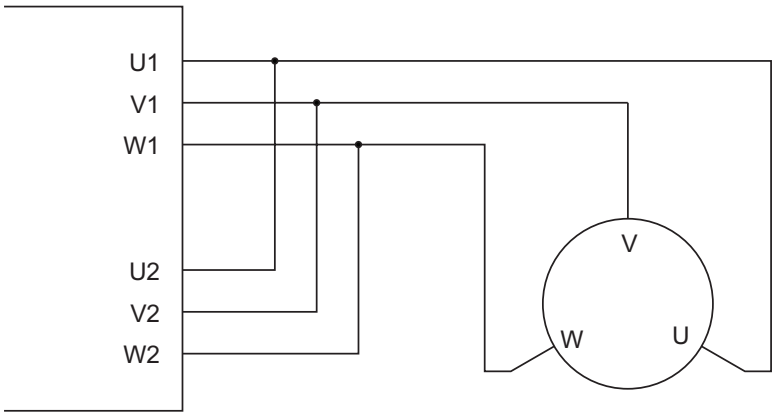


FIGURE 4. Single Channel wiring diagram

Caution

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 -S model before you wire in this manner.

Hall Sensors Connection

Connection to the Hall Sensors is done using a 10-pin Molex Microfit 3.0, ref. 43025-1000. Pin assignment is in table 1.

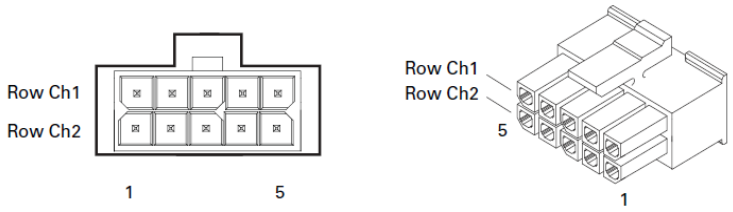


FIGURE 5. Hall Sensors connector

TABLE 1.

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

Important Note

Hardware revisions prior to 2.1 have a maximum supported Hall sensor frequency of 1.6 kHz.

Connection to SSI Absolute Encoder

Both multi-turn and single-turn SSI sensors are supported in sinusoidal mode, with pure binary encoding (no Gray code, offset binary, etc.) and a resolution of up to 47 bits. These SSI sensors must be connected to the 10-pin Molex connector, which is also used for Hall sensors. The specific sensor connected to the Molex connector can be determined through the controller's configuration settings. The controller employs differential signals for both clock and data. While data signals are separate for each channel, the clock signal is common to both. Therefore, for dual-channel operation, both sensors should be connected to the 'Clock -' and 'Clock +' pins. The Molex connector pin assignment for the SSI sensor is shown in Table 2.

TABLE 2.

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

Connection to Analog Sin/Cos Absolute Encoder

The FBLG2360Txx features four high-speed analog inputs, designed to capture the absolute angular position data from either resolvers or magnetic sensors that have sin/cos voltage outputs. For the sin/cos sensors, the signal must range from 0 to 5V, with 0 at 2.500V. Please note that for proper operation, the number of sensor poles must not exceed the number of motor poles pairs. The table 3 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

The wiring for the resolver is similar to a Sin/Cos sensor with the addition of an excitation signal. Figure 6 shows the necessary connections.

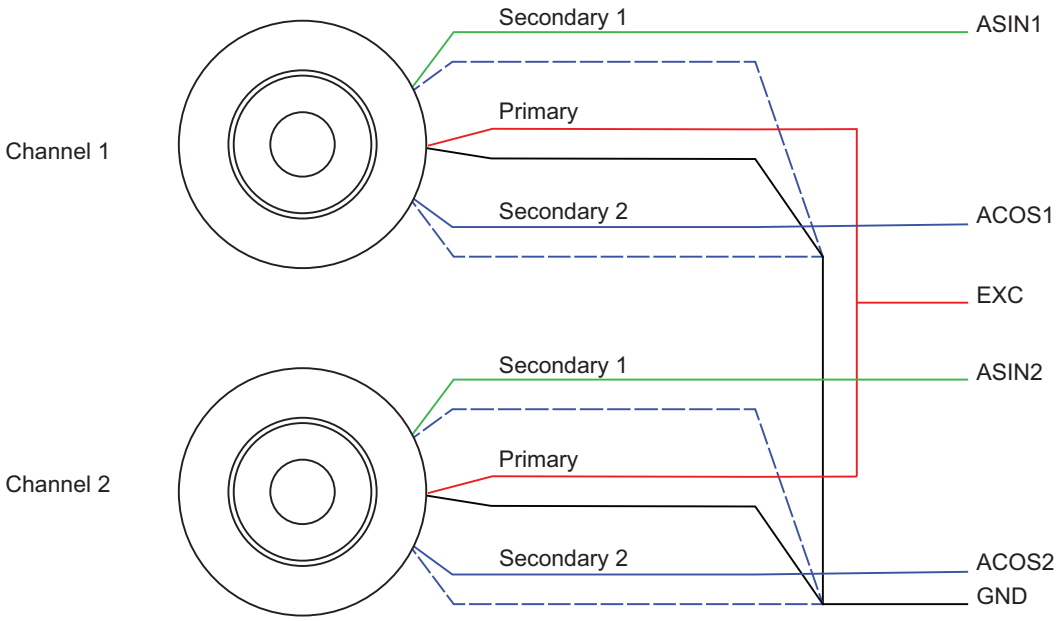


FIGURE 6. Resolver wiring

The table 4 shows the resolver signals assignment on the 25-pin connector.

TABLE 4.

Signal	Pin Number	Pin Name
Sin1	9	ASIN1
Cos1	10	ACOS1
Sin2	24	ANA7/ASIN2
Cos2	12	ANA8/ACOS2
Exc	17	ANA4/EXC
GND	1-5 or 13	GND

Important Note

Sensor error detection should be disabled when performing motor/sensor setup through USB, as the protection might be triggered due to signal interference. This interference will not affect the motor/sensor setup process or motor control.

Commands and I/O Connections

Connection to external devices, such as RC radios, microprocessors, joysticks, sensors, and low current actuators, is done through the DB25 connector. The controller is equipped with general-purpose inputs that can be configured to function as digital, analog, or pulse inputs. Additionally, it features open collector outputs capable of driving resistive or inductive loads of up to 1 A. The pin assignment can be found on table 5. Please note that the signals from the DB25 port are susceptible to electrical noise interference, which can distort them and affect their readability. To mitigate this issue, always add Common Mode Choke coils when using DB25 connector cables that are longer than 1 meter.

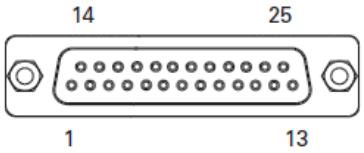


FIGURE 7. Main Connector pin locations

TABLE 5.

Connector Pin	Power	Dout	STO	Com	Pulse	Ana	Dinput	Enc
1	GND							
14	5VOut							
2				RS TxD				
15			STO1 (1)		RC1 (3)	ANA1	DIN1	
3				RS RxD				
16			STO2 (1)		RC2 (3)	ANA2	DIN2	
4					RC3	ANA3	DIN3	
17					RC4	ANA4/EXC (2)	DIN4	
5	GND							
18		DOUT1						
6		DOUT2						
19		DOUT3						
7		DOUT4						
20				CANH				
8				CANL				
21					RC5 (4)	ANA5	DIN5	ENC2A
9						ASIN1	DIN9	
22					RC6 (4)	ANA6	DIN6	ENC2B
10						ACOS1	DIN10	
23				485 +				
11				485 –				
24					RC7	ANA7/ASIN2	DIN7	ENC1A

TABLE 5.

Connector Pin	Power	Dout	STO	Com	Pulse	Ana	Dinput	Enc
12					RC8	ANA8/ACOS2	DIN8	ENC1B
25	5VOut							
13	GND							

Note 1: STO jumper must be removed for STO signals to be active. See STO section for details.
Note 2: Input 4 has a large capactitace which may degrate the Pulse signal. Prefer any of the other pulse inputs.
Note 3: Do not use for multiPWM input signals.
Note 4: Not compatible with multiPWM when SSI sensor is used.

Enabling Analog Commands

The Analog command mode is disabled by default. To enable this mode, use the PC utility and set "Analog" in Command Priority 2 or 3 (leave "Serial" as priority 1). Note that by default, additional safety features are enabled, preventing the motor from starting unless the potentiometer is centered, or if the voltage is below 0.25V or above 4.75V. Use the PC utility to enable and assign analog inputs.

Connecting Thermistors

NTC temperature sensors can be connected to the controller's analog inputs. This enables reading of motor temperature through the controller's runtime variables and allows for active temperature protection. This connection can be achieved by using a pull-up resistor with a value equal to the thermistor's resistance between the analog input and the controller's 5V output. For more information about motor temperature readings and controller parameterization, please refer to the Roboteq Controller's User Manual.

USB Communication

Use the USB only for configuration, monitoring, and troubleshooting purposes. USB is not a reliable method of communication and can lead to disconnections when used in electrically noisy environments. These disconnections often require resetting the USB connection or even the controller. For more reliable interfacing with a computer, always opt for RS232 communication.

Important Note

Always use a USB isolator to protect both the drive and the PC from potential electrical damage. When using a portable PC, operate it on battery power to avoid an accidental ground path return via the charger.

CAN Communication

CAN is the FBLG2360Txx's primary and recommended communication interface. Up to 127 drives can be networked on a twisted pair network up to 1000m long and at speeds up to 1Mbit/s. Roboteq support four CAN protocols:

- CANOpen for interoperability with other vendor's DS301 and DS402 compliant devices
- RoboCAN, a simple and effective peer to peer meshed network protocol
- MiniCAN, a simplified subset of CANOpen PDOs
- Raw CAN, a low-level system used with scripting for constructing and parsing CAN frames to handle any protocols

TABLE 6. CANOpen Communications Specification

Feature	Value
Motion Network type	CAN, CANOpen
CANOpen Standards Support	DS301, DS402
Operating Modes	Cyclic sync torque, cyclic sync velocity, cyclic sync position, profile position, profile velocity, profile torque modes, homing
Process Data Objects (PDO)	Cyclic sync and free run modes. Cyclic messages can be set for 20 objects on 4 maps

RS485 Communication

RS485 is a robust industry standard for serial communication, well-suited for long distances and electrically noisy industrial settings. It uses balanced signaling for enhanced stability, allowing the connection of multiple receivers on a single network. The protocol supports half-duplex operation and is particularly compatible with Modbus. The 25-pin connector features designated pins for RS485+ and RS485-.

Ethernet Communication

Ethernet communication is currently only available on the E versions of applicable Roboteq product. There is a connection port on the top of the unit for easy and rapid access. While the TCP and Modbus TCP protocols are supported, Serial is the preferred method to access all native commands.

Status LED Flashing Patterns

After the controller is powered on, the Power LED will turn on, indicating that the controller is active. The Status LED will flash at two-second intervals. The flashing pattern and color provide information on operating status or exceptions.

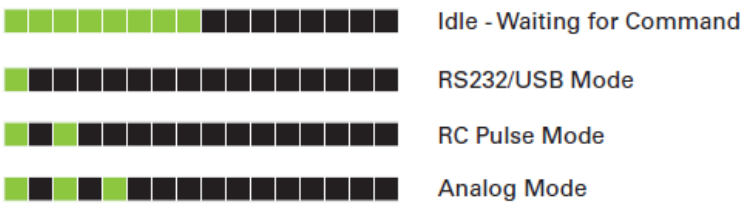


FIGURE 8. Normal Operation Flashing Patterns

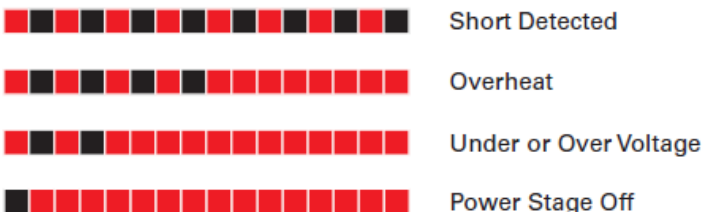


FIGURE 9. Exception or Fault Flashing Patterns

Additional information about the controller's status and fault conditions can be obtained by monitoring the controller through the PC utility. The Communication LED indicates the status of USB and CAN Bus connectivity.

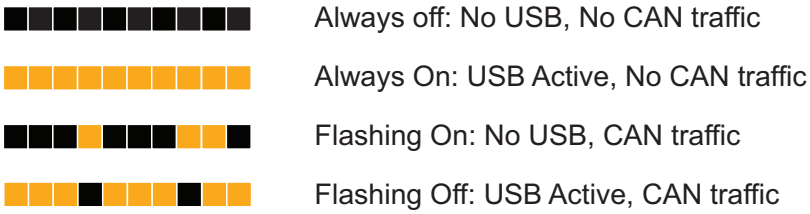


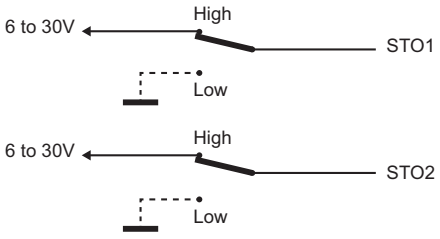
FIGURE 10. Exception or Fault Flashing Patterns

Safe Torque Off - STO

Safe Torque Off (STO) is a secure method for switching the controller into a state where no torque is generated, regardless of whether the controller is operating normally or is faulty. The STO functionality is achieved through redundant circuitry, incorporated into the STO1 and STO2 inputs of the controller. For the controller to operate normally, both STO inputs must be supplied with a voltage ranging from 6 to 30V. The controller performs a self-test of the STO circuitry every time it powers on, or when both STO inputs go high. If the STO circuitry is found to be functioning properly, the controller will allow the motor to be energized. In the event of an STO failure or if not both STO inputs are in a high state, the power stage will be cut off. Since STO is a hardware implementation and has been verified and validated by Roboteq, it can be trusted to bring the motor to a no-torque condition without the need for an external relay to cut power to the motor.

By factory default, the STO functionality is disabled by adding a jumper that bypasses the STO circuitry. To enable the STO feature, remove the jumper located on the front side of the controller and then enable the STO function in the controller's configurations. The exact location of the jumper can be observed in figure 1.

Figure 12 illustrates the STO operation. To properly trigger the STO, both STO inputs must be in a high state. To properly release the STO, both STO inputs must be low. Having only one of the two STO inputs in a high state will trigger the "STO fault" alarm.



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

FIGURE 11. STO input levels effects on controller output

Warning

Activating STO causes the motor to float and cease torque generation. Since the motor will not be actively braked, it will decelerate solely due to the system's friction. In mobile robot applications, the robot may continue moving for several meters before coming to a complete stop. For safe operation, additional braking measures should be implemented when STO is enabled, such as utilizing a mechanical or electrical brake. Roboteq offers one solution in the form of the SBSxxxx Safety Electric Brake Switch series, which quickly stops the motor by shorting its phases when STO is triggered.

For more information about STO operation, refer to the STO manual.

Electrical Specifications

Absolute Maximum Values

The values in Table 7 should never be exceeded, as doing so may result in permanent damage to the controller.

TABLE 7.

Parameter	Measure Point	Min	Max	Units
Vmot Voltage	Ground to Vmot wire	-0.5 (1)	63 (2)	VDC
Power Control Voltage	Ground to Vmot wire	-0.5 (1)	63 (2)	VDC
Motor Leads Voltage	Ground to U/V/W wires		63 (3)	VDC
Digital Output Voltage	Ground to Output pins	-0.5	30	VDC
General Purpose Inputs Voltage (4)	Ground to Input pins	-0.5	30	VDC
Hall Inputs voltage (5)	Ground to Hall A/B/C pins	-0.2	5.5	VDC
RS232 Tx Voltage	Ground to Tx pin	-12	12 (6)	VDC
RS232 Rx Voltage	Ground to Rx pin	-16	16	VDC
RS485 A/B Voltage	Ground to A/B pins	-10	10	VDC
RS485 Common Mode Voltage (7)		-7	12	VDC
CAN High/Low Voltage	Ground to CANH/CANL pins	-12	12	VDC
CAN Bus Dominant Common Mode Voltage (8)		1.5	3.5	VDC
CAN Bus Recessive Common Mode Voltage (9)		-12	12	VDC

Note 1: The drive does not have reverse battery protection. Applying a negative voltage on Vmot will result in power stage destruction.

Note 2: Operating above 63 V will damage the drive. The Vmot voltage can also increase when the motor regenerates. Additional countermeasures, such as a shunt regulator or similar devices, should be used to dissipate regenerative energy if necessary.

Note 3: Maximum motor voltage including regeneration. Never inject a DC voltage from a battery or other fixed source.

Note 4: Ranges apply to all general-purpose inputs that are configured to accept analog, digital, or pulse signals, including encoder inputs that are mapped to the DB port.

Note 5: Ranges apply to the Hall inputs that are mapped to the Molex connector.

Note 6: No voltage must be injected into the Tx pin.

Note 7: The average voltage of A and B lines ($\frac{V_A + V_B}{2}$), measured relative to the receiver's ground.

Note 8: The average voltage of CANH and CANL lines ($\frac{CAN_H + CAN_L}{2}$), referenced to system ground, when transmitting a Dominant state.

Note 9: The average voltage of CANH and CANL lines ($\frac{CAN_H + CAN_L}{2}$), referenced to system ground, when transmitting a Recessive state.

Power Stage Electrical Specifications (at 25ºC ambient)

TABLE 8.

Parameter	Measure point	Model	Min	Typ	Max	Units
Vmot Voltage	Ground to Vmot	All	14		60	Volts
Motor Voltage	Ground to U, V, W wires	All	0		60 (1)	Volts
Power Control Voltage	Ground to Power Control wire	All	12		60	Volts
Over Voltage protection range	Ground to Vmot	All	5	60 (2)	60	Volts
Under Voltage protection range	Ground to Vmot	All	0	10 (2)	50	Volts
Input Capacitance	Ground to Vmot	All		2350		uF
Idle Current Consumption	Vmot or PwrCtrl wires	All	50	100 (3)	150	mA
ON Resistance (Excluding wire resistance)	Vmot to U, V or W. Ground to U, V or W	FBLG2360Tx		2.5		mOhm
		FBLG2360TxS		1.25		mOhm
Max Current for 30s	Motor current	FBLG2360Tx			60	Amps
		FBLG2360TxS			120	Amps
Continuous Max Current per channel	Motor current	FBLG2360Tx			40 (4)	Amps
		FBLG2360TxS			80 (4)	Amps
Current Limit range	Motor current	FBLG2360Tx	10	50 (5)	60	Amps
		FBLG2360TxS	20	100 (5)	120	Amps
Stall Detection Amps range	Motor current	FBLG2360Tx	10	60 (2)	60	Amps
		FBLG2360TxS	20	120 (2)	120	Amps
Stall Detection timeout range	Motor current	All	1	500 (6)	65000	msec
Short Circuit Detection threshold (7)	Between Motor wires or Between Motor wires and ground or Between Motor wires and Vmot	FBLG2360Tx			72 (8)	Amps
		FBLG2360TxS			144 (8)	Amps
	Between Motor Wires and Vmo	All	No protection. Permanent damage will occur.			
Power cable thickness	Power input and output	All		8		AWG
Overvoltage category				III (9		

Note 1: Maximum voltage in normal operation, including regeneration.

Note 2: Factory default value. Adjustable in 0.1V increments

Note 3: Current consumption is lower when higher voltage is applied to the controller's VBat or PwrCtrl wires

Note 4: Limited by case temperature. Current may be higher with better cooling

Note 5: Factory default value. Adjustable in 0.1A increments

Note 6: Factory default value. Time in ms that Stall current must be exceeded for detection

Note 7: Related to any high-current event that may not necessarily be produced by an actual short circuit.

Note 8: RMS value

Note 9: The product was evaluated for use in and under the provisions for installation in an Overvoltage Category III environment.

Command, I/O and Sensor Signals Specifications

TABLE 9.

Parameter	Measure point	Min	Typ	Max	Units
Main 5V Output Voltage	Ground to 5V pins on	4.6	4.9	5.2	Volts
5V Output Current	5V pins on RJ45 and DSub15			200 (1)	mA
Digital Output Voltage	Ground to Output pins			30	Volts
Output On resistance	Output pin to ground		0.25	0.5	Ohm
Output Short circuit threshold	Output pin	1.7		3.5	Amps
Digital Output Current (2)	Output pins, sink current			1.5	Amps
Input Impedances (except DIN11-19)	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	3.8		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
Analog Input Floating Voltage (3)	Ground to Input pins	100		300	mV
Encoder Frequency	Encoder input pins			600 (4)	kHz
Encoder Inputs Voltage	Ground to Encoder inputs of Molex connector			24	Volts
SSI Frequency (5)	SSI input pins	330 330		10800	KHz
SSI Total Number of Bits (6)	-			47	Bits
SSI Singleturn Number of Bits	-			31	Bits
SSI Multiturn Number of Bits	-			31	Bits
Hall Inputs Voltage	round to Encoder inputs of Molex connector			5	Volts
Pulse durations	Pulse inputs	20000		10	us
Pulse repeat rate	Pulse inputs	50		250	Hz
Pulse Capture Resolution	Pulse inputs		1		us
Min Pulse On/Off Duration	Pulse inputs		25		us
Frequency Capture	Pulse inputs	100		1000	Hz
Resolver Excitation Frequency	Resolver Exc. Output		8		KHz
Resolver Excitation Voltage	Resolver Exc. Output		3.4		V
Zrs @ 8KHz (7)	Resolver Exc. Output	4.68			Ohm

Note 1: Sum of all 5VOut outputs

Note 2: Outputs are Open Drain. They pull to ground when on and float when off. Load must be connected between output and positive voltage

Note 3: The minimum voltage that can be read when the input is configured as an analog input and left floating.

Note 4: The maximum supported encoder PPR is proportional to the motor max speed and can be calculated as follows:

$$Max\_PPR = 60 \times 600000/Max\_RPM$$

Note 5: The "First Clock Delay" function is not supported.

Note 6: The combined number of Singleturn and Multiturn bits must not exceed 47.

Note 7: The minimum supported Rotor Impedance with Stator shorted (Zrs) at 8 kHz. Ensure that the motor drive can supply efficient current to the resolver sensor by staying within the specified limits. If the Rotor Impedance is a complex number, the absolute value should be calculated as follows: $|Zrs| = \sqrt{real^2 + imag^2}$.

Operating & Timing Specifications

TABLE 10.

Parameter	Measure Point	Min	Typ	Max	Units
Command Latency	Command to output change	0	0.5	1	ms
Max PWM duty cycle	Motor Output			93.8	%
Closed Loop update rate	Internal		1000 (1)		Hz
Current Loop update rate	Internal		16000		Hz
Torque Mode Resolution	Internal		0.1		A
Speed Mode Resolution	Internal		1		RPM
Position Mode Resolution	Internal		1		Counts
RS232 baud rate	Rx & Tx pins		115200 (2)		Bits/s
RS232 Watchdog timeout	Rx pin	1 (3)		65000	ms

Note 1: Applies to closed loop speed and closed loop position modes only

Note 2: 115200, 8-bit, no parity, 1 stop bit, no flow control

Note 3: May be disabled with value 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 time constant (L/R) and maximum electric operating speed requirements. The minimum required inductance is necessary to ensure low Total Harmonic Distortion (THD) of the motor current. Furthermore, to achieve proper current control and stability, the controller's current loop sampling rate will determine the minimum permissible motor time constant and the maximum operating electric speed.

TABLE 11.

Parameter	Input DC Voltage (V)	Value	Units
Minimum load phase inductance (1)	24	40	uH
	48	60	uH
	60	80	uH
Minimum load inductance/resistance ratio (1)	0 - 60	0.063	msec
Maximum theoretical electric speed (2) (3)	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

Note 3: The maximum electrical speed is theoretical and requires minimum sensor latency

Scripting

TABLE 12.

Parameter	Measure Point	Min	Typ	Max	Units
Scripting Flash Memory	Internal		32K		Bytes
Max Basic Language programs	Internal	2000		3000	Lines
Integer Variables	Internal		4096		Words (1)
Boolean Variables	Internal		8192		Symbols
Execution Speed	Internal	50 000	100 000		Lines/s
Note 1: 32-bit words					

Thermal and Environmental Specifications

TABLE 13.

Parameter	Measure Point	Min	Typ	Max	Units
Heatsink Temperature	External Heatsink			75 (1)	°C
Thermal Protection range	PCB	0		90 (2)	°C
Power Dissipation	Case			70	Watts
Thermal resistance	Power MOSFETs to case			0.8	°C/W
Humidity	Case			93 (3)	%
Ambient temperature	Ambient	-10		70	°C
Storage temperature	Ambient	-20		80	°C
Pollution Degree	-	PD2 (4)			
Fast fuse to install (5)	FBLG2360Tx		Check Note 6	2 x 60	Amps
	FBLG2360TxS		Check Note 6	2 x 60	Amps
Overload motor protection	-	Check note 7			

Note 1: The motor drive features overtemperature protection, derating current and power when internal temperature reaches 85°C. Keep the cooling plate temperature below 75°C to maintain rated current at maximum ambient temperatures

Note 2: Max allowed power will start degrade from the selected value

Note 3: Non-condensing

Note 4: The product was designed to be used in a pollution 2 degree environment.

Note 5: There are two power terminal tabs. One fuse should be installed for each channel. Power source must be capable to blow the fuse instantly in case of short circuit.

Note 6: Based on application requirements

Note 7: Current limiting mechanism available through firmware. External overload motor protection can be used if required (provided by user)

STO Specifications

TABLE 14.

Parameter	Measure Point	Min	Typ	Max	Units
STO Input High Level	Ground to STO input pin		6	30 (1)	Volts
STO Input Low Level	Ground to STO input pin		0	1	Volts
STO Response Time	Input to output change		5		msec
STO Self Check Time	Internal		1080		msec
Cable Length	2				m
EMC Immunity	According to IEC 61800-3 and IEC 61800-5-2 Annex E				
CE Declaration	Available at www.roboteq.com				

Mounting and Thermal Consideration

Mechanical Specifications

TABLE 15.

Parameter	Measure Point	Min	Typ	Max	Units
Weight	Board		500 (1)		g (lbs)
Power Connectors width	Terminal tab		0.25		Inches
Torque	D-sub standard connector		0.4 (3.54)		Nm (in-lbs)
Torque	Terminal block		0.8 (7.10)		Nm (in-lbs)
Torque	Mounting screws (4/M2.5)		0.36 (3.2)		Nm (in-lbs)
IP rating			IP40		

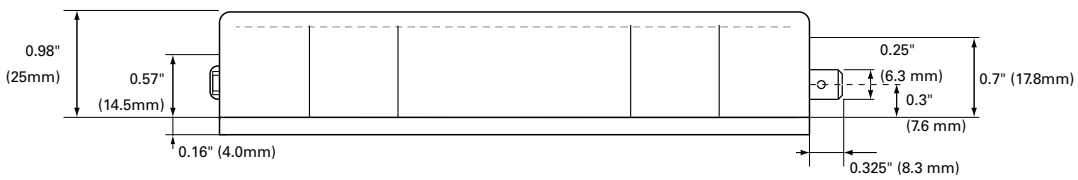


FIGURE 12. FBLG2360Txx side view and dimensions

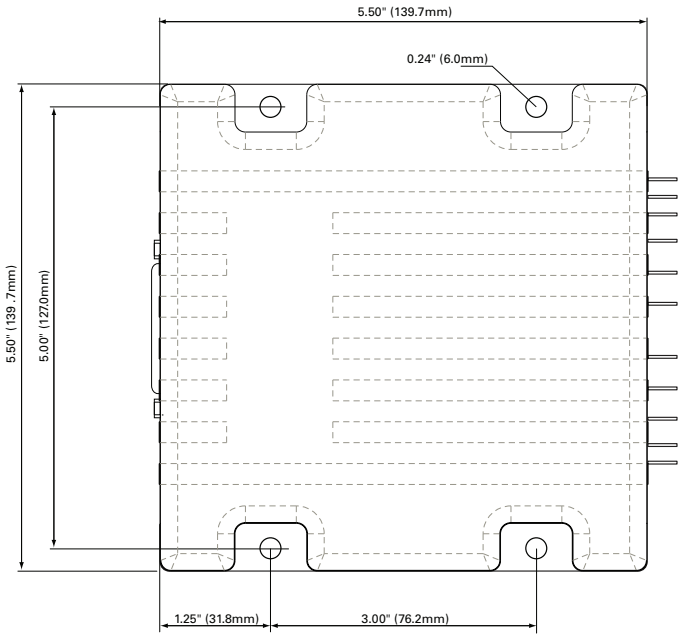


FIGURE 13. FBLG2360Txx top view and dimensionsMechanical Specifications

Conditions of Acceptability for UL recognition (CoA)

For use only in (or with) complete equipment where the acceptability of the combination is determined by UL LLC

1. Model FBLG2360Txx Series is suitable for factory wiring only. The suitability of the connections to the end use system shall be determined in the end use.
2. Series FBLG2360Txx was not considered to have any accessible circuits. All circuits shall be enclosed in the end use application.
3. These models were tested with an additional heat sink, made of aluminum, dimensions 300 mm x 240 x 40 mm, 28 cooling fins.
4. Considerations shall be given in the end-product evaluation to the conduct of a Temperature Test may be required, if another heat sink is used.
5. Integral solid state short circuit protection does not provide branch circuit protection. Branch circuit protection must be provided in accordance with the National Electrical Code and any additional local codes.
6. Integral solid state short circuit protection does not provide branch circuit protection. Branch circuit protection must be provided in accordance with the Canadian Electrical Code, Part I.
7. Use in a Pollution Degree 2 environment.
8. Suitable for use on a circuit capable of delivering not more than 5000 RMS symmetrical amperes, 60 DC volts maximum, when protected by 60A fuses per input line.