

## Advanced Features 2 x 30A or 1 x 60A Brushless PMAC Motor Controller with USB and CAN



Roboteq's SBLM23xx is a feature-packed, medium-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 motors' three windings in order to generate smooth continuous rotation. The controller also uses the Hall sensor and/or Encoder information to compute speed and measure traveled distance. The motors may be operated in open or closed loop speed mode, position mode or in torque mode. The SBLM23xx features several Analog, Pulse and Digital I/Os which can be remapped as command or feedback inputs, limit switches, or many other functions. The SBLM23xx 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 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 (AGV)
- 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, RS232 or TTL Serial, 0-5V Analog, or Pulse (RC radio) command modes
- CAN bus interface up to 1Mbit/s with multiple protocol support
- 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 Permanent Magnets AC motors at up to 30A each
- Output channels can be paralleled in order to drive a single motor at up to 60A
- Multiple Motor Operating mode
  - Trapezoidal with Hall Sensors
  - Trapezoidal Sensorless
  - Sinusoidal with Encoders
  - Sinusoidal with Hall Sensors
- Support for absolute angle encoders
  - sin/cos analog
  - SSI digital
- Differential or Single-Ended Analog angle sensor input
- Field Oriented Control (Vector Drive) in Sinusoidal modes
- Full forward and reverse motor control. Four quadrant operation. Supports regeneration
- Operates from a single 10V-60V power source
- STO - Safe Torque Off support - Certification Pending
- Programmable current limit up to 30A (60A on single channel version) per motor for protecting controller, motor, wiring and battery.
- Separate connector for rotor Sensors
- Accurate speed and Odometry measurement using Hall Sensor or Encoder data
- Up to eight Analog Inputs for use as command and/or feedback
- Up to eight 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 two Quadrature Encoders
- Four general purpose 24V, 1.5A output for brake release or accessories
- Two variable voltage brake outputs for energy optimization
- Selectable min/max, center and deadband in Pulse and Analog modes
- Selectable exponentiation factors for each command inputs
- Trigger action if Analog, Pulse or Rotor 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 12V backup power input for powering safely the controller if the main motor batteries are discharged
- Power Control input 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 9.0 mOhm ON resistance MOSFETs (4.5 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
- ABS plastic enclosure with heat conducting bottom plate
- Efficient heat sinking. Operates without a fan in most applications.
- Dustproof and weather resistant. IP51 NEMA rating
- Power wiring using high-current-handling Molex MegaFit type connectors terminals
- 4.8" (123.0mm) L, 3.3" W (83.0mm), 1.0" (25mm) H
- -40° to +85° C operating environment
- Weight: 0.47 lbs (215g)
- 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
<b>SBLM2360T</b>	2	30	60
<b>SBLM2360TS</b>	1	60	60

## Important Safety Disclaimer

A 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 their 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 Terminals Identifications and Connection

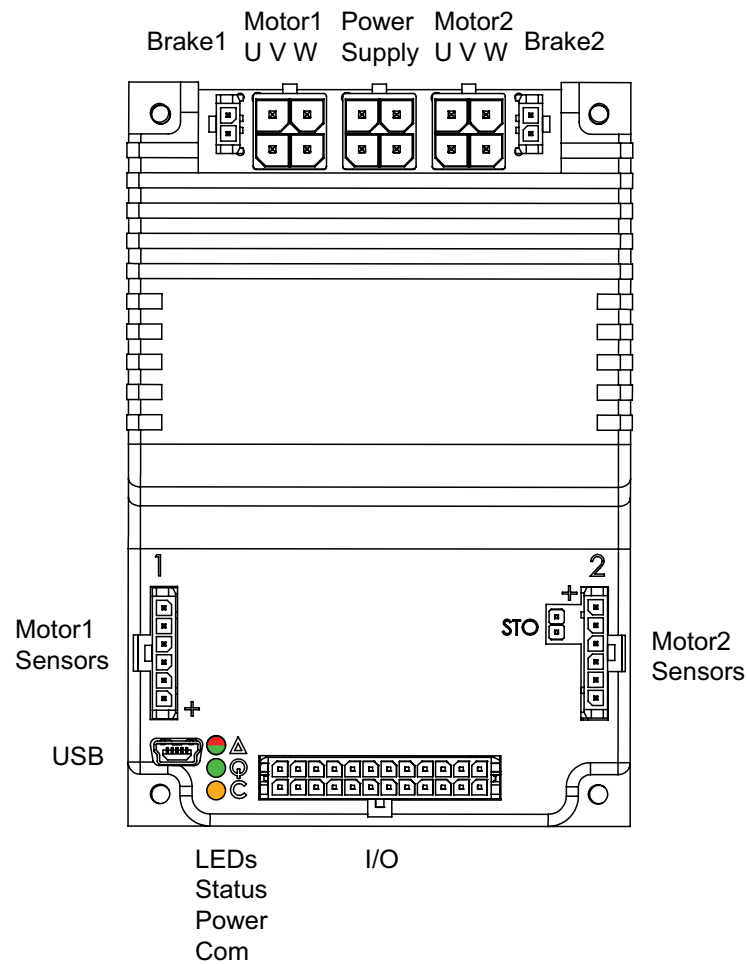


FIGURE 1. SBLM23xx C

Figure 2, below, shows how to wire the controller in a dual motor configuration, and how to turn power On and Off.

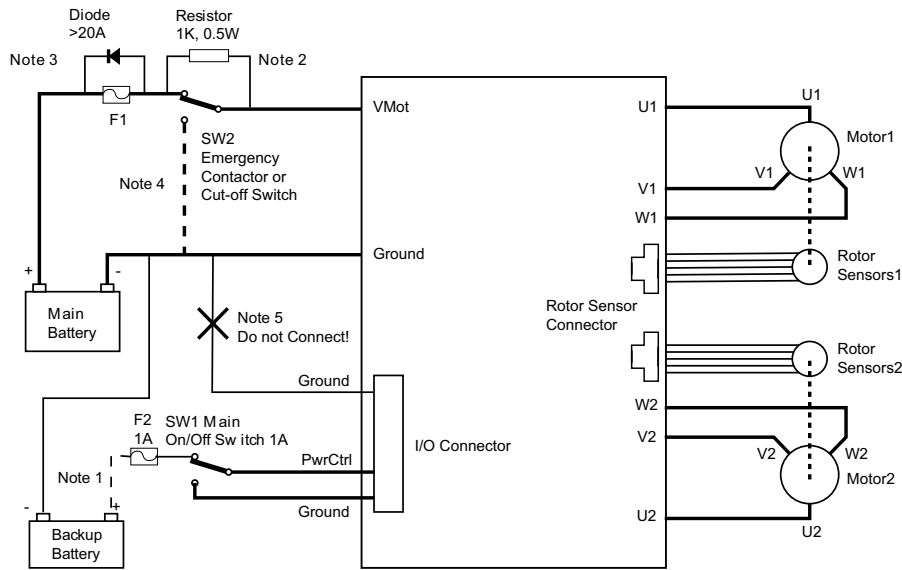


FIGURE 2. Powering the Controller. Thick lines identify MANDATORY connections

## 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 2, above, in order to ensure a safe and trouble-free operation. All connections shown as thick black lines are mandatory. The controller must be powered On/Off using switch SW1 on the Pwr Ctrl pin on the IO connector. Use a suitable 0.5A to 2A 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 VMot terminal via a high-power emergency switch or contactor SW2 as an 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: A backup battery is recommended to ensure motor operation with weak or discharged batteries. Connect a second battery to the Power Control pin via the SW1 switch.

Note 2: Use precharge 1K, 0.5W Resistor to prevent switch arcing.

Note 3: Insert a high-current diode to ensure a return path to the battery during regeneration in case the fuse is blown.

Note 4: Users have the option to ground the VMot terminal when the controller is Off. Grounding the VMot will cause the motors to have their leads shorted through the diodes inside the power MOSFETs. This will cause a rapid braking and will make the motors difficult to push accidentally.

Note 5: Be careful 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 SBLM23xxS, each of the motor wires must be connected to both output terminals of the same letter as shown in Figure 3, below. Use the Encoders and/or Hall sensors of Channel 1 for operation.

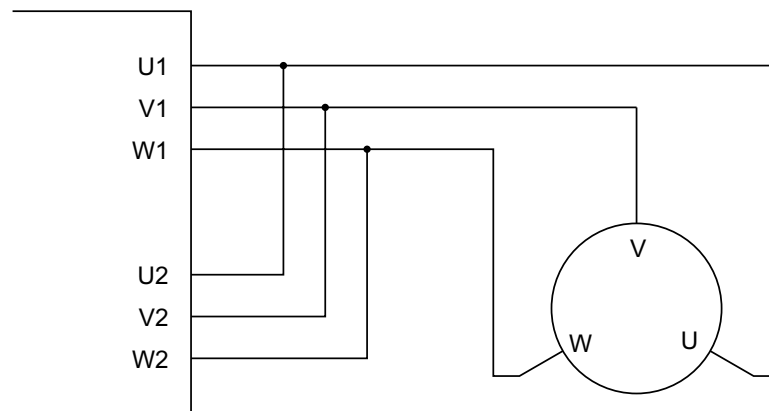


FIGURE 3. Single Channel Wiring Diagram

### Important Warning

**The wiring shown in Figure 3 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 SBLM2360S 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 personal injury can occur due to uncontrolled motor operation resulting from a failure in the controller's power output stage.

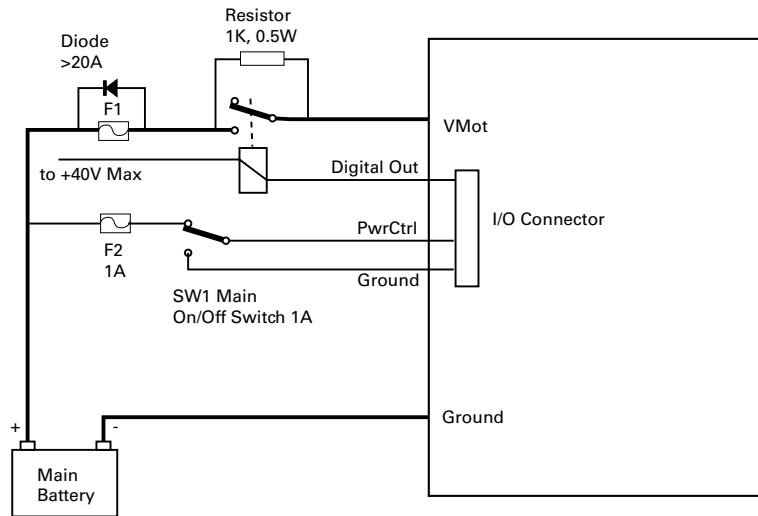


FIGURE 4. Contactor Wiring Diagram

The contactor coil must be connected to a digital output configured to activate when a “No MOSFET Failure” occurs. The controller will automatically deactivate the coil if the output is expected to be off and a 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.

## Power and Motor Connections

Connection to the battery is made using two a 4-pin Molex MegaFit connectors. Use mating connector model 170001-0104. Both GND and VMOT pins are doubled in order to carry higher current.

Another 4-pin Molex MegaFit connector is provided for each motor. 3 pins supply the U, V and W phase voltages. A Ground pin can be used for an optional motor cable shield.

A 2-pin Molex MicroFit connector is provided for connecting a brake for each motor (see next section). Use mating connector model 436450200

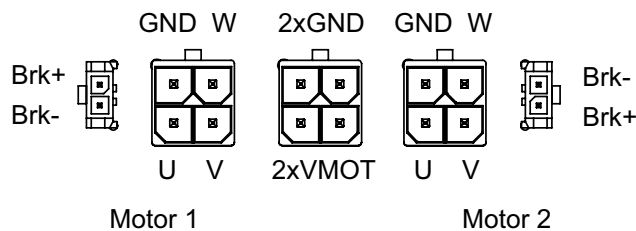


FIGURE 5. SBLM23xx Power and Motor Connectors

## Motor Brake Connection

Two pins on the motor connector are provided for connection to a motor brake. The output is modulated with a PWM signal so that a higher voltage can be initially applied to energize the coil, and then reduced to maintain the brake released while consuming less energy.

## Important Warning

**The Brk+ is internally connected to the VMOT supply voltage. Exercise care to avoid short circuits during wiring.**

**Note that brake outputs activations 1 and 2 are shared with digital outputs 3 and 4 on the 24-pin I/O connector.**

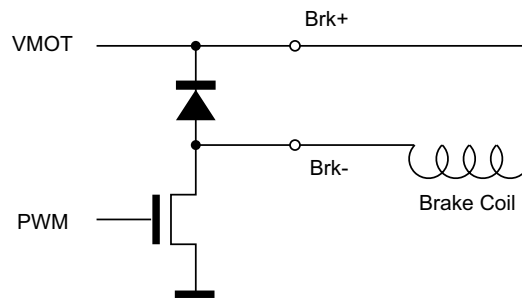


FIGURE 6. Brake drive circuit and connection

## Controller Mounting

During motor operation, the controller will generate heat that must be dissipated. The published amps rating can only be fully achieved if adequate cooling is provided. Good conduction cooling can be achieved by mounting the controller to a metallic surface, such as the chassis, cabinet, etc.

## Hall Sensors Connection

Connection to the Hall Sensors is done using connectors at the left and right side of the controller. The Hall sensor connector is a 6-pin Molex Microfit 3.0, ref. 436450600.

Pin assignment are shown in Figure 7, below:

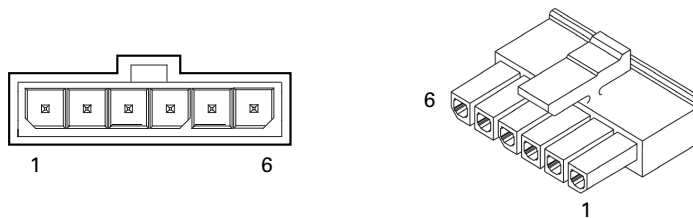


FIGURE 7. Motor Sensors Connector

TABLE 1.

Pin Number	1	2	3	4	5	6
Signal	5V		Hall C	Hall B	Hall A	Ground

### 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.

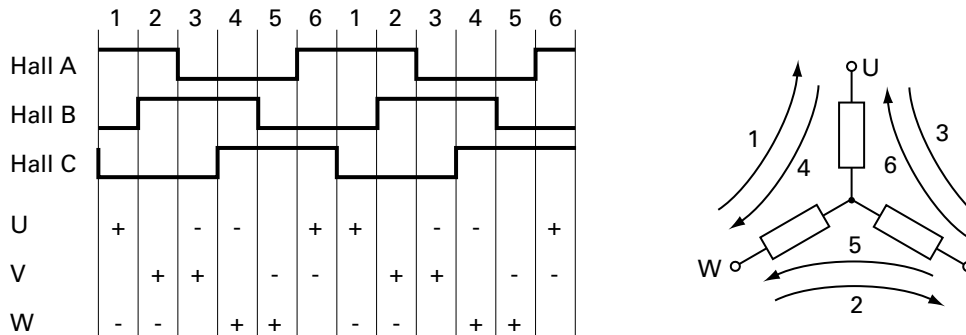


FIGURE 8. Hall Sensors Sequence

### 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 6-pin Molex connector that is otherwise used for the Hall Sensors. The controller issues a clock signal to, and receives data signals from, the encoder.

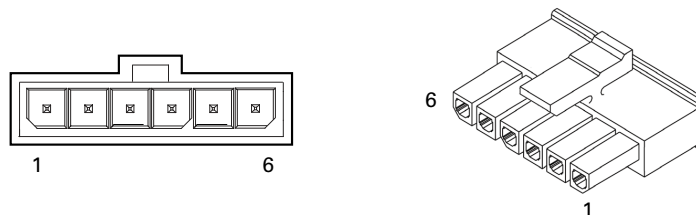


FIGURE 9. Motor sensor connector used for SSI Encoders

TABLE 2.

Pin Number	1	2	3	4	5	6
Signal	5V	Clock -	Clock +	Data -	Data +	Ground



### Connection to Analog Sin/Cos Absolute Encoder

The SBLM23xx has four high-speed analog inputs that can be used to capture absolute angle position from angular sensors with sin/cos voltage outputs. The sensor can be single ended or differential. Single ended signal must be 0-5V max with the 0 at 2.500V.

TABLE 3. Differential Sin/Cos signals on the SBLM23xxx

Pin Number	1	2	3	4	5	6
Signal	5V	Cos-	Cos+	Sin-	Sin+	Ground

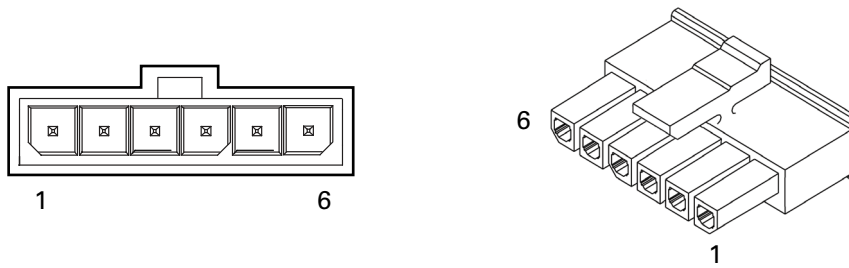


FIGURE 10. Motor sensor connector pin identification

### Commands and I/O Connections

Connection to RC Radios, Microcomputers, Joysticks and other low current sensors and actuators are done via the 24-pin Molex Microfit connector. Use mating connectors models 44914-24010 or 44914-24000. The functions of many pins vary depending on controller model and user configuration. Pin assignments can be found in Table 4, below.

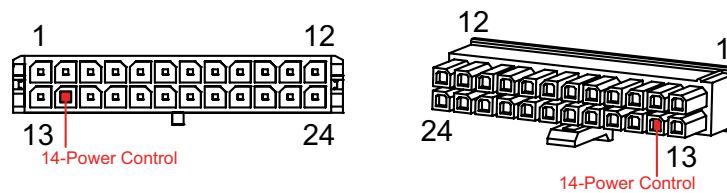


FIGURE 11. Main Connector Pin Locations

TABLE 5.

Connector Pin	Power	Dout	Com	Pulse	Ana	Dinput	Enc	STO
1	GND							
13	5VOut							
2				PIN8	ANA8	DIN8	ENC1B	
14	Power Ctrl							
3						DIN10		
15				PIN7	ANA7	DIN7	ENC1A	
4						DIN9		
16				PIN6	ANA6	DIN6	ENC2B	
5			CANL					
17				PIN5	ANA5	DIN5	ENC2A	
6		DOUT4						
18			CANH					
7		DOUT2						
19		DOUT3						
8	GND							
20		DOUT1						
9				PIN3	ANA3	DIN3		STO1
21				PIN4	ANA4	DIN4		STO2
10			RS RxD					
22				PIN2	ANA2	DIN2		
11			RSTxD					
23				PIN1	ANA1	DIN10		
12	GND							
24	5VOut							

### 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 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.

### 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. 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 environment. Further, communication will not always recover after it is lost without unplugging and replugging the connector, or restarting the controller. RS232 is the preferred communication method when interfacing with a computer. USB and CAN can operate at the same time on the SBLM2360.

**Status LEDs and Flashing Patterns**

The controller is equipped with three LEDs. A Green Power LED, a Red/Green Status LED, and a Yellow Communication LED.

After the controller is powered on, the Power LED will turn on, indicating that the controller is On. The Status LED will be flashing at a two second interval. The flashing patterns and colors provide operating or exception status information.

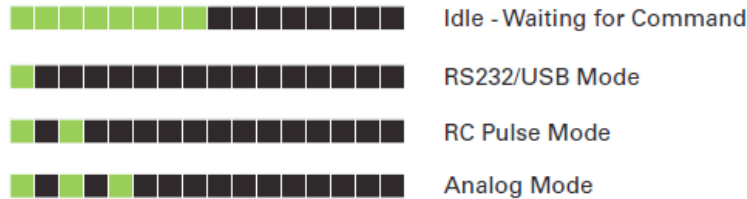


FIGURE 12. Normal Operation Flashing Patterns

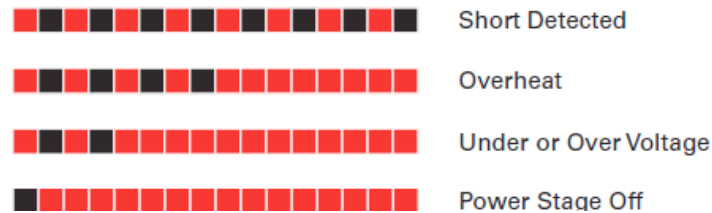


FIGURE 13. Exception or Fault Flashing Patterns

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.

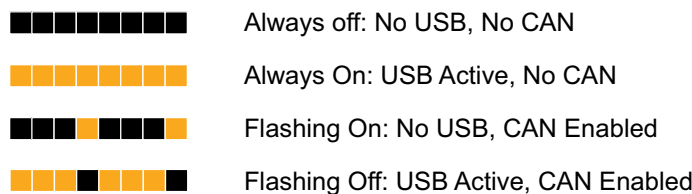


FIGURE 14. Communication LED Flashing Patterns

## Measured Amps

The controller includes Amps sensors in line with the motor terminals and on the battery ground terminals. Both Motor Amps and Battery Amps are therefore measured with precision.

## Safe Torque Off - STO (Certification Pending)

Safe Torque Off is a secure method for stopping the motor, regardless whether the controller is operating normally or is faulty. STO is Hardware-based, meaning that the MCU does not need to be processing the inputs or drive the motor outputs. When STO is enabled, two digital inputs, DIN3 and DIN4 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, even in the case where any one component inside the controller is damaged. The STO circuit is verified and validated by TUV (certification pending) and can therefore be trusted in lieu of external relays.

By factory default STO is disabled. It must be enabled by removing the STO jumper on the controller.

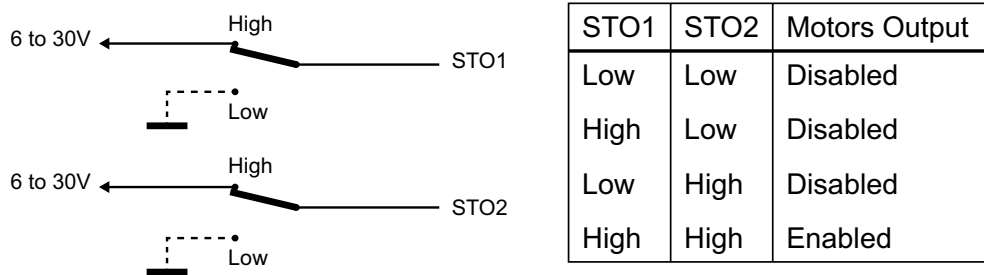


FIGURE 15. STO input levels effects on controller output

## Electrical Specifications

### Absolute Maximum Values

The values in Table 5, below, should never be exceeded, permanent damage to the controller may result.

TABLE 6.

Parameter	Measure point	Model	Min	Typ	Max	Units
Battery Leads Voltage	Ground to VBat	SBLM2360			63	Volts
Reverse Voltage on Battery Leads	Ground to VBat	All	-1			Volts
Power Control Voltage	Ground to Pwr Control wire	SBLM2360			30	Volts
					30	Volts
Motor Leads Voltage	Ground to U, V, W wires	SBLM2360			63 (1)	Volts
Digital Output Voltage	Ground to Output pins	All			40 (2)	Volts

TABLE 6.

<b>Parameter</b>	<b>Measure point</b>	<b>Model</b>	<b>Min</b>	<b>Typ</b>	<b>Max</b>	<b>Units</b>
Analog and Digital Inputs Voltage	Ground to any signal pin on 15-pin & Hall inputs	All			30	Volts
RS232 I/O pins Voltage	External voltage applied to Rx pin	All			30 (3)	Volts
Case Temperature	Case	All	-40		85	°C
Humidity	Case	All			100 (4)	%
Note 1: Maximum regeneration voltage in normal operation. Never inject a DC voltage from a battery or other fixed source 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: No external voltage must be applied to Rx pin. Damage to driver will occur Note 4: Non condensing						

**Power Stage Electrical Specifications (at 25oC ambient)**

TABLE 7.

<b>Parameter</b>	<b>Measure point</b>	<b>Model</b>	<b>Min</b>	<b>Typ</b>	<b>Max</b>	<b>Units</b>
Battery Leads Voltage	Ground to VMot	SBLM2360x	0 (1)		63	Volts
Motor Leads Voltage	Ground to U, V, W wires	SBLM2360x	0 (1)		63 (2)	Volts
Power Control Voltage	Ground to Power Control wire	All	0 (1)		30	Volts
Minimum Operating Voltage	VBat or Pwr Ctrl wires	All	9 (3)			Volts
Over Voltage protection range	Ground to VMot	SBLM2360x	5	60 (4)	63	Volts
Under Voltage protection range	Ground to VMot	SBLM2360x	0	5 (4)	63	Volts
Idle Current Consumption	VMot or Pwr Ctrl wires	All	50	100 (5)	150	mA
ON Resistance (Excluding wire resistance)	VMot to U, V or W. Ground to U, V or W	SBLM23xx		9.0		mOhm
		SBLM23xxS		4.5		mOhm
Max Current for 30s	Motor current	SBLM23xx			30	Amps
		SBLM23xxS			60	Amps
Continuous Max Current per channel	Motor current	SBLM23xx			20 (6)	Amps
		SBLM23xxS			40	Amps
Current Limit range	Motor current	SBLM23xx	10	50 (7)	30	Amps
		SBLM23xxS	20	100 (7)	60	Amps
Stall Detection Amps range	Motor current	SBLM23xx	10	30 (7)	30	Amps
		SBLM23xxS	20	60 (7)	60	Amps

TABLE 7.

Parameter	Measure point	Model	Min	Typ	Max	Units
Stall Detection timeout range	Motor current	All	1	500 (8)	65000	milli-seconds
Short Circuit Detection threshold (9)	Between Motor wires or Between Motor wires and round	SBLM23xx			85 (10)	Amps
		SBLM23xxS			190 (10)	Amps
Short Circuit Detection threshold	Between Motor wires and VBat	All	No Protection. Permanent damage will result			
Motor Acceleration/Deceleration range	Motor Output	All	100	500 (11)	65000	milli-seconds

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

Note 6: Estimate. Limited by case temperature. Current may be higher with better cooling

Note 7: Factory default value. Adjustable in 0.1A increments

Note 8: Factory default value. Time in ms that Stall current must be exceeded for detection

Note 9: Controller will stop until restarted in case of short circuit detection

Note 10: Approximate value

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

## Command, I/O and Sensor Signals Specifications

TABLE 8.

Parameter	Measure point	Min	Typ	Max	Units
Main 5V Output Voltage	Ground to 5V pins on	4.6	4.75	4.9	Volts
5V Output Current	5V pins on Molex and DSub25			100 (1)	mA
Digital Output Voltage	Ground to Output pins			30 (2)	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	Output pins, sink current			1.5 (2)	Amps
Input Impedances (except DIN7-8)	AIN/DIN Input to Ground		53		kOhm
Digital Input 0 Level	Ground to Input pins	-1		1	Volts

TABLE 8.

<b>Parameter</b>	<b>Measure point</b>	<b>Min</b>	<b>Typ</b>	<b>Max</b>	<b>Units</b>
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
Frequency Capture	Pulse inputs	100		2000	Hz

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

## Operating & Timing Specifications

TABLE 9.

<b>Parameter</b>	<b>Measure Point</b>	<b>Min</b>	<b>Typ</b>	<b>Max</b>	<b>Units</b>
Command Latency	Command to output change	0	0.5	1	ms
PWM Frequency	Motor Output	10	16	20	kHz
Closed Loop update rate	Internal		1000		Hz
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 10.

<b>Parameter</b>	<b>Measure Point</b>	<b>Min</b>	<b>Typ</b>	<b>Max</b>	<b>Units</b>
Scripting Flash Memory	Internal		32000		Bytes
Max Basic Language programs	Internal	1000		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 Specifications

TABLE 11.

Parameter	Measure Point	Min	Typ	Max	Units
Case Temperature	Case	-40		85 (1)	°C
Thermal Protection range	Case	80		90 (2)	°C
Power Dissipation	Case			10 (2)	Watts
Thermal resistance	Power MOSFETs to plate			0.6	°C/W
Humidity	Case			100(3)	%

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  
 Note 3: Attach plate to metallic surface to achieve higher power dissipation

## Mechanical Specifications

TABLE 12.

Parameter	Measure Point	Min	Typ	Max	Units
Weight	Board		215 (0.47)		g (lbs)
Power Connectors Wiring	Terminals	14		22	AWG

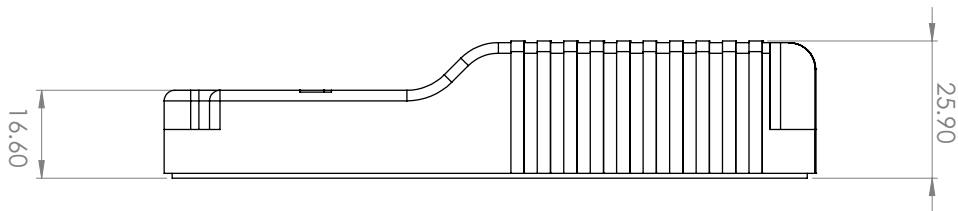


FIGURE 16. SBLM23xx Side View and Dimensions



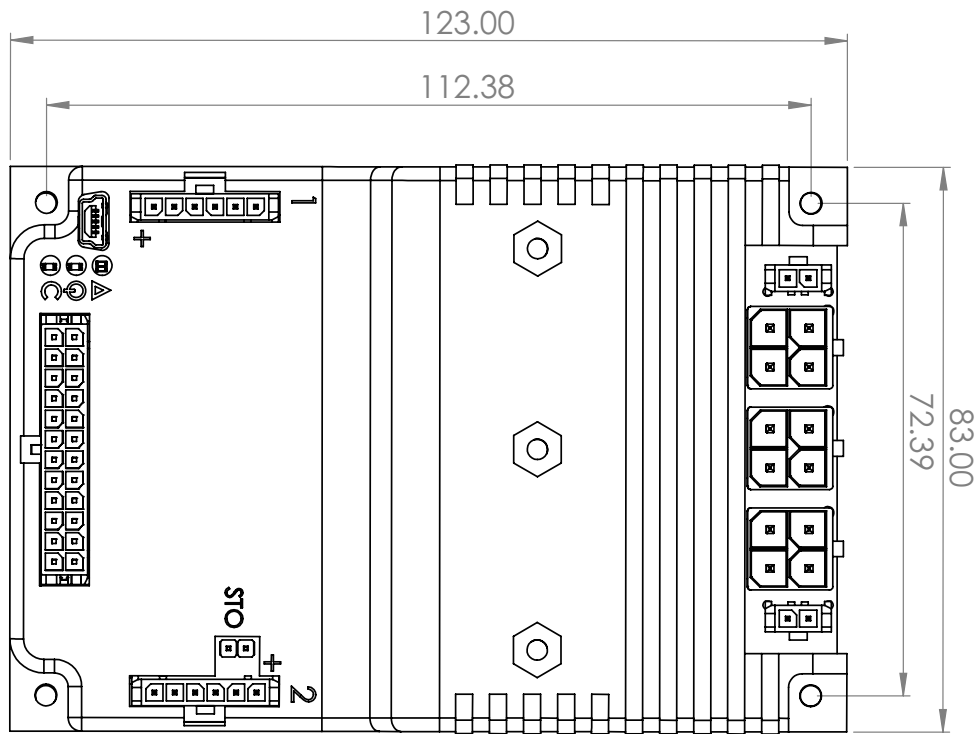


FIGURE 17. SBLM23xx Top View and Dimensions