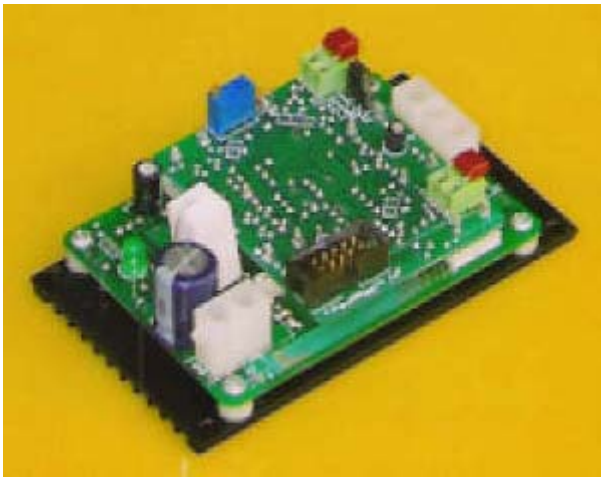
BLMC-L-SL-I Low Voltage Sensorless Brushless DC Motor Controller

Product Datasheet

BLMC-L-SL-I is a low voltage, three phase, six step, full wave and sensorless Brushless DC Motor controller. Its maximum output current is 10A. This controller has two sub-types, BLMC-L-SL-I17/59. BLMC-L-SL-I17 is suitable for 9 to 17VDC power supply. And BLMC-L-SL-I59 is suitable for 17 to 59VDC power supply.

- Three Phase MOSFET H-Bridge (23kHz PWM)
- Sensorless, Three Phase Lines, No Centertap
- Forward/Reverse Direction--F/R
- Run Enable/Disable--En
- Dynamic Braking--Brk
- Open Loop Speed Control--Adj
- Close Loop Speed-Frequency Feedback--FG
- Close Loop Speed-Voltage Feedback--FV (Optional)
- PWM Cycle-By-Cycle Current Limit
- Internal Undervoltage Lockout



Please read Safety Warning below carefully before installing and operating this controller!

- **This product should be installed and serviced by a qualified technician, electrician, or electrical maintenance person familiar with its operation and the hazards involved.**
- **To connect or disconnect J1 when power on (Power LED on) is FORBIDDEN. J1 phase missing is FORBIDDEN.**
- **Insulated adjustment tools must be used when power on (Power LED on). Do not touch the PCB board and junctions when power on (Power LED on).**
- **All output and input terminals are NOT isolated from the incoming supply.**

Absolute Maximum Ratings

(The Absolute Maximum Ratings are those values beyond which the safety of the controller cannot be guaranteed)

Parameter	Symbol	Value	Unit
Power Supply Peak Voltage	Vcc (BLMC-L-S-I17) Vcc (BLMC-L-S-I59)	17 59	VDC
Peak Current	I_{CC}, I_A, I_B, I_C	15 (Less than 10s)	A
Continuous Current	I_{CC}, I_A, I_B, I_C	10	A
Digital Inputs Voltage	F/R, En, Brk	-0.3 to 6	V
Speed Control Input Voltage	Adj	-0.3 to 6	V
Speed Feedback Output Current	I_{FV}, I_{FG}	5 (Sink or Source)	mA
Max Controllable Motor Speed	One Magnetic Pole-pair Rotor	50000	rpm
Surface Temperature of the Sink	Ts	85	℃
Operating Ambient Temperature Range	Ta	0 to +70	℃

Thermal Characteristic

(Vcc=24VDC, I_{CC}=5A, Ta=20℃, Motor Speed=5000rpm, Good Free-convection Cooling)

Parameter	Symbol	Min	Typ	Max	Unit
Sink Surface Temperature	Ts	-	60	-	℃

Electrical Characteristics

(Vcc=24VDC, Ta=20℃, unless otherwise noted)

Parameter	Symbol	Min	Typ	Max	Unit
Vcc--DC Power Supply					
BLMC-L-SL-I17	Vcc	9	12	17	VDC
BLMC-L-SL-I59	Vcc	17	24, 36, 48	59	VDC
Quiescent Current	I_Q	-	35	50	mA
F/R--Forward/Reverse Direction Digital Input					
High Threshold Volt	V_{IH}	3.5	-	5	V
Low Threshold Volt	V_{IL}	0	-	1.5	V
High State Current	I_{IH}	30	-	75	uA
Low State Current	I_{IL}	-1	-	0	uA
En--Run Enable Digital Input					
High Threshold Volt	V_{IH}	1.8	-	5	V
Low Threshold Volt	V_{IL}	0	-	1.5	V
High State Current	I_{IH}	11	-	45	uA
Low State Current	I_{IL}	0	-	9	uA

Brk--Dynamic Braking Digital Input

High Threshold Volt	V_{IH}	2.7	-	5	V
Low Threshold Volt	V_{IL}	0	-	0.7	V
High State Current	I_{IH}	110	-	230	uA
Low State Current	I_{IL}	0	-	18	uA

Adj--Open Loop Speed Control Analog Input (Motor No Load Speed)

Full Speed Volt	V_{Up}	3.8	4.0	4.2	V
Zero Speed Volt	V_{Dn}	0.8	1.0	1.2	V
ADC Resolution	ΔV	-	1/64	-	-

FV-- Close Loop Speed-Voltage Feedback Digital Output

High State Volt	V_{OH}	-	4.5	-	V
Low State Volt	V_{OL}	-	1	-	V
Output Current	I_O	-	-	±5	mA

FG--Close Loop Speed-Frequency Feedback Digital Output

High State Volt	V_{OH}	4.0	-	5	V
Low State Volt	V_{OL}	0	-	0.5	V
Output Current	I_O	-	-	±5	mA

Undervoltage Lockout

Undervoltage	UV	-	8	9	VDC

Junction Table

Junction	Pin	Type	Function
J1	A	Driver Output	A Phase Winding Driver
	B	Driver Output	B Phase Winding Driver
	C	Driver Output	C Phase Winding Driver
J2	Vcc	Power Supply	DC Power Supply, Positive Line
	GND	-	Power Supply GND, Negative Line
J3	1, 2, 3	Jumper Switch	Pin 1 Short Circuit to Pin 2 Suitable for Low Speed Motor; All Open Suitable for Middle Speed Motor; Pin 2 Short Circuit to Pin 3 Suitable for High Speed Motor
J4	F/R	Digital Input	Forward/Reverse Direction, TTL Compatible
	En	Digital Input	Run Enable, Logic Low or Float Active, TTL Compatible
	Brk	Digital Input	Dynamic Braking, Logic High Active, TTL Compatible
	Up	Voltage Divider	Potentiometer Up Pin
	GND	-	Signals GND
	Adj	Analog Input	Open Loop Speed Control
	GND	-	Signals GND
	Dn	Voltage Divider	Potentiometer Down Pin
	FV (Optional)	Digital Output /(NC)	Close Loop Speed-Voltage Feedback, TTL Compatible /(NC)
	FG	Digital Output	Close Loop Speed-Voltage Feedback, TTL Compatible

Main Functions Description

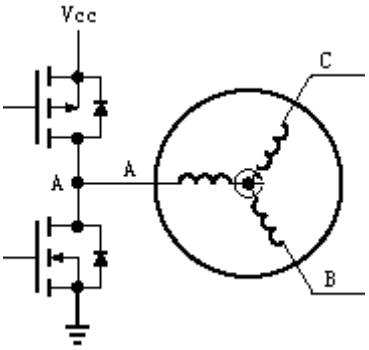
Vcc--Power Supply:

A stabilized power supply or battery is recommended. Please see the “Absolute Maximum Ratings” for proper operation.

This controller has two sub-types, BLMC-L-SL-I17/59. BLMC-L-SL-I17 is suitable for 9 to 17VDC power supply. And BLMC-L-SL-I59 is suitable for 17 to 59VDC power supply. Because of the difference of the “Absolute Maximum Ratings”, they cannot be substituted for each other.

A, B, C--MOSFET H-Bridge:

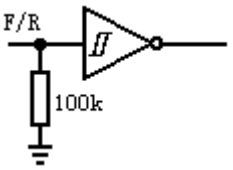
The driver circuit is shown in right figure. This controller could drive either Y or delta winding motor. Centertap is unwanted. Please see the “Commutation Truth Table” for details.



The use of 23kHz pulse width modulation at the three bottom MOSFETs provides an energy efficient method of controlling the motor speed by varying the average voltage applied to each stator winding during the commutation sequence.

The running direction depends on the connection sequence of three phase lines. Exchanging any two lines of the three will cause the motor to run in the opposite direction. The running direction also depends on the state of F/R and the structure of BLDC motor.

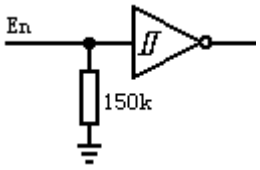
F/R--Forward/Reverse Direction Digital Input:



This signal is TTL compatible. The input circuit is shown in right figure. Please see the "Commutation Truth Table" for details.

When F/R signal is low or float, the direction of motor rotation is forward. When F/R is high, it is reverse. The running direction also depends on the connection sequence of A, B, C three phase lines and the structure of BLDC motor.

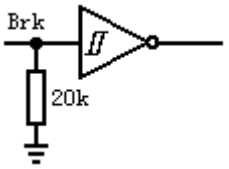
En--Run Enable Digital Input:



This signal is TTL compatible. The input circuit is shown in right figure. Please see the "Commutation Truth Table" for details.

A logic low or float at En pin causes the motor to run, while a high causes it to coast.

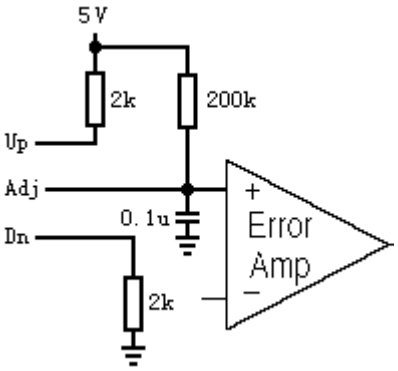
Brk--Dynamic Braking Digital Input:



This signal is TTL compatible. A logic low or float at Brk pin allows the motor to run, while a logic high causes it to brake--high damp rapid deceleration. The input circuit is shown in right figure.

Please fix the motor and the load carefully before this function is activated. Otherwise the load maybe broken by the brake force and people maybe injured.

Adj--Open Loop Speed Control Analog Input:



The input circuit is shown in right figure. There are three methods to control the speed of the motor:

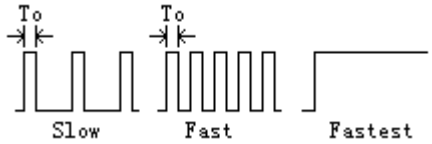
First, connect the top side and bottom side of a 10k ohm potentiometer to the Up pin and Dn pin of the junction separately. And connect the middle pin of the potentiometer to Adj pin.

Second, using an operational amplifier (or D/A). Connect the output of operational amplifier (or D/A) directly to Adj pin.

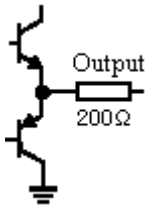
Third, connect a filtered PWM signal to Adj pin. The internal filter capacitance of this controller is 0.1uF. An external series-connection filter resistance is necessary and 10k ohm is recommended. The frequency of PWM should be greater than 5kHz.

When the average input voltage of Adj is higher than 4V, the motor runs at maximum speed if no load. When the average input voltage of Adj is lower than 1V, the motor stops. Usually before the motor stops, the controller comes into ramp mode. Ramp mode varies depending on the characteristics of the motor and its load. Please see the "Ramp Mode and Adjusting Components" for details.

FV--Close Loop Speed-Voltage Feedback Digital Output:



FV signal is a monostable pulse output, TTL compatible. The output circuit is shown in right figure. Its frequency and average voltage after filter are directly proportional to the motor speed. The output waveforms are shown in left figure.



FV (Hz)=Speed (rpm) * 6 * N / 60. N means the number of magnetic pole-pairs (NOT POLES) of the rotor.

Because of different rotation speed and magnetic pole-pairs, VR2 potentiometer must be adjusted for different motor,

in order to match the output voltage range to motor speed range.

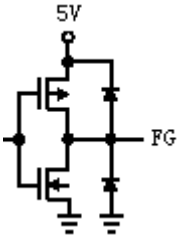
This function is optional. If customer does not order, this module will not be installed and FV pin is NC.

FG--Close Loop Speed-Frequency Feedback Digital Output:

FG signal is TTL compatible. The output circuit is shown in right figure.

Its frequency is directly proportional to the motor speed. The output waveforms are shown in left figure.

FG (Hz) = Speed (rpm) * N * 3 / 60. N means the number of magnetic pole-pairs (NOT POLES) of the rotor.



PWM Cycle-By-Cycle Current Limit:

There is a PWM Cycle-By-Cycle current limit circuit in this controller. The value of the limit is adjustable. To adjusting the VR1 potentiometer, clockwise decreases the value of the limit, counter-clockwise increases the value of the limit. For most applications, the current limit should be about 1.2 to 1.3 times as much as rated load current. But it must be less than 15A.

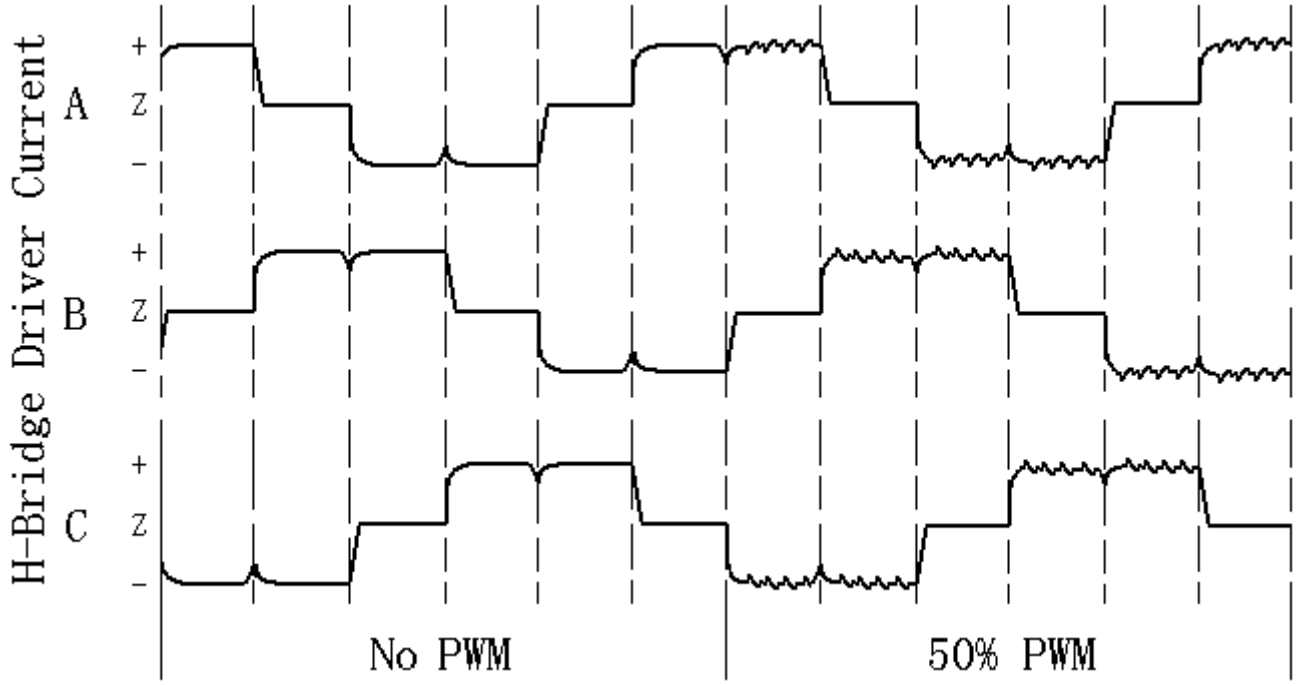
If the current limit works for long time, the controller may be damaged by hotness.

Undervoltage Lockout:

An undervoltage lockout has been incorporated to prevent damage to the IC and the MOSFETs. When Vcc falls below 8VDC, the IC acts as though the Run Enable Pin was high state and all the functions are disabled.

Commutation Truth Table

Control Inputs			Internal Protections	MOSFET H-Bridge Driver		
F/R	En	Brk	CL or UV	A	B	C
X	X	X	Anyone Active	Z	Z	Z
X	X	1	All Inactive	0	0	0
X	1	0	All Inactive	Z	Z	Z
1/0	0	0	All Inactive	Normal Commutation (Figure Below)		



Normal Commutation Waveforms (Not Ramp Mode)

Note: “1”=High, “0”=Low, “X”=Don’t care, “Z”=High impedance, “+”= Positive current, “-”=Negative current

Ramp Mode and Adjusting Components

Ramp Mode:

When the motor is stationary, runs very slowly or forward/reverse through zero speed, there is no or not enough back-EMF and the rotor position is unknown. For this reason, the sensorless BLDC controller has to activate the rotor in forced commutation mode. This mode is called ramp mode. During ramp period, current will be higher and the rotor will oscillate or jump for a short while, usually less than 3 seconds. Long time ramp mode maybe cause the controller damaged by hotness.

Ramp mode varies depending on the characteristics of the motor and its load, and can be adjusted by matching the below components on the controller.

Adjusting Components:

There are three adjustable components: J3, C1 and C2.

J3 is a jumper, designed to match the motor speed. Pin 1 short circuit to pin 2 is suitable for low speed motor. If the rotor is one magnetic pole-pair, the speed range is about below 5000rpm. J3 all open is suitable for middle speed motor,

approximately between 5000rpm and 15000rpm for one pole-pair rotor. Pin 2 short circuit to pin 3 is suitable for high speed motor, above 15000rpm for one pole-pair rotor. Pin 1 short circuit to pin 3 is forbidden, will cause the controller broken.

C1 is a capacitor, designed to adjust the startup current of the motor. Smaller C1 will cause the startup current higher, vice versa. High power, high torque and high inertia motor need high startup current, vice versa. If the startup current is too low, the motor will have not enough torque to ramp. But the startup current should not exceed the current limit.

C2 is a capacitor, designed to adjust the time of ramp mode. Smaller C2 will cause the ramp time shorter, vice versa. High torque, high damp and high inertia motor need long ramp time, vice versa. Of course, short ramp time is always wanted. But, on the contrary, too short ramp time will extend ramp process because the motor has not enough time to ramp up.

Experientially, C1 is about 2 times as much as C2. C1=0.47uF and C2=0.22uF seem to be suitable for most no-load motors.

Usually, because the details of client's application are unknown, the default values of the above three components are set only for no load characteristics. Loaded values must be matched by client's technician carefully and experimentally.

If you do not know one or more of the above values, it is still possible to pick components for the controller, but some experimentation may be necessary to determine the optimal value. You can set about the experimentation from the default (no load) values. When loaded, C1 should be decreased and C2 should be increased bit by bit. J3 should be maintained the default value or jumped to the next lower speed range. Shorter ramp time (usually less than 3 seconds) and rational startup current is the end of the experimentation.

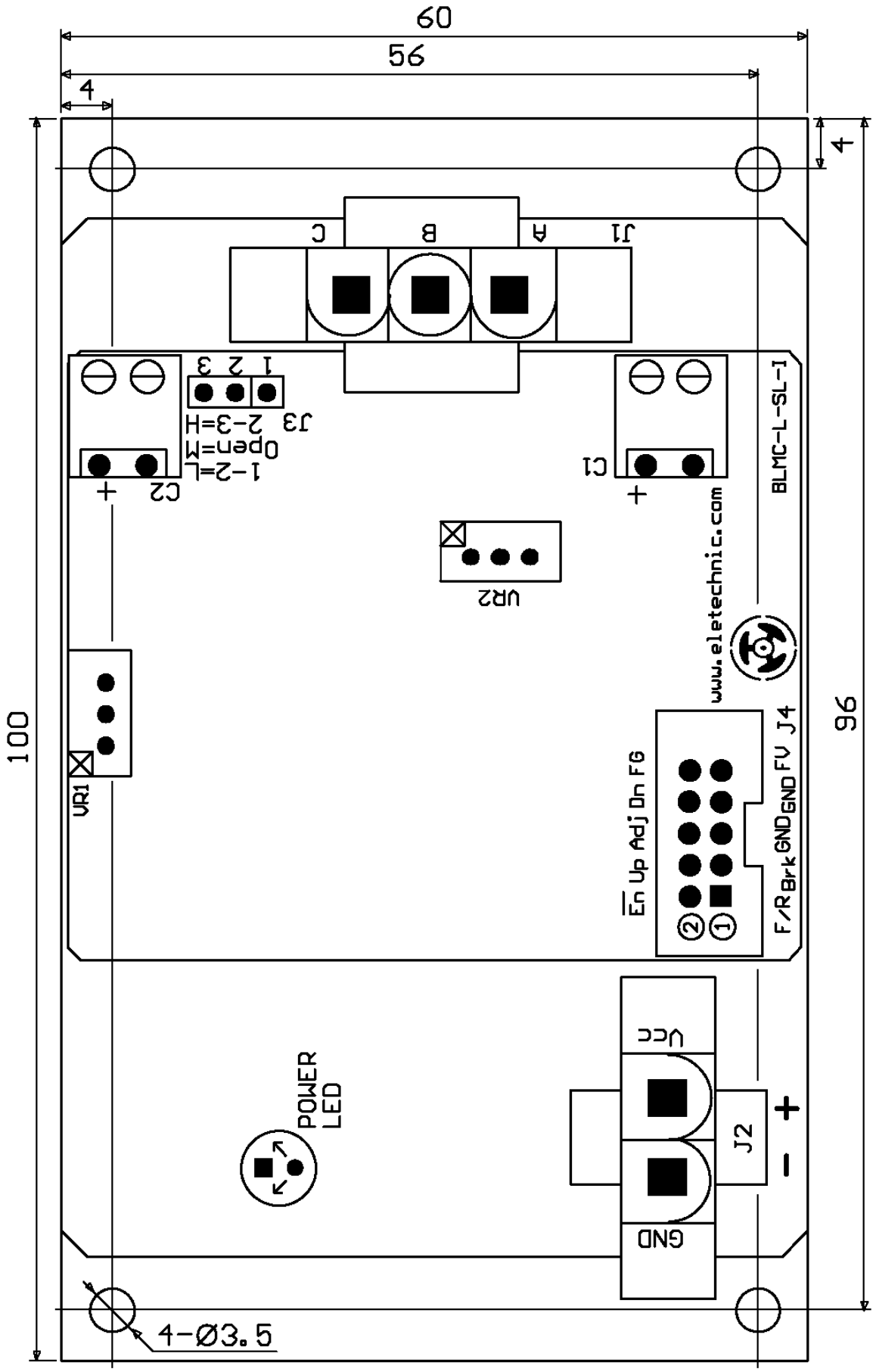
If the motor type or load is changed, the above three components must be re-adjusted.

Controller Dimension and Connection Diagram (Unit: mm)

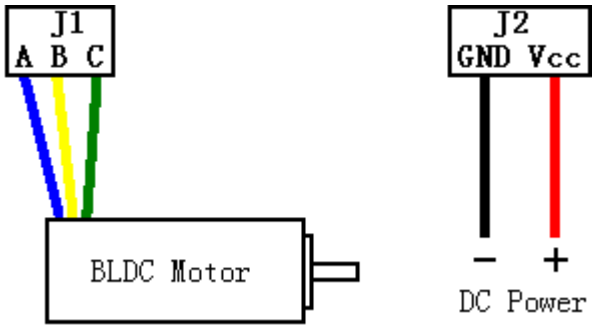
The controller dimension is 100 (L) X 60 (W) X 47 (H). This dimension includes integrated sink. Heat sink can be custom-made according to the motor power, heating and cooling of the application.

If the surface temperature of the sink is higher than 85℃, cooling fan must be installed. Otherwise the controller may be damaged by hotness.

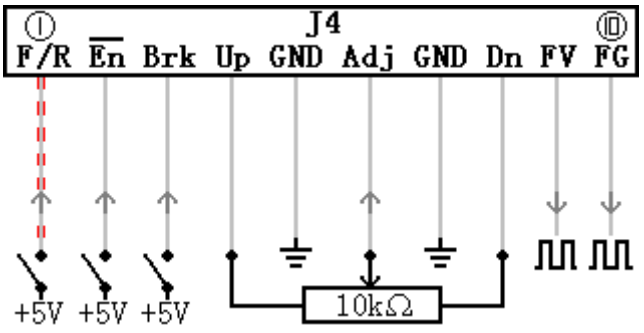
Line length is 0.5m, if customer does not specially order. The approximate weight of the controller is 170g, including 0.5m lines and intrinsic sink.


60
56
4
4
100
96
J1
C
B
A
1 2 3
J3 2-3=H
Open=M
1-2=L
C2
+
C1
+
BLMC-L-SL-1
VR2
www.eletechnic.com
VR1
J4
En Up Adj Dn FG
F/R Brk GND GND FV
2
1
POWER
LED
Vcc
GND
J2
+
-
4-Ø3.5

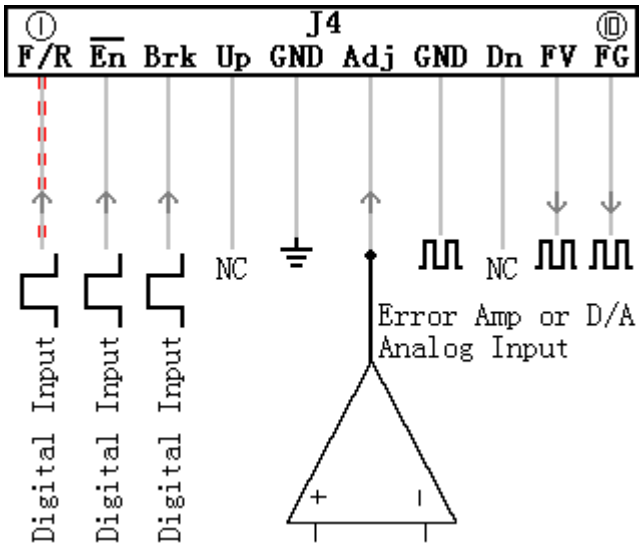
Application Circuit Examples



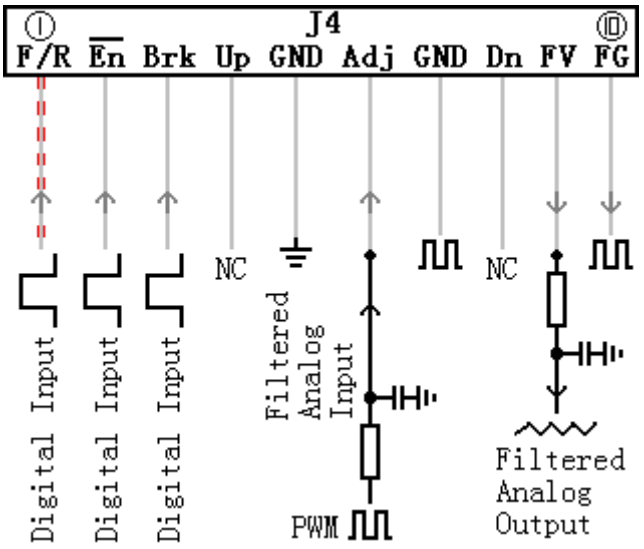
The Connection of BLDC Motor and Power



The Connection of On-off Control
and Potentiometer Speed Control



The Connection of Digital Control
and Operational Amplifier (or D/A) Speed Control



The Connection of Digital Control
and PWM Speed Control

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