

# Specification of Motor Controller for Electric Motorcycle

Product model: MC2K-72H220



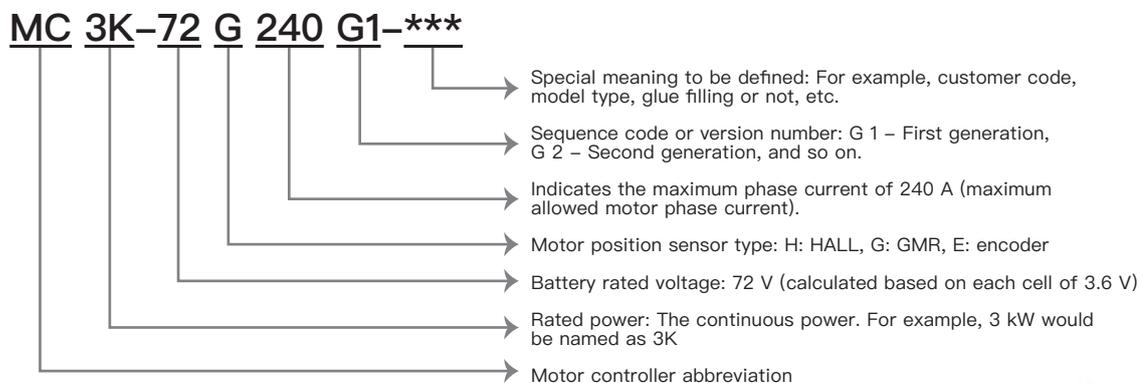
## Table of Contents

<b>1 Product Information</b> .....	<b>1</b>
1.1 Product designation.....	1
1.2 Application scope.....	1
1.3 Product overview .....	2
1.4 Product dimensions .....	3
1.5 Product weight.....	3
<b>2 Product Function Descriptions</b> .....	<b>4</b>
2.1 Motorcycle function .....	4
2.2 Safety protection functions.....	5
<b>3 Product Electrical Specification</b> .....	<b>6</b>
3.1 Controller technical parameters .....	6
3.2 Power supply boundary.....	7
3.3 Electrical safety .....	9
<b>4 Electrical Connection and Interface Definition</b> .....	<b>9</b>
4.1 Electrical structure block diagram.....	10
4.2 Control port pin definition .....	10
4.3 Power terminal wiring definition.....	12
<b>5 Product Environmental Adaptation Specifications</b> .....	<b>13</b>
5.1 Ambient temperature range .....	13
5.2 Product environment adaptation .....	13
<b>6 Product Packing</b> .....	<b>14</b>

6.1 Controller assembly precautions .....	14
6.2 Harness assembly precautions .....	14

# 1 Product Information

## 1.1 Product designation



### Note:

- ① Rated power measurement conditions: ambient temperature  $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$ , natural cooling. For example, 5.5 kW would be named 6K, and 15 kW would be named 15K.
- ② Maximum phase current measurement conditions: Ambient temperature  $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$ , natural cooling. 240 A indicates the maximum phase current capability of 240 A sustained for 1 minute. This value may vary depending on the motor and usage scenario.

## 1.2 Application scope

This specification provides relevant technical information of the electric motorcycle controller made by Hobbywing Technology Co., Ltd. (i.e. HW), including the functional safety descriptions, allowable operating conditions, technical boundary conditions of the Hobbywing electric motorcycle controller, as well as the interface technical conditions of other modules and related installation & operation precautions.

Hobbywing electric motorcycle controller is designed to only operate under the conditions set out in this specification. Hobbywing will assume no responsibility for operation under the conditions beyond this specification. Hobbywing will assume responsibility for controller failure pertaining to problems in design, production and transportation. However, controller failure arising from failure of other components of the motorcycle system is beyond the Hobbywing's responsibility.

Customers are recommended to include the following safety precautions in the manual of the motorcycle using HW controller, as detailed below:

- 1) Ensure the motorcycle handlebar will not send the incorrect speed regulation signal during operation.

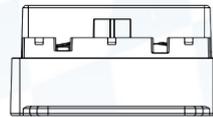
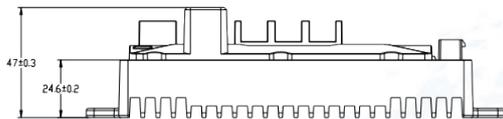
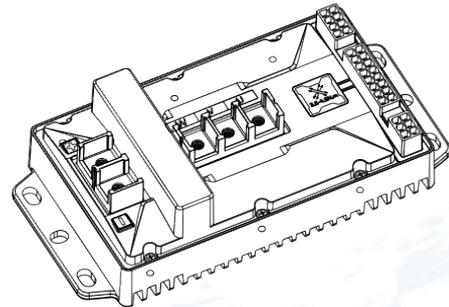
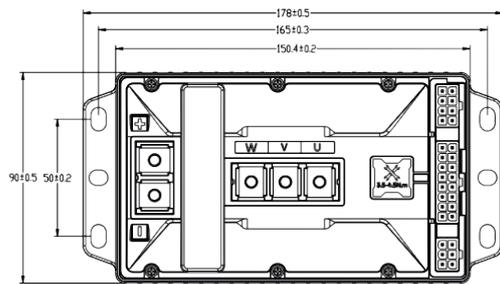
- 2) Ensure the controller can receive the reliable electric brake signal.
- 3) Ensure the mechanical brake can function well.
- 4) The controller may get pretty hot on the surface if the motorcycle runs at high load. Thereby, users shall be aware of taking measures against scald before coming in contact with the pretty hot controller or other mounting areas.
- 5) In case of the controller operating voltage exceeding the specified 36 V safety voltage, users shall be aware that they shall not come in contact with the live part of the controller (connector) to prevent electric shock.

### 1.3 Product overview

This product utilizes a 32-bit ARM high-speed MCU as its main control chip, plus a highly reliable automotive-grade software architecture and FOC algorithm. This configuration ensures smooth power delivery, low noise, and powerful acceleration. The appropriately tuned software ensures the high overall power efficiency and long endurance, while also supporting power tuning for a variety of personalized driving experiences. It features the comprehensive protections, such as voltage, current, temperature, short circuit, and locked-rotor protection, along with power-on self-check functionality, and IP67 rating protection, ensuring reliable operation of the power system. It is configured for three-gear operating mode switching, EABS braking, TCS, limp home, cruise control, Boost acceleration, assisted pushing and other functions, which greatly contribute to improved driving experience and safety. It can perform OTA upgrades, black-box troubleshooting, motor self-learning, and allows for multiple communication interfaces and encoder types, giving the controller exhibits excellent compatibility, and rapid troubleshooting capabilities. Founded in 2005, HOBBYWING has been deeply involved in the drone industry for over 20 years, demonstrating reliable aviation-grade quality control capabilities.

## 1.4 Product dimensions

Controller dimension (178 × 90 × 47) mm



## 1.5 Product Weight

The controller weighs about 630 g.

## 2 Product Function Descriptions

### 2.1 Motorcycle function

The basic functions of the motorcycle are defined in the table below (the functions can be customized).

Seq. No.	Motorcycle function	Function Description
1	Stepless speed regulation	Check the handlebar input (1.2 V – 3.8 V) for stepless speed regulation on the motorcycle.
2	Gear (three-speed)	Determine whether to switch gears by checking the gear level. Three gear levels are available: high, medium, and low.
3	Parking	Check the parking level fluctuation to see if the parking is working well. If not, the motorcycle must not be started.
4	Braking	Check the brake level fluctuation to see if the brake is working well. The high and low level brakes are available.
5	Reverse	Activate reverse mode via combination key.
6	Pushing	Activate pushing mode via combination key.
7	Side stand	Activate the side stand function by checking the side stand level. It is impossible to start the motorcycle in case of failure of side stand level.
8	Cruise control	Activate cruise mode via combination key, and exit it via accelerator or brake.
9	Seat cushion detecting	Activate the seat cushion function by checking the seat cushion level.
10	Anti-theft	Activate the antitheft mode by checking the antitheft lock signal. The motorcycle can be locked directly when not in motion. When riding, stop the motorcycle before locking.
11	One-click repair	Activate this function via combination key in case of handlebar or brake failure
12	TCS	This function may prevent wheels from slipping and improve motorcycle stability and safety.
13	EPB (Electrical Park Brake)	When parking on a slope, enter the assisted parking mode via combination key.
14	Self-learning	The controller has a self-learning function that adapts to the parameters of the motor it operates.
15	Active energy recovery	The controller will enter the brake feedback state by releasing the throttle or using the brake.

## 2.2 Safety protection functions

This product can perform varieties of software-based fault detection, including handlebar fault, brake fault, position sensor fault, overvoltage fault, undervoltage fault, overcurrent fault, locked-rotor fault, controller overtemperature fault, and motor overtemperature fault, etc.

Seq. No.	Safety protection functions	Function descriptions
1	Overvoltage protection	The controller may stop its output to the motor in case of battery overvoltage.
2	Soft undervoltage protection	When the battery voltage falls below the soft undervoltage threshold, the battery current limit starts to decrease until it reaches the minimum.
3	Undervoltage protection	The controller may stop its output to the motor in case of battery undervoltage.
4	Over-current protection (Motor phase line shorted)	The controller may remain unaffected despite the motor phase shorting line-to-line. Note: Short-circuit protection is only applies between any two phases of the motor, and between a phase and the positive power source, and does not apply to phase to ground short circuits.
5	Over-temp protection	The controller has the over-temp. protection function in place to prevent damage due to overheating.
6	Open-phase protection	Configured for open-phase detection at zero motorcycle speed.
7	Locked-rotor protection	If the motor is stalled, the controller will cut off the output within 2 seconds.
8	Sensor fault	If the controller detects the loss of more than one motor position signal, it will cut off its output.
9	Throttle fault	In the event of an open circuit in any one of the speed control handlebars or short circuit between any two of these cables, the controller will stop motor operation.
10	Start lock	If the handlebar is not at the zero position (> 1.2 V) at power up, the controller will not drive the motor. The handlebar must be reset and then turned again to start the electric vehicle normally.

### 3 Product Electrical Specification

#### 3.1 Controller technical parameters

Models	<b>MC2K-72H220</b>
<b>Specifications</b>	
Bus max. current	60 A
Phase max. current (amplitude)	220 A
Rated bus voltage	48 V, 60 V, 72 V
Rated power	2 kW
Peak power	4 kW
Boundary voltage	Refer to the controller power supply boundary conditions in Table 1
Motor sensor	H: HALL G: GMR
Control mode	Sensor-based FOC
Communication mode	CAN/RS485/UART/ISDN/Bluetooth
Max. controller efficiency	98%
Cooling mode	Natural air cooling
Operating ambient temperature	-25°C ~ 60°C
Humidity boundary	0% ~ 95% RH
IP grade	IP67

### 3.2 Power supply boundary

Table 1 Controller power supply boundary conditions (Note: Parameters marked with \* in the table may vary depending on the customer's technical specifications.)

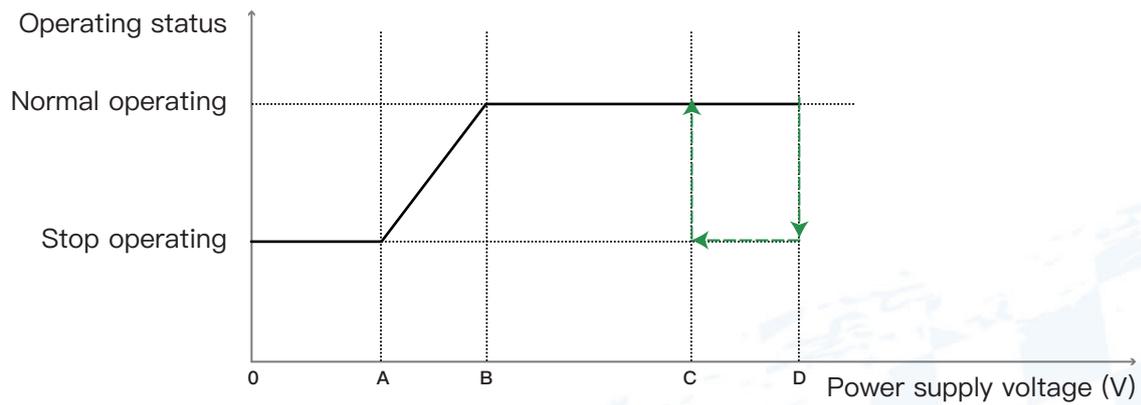


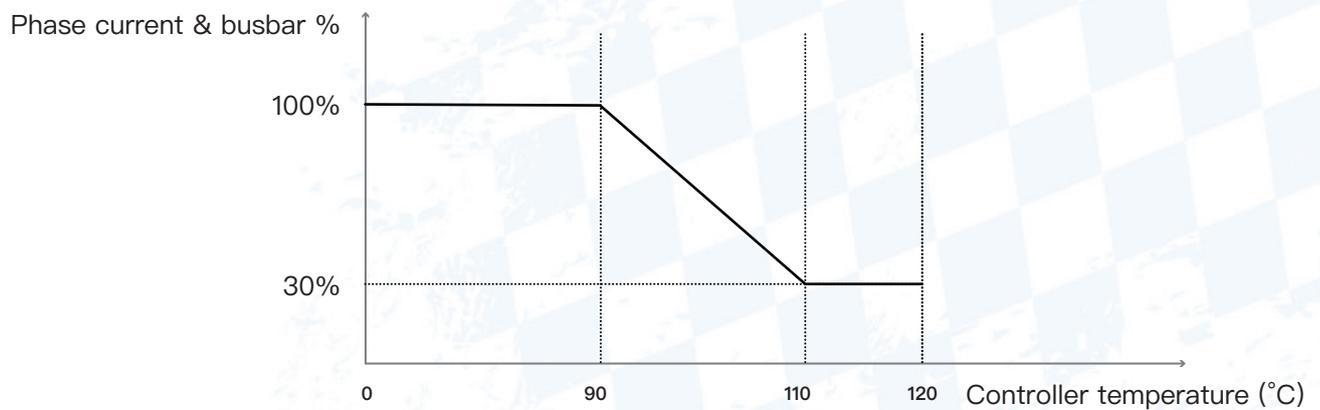
Table 2 Undervoltage/Overvoltage protection boundary conditions (Note: Parameters marked with \* in the table may vary depending on the customer's technical specifications.)

Battery voltage	A	B	C	D
48 V	35 V*	40 V*	56 V*	58 V*
60 V	48 V*	53 V*	70 V*	72 V*
72 V	58 V*	62 V*	84 V*	86 V*

Table 3 Rated current/peak current boundary conditions (Note: Parameters marked with \* in the table may vary depending on the customer's technical specifications.)

Models	Performance parameters	Boundary descriptions
MC2K-72H220	Rated current	Ambient temperature of $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$ , natural air cooling, line current of <b>50 A</b> and phase current of <b>80 A</b> , continuous operation for <b>30 min.</b>
	Peak current	Ambient temperature of $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$ , natural air cooling, line current of <b>60 A</b> and phase current of <b>220 A</b> , continuous operation for <b>60s, 240A 30s.</b>

Fig. 1 Busbar current and phase current temperature boundary conditions (Note: Parameters marked with \* in the table may vary depending on the customer's technical specifications.)



### 3.3 Electrical safety

Seq. No.	Test Items	Test conditions/requirements
1	Insulation resistance test	The positive output terminal is connected to the power input/output, while the negative terminal is connected to the signal output terminal or ground (housing). Apply DC 500 V to carry out test for 1 min. The insulation resistance between the power terminals and the signal terminal, as well as the housing, must all be greater than 1 M $\Omega$ . After test, the controller operates well.
2	Dielectric strength test	DC 1500 V is applied between the wire of the test controller and the protective earth circuit for 1 minute to perform the test. During the test, the leakage current shall be $\leq 10$ mA with no breakdown or flashover detected. After test, the controller operates well.

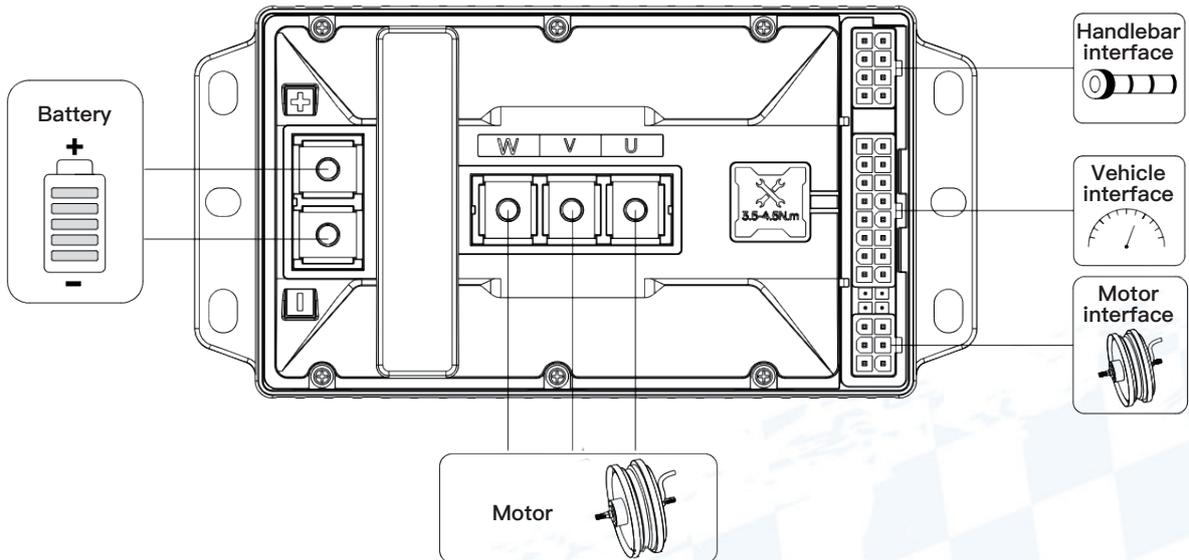
## 4 Electrical Connection and Interface Definition

There are two types of wires for controller connection: signal harness and power harness.

The signal harness is attached to the controller's control port via its connector to achieve the signal connection.

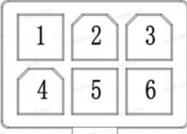
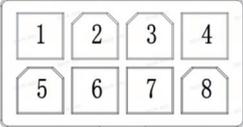
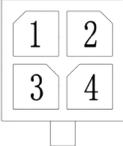
The power harness is connected to the controller's power terminal via the wiring terminal to ensure that the controller receives power from the battery, and to enable the controller to regulate the power output to the motor.

## 4.1 Electrical structure block diagram



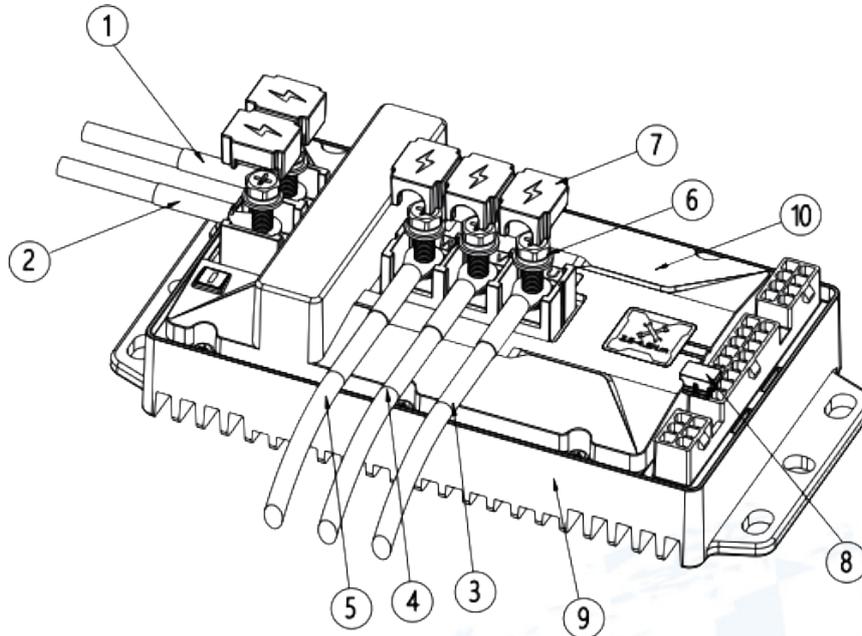
## 4.2 Signal Harness Definition

The control port model is a 6-16-8PIN female connector, which is designed to mate with the following connectors: Zhejiang ZEET ZTA31006-6P-A, ZTA31006-8P-A, and ZTA31006-16P-A. In addition, a 4PIN external Bluetooth port (corresponding plug model: ZTA31006-4P-A) and a 4PIN debugging port are reserved.

	Pin no	Pin Types	Pin Functions
 <p>5559-6P</p>	1	Inputs	HALL A
	2	Inputs	HALL B
	3	Inputs	HALL C
	4	Ground	Ground
	5	Inputs	Motor temperature
	6	Power Supply	Hall power
 <p>5559-8P</p>	1	Communication	TX/CANH/RS485A
	2	Inputs	Anti-theft (Motor lock)
	3	Output	Audio/Alarm
	4	External Bluetooth	Bluetooth TX
	5	Communication	RX/CANL/RS485B
	6	External Bluetooth	Bluetooth RX
	7	Power Supply	Battery Positive – VBUS
	8	Output	Wheel signal
 <p>5559-16P</p>	1	Power Supply	ACC
	2	Inputs	Side stand
	3	Output	ISDN
	4	Inputs	High brake
	5	Inputs	Low brake/voltage selection
	6	Inputs	P
	7	Inputs	Handle signal
	8	Power Supply	Side stand power
	9	Inputs	Magnetic coding PWM
	10	Ground	Ground
	11	Input/output	Reversing
	12	Input/output	Soft/hard start/Left turn signal control
	13	Input/output	Gear-/Tail light control
	14	Input/output	Gear+/Right turn signal control
	15	Ground	Handle GND
	16	Power Supply	Handle power
	1	Programming	CLK
	2	Ground	GND
	3	Programming	DIO
	4	Power Supply	3.3 V

## 4.3 Power terminal wiring definition

The power cable termination definition is illustrated below:



Seq. No.	Terminal wiring	Material	Quantity	Mouting torque(N·m)
1	SC16-5 terminal at negative of power source		1	3.5 ~ 4.5
2	SC16-5 terminal at positive of power source		1	3.5 ~ 4.5
3	SC16-5 terminal at U phase line		1	3.5 ~ 4.5
4	SC16-5 terminal at V phase line		1	3.5 ~ 4.5
5	SC16-5 terminal at W phase line		1	3.5 ~ 4.5
6	Terminal fixing screws	Carbon steel/Natural color/Grade 8.8	5	Triple combination outer hexagonal inner cross M5*12
7	Plastic cover plate locking screws PA4*8	Silicone rubber/60 A	2	
8	Plastic cover plate	Silicone rubber/60 A	1	
9	Plastic face housing	ADC12/Natural color	1	
10	Aluminum bottom housing	ADC12/Natural color	1	

## 5 Product Environmental Adaptation Specifications

### 5.1 Ambient temperature range

Operating ambient temperature range:  $-25^{\circ}\text{C} \sim 60^{\circ}\text{C}$

Ambient temperature range for long-term storage:  $-10^{\circ}\text{C} \sim 40^{\circ}\text{C}$

Temperature range for storage environment adaptability:  $-40^{\circ}\text{C} \sim 85^{\circ}\text{C}$

### 5.2 Product environment adaptation

Seq. No.	Test items	Test conditions/requirements														
1	Low-temp. storage test	The controller is placed in a temperature control box at $-40^{\circ}\text{C}$ for 24 h and can work well at room temperature again.														
2	High-temp. storage test	The controller is placed in a temperature control box at $85^{\circ}\text{C}$ for 48 h and can work well at room temperature again.														
3	Constant-temperature and humidity test	A constant humid heat test is performed at a temperature of $40^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and relative humidity of $93\% \pm 5\%$ for a period of 48 hours without significant appearance abnormalities.														
4	Vibration test	<p>Sweep frequency vibration: Frequency: <math>10 \sim 25\text{ Hz}</math>; double amplitude of <math>1.2\text{ mm}</math>; frequency of <math>25 \sim 500\text{ Hz}</math>, acceleration of <math>30\text{ m/s}^2</math>. 3 direction: X, Y, and Z, vibration time per direction: 8 h.            Random vibration: X, Y, and Z directions, vibration time per direction: 8 h.            Random vibration: Conduct each axial test for 8h, and the root mean square (r.m.s.) of acceleration is <math>27.8\text{ m/s}^2</math>, and relationship between PDS and frequency:</p> <table border="1" data-bbox="737 1550 1217 1809"> <thead> <tr> <th>Frequency Hz</th> <th>PDS (<math>\text{m/s}^2</math>)<sup>2</sup>/Hz</th> </tr> </thead> <tbody> <tr> <td>10</td> <td>20</td> </tr> <tr> <td>55</td> <td>6.5</td> </tr> <tr> <td>180</td> <td>0.25</td> </tr> <tr> <td>300</td> <td>0.25</td> </tr> <tr> <td>360</td> <td>0.14</td> </tr> <tr> <td>1000</td> <td>0.14</td> </tr> </tbody> </table> <p>After test, no deformation, breakdown (crack) on the shell, and unsecured components and set screws are allowed. The controller shall work well during and after test.</p>	Frequency Hz	PDS ( $\text{m/s}^2$ ) <sup>2</sup> /Hz	10	20	55	6.5	180	0.25	300	0.25	360	0.14	1000	0.14
Frequency Hz	PDS ( $\text{m/s}^2$ ) <sup>2</sup> /Hz															
10	20															
55	6.5															
180	0.25															
300	0.25															
360	0.14															
1000	0.14															

## 6 Product Packing

### 6.1 Controller assembly precautions

- 1) The mounting area must be level and free of foreign objects, burrs and welding residue, etc.
- 2) The heat dissipation surface must have good air circulation to improve the cooling efficiency of the controller, thereby maximizing its operation performance.
- 3) Carefully check that the assembled cables do not interfere with the motorcycle to avoid cable wear and short circuits that could cause malfunctions.
- 4) The controller is secured with bolts (M6 bolts are recommended), at the locking torque of 3.5 N·m ~ 4.5 N·m.
- 5) The connector mating cycle shall be less than 20 times within the life cycle of the controller; If not, it will increase the contact resistance, which may subsequently result in excessive temperature rise.
- 6) The power terminals of the controller are secured with screws with appropriate torque to ensure that the terminals are properly tightened. Failure to do so may result in poor electrical contact, which may lead to overheating.
- 7) The control terminals of the controller must be inserted firmly into the controller sockets, making sure that they are fully inserted in place. Failure to do so may result in loose connections.

### 6.2 Harness assembly precautions

- 1) The wiring harness uses different colored wires and tamper-proof connectors to prevent incorrect wiring. Incorrect wiring can cause the controller to malfunction.
- 2) High-temperature wires must not be bundled with non-high-temperature wires to prevent damage to the insulation layer which could result in short circuits.
- 3) Ensure proper battery wiring to prevent reverse polarity connections or incorrect connections of battery wires to phase wires.
- 4) Ensure proper motor wiring to prevent the phase lines from short circuits or open circuits.
- 5) Ensure that proper controller wiring procedures are followed, with phase lines and power wires connected according to specified instructions. Failure to do so may result in motor.
- 6) At the end of harness assembly, it is necessary to install silicone dust plugs on the controller.



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