



ZHEJIANG ALPHA AUTOMOBILE TECHNOLOGY LO., LTD

Specification of 40kW Motor controller

版/次: A / 0

ACA03-SJ-CPJSSJGF-A03

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# Product specification

Part Number: ACA03-0000000

Part Name: Motor controller

Product number:

## Revised resume

[illegible]

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## 1. Document description

### 1.1 Purpose and scope

This document introduces the main functions and performance of 144VDC, motor rated / peak power 20kW / 40kW motor controller assembly products, including the main parameters, functional block diagrams, constraints, structural descriptions, safety specifications, precautions for use, to help users correct Use this power electronic unit product.

### 1.2 Definition of terms and abbreviations

Table 1 Terms and abbreviations

Terminology / Abbreviation	English	Chinese
PEU	Power Electric Unit	电力电子单元
EV	Electric Vehicle	电动汽车
DCDC	Direct Current to Direct Current	直流-直流变换器
MCU	Motor Control Unit	电机控制器
CAN	Controller Area Network	控制器局域网
VCU	Vehicle Control Unit	整车控制器
OBC	On Board Charge	车载充电器
PDU	Power Distributed Unit	配电单元
TBD	To Be Decided	待定

### 1.3 Reference Standard

The following table lists the Chinese national standards (referred to as national standards) and related international standards that the design needs to refer to. If the attached standard is revised, please use the latest version of the standard.

Table 2 Citing domestic standards

No.	Standard	Standard name (name)	Standard type (standard type)	Remarks (remark)
1	GB/T18488.1-2015	电动汽车用电机及其控制器第1部分：技术条件	National standard	Motor System
2	GB/T18488.2-2015	电动汽车用电机及其控制器第2部分：试验方法	National standard	Motor System
3	GB/T 755-2008	旋转电机定额和性能	National standard	Motor
4	GB/T 1029-2005	三相同步电机试验方法	National standard	Motor
5	GB/T2423.34-2005	电工电子产品环境试验温度/湿度组合循环试验	National standard	Motor
6	GB/T2423.17-2008	电工电子产品环境试验试验Ka：盐雾	National standard	Motor
7	GB/T 4942.1-2006	旋转电机整体结构的防护等级分级	National standard	Motor
8	GB/T 4942.2-1993	低压电器外壳防护等级	National standard	Motor
9	GB/T 14711-2013	中小型旋转电机安全要求	National standard	Motor
10	GB/T 2828.1-2012	计数抽样检验程序：第一部分：按接收质量限（AQL）检索的逐批检验抽样计划	National standard	Motor
11	JB/T 9615.2-2000	交流低压电机散嵌绕组匝间的绝缘试验限值	Mechanical area	Motor
12	QC/T 413-2002	汽车电气设备基本技术条件	Automotive area	Motor
13	GB/T 18384.2-2001	电动汽车安全要求第2部分：功能安全和故障防护	National standard	Motor System
14	GB/T 18384.3-2015	电动汽车安全要求第3部分：人员触电防护	National standard	Motor System
15	GB 18655-2002	用于保护车载接收机的无线电骚扰特性的限值和测量方法	National standard	Motor System
16	GB/T 18387-2008	电动车辆的电磁场发射强度的限值和测量方法,宽带,9kHz ~ 30MHz	National standard	
17	GB 14023-2006	车辆、船和由内燃机驱动的装置无线电骚扰特性限值和测量方法	National standard	
18	DB 31/T634-2012	电动乘用车示范运行安全和维护保障技术规范	Shanghai local	
19	GB/T19751-2005	混合动力电动汽车安全要求	National standard	
20	GB/T24347-2009	电动汽车DC/DC变换器	National standard	

Table 3 Citing international standards

<b>International Standard Code</b>	<b>International Standard Name</b>	<b>Note</b>
ISO1940-1-2003	Mechanical Vibration-Balance Quality of Rigid Rotors Determination of Permissible Residual Unbalance	International standard
ISO 16750	Road vehicles-Environmental condition and testing for electrical and electronic equipment	International standard
EN/IEC 60068	Environmental testing	International standard
ISO 6469-3	Electric road vehicles-Safety specifications Part3:Protection of persons against electric hazards	International standard
ISO 7637-2	Road vehicles-Electrical disturbances from conduction and coupling Part2:Electrical transient conduction along supply lines only	International standard
ISO 11452-2	Road vehicles-Component test methods for electrical disturbances from narrowband radiated radiated electromagnetic energy Part2:Absorber lined shielded enclosure	International standard
EN61000-4-2	Electromagnetic compatibility Part4:Testing and measurement techniques	International standard
ISO 26262-2011	Road vehicles — Functional safety	International standard
IEC 61508-2006	Functional safety of electrical/electronic/programmable electronic safety-related systems	International standard

## 2. Product Overview

### 2.1 product description

The power electronic unit referred to in this article includes: MCU.

The MCU unit performs electric, feed and other modes of operation in forward, backward and neutral gears according to the gear and accelerator pedal signals, and cooperates with the complete vehicle system of the electric vehicle to realize the switch, drive / brake (shift) Vehicle, fault alarm and processing functions, while meeting the high and low voltage, EMC, protection level, vibration, collision and other performance requirements of the vehicle.

The cooling mode of the motor controller is liquid cooling, and the required cooling liquid flow is 8 ~ 10L / min.

### 2.2 Application range

It is suitable for new energy A00-class passenger cars, tricycles, micro-cards, micro-planes and other logistics vehicles.

### 2.3 Basic Information

Table 4 Spatial quality parameters

index	parameter	Remarks
Dimensions	345×186×151.5mm	Adjusted according to user requirement
Weight (Kg)	≤5.5kg	Adjusted according to user requirement

### 3. working environment

Table 5 Working environment and protection parameters

index	parameter	Remarks
cooling method	Liquid cooled form, water / ethanol (50% / 50%); Coolant flow: $\geq 8\text{L} / \text{min}$ ;	Withstand 0.2Mpa water pressure
Inlet water temperature	$\leq 65^{\circ}\text{C}$	
Outlet water temperature	Typical value $60^{\circ}\text{C}$ but not more than $75^{\circ}\text{C}$	According to the actual cooling power change
Operating temperature	$-40^{\circ}\text{C} \sim +85^{\circ}\text{C}$	
Storage temperature	$-40^{\circ}\text{C} \sim +85^{\circ}\text{C}$	
Product protection level	IP67	

Note: Within the scope of the environmental requirements specified in the table above, the power electronic unit should be able to fully exert its product performance

### 4. Product Features

#### 4.1 Motor controller working performance parameters

Table 6 Motor controller related performance parameters

index	parameter	Remark
Bus voltage (V)	144	
Rated power (kW)	20	
Peak power (kW)	57	TBD
Rated output current (A, rms)	150	
Maximum output frequency (Hz)	600Hz	9000rpm
Maximum working current (A, rms)	450	Continue 30s
Input voltage range (V)	105~170	Adjustable according to
Maximum efficiency (%)	98%	

Active discharge time (S)	$\leq 3$	
Passive discharge time (min)	$\leq 5$	Discharge to below 36V
Power-on self-test time (ms)	$\leq 300$	
Rated control voltage (V)	12	
Control voltage range (V)	9~16	
Control current (A)	$\leq 2$	
Static power consumption (mA)	$\leq 1$	Adjusted according to low-voltage power-on mode
Torque response time (ms)	$\leq 200$	0~max
Speed response time (ms)	$\leq 200$	Reach to Peak speed
Torque control accuracy	100Nm以上 : $\leq \pm 5\%$ ; 100Nm以下 : $\leq \pm 5\text{Nm}$	
Speed control accuracy	$\pm 5\text{rpm}$	

## 4.2 Motor controller control mode

This product has two basic working modes: torque mode and speed mode;

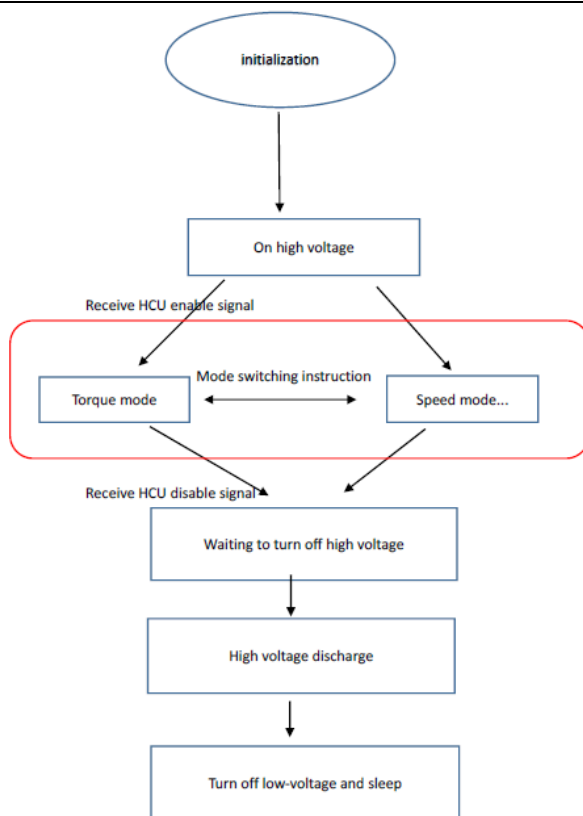


Figure 4.1 Work mode control process

Torque mode: control the motor to execute torque commands, according to the energy conversion needs of the vehicle, in this mode, the user can make the vehicle work in two states: traction drive and brake feed;

Speed mode: control the motor to execute the speed command, according to the functional requirements of the vehicle, in this mode, the user can make the vehicle work in a stopped state;

### 4.3 Motor controller power-on and power-off process

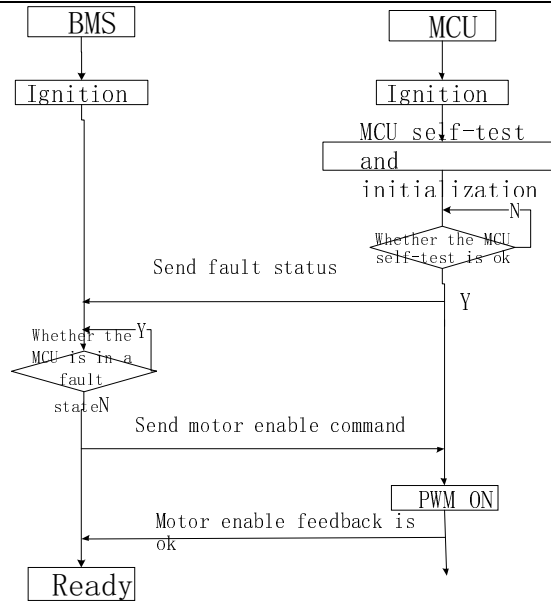


Figure 4.2 Current on MCU

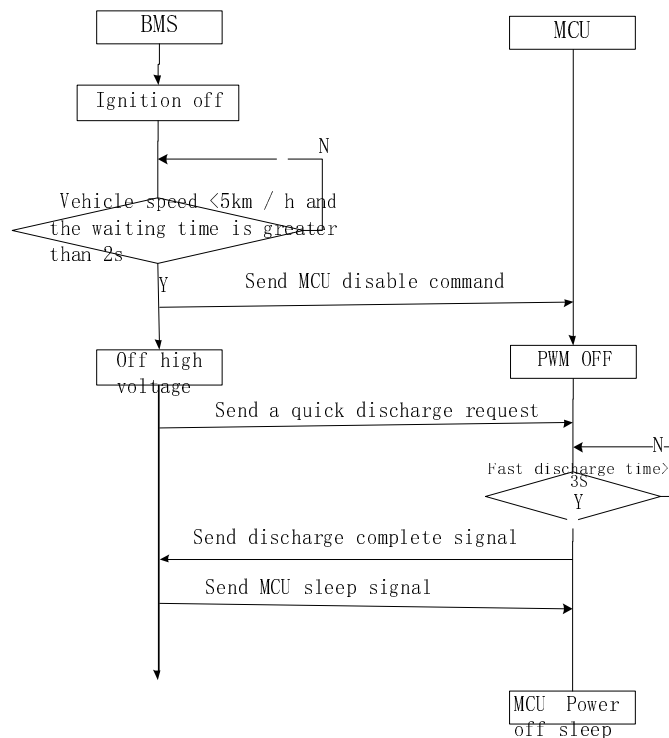


Figure 4.3 MCU power-off process

This product can adjust the power-on and power-off process according to the needs of the vehicle. If the user has no special requirements, please refer to the schemes shown in Figure 4.2 and 4.3.

#### 4.4 Motor controller fault diagnosis function

This product has the function of on-board diagnosis of faults. The faults are divided into three levels, and the troubleshooting methods for each level are shown in the table below. Users can use the diagnostic instrument that supports UDS protocol to view the fault.

Table 7 Fault handling strategy table

Failure level	description	Fault handling strategy
0	No fault	None
一	General failure (Warning)	None
二	Serious failure	1. Notify the fault code and fault level to reduce the maximum output torque; 2. If the duration of the fault exceeds the threshold, other three serious faults will be triggered;
三	Fatal failure	Automatically turn off PWM Wait for the motor speed to drop below 100rpm, power off the high voltage, and request power off from BMS

#### 4.5 CAN matrix protocol

The communication method of this product uses CAN 2.0A (Motorola LSB) to exchange information with the vehicle's power CAN network. The diagnosis function is developed based on UDSonCAN.

## 5. Restrictions

### 5.1 Structural boundary

See Appendix I for structural boundary dimensions.

### 5.2 Harness installation

See the table below for the connector specifications of this product.

Table 8 Connector specification table

Part Name	Connector Name	Part Side Connector		Mating Connector (wiring harness)	
		P/N	Supplier	P/N	Supplier
Motor controller assembly	Controller low-voltage signal line and vehicle	Socket 776231-1	AMP	Sheath: 771644-1 Terminal: 770520-1	AMP

### 5.3 Electrical connections

The electrical components related to this product in the vehicle

are key switch, gear switch, accelerator pedal, 12V battery, power battery, BMS, BCM. The electrical connections are shown in Figure 5.1; Strong wire harnesses must be shielded.

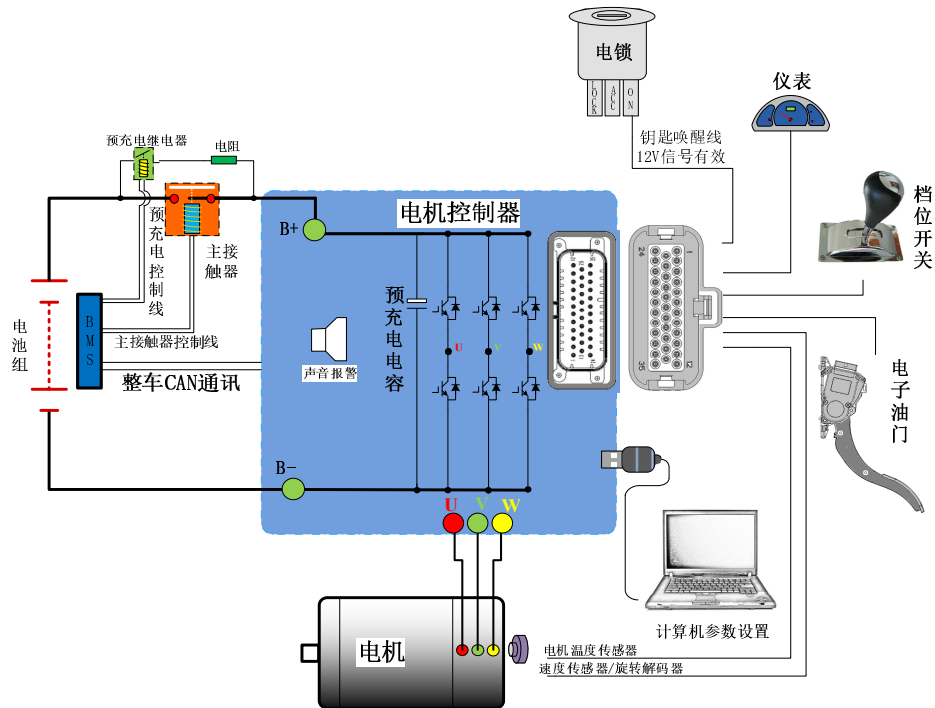
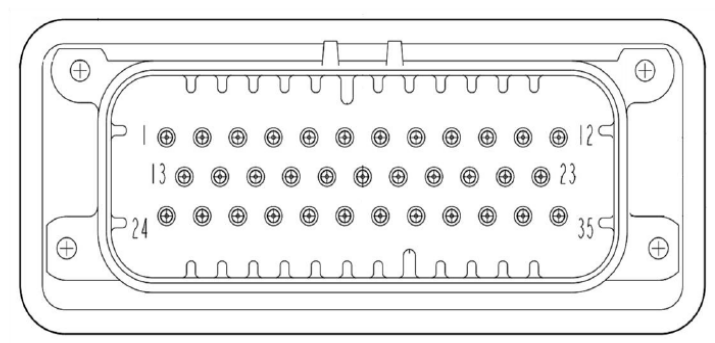


Figure 5.1 Schematic diagram of electrical connection

## 5.4 Electrical pin definition

### 5.4.1 Motor controller low voltage connector



型号: 776231-1

Figure 5.2 Electronic controlled low-voltage plug-in

Table 9 Pin definition of electric control low voltage connector

Pin No.	Pin definition	signal type	Signal voltage / current range	Remarks
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Pin No.	Pin definition	signal type	Signal voltage / current range	Remarks
1	/			
2	Resolver excitation negative	Analog signal output	<100mA	Resolver encoder signal
3	Resolver COS +	Analog signal input	/	Resolver encoder signal
4	Resolve SIN-	Analog signal input	/	Resolver encoder signal
5	D signal	Analog signal input	0~12V/10mA	Forward gear signal, 12V high effective
6	R signal	Analog signal input	0~12V/10mA	Reverse gear signal, 12V high effective
7	Throttle power supply negative	Power Output	0V/20mA	Electronic throttle power supply negative
8	/			
9	Fan control output	Digital signal output	0~12V/200mA	Fan control signal is positive, 12V low effective
10	Pump control output	Digital signal output	0~12V/200mA	The pump control signal is positive, 12V is low and effective
11	Continue electricity 12V-	power input	0V/1A	Controller low voltage circuit power supply negative
12	CAN communication low	can communication signal		can communication signal
13	Resolver excitation positive	Analog signal output	<100mA	Resolver encoder signal
14	Resolving COS-	Analog signal input	/	Resolver encoder signal
15	Resolver SIN +	Analog signal input	/	Resolver encoder signal
16	/			
17	N signal	Analog signal input	0~12V/10mA	Neutral signal, 12V high effective
18	Throttle power supply is positive	Power Output	10~14V/20mA	Electronic throttle power supply positive
19	/			
20	Fan control 12V-	Power Output	0V/1A	Fan water pump control signal negative
21	continue electricity 12V-	power input	0V/1A	Controller low voltage circuit power supply negative



Pin No.	Pin definition	signal type	Signal voltage / current range	Remarks
22	Wake up signal	Analog signal input	9~16V	Controller hard-wire wake-up signal
23	CAN communication high	can communication signal	Matching resistance 120 $\Omega$	CAN communication signal
24	Motor temperature +	Analog signal input	0~5V/10mA	Motor temperature, matching PT1000
25	Motor temperature-	Analog signal input	0V	Motor temperature, matching PT1000
26	/			
27	/			
28	/			
29	Brake signal	Analog signal input	0~12V/10mA	Brake signal, 12V, low effective
30	Throttle switch signal	Analog signal input	9~16V/10mA	Check signal of electronic throttle switch
31	Throttle acceleration signal	Analog signal input	0~5V/10mA	Accelerator pedal signal input
32	continue electricity 12V+	power input	0~16V/1A	Controller low voltage circuit power supply positive
33	continue electricity 12V+	power input	0~16V/1A	Controller low voltage circuit power supply positive
34	/			
35	/			

## 5.4.2 Motor controller bus input, three-phase output wiring

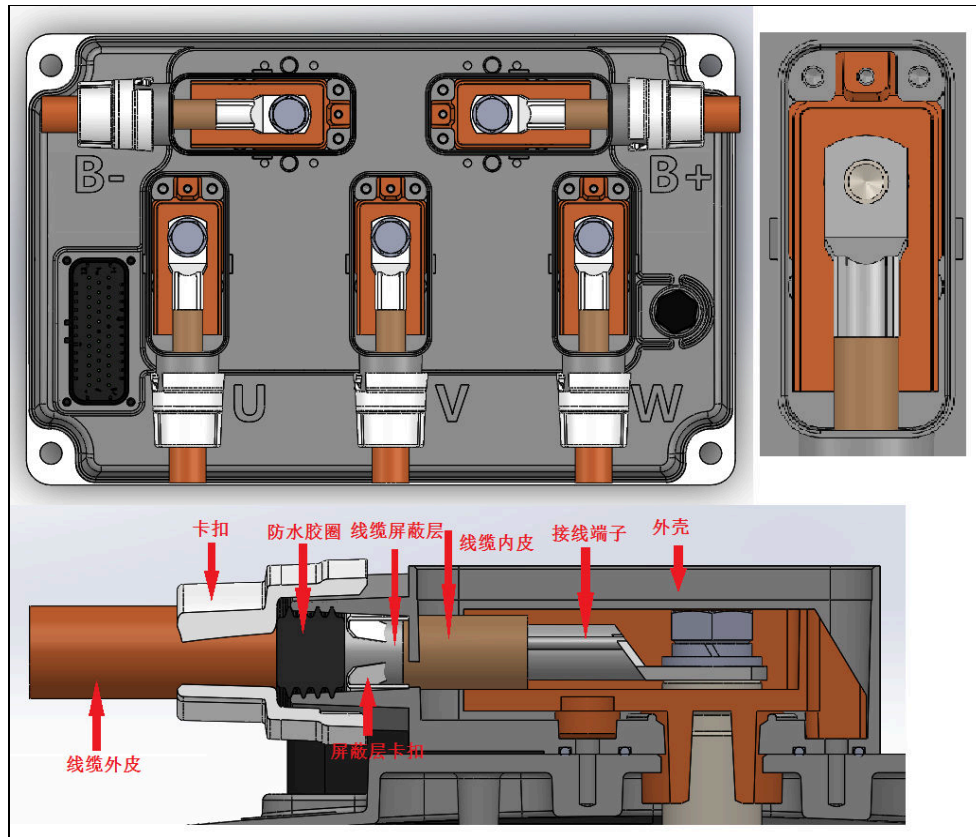


Figure 5.3 High voltage terminal wiring diagram

Table 10 Motor controller DC two-core input, three-phase output plug-in definition table

Pin	Features	Rated current	Min	Max	signal type	Remarks
B+	Battery positive	125A	/	350A	DC	35 mm <sup>2</sup>
B-	Battery negative	125A	/	350A	DC	35 mm <sup>2</sup>
A	Motor U phase	150A	/	450A	AC	35 mm <sup>2</sup>
B	Motor V phase	150A	/	450A	AC	35 mm <sup>2</sup>
C	电机W相	150A	/	450A	AC	35 mm <sup>2</sup>

## 6. Security features

### 6.1Withstand voltage

Table 11 Resistance characteristics

index	parameter	Remarks
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Withstand voltage	2200VDC / 1 minute	Meet GB / T 18488.1-2015 5.2.8.2 requirements
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## 6.2 Insulation resistance

Table 12 Insulation resistance parameters

index	parameter	Remarks
Cold and hot insulation resistance	The insulation resistance between each live circuit and ground is not less than $1M\Omega$	Meet the requirements of GB / T 18488.1-2015 5.2.7.3
Resistance between shell and ground	$\leq 0.1\Omega$	Set a fixed installation point

## 7. Electromagnetic compatibility characteristics

Table 13 EMC specifications

index	parameter	Remarks
Electromagnetic radiation	1、RE , level 2 ; CE , level 2	CISPR 25
Electromagnetic radiation immunity	2. The transient immunity of the motor controller power line meets the ISO7637-2 test requirements; the transient coupling immunity of the motor controller signal line meets the ISO7637-3 test requirements; 3. RI, ISO11452-2, in the frequency range of 80M ~ 2000MHz, the injection intensity is 75V / m; 4. BCI, ISO11452-4, in the frequency range of 1MHz ~ 400MHz, the injection intensity is 75mA;	

## 8. Warranty

Ensure that the vehicle travels more than 8 years or 120,000 kilometers. (Specifically subject to the terms of supply).

## 9. Reliability

Table 14 Reliability specifications

index	parameter	Remark
Work at high temperature	Meet GB28046.4-2011	
Temperature shock	Meet GB28046.4-2011	
Salt spray	Meet GB/T 2423.17-2008	
vibration	Meet QC/T413-2002 : 3.12	Three-dimensional swept frequency vibration test
Protection level	IP67	

## 10. Labeling, packaging, transportation, storage

### 10.1 package

The packaging box contains the product name, model, manufacturer's logo, manufacturer's quality department's inspection certificate, manufacturing date, etc. The packaging box has a list of accessories.

### 10.2 transport

When transporting the product, there should be a firm packaging box, the outside of the box should comply with the relevant national standards, and there should be signs such as "careful handling" and "moisture-proof". The packaging box containing the product is allowed to be transported by various means of transportation. Avoid direct rain and snow and mechanical impact during transportation.

### 10.3 storage

The product should be stored in the packing box when not in use. The warehouse ambient temperature is  $-10 \sim 40$  °C and the relative humidity is not more than 80%. No harmful gases, flammable,

explosive products and corrosive chemicals are allowed in the warehouse , And without strong mechanical vibration, impact and strong magnetic field. The packing box should be at least 20cm high from the ground and at least 50cm away from the wall, heat source, window or air inlet. The storage period under these conditions is generally 2 years, and the inspection should be re-examined after more than 2 years.

## 11. Troubleshooting and troubleshooting

The following is a list of countermeasures for common faults of this product, including abnormal insulation impedance, abnormal motor temperature, abnormal resolver decoding, and abnormal CAN communication. The user can choose the corresponding processing strategy according to different reasons. If the user cannot handle it by himself, please contact Alpha.

Table 15 Common faults and elimination of CAN communication

<b>Fault description</b>	<b>Troubleshooting direction</b>	<b>Fault maintenance and treatment</b>
After the MCU is powered on, PCAN cannot receive any message information	Whether the MCU constant power is normal;	1. Check whether the MCU constant power insurance is intact; 2. Check whether the battery is intact;
	Whether the ON file signal is given to the inside of the MCU;	1. Check whether the key hits the ON file; 2. Check the low-voltage wiring harness of the vehicle related to the MCU;
	Check if CAN_L and CAN_H are connected correctly;	If the CAN line is connected incorrectly, check the line and connect the CAN line correctly;
After the MCU is powered on, there is a message, but after a short time, the message disappears	Check whether the battery voltage is normal;	If the battery voltage is lower than the normal voltage in the ON gear, you need to charge the battery or replace the battery;
After the MCU is powered on, PCAN receives an error message	Check whether the received messages are all wrong, the rolling code increases, and the trace data are all wrong (all red)	1. Check whether the MCU line is short-circuited with GND, if it is, then exclude the CAN network nodes of the vehicle one by one; 2. If all components are still short-circuited after being unplugged, replace the CAN harness

	Check whether the terminal resistance of the CAN network is correct;	If the terminal resistance of the MCU CAN network is incorrect, replace the MCU main control board;
	Check if there are any parts with inconsistent baud rate in the CAN network node of the vehicle;	If there is a part whose baud rate is inconsistent with the whole vehicle, the part is excluded;

Table 16 Common faults and elimination of insulation

<b>Fault description</b>	<b>Troubleshooting direction</b>	<b>Fault maintenance and treatment</b>
The insulation resistance of the MCU high voltage line is too small	Check the insulation between the three-phase motor end and the motor housing	If the insulation resistance is too small, check whether the insulation of the three-phase connection is damaged.
	Check the insulation between the positive and negative MCU high voltage and the housing	If the insulation resistance is too small, open the upper cover of the MCU and check whether the safety distance between the strong current and the housing meets the requirements or whether the insulation film is worn;

Table 17 Common faults and troubleshooting of resolver decoding

<b>Fault description</b>	<b>Troubleshooting direction</b>	<b>Fault maintenance and treatment</b>
After the MCU is powered on, it will report the resolver fault	Check whether the pins of the MCU low voltage connector and the motor end rotary transformer connector are withdrawn, bent, broken, etc .;	If there is the above phenomenon of needle withdrawal, correct the stitch;
	Check whether the MCU end of the resolver harness is consistent with the motor end definition;	If the actual harness is inconsistent with the definition, change the harness;
	Check whether the resistance between the motor end spin excitation signals R1 and R2 is normal; Check whether the resistance between the motor-side sine signal S2 and S4 is normal; Check whether the resistance between the motor-side rotary cosine signals S1 and S3 is normal;	If there is the above phenomenon, please contact the motor manufacturer to deal with this problem;
	Check whether the connector pins of the MCU circuit board's resolver are soldered;	If there is virtual soldering, replace the MCU main control board;
After applying high voltage, MCU reports resolver fault	Repeatedly confirm whether the resolver fault is reported after applying high voltage;	If the above phenomenon exists, add a shielding layer to the vehicle's resolver harness;

Table 18 Common faults and elimination of motor temperature

Fault description	Troubleshooting direction	Fault maintenance and treatment
The MCU is constantly powered, the motor has not yet run, and the motor reports a temperature overheat fault (the motor temperature is the maximum value)	Check whether the low-voltage wire harness of the MCU has any pins withdrawn;	If there is the above situation, then open the upper cover to withdraw the pin out or replace the entire low-voltage wiring harness inside the MCU;
	Check whether the pin of the low-voltage harness of the vehicle is withdrawn	Pull out the withdrawal pin and revise the pin again;
	Check whether the resistance value at both ends of the motor temperature sampling line is correct;	If it is not correct, contact the motor manufacturer for processing;
	Check whether the resistance between the two pins of the motor temperature sampling at the MCU end is normal;	If it is not normal, open the MCU cover and replace the MCU main control board;

## 12. Safety guide

### **Warning: Remind the user that the operation is dangerous!**

※ It is strictly forbidden to disassemble and modify the MCU without permission for maintenance and debugging;

※ Please don't place it in the raining position or soak the water without connecting the harness connector.

※ Please confirm that the shell is intact before installation. If damaged, please replace it immediately or contact Alpha;

※ All connectors and harness ends should be connected and fastened, and if damaged or loose, please replace them immediately;

※ Please make sure that the input low-voltage power line is not too long (more than 2 meters) to avoid the fault diagnosis system triggered by excessive wiring harness voltage difference;

※ If there is any abnormal sound or smell during the work of MCU, please turn off the high voltage power supply as soon as possible;

※ Please disconnect the low-voltage power cord and high-voltage connector when disassembling and installing the MCU to avoid the risk of electric shock;

※ Do not use corrosive liquid to cool PEU;

※ Please store for a long time without using.

## Appendix I

### 2D drawing of motor controller assembly

