Technical documents of high voltage electric heater

（W09-2， 600V ， CAN）

Version: B1

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Change history

Version number	Change details	Signature and approval
A1		
A2		
A3		
A4		

Content

1 Introduction

1.1 Scope of application

This technical document is used in new energy automotive air conditioning systems or battery thermal management systems, high voltage water heating electric heater (hereinafter referred to as "PTC"). It describes the functionality of PTC implementation, component interface, technical parameters, and shape size.

1.2 Abbreviation

Abbreviation	Unit	Full name
AD		Digital simulation
CH		Water heating heater
DTC		Diagnostic problem code
ECU		Electronic control unit
EEPROM		Electrically Erasable Programmable read only memory
EMC		Electro Magnetic Compatibility
ESD		Electro-Static discharge
f	Hz	Frequency
f_{PWM}	Hz	Pulse width modulation frequency
GND		Ground
h	mm	Height
h_{asl}	m	Height above sea level
HR	%	Relative humidity
I_{max}	A	Surge current generated by PTC water heating heaters under normal test conditions
I_n	A	Stable current of PTC water heating heater under normal test conditions
I_{KI15}	A	BATT, battery current (24V)
$I_{HV+/HV-}$	A	High voltage current
$I_{HV+/HV-max}$	A	Maximum current generated under normal test conditions
I_{off}	A	Sleep current
IGBT		Insulated gate bipolar transistor
L	mm	Length
M_{bolt}	Nm	Ground bolt torque
µC		Microcontroller
m	g	Quality
n.c.		Not connected
n.s.		Unfained
NTC		Negative temperature coefficient
Δp	Pa	Pressure drop
$P_{n\ el.}$	W	Electric power
$P_{n\ therm.}$	W	Thermal power
PN	bar	Nominal system pressure
PWM		Pulse width modulator
$Q_{coolant}$	L/min	Medium volume flow
PTC		Resistance material for positive temperature coefficient
R_{cont}	mΩ	Plug-in contact resistance

R_{iso}	MΩ	Insulation resistance
SNA		Invalid signal
$T_{coolant\ out}$	℃	Medium outlet temperature
$T_{coolant\ in}$	℃	Medium inlet temperature
$T_{coolant}$	℃	Medium temperature
$T_{ambient}$	℃	Ambient temperature
tbc		To be confirmed
tbd		To be defined
$T_{hot\ spot}$	℃	The heater can be achieved hot-pot temperature
$T_{storage}$	℃	Storage temperature
$T_{operating}$	℃	Operating temperature
t	s/min	Test period
$t_{storage}$	h	Storage time
U	V	Voltage
U_{max}	V	Maximum working voltage
U_{min}	V	Minimum working voltage
U_n	V	Rated voltage
U_{test}	V	Test voltage
U_{HV}	V	More than 60V voltage (B voltage)
U_{LV}	V	Less than 60V voltage (A grade voltage), normal 24V
U_{KI30}	V	24V battery voltage (BATT +)
U_{KI31}	V	24V ground battery (GND)
U_{KI15}	V	Ignition switch voltage
$U_{HV+/HV-}$	V	Heater input high voltage electricity
$U_{peakHV+/HV-}$	V	Peak voltage

2 Product description

The heater is mainly used for heating the passenger compartment ,defrosting and removing fog on the window,or preheating battery thermal management system battery ,to meet the corresponding regulations, functional requirements.

2.1 Product Features

The main functions of the integrated circuit water heating heater are:

- Control function: The heater control mode is power control and temperature control;
- Heating function: Electrical energy conversion to thermal energy;
- Interface function: Heating module and control module energy input, signal module input, grounding,water inlet and water outlet .

2.2 Product parameters

2.2.1 Operation performance

Overall

Parameter	Description	Condition	Minimum value	Rated value	Maximum value	Unit
$P_{n\ el.}$	Power	Nominal working condition: U_n = 600 V $T_{coolant\ In}$= 40 ° C $Q_{coolant}$ = 10L/ min Coolant = 50: 50	6300	7000	7700	W
m	Weight	Net weight (no coolant)	2400	2550	2700	g

Temperature

Parameter	Description	Condition	Minimum value	Rated value	Maximum value	Unit
$T_{operating}$	Work temperature (environment)		-40		110	°C
$T_{storage}$	Storage temperature (environment)		-40		120	°C
$T_{coolant}$	Coolant temperature		-40		85	°C

Low voltage

Parameter	Description	Condition	Minimum value	Rated value	Maximum value	Unit
$U_{KI15/KI30}$	Power supply voltage		16	24	32	V
	12V system optional		9	12	16	V
$I_{KI15/KI30}$	Power current		20	60	100	mA
$I_{quiescent}$	Sleep current		-	-	-	mA

High voltage

Parameter	Description	Condition	Minimum value	Rated value	Maximum value	Unit
$U_{HV+/HV-}$	Power supply voltage	Unrestricted power	400	600	750	V
		Upper limit work ability	750		760	V
		Lower limit work ability	380		400	V
$U_{peakHV+/HV-}$	Power supply voltage	High voltage lasts for 400			850	V/ms

		milliseconds of maximum				
$U_{peakHV+/HV-}$	Power supply voltage	High voltage lasts for 1 microsecond, maximum			1000	V/ms
$I_{HV+/HV-}$	Power supply voltage	Nominal working condition	10.5	11.6	12.8	A
$I_{HV+/HV-max}$	Surdere current (effective value)	Nominal working condition			＜23.5	A
		$U_{HV+/HV-}$=750V $T_{coolant}$=85℃			＜30	A
$I_{quiescent}$	Sleep current that the heater does not work		-	-	-	mA

Insulation resistance and dielectric strength

Parameter	Description	Condition	Minimum value	Rated value	Maximum value	Unit
R_{ISO}	At the beginning of the lifecycle	1000VDC/60s	100			MΩ
R_{ISO}	At the end of the lifecycle	1000VDC/60s	50			MΩ
U_{test}	Test dielectric strength	2700VDC/60s			3000	Vdc
$U_{design\ dc}$	Design dielectric strength	2700VDC/60s			3000	Vdc

Other

Parameter	Description	Condition	Minimum value	Rated value	Maximum value	Unit
HR	Relative humidity		5		95	%
PN	Burst pressure	Room temperature			0.49	Mpa
$t_{Discharge}$	Discharge time	After disconnecting the high voltage			5	S
IP-Protect				6K 9K 67		
h_{asl}	Height above sea level	The heater should not be used above this altitude			5500	m
	Heater volume			215		ml
	Antifreeze Type			50/50		
t response	Startup response time	Rated working condition		100		ms

2.2.2 Product characteristic

- Life cycle of 8 years or 200,000 kilometers;
- The accumulated heating time in the life cycle can reach up to 8000 hours;
- In the power-on state, the working time of the heater can reach up to 10,000 hours (Communication is the working

state);

- Up to 50,000 power cycles;
- The heater can be connected to constant electricity at low voltage during the whole life cycle. (Usually ,when the battery is not depleted; the heater will go into sleep mode after the car is turned off);
- Provide high-voltage power to the heater when starting the vehicle heating mode;
- The heater can be arranged in the engine room, but it cannot be placed within 75mm of the parts that continuously generate heat and the temperature exceeds 120℃.

2.3 Heater performance

2.3.1 Performance Analysis Table

$P=f(T_{coolant\ In}, Q_{coolant})$; 600V

Table 1 Heater performance table（maximum heating capacity）

Coolant temperature [°C]	Flow [L/min]	Power [W]/Typical value
-20	10	8850
0	10	8430
20	10	7925
40	10	7350
60	10	6750

2.3.2 Coolant temperature-power diagram

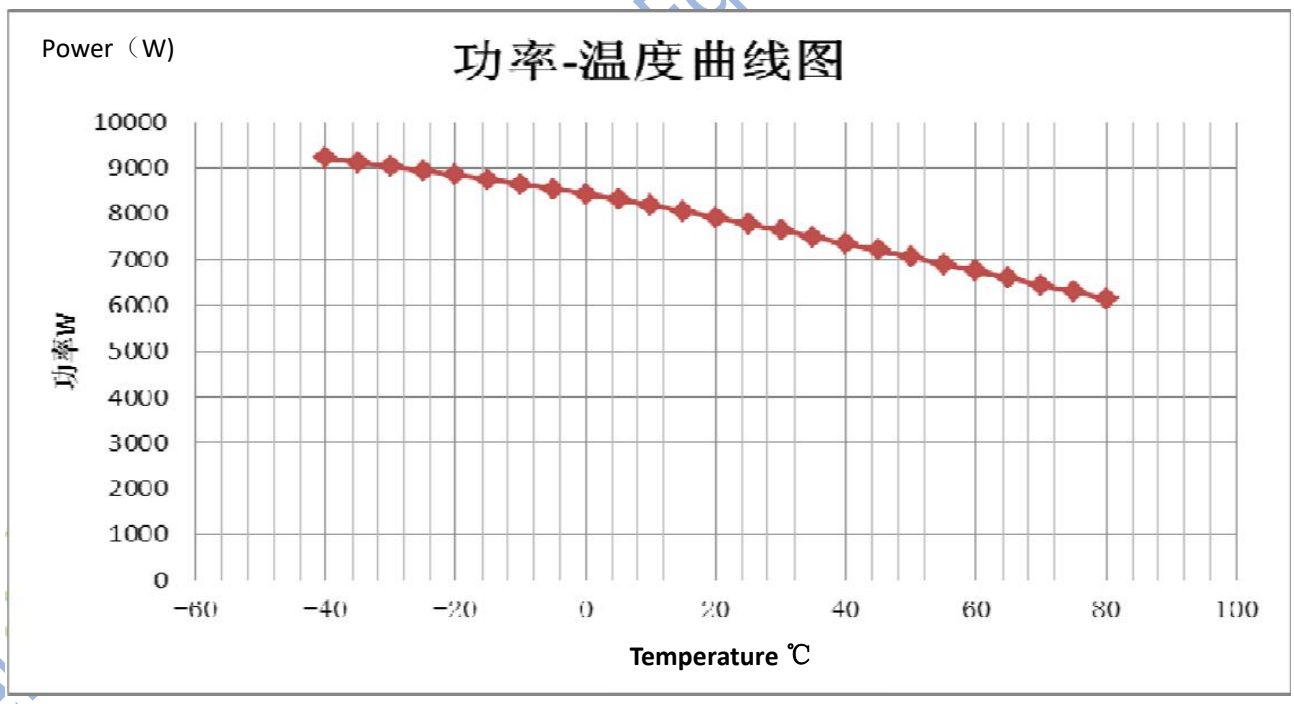


Figure 2.1 Coolant temperature-power diagram @10L/min 600V

2.3.3 Coolant flow-power diagram

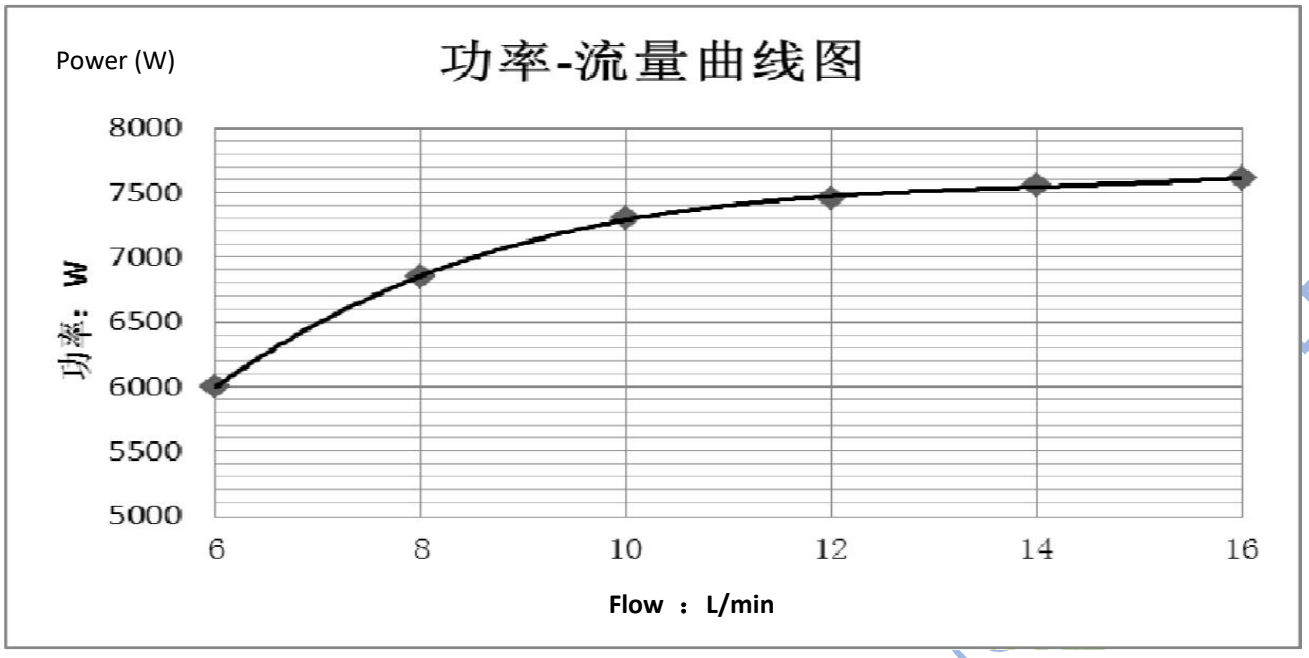


Figure 2.2 Coolant flow-power diagram @T_In40℃600V

2.3.4 Coolant voltage-power diagram

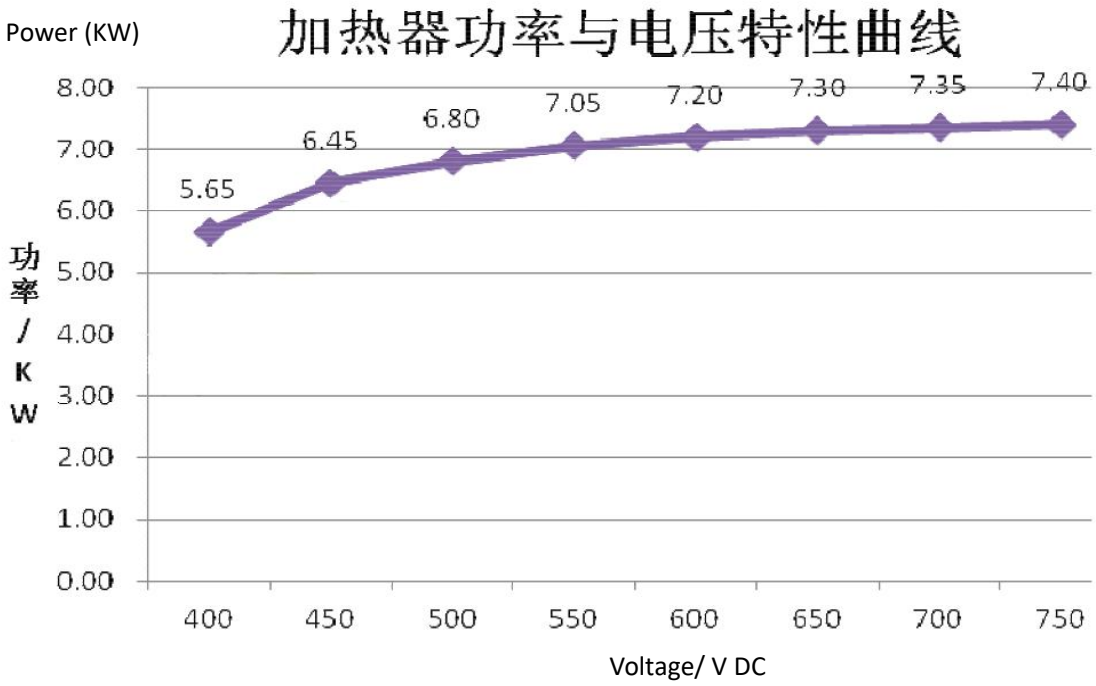


Figure 2.3 Voltage-power diagram @T_In40℃ 10L/min

2.4 Pressure loss

Table 2 Heater Pressure Drop Table

Coolant temperature [°C]	Flow rate [l/min]	Pressure loss [Kpa], heater off state
25	10	4.6
70	10	4.4

3 Assembly

3.1 Heater assembly

3.1.1 Dimensions

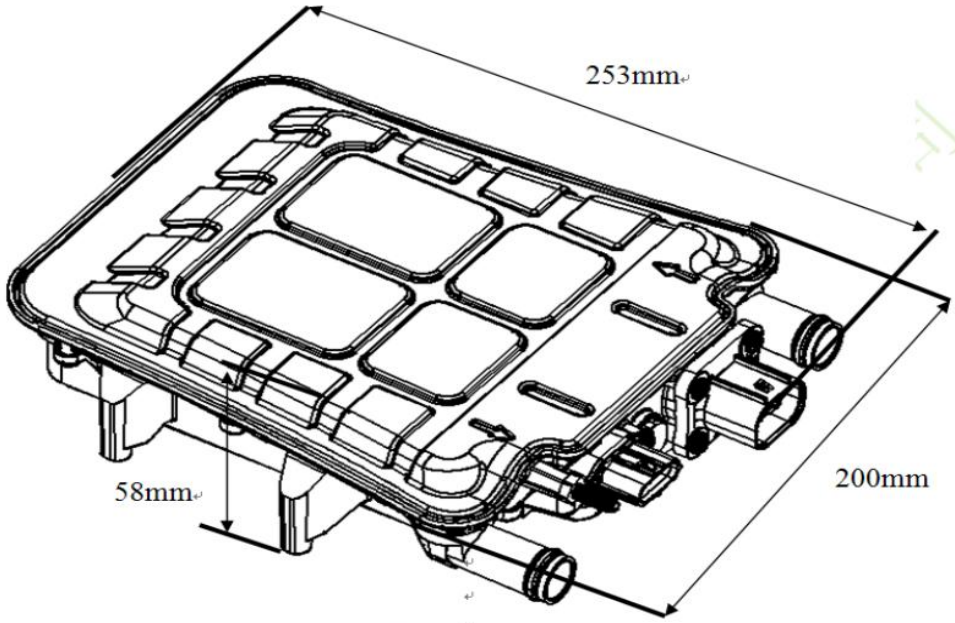
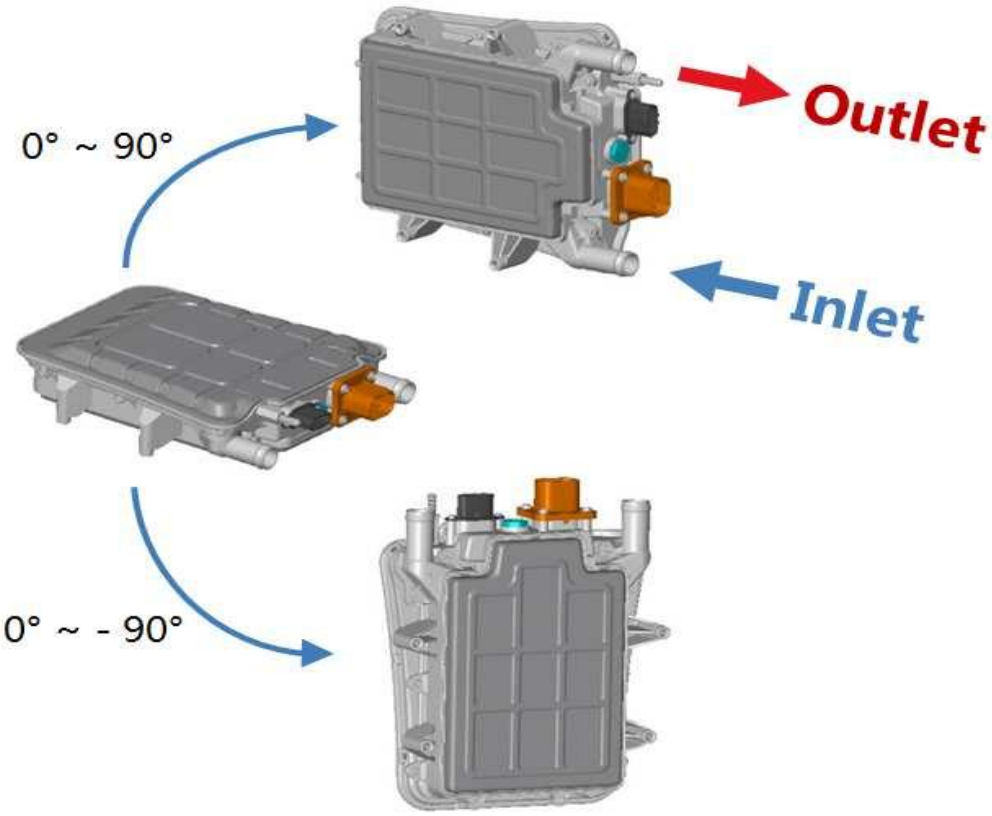


Figure 3.1 Heater Dimensions

Dimensional Details and Assembly Port Locations，please check the drawings and heater 3D models.

3.1.2 Installation method



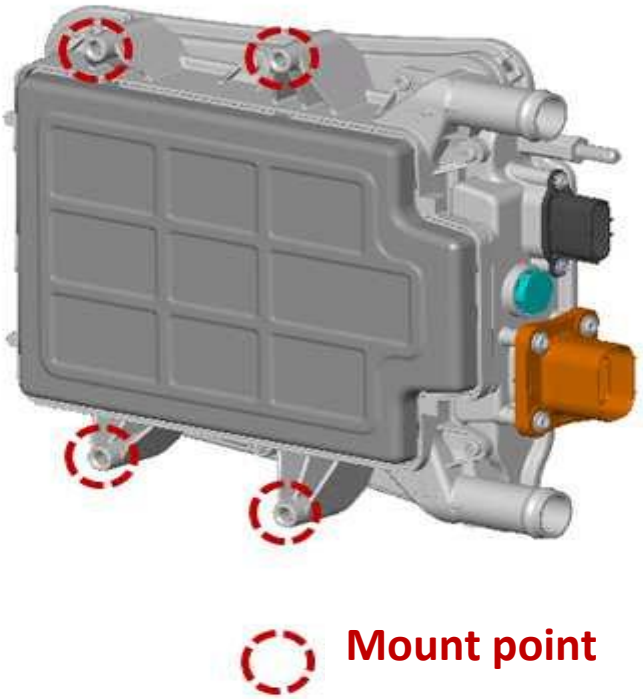
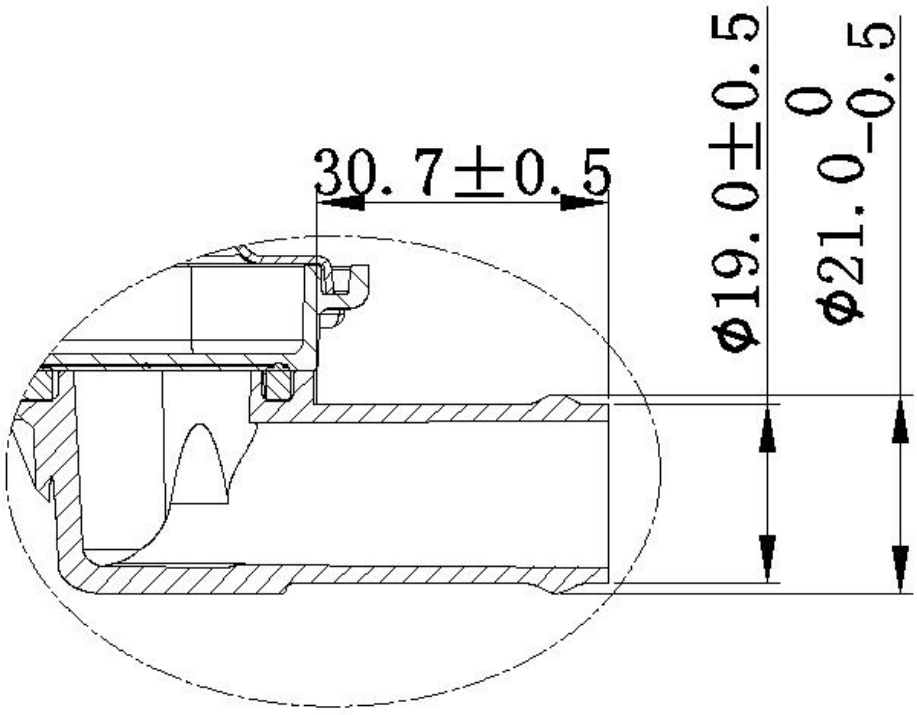


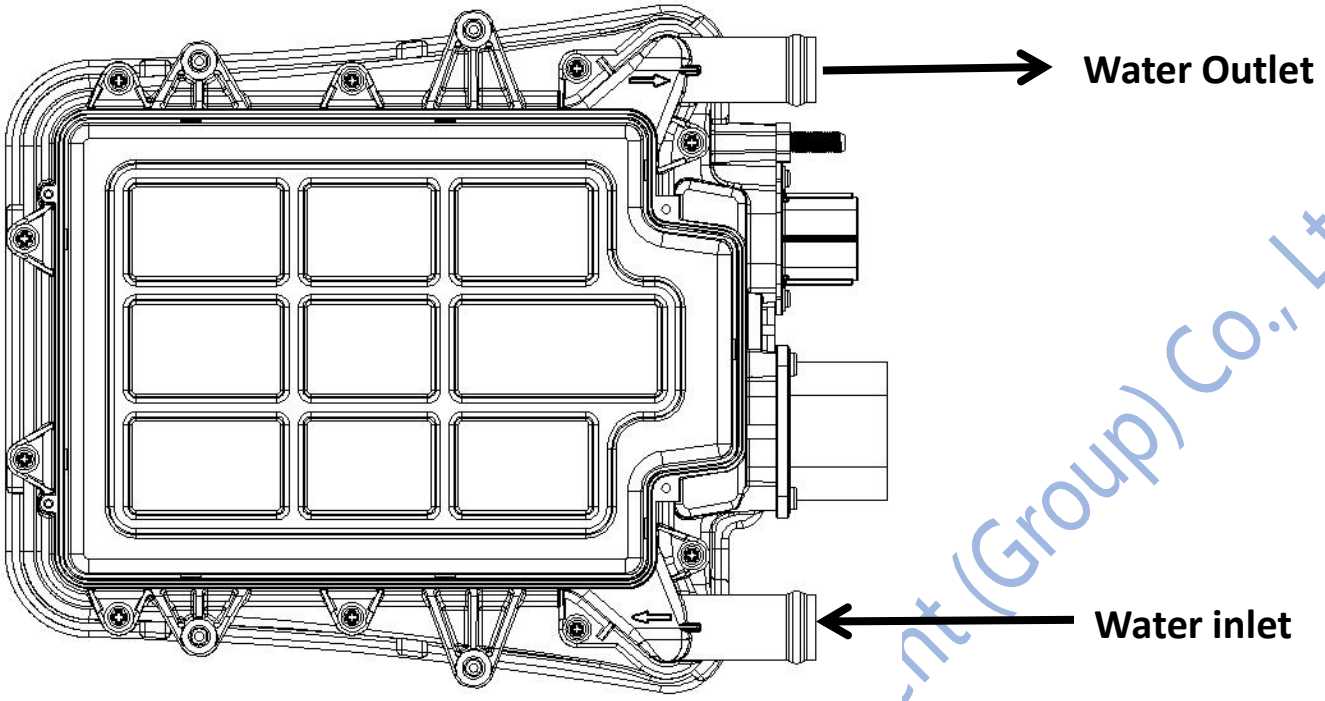
Figure 3.2 Bolt Mounting Points

See drawings and 3D data files for location.

3.1.3 Heater inlet and outlet dimensions

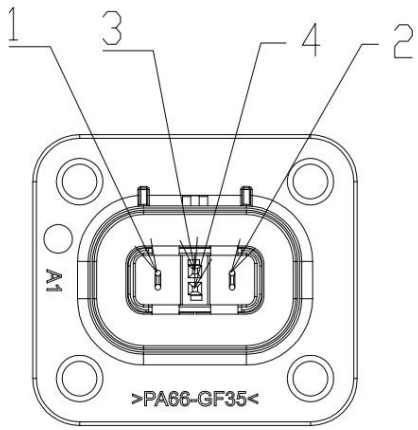


3.1.4 Location of heater inlet and outlet



Note: There is no coolant flowing in the heater, and the heater will enter the high temperature protection state. When the coolant is not drained properly, it will affect the heating capacity of the heater and the accuracy of the temperature collection of the water outlet. Long-term operation will reduce the reliability of the heater.

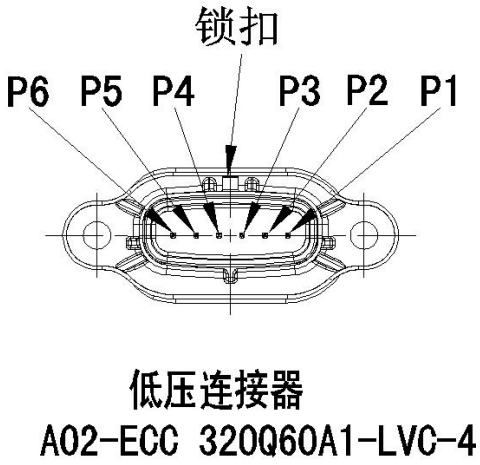
3.2 High Voltage Connectors



PIN	Function
1	HV (+)
2	HV (-)
3	Interlock
4	Interlock

PTC terminal number: HVPO40-RE2-A (Lida)
Harness terminal number: HVPO40-PS2-A (Lida)
Color: Orange

3.3 Low-voltage connectors



PN	Function	Explanation
P1	24VDC+	
P2	24VDC-	
P3	CAN-H	
P4	CAN-L	
P5	HV Interlock	
P6	HV Interlock	High and low voltage interlock

Harness terminal number: Sumitomo 6189-1083
Colour: Black

3.4 Low-voltage electrical connection requirements

None

3.5 Grounding

The grounding is M6 bolt, the maximum tightening torque is 10N.m

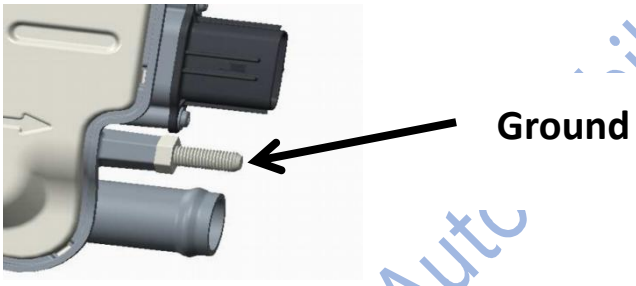


Figure 3.6 Grounding bolt See drawings and 3D data files for location

Note: Disconnect high voltage power when installing or moving heaters.

3.6 Necessary conditions for heater:

- The heater is controlled by CAN communication
- High voltage power supply
- Low voltage power supply (BATT) or KI_{15} (ignition switch voltage), KI_{31} (GND)
- The heater needs to set a high voltage interlock circuit
- The vehicle must be equipped with an insulation monitoring device to monitor:
  - Over (under) voltage protection
  - Short circuit protection (current-limiting fuse in distribution box)
  - Leakage protection
  - Interlock response
- High voltage electric heater must be equipped with 30A current-limiting fuse

- It must be ensured that the high voltage power supply has no reverse polarity
- The vehicle needs to be powered off when overvoltage occurs
- High voltage input should be precharged
- The high voltage input should be equipped with a relay, when a serious fault occurs, the high voltage can be cut off without affecting the safety of the whole vehicle.

4. Electrical Principles

4.1 Electrical framework

4.1.1 System framework

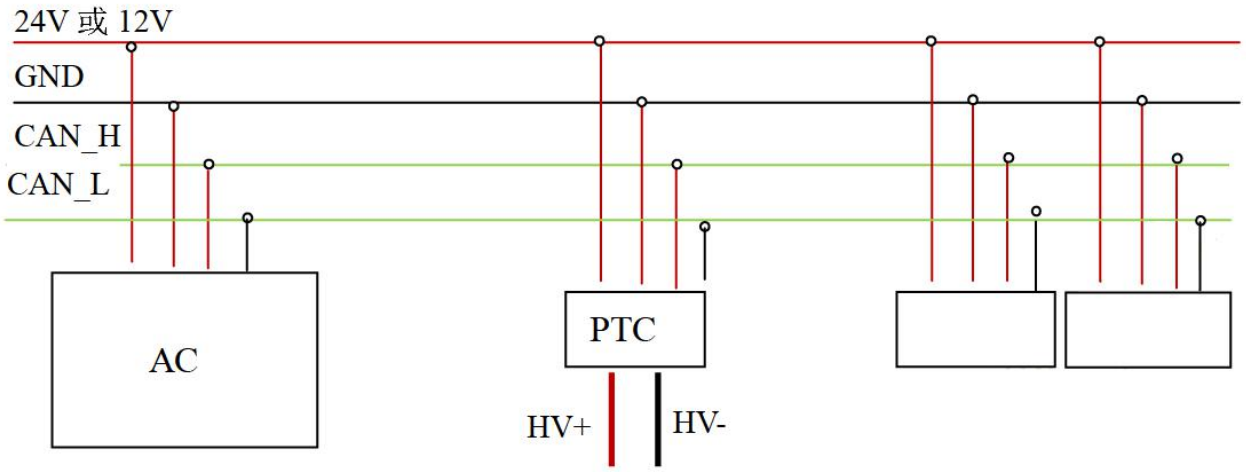
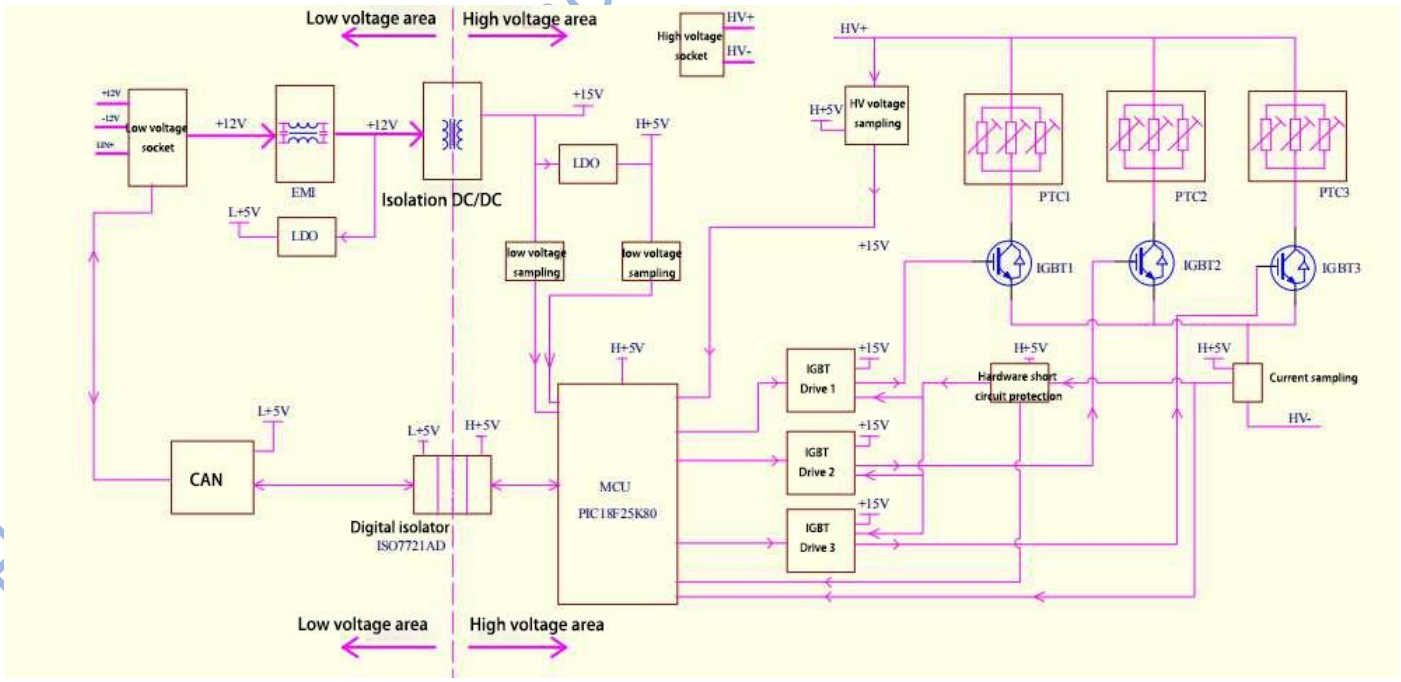


Figure 4.1 System frame diagram

4.1.2 Heater Frame Diagram



4.2 Signal control system and faults

4.2.1 Definitions

The information transmission between the CAN communication systems of the ECU is based on the CAN2.0B standard. The following are the specified parameters of the high-voltage electric heater CAN:

Communication baud rate: 500Kbps

Frame Type: Standard Frame

PTC ID: 0×270

Vehicle Controller ID: 0×268

Period: 400ms

4.2.2 Diagnostic Services

Diagnostic service is not currently supported

4.2.3 CAN network

There are two signal frames related to the PTC heater. AC_0X268 is the control command sent by the air conditioner controller to the PTC heater. PTC_0X270 is the parameter and status of PTC feedback.

Name	ID address	Length（Byte）	Description
AC_0X268	0x268	8	The vehicle loading controller sends commands, including start and stop, target power, target temperature, etc.
PTC_0X270	0x270	8	PTC upload parameters, including inlet and outlet water temperature, voltage, current, power, PTC status, fault status, etc.

4.2.4 The air conditioner controller sends the signal AC_0×268

AC_0X268 is the control signal sent by the air conditioner controller, and the signal matrix is as follows.

Byte	D7	D6	D5	D4	D3	D2	D1	D0
0	Reserved 7	Reserved 6	Reserved 5	Reserved 4	Reserved 3	Reserved 2	Reserved 1	Reserved 0
1	Reserved 15	Reserved 14	Reserved 13	Reserved 12	Reserved 11	Reserved 10	Reserved 9	Reserved 8
2	Reserved 23	Reserved 22	Reserved 21	Reserved 20	Reserved 19	Reserved 18	Reserved 17	Reserved 16
3	Reserved 31	Reserved 30	Reserved 29	Reserved 28	Reserved 27	Reserved 26	Reserved 25	Reserved 24
4	PTC power ratio msb 39	38	37	36	35	34	33	lsb 32
5	Temperature setting msb 47	46	45	44	43	42	41	lsb40

6	Reserved 55	Reserved 54	Reserved 53	Reserved 52	Reserved 51	Reserved 50	Reserved 49	PTC_ON_OFF 48
7	Reserved 63	Reserved 62	Reserved 61	Reserved 60	Reserved 59	Reserved 58	Reserved 57	Reserved 56

4.2.4.1 PTC power ratio

Signal	Start byte	Start bit	Length	Interval (Physics)	Start	Unit	SNA
PTC power ratio	4	32	8	0~255	0	%	

PTC power ratio: PTC power ratio setting value, the precision is 1, and the offset is 0.

When the heating temperature does not reach the Temperature setting, the corresponding relationship between the setting power and the output power is as follows:

0-10%: Stop

11-95%: Divided into 9 power gears, refer to 4.3.2

More than 95% (96-255): full power output (without limiting the power output of the heating element)

4.2.4.2 PTC Temperature setting

Signal	Start byte	Start bit	Length	Interval(Physics)	Start	Unit	SNA
Temperature setting	5	40	8	0~255	0	℃	-

Temperature setting: PTC temperature setting, precision is 1, offset is 0.

When the heating water temperature is <Temperature setting, it will be heated according to the PTC power ratio; when the heating temperature is ≥ Temperature setting, the power output will be automatically reduced to achieve constant temperature control.

Temperature setting: The data range is 0-85°C. When the setting exceeds 85°C, it will work according to the temperature setting of 85°C.

4.2.4.3 PTC_ON_OFF

Signal	Start byte	Start bit	Length	Interval(Physics)	Start	Unit	SNA
PTC_ON_OFF	6	48	1	0~1	0	-	-

PTC_ON_OFF: PTC start\stop signal

PTC_ON_OFF =0 stop heating

=1 start heating

4.2.5 PTC heater upload signal PTC_0X270

PTC_0X270 uploads signals for PTC heaters, including voltage, current, operating power, temperature, operating status, etc. For specific signals, see the signal matrix below.

Byte	D7	D6	D5	D4	D3	D2	D1	D0
0	Ptc_Power msb 7	6	5	4	3	2	1	lsb 0
1	Temperature_ of_OutWater msb 15	14	13	12	11	10	9	lsb 8
2	Temperature_ of_PTC msb 23	22	21	20	19	18	17	lsb 16
3	Reserved 31	Reserved 30	Reserved 29	Reserved 28	Reserved 27	Reserved 26	RunStatus msb25	lsb 24
4	Err_Code msb 39	38	37	36	35	34	33	lsb 32
5	Reserved 47	Reserved 46	Reserved 45	Reserved 44	Reserved 43	Reserved 42	Error_ Level msb 41	lsb 40
6	PTC_running _current msb 55	54	53	52	51	50	49	lsb 48
7	HV_Voltage msb 63	62	61	60	59	58	57	lsb 56

4.2.5.1 PTC upload power (Ptc_Power)

Signal	Start byte	Start bit	Length	Interval(Physics)	Resolution ratio	Unit	Init/SNA
Ptc_Power	0	0	8	0~255	100	W	-

Ptc_Power : PTC operating power, the precision is 100, the offset is 0, the actual power = value * 100, for example: Byte0=0×32, the corresponding power is 50*100=5000W.

4.2.5.2 PTC Temperature_of_Out Water

Signal	Start byte	Start bit	Length	Interval(Physics)	Resolution ratio	Unit	Init
Temperature_of_ OutWater	1	8	8	0~255	1	℃	-

OutWaterTemp: The temperature of the water outlet, the precision is 1, the offset is -40, the actual water temperature = N-40℃, and the effective temperature range is -40~+215°C;

4.2.5.3 Temperature_of_PTC

Signal	Start byte	Start bit	Length	Interval(Physics)	Lower limit value	Unit	Init/SNA
Temperature_of_PTC	2	16	8	0~255	1	℃	-

Temperature_of PTC: PTC temperature, the precision is 1, the offset is -40, the actual water temperature = N-40℃, the

effective temperature range is -40~+215℃;

4.2.5.4 PTC RunStatus

Signal	Start byte	Start bit	Length	Interval(Physics)	Lower limit value	Unit	Init
RunStatus	3	24	2	0~3	0	-	-

RunStatus :Indicates the running status of the PTC

RunStatus=0 Standby

=1 Run

=3 Fault

=2 Invalid

4.2.5.5 PTC Err_Code

Signal	Start byte	Start bit	Length	Interval(Physics)	Init	Unit	SNA
Err_Code	4	32	8	-	0	-	-

Err_Code is the fault code of the PTC heater, the meaning of the code is as follows

HV_PTC Status-> **0x00:** No fault **(Error_Level=0)**

Bit0: IGBT fault (Error_Level=3)

Bit1: Overvoltage (Error_Level=2)

Bit2: Undervoltage (Error_Level=1)

Bit3: NTC is bad (Error_Level=2)

Bit4: High outlet temperature (Error_Level=2)

Bit5: Dry burning (Error_Level=3)

Bit6: Overcurrent (Error_Level=2)

Bit7: reserved

4.2.5.6 PTC Error_Level

Signal	Start byte	Start bit	Length	Interval(Physics)	Init	Unit	SNA
Error_Level	5	40	2	0~3	0	-	-

Error Level = 0 normal

=1 minor failure

=2 general failure

=3 Serious failure (when the PTC reports a serious fault, disconnect the high voltage input)

4.2.5.7 PTC_running_current

Signal	Start byte	Start bit	Length	Interval(Physics)	Init	Unit	SNA
PTC_running_current	6	48	8	0~255	0	A	-

PTC_running curent: PTC running current, the accuracy is 0.2, the offset is 0, the actual current = value * 0.2A, and the effective current range is 0~51A;

4.2.5.8 PTC working voltage (HV_Voltage)

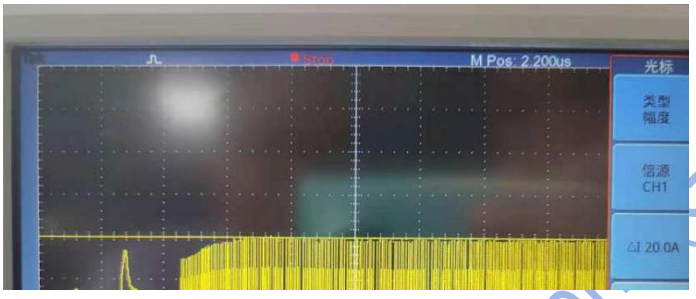
Signal	Start byte	Start bit	Length	Interval(Physics)	Init	Unit	SNA
HV_Voltage	7	56	8	0~255	0	V	-

HV_Voltage: DC high voltage, the precision is 4, the offset is 0, the actual voltage = value * 4V, the effective voltage range is 0~1000V (the controller acquisition voltage range is 0-800V);

4.3 Functional Control Principle

4.3.1 Soft start

W09, the PTC heater adopts the way of group soft start, and the interval between each group is 8-10S, a total of 3 groups. After the soft start is over, the PWM mode is used to adjust the power.



Figure, soft-start current change trend diagram

4.3.2 Power and temperature control

Temperature control range +3 degrees Celsius,

- When the outlet water temperature is lower than the target temperature -3 degrees, the output power will be increased at a certain frequency.
- When the outlet water temperature is at the target temperature>target temperature-3 and less than or equal to the target temperature, the position output power.
- When the outlet water temperature > target temperature, reduce the output power
- When the outlet water temperature> target temperature +3, the heating will be stopped and an over-temperature fault will be reported.

5 Safety features

PTC water heater self-protection function:

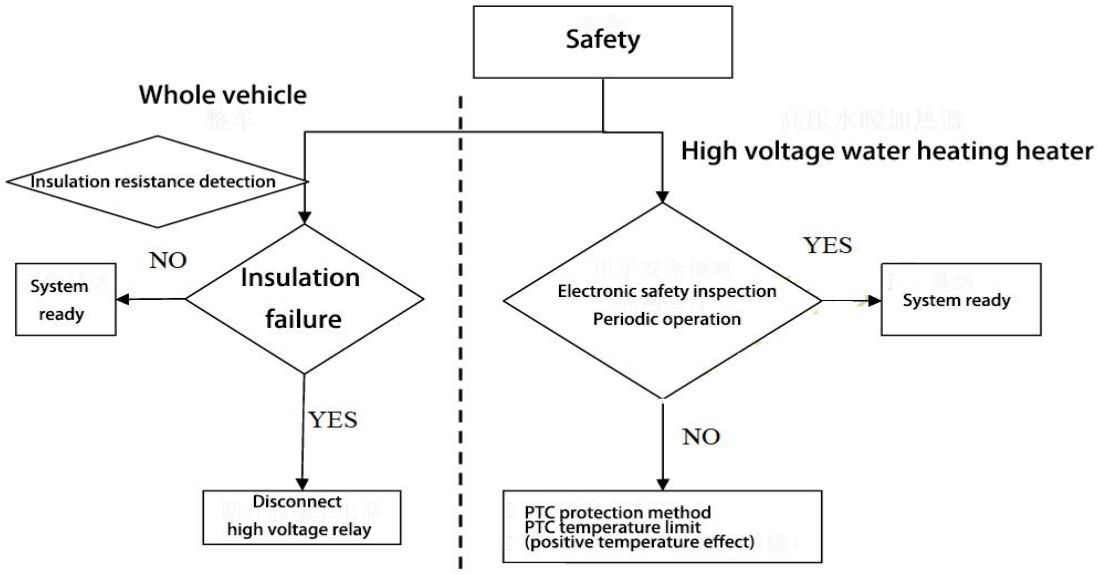


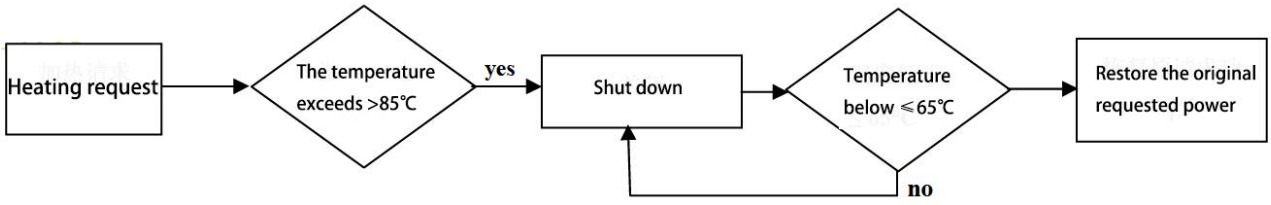
Figure 5.1 PTC self-protection function block diagram

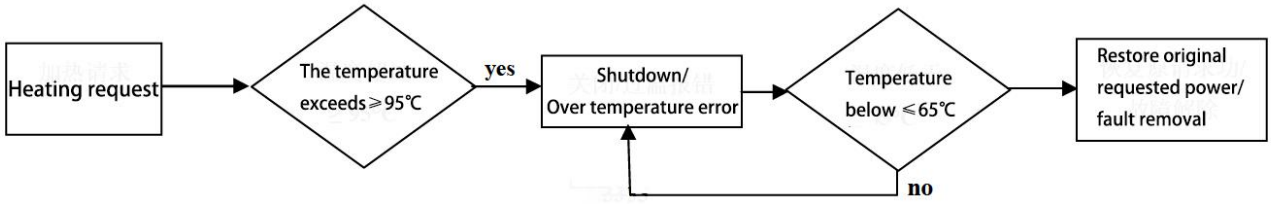
5.1 Security protection functions and processing methods

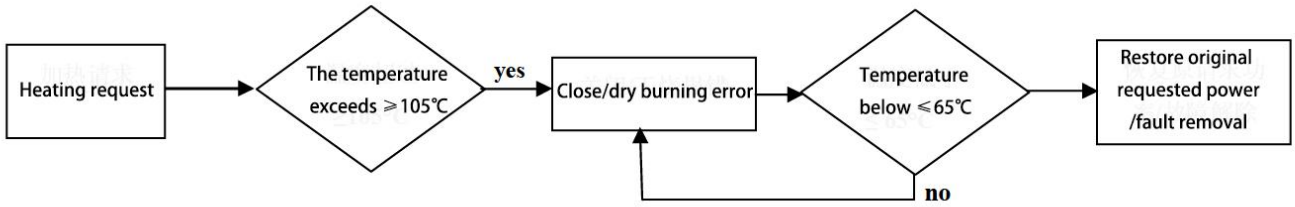
5.1.1 Heater safety temperature

The temperature sensor (NTC: $T_{coolant\ Out}$) is used to monitor the coolant temperature and the internal temperature of the heater, and protect the heater through shutdown protection.

NTC: $T_{coolant}$ temperature protection logic is as follows:







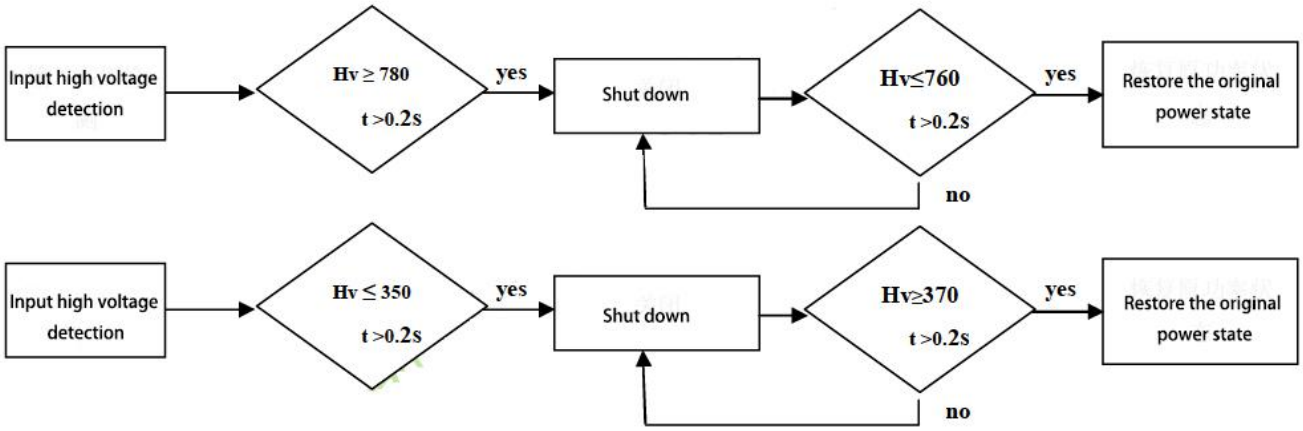
NTC2: $T_{coolant\ Out}$ temperature protection logic is as follows:

NOTE: The following faults indicate system problems

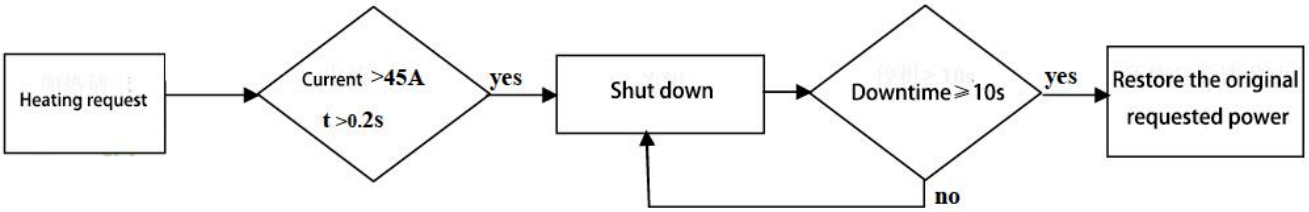
- The coolant does not flow, the reason for the pump
- Or there are air bubbles in the cooling system
- Or coolant leakage

Recommendation: Repair as soon as possible, otherwise permanent damage to the heater will occur.

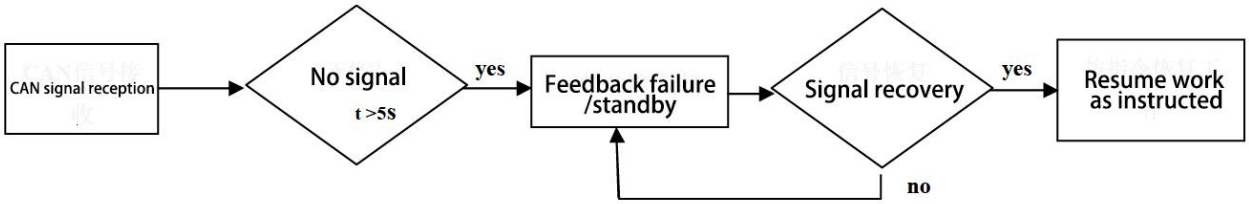
5.1.2 High Voltage Safety Detection



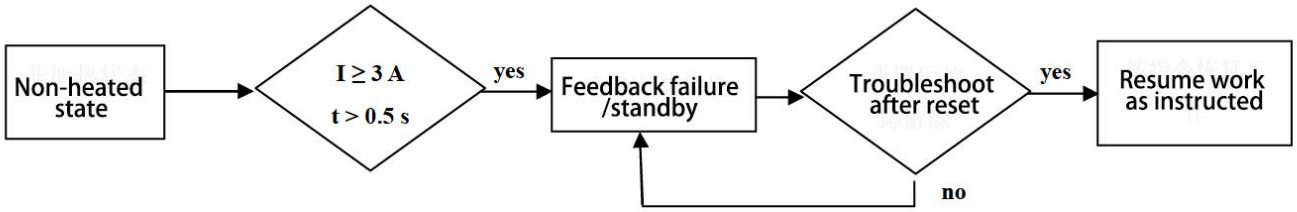
5.1.3 Excessive current detection



5.1.4 CAN Signal Detection

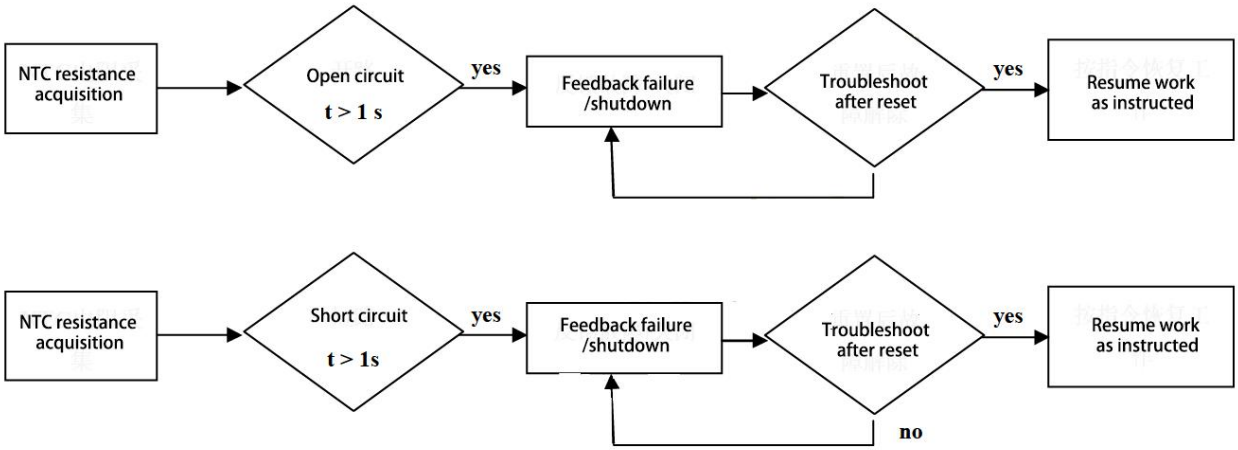


5.1.5 IGBT short circuit or high voltage reverse connection detection



If the fault is not resolved after reset, please check the fault; do not continue to use the heater with IGBT short circuit; high voltage reverse connection will cause the heater to run under heating, which will damage the IGBT and may cause the IGBT to break down. It can only be used in general testing occasions.

5.1.6 NTC Status Detection



5.1.7 High Voltage Interlock

The passive interlock loop effectively monitors the connection of high voltage connectors, and the interlock loop is a simple bridge. Depending on the manufacturer's design, this loop can be implemented inside the high-voltage connector or the low-voltage connector.

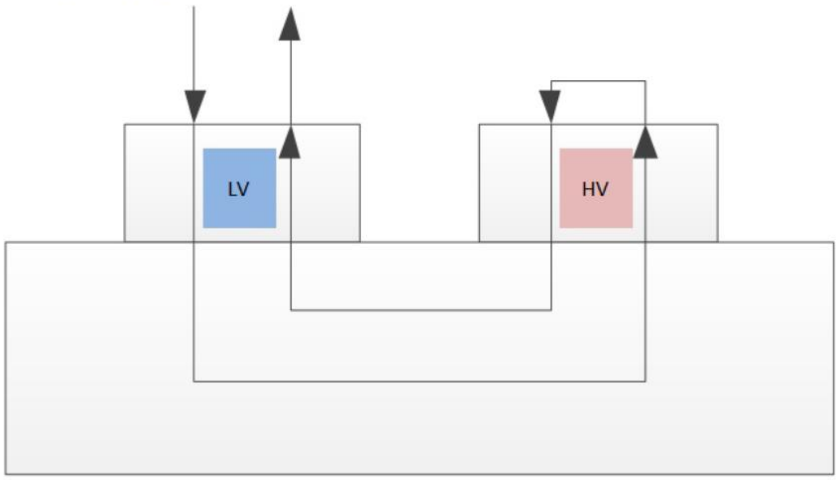


Figure 5.2 Interlock circuit

5.1.8 Power-on inspection

Only high voltages operate without limiting heater performance.

After turning on or resetting the heater, the heater waits for a power request on the CAN bus, and once a valid power request is received, the power-on check starts.

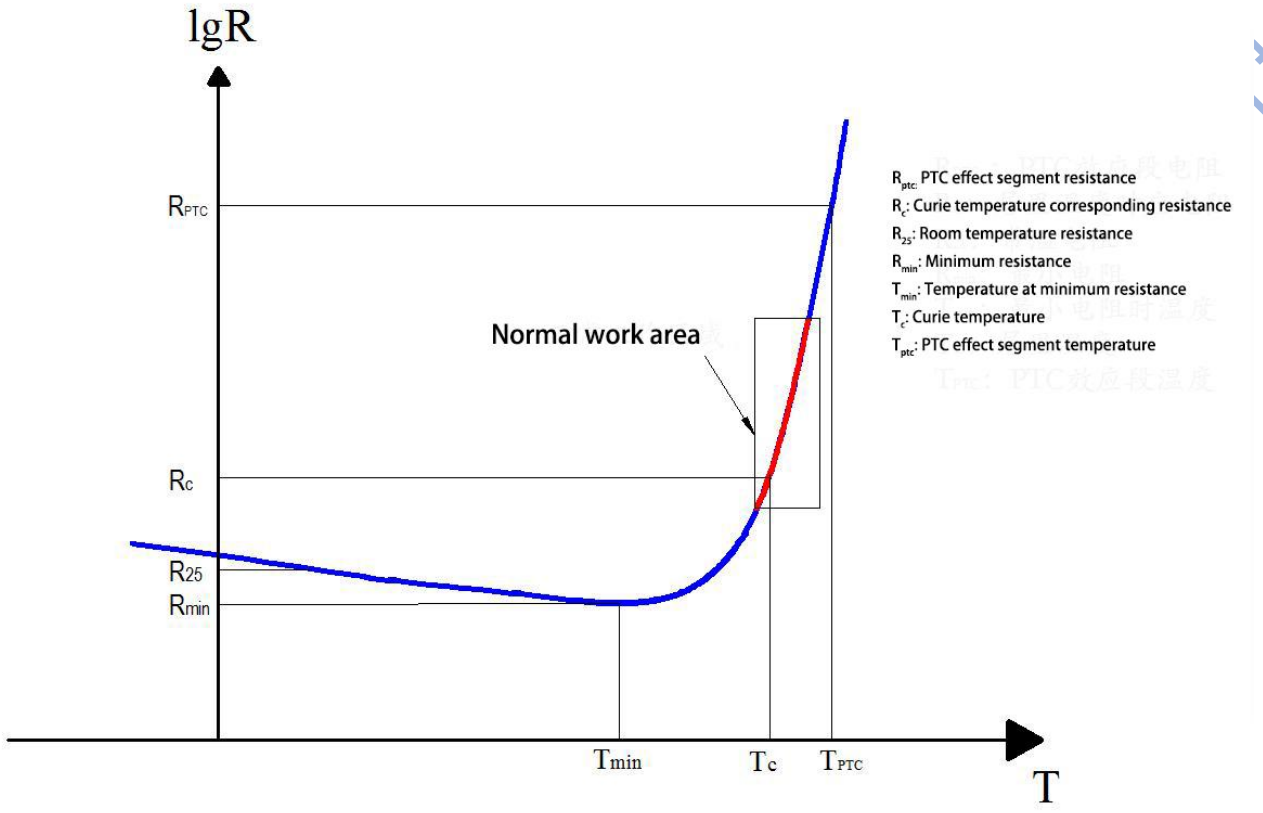
First, check the total current when all heating circuits of the heater are not activated. If it exceeds a predetermined value, the heater is not working at this time, so this fault indicates a short circuit, leakage current or open circuit fault.

5.1.9 Watchdog software

This product comes with external hardware watchdog software that restarts the microcontroller after being suspended.

5.2 PTC Safe Working Scope

The heater uses a low T_C(215°C) PTC element, which limits the maximum temperature that the system can reach (without control circuits), which is within the temperature range that the surrounding components can withstand (even under the worst conditions).



5.3 Insulation fault detection

The customer must connect the ground bolts to the chassis to detect heater insulation failures through the vehicle's insulation detection system.

6 Quality

6.1 Maintenance

This machine is a maintenance-free product.If disassembly is required, only allow our technicians to disassemble.

6.2 Flame retardancy

The flame retardant of this heater complies with the GB2408-2008 standard.

6.3 Prohibited substances

This heater complies with ROHS.

6.4 Cleaning

This heater needs to be sent clean, keep away from dirt, solids or liquids that will damage the operation or appearance of the unit.

6.5 Warranty

The warranty of this machine complies with Chinese laws. Unless otherwise agreed, the warranty period is 12 months.

6.6 Quality Responsibility

If the product is not used according to the requirements of the product, or the use conditions provided are not clear, resulting in quality problems during the use of the product, our company will not be responsible for quality accidents.

7 Other

7.1 Identification and Operation

The heating element has a high-voltage reminder warning to prevent fatal accidents such as electric shock. According to the requirements of the International Electrotechnical Commission, distributors and storage and delivery locations must be marked.

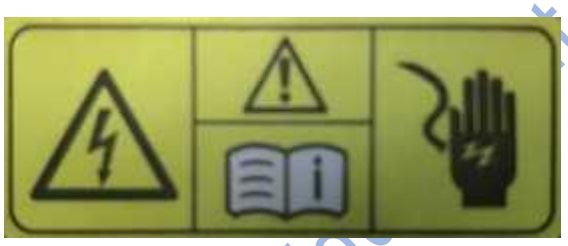


Figure 7.1 Security Label

Note: The power cord cannot be connected incorrectly

Note: Be sure to cut off the power when installing or removing the heater.

8 PTC Basics

8.1 Concept Definition

PTC: temperature coefficient (Positive temperature coefficient, referred to as PTC); the PTC effect is the phenomenon that the resistance increases with the increase of temperature.

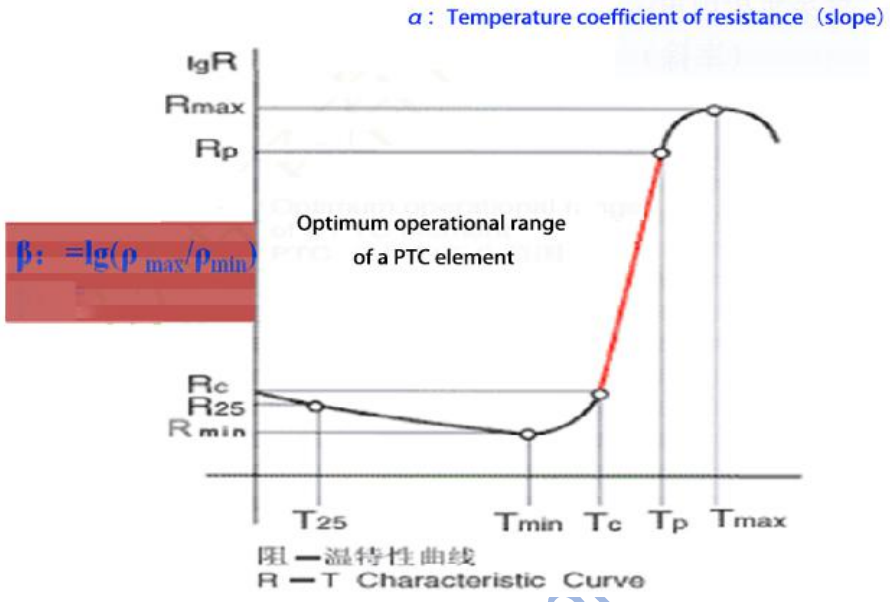
NTC: The opposite of the PTC effect is the NTC (Negative Temperature CoeffiCient) effect.

Ceramic PTC resistor: that is, a ceramic thermal semiconductor resistor with PTC effect, the main material is $Pb_xBa_{(1-x)}TiO3$.

PTC heater: refers to all types of heaters that use ceramic PTC resistors as heating elements, including thermostatic PTC heaters, air-heated PTC heaters, and plumbing PTC heaters.

8.2 Characteristics of Ceramic PTC Resistors

1) R-T characteristics (resistance changes with temperature)

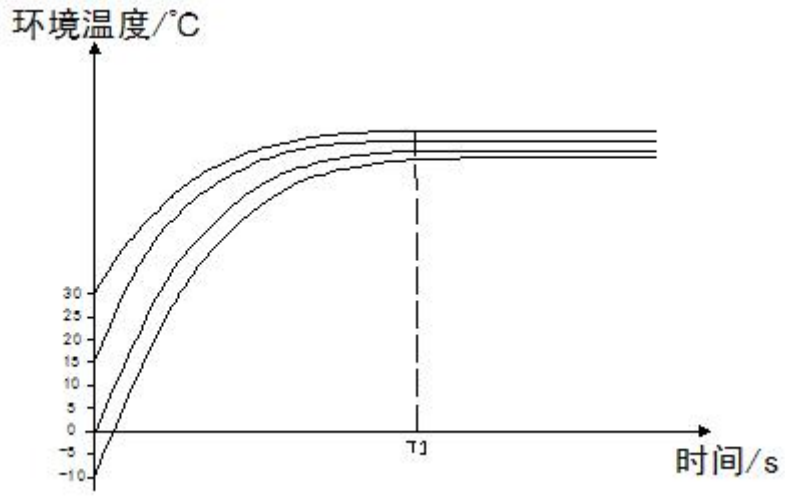


R-T characteristic curve of PTC element

(Note: 1. The PTC element does not generate heat, and the resistance and temperature change trend graph obtained under external heating conditions)

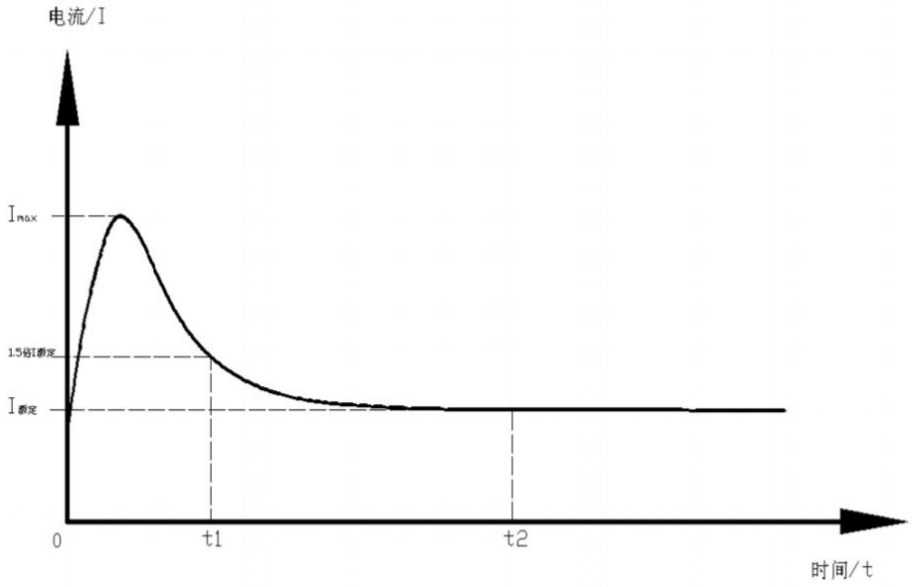
Self-controlling temperature: The PTC resistor enters the PTC effect section (red area), the resistance increases sharply, the heating power drops sharply, and finally the heat generation and the external heat dissipation reach a thermal balance, realizing self-controlling temperature. Self-controlling temperature is a physical property and never fails.

The performance of the self-controlling temperature characteristics in the use of the heater: the power is automatically adjusted within a certain voltage range, and the constant power is basically maintained; the better the external heat dissipation condition of the PTC, the greater the heating power.



Temperature trend diagram of automatic temperature control under different temperatures of PTC components

2) Impulse current: When the PTC resistance enters the stable working process from normal temperature, it first passes through the NTC effect section, the resistance decreases, and then enters the PTC effect section, and the resistance increases sharply; when the voltage remains basically unchanged, the current will first increase and then decrease. to stable. The maximum current is defined as the inrush current of the PTC. The higher the voltage, the greater the inrush current.



Variation trend of starting current under rated voltage of PTC element

3) Working voltage: When the working voltage is too low, the PTC cannot enter the PTC effect section, and the self-controlling temperature and power automatic adjustment ability are lost. At the same time, the working temperature of the heating element is low, and the heater power is much lower than the rated power. PTC is a semiconductor resistor, and if the working voltage is too high, the PTC will be permanently damaged.

8.3 Characteristics of Ceramic PTC Resistors

Safe (self-controlled temperature), reliable, long life, high electrothermal conversion efficiency, wide voltage range.