Worldwide Air Conditioner Partner

Service Manual

R290 Tri-thermal Ultra Mono Series



tcl-tekniikka.fi

CONTENTS

Part 1 General Information ..... 1 1. Unit Capacities 2
1.1 Unit Capacities 2
2. External Appearance 3
2.1 Unit Appearance 3
Part 2 Refrigerant Circuits ..... 4 1. Piping Diagrams 5
1.1 Unit Piping 5
2. Refrigerant Flow Diagrams ..... 7 Part 3 Control ..... 8 1. Stop Operation 9
2. Standby Control 9
2.1 Self-preheat control 9
2.2 Water Pump Control 9
3. Startup Control 9
3.1 Compressor Startup Delay Control 9
3.2 Startup Control for Heating and Domestic Hot Water Operation 10
3.3 Startup Control for Cooling Operation 10
4. Normal Operation Control 11
4.1 Component Control during Normal Operation 11
4.2 Compressor Output Control 11
4.3 Compressor Step Control 11
4.4 Four-way Valve Control 11
4.5 Electronic Expansion Valve Control 12
4.6 Outdoor Fan Control 12
5. Protection Control 12
5.1 High Pressure Protection Control 12
5.2 Low Pressure Protection Control 13
5.3 Discharge Temperature Protection Control 13
5.4 AC Current Protection Control 13
5.5 AC Voltage Protection Control 14
5.6 Water Side Heat Exchanger Anti-freeze Protection Control 14
6. Special Control 15
6.1 Oil Return Operation 15
6.2 Defrost Control 15
6.3 Fast DHW Operation 15
6.4 Buffer Hot Water Tank 16
6.5 OTA Update 16
6.6 Dry Contract M1M2 Control 16

2. PCBs 20
2.1 Main Control Board for Water System 20
2.2 Driving Board for Refrigerant System 23
2.3 Digital Display Output 26
2.4 DIP switch setting and Modbus function 27
3. Error ID Table 28
4. Troubleshooting 30
4.1 Warning 30
4.2 L8 Troubleshooting 30
4.3 E0 Troubleshooting 31
4.4 d1/dn/d6/d4/d5/d3/d2/dj/dH/dF/dA/db/dC/d7/d8/d9 Troubleshooting 33
4.5 Troubleshooting 35
4.6 Troubleshooting 36
4.7 EE Troubleshooting 36
4.8 EC Troubleshooting 38
4.9 EF Troubleshooting 39
4.10 H3 Troubleshooting 40
4.11 H2 Troubleshooting 41
4.12 H1 Troubleshooting 43
4.13 FA Troubleshooting 45
4.14 P1 Troubleshooting 47
4.15 P6 Troubleshooting 48
4.16 P7 Troubleshooting 49
4.17 P8 Troubleshooting 50
4.18 F6 Troubleshooting 51
4.19 F7 Troubleshooting 52
4.20 F8 Troubleshooting 53
4.21 P2 Troubleshooting 54
4.22 P4 Troubleshooting 55
4.23 P0 Troubleshooting 57
4.24 L1/L2/L3/L4/L5/L6 Troubleshooting 58
4.25 Lb/LC Troubleshooting 59
4.26 P5 Troubleshooting 61
5. Appendix to Part 4 62
5.1 Temperature Sensor Resistance Characteristics 62

Part 1 General Information

1. Unit Capacities

1.1 Unit Capacities

Table1-1.1:Standardunitcapacity range

Model	THM4DF3dB THM4DFB	THM6DF3dB THM6DFB	THM8DF3dC THM8DFC	THM10DF3dC THM10DFC	THM12DF3dC THM12DFC
Capacity	4kW	6kW	8kW	10kW	12kW
Model	THM14DF3dC THM14DFC	THM16DF3dC THM16DFC	THM12SF9dC THM12SFC	THM14SF9dC THM14SFC	THM16SF9dC THM16SFC
Capacity	14kW	16kW	12kW	14kW	16kW

2. External Appearance

2.1 Unit Appearance

Table 1-2.1: Unit appearance

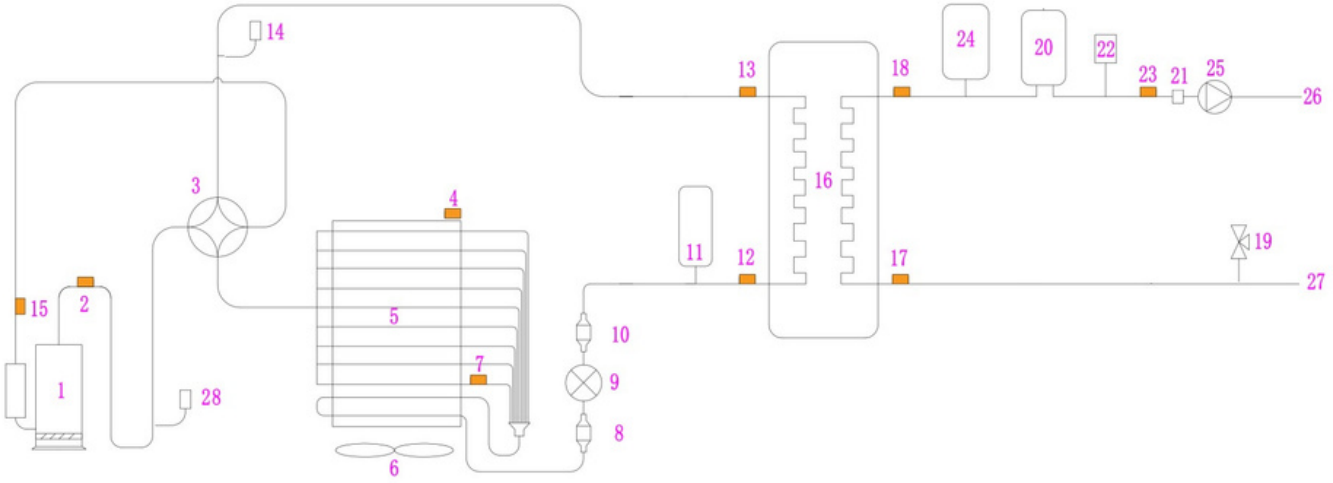
THM4DF3dB THM4DFB THM6DF3dB THM6DFB	THM8DF3dC THM8DFC THM10DF3dC THM10DFC	THM12DF3dC THM12DFC THM14DF3dC THM14DFC THM16DF3dC THM16DFC	THM12SF9dC THM12SFC THM14SF9dC THM14SFC THM16SF9dC THM16SFC
			

Part 2 Refrigerant Circuits

1. Piping Diagrams

1.1 Unit Piping

Figure2-1.1:Unitpipingdiagram



Legend			
1	Compressor	15	Suction temperature sensor
2	Discharge temperature sensor	16	Plate heat exchanger
3	4-way valve	17	Plate heat exchanger inlet water temperature sensor
4	Outdoor ambient temperature sensor	18	Plate heat exchanger outlet water temperature sensor
5	Condenser	19	Safety valve
6	Fan	20	Auxiliary electric heater
7	Condenser tube temperature sensor	21	Gas separator
8	Filter	22	Flow switch
9	Electronic expansion valve	23	Total outlet water temperature sensor
10	Filter	24	Expansion vessel
11	High pressure tank	25	Water pump
12	Refrigerant liquid pipe temperature sensor	26	Outlet water
13	Refrigerant gas pipe temperature sensor	27	Inlet water
14	Pressure sensor	28	Low pressure switch

Key components:

1．Compressor:

Circulate refrigerant and establish refrigerant high and low pressure.

2．Electronic expansion valve (EXV):

Controls refrigerant flow and reduces refrigerant pressure.

3．Four-way valve:

Controls refrigerant flow direction. Closed in cooling mode and open in heating/DHW mode. When closed, the fin

heat exchanger functions as a condenser; when open, the fin heat exchanger functions as an evaporator.

4．High pressure tank:

Store the liquid refrigerant after the heat exchanger, reducing the high-pressure of the system.

5．Gas separator：

Automatically bleeds the air and refrigerant from the water circuit.

6．Safety valve:

Preventsexcessivewaterpressurebyopeningwhenthepressurereaches0.3MPa(3bar)anddischargingwaterfrom the water loop.

7．Expansion vessel:

By absorbingandreleasing moisture to regulate the pressure within the system, safety risks caused by excessive pressure can be prevented

8．Water flow switch:

Detects water flow rate to protect compressor and water pump when water flow is insufficient .

9．Backup electric heater:

Provides additional heating capacities when the heating capacity of the heat pump is insufficient due to low outdoor temperature, protects the external water pipes from freezing, and serve as a backup heat source in case of heat pump failure.

10．Water pump

Circulates water in the watercircuit.

2. Refrigerant Flow Diagrams

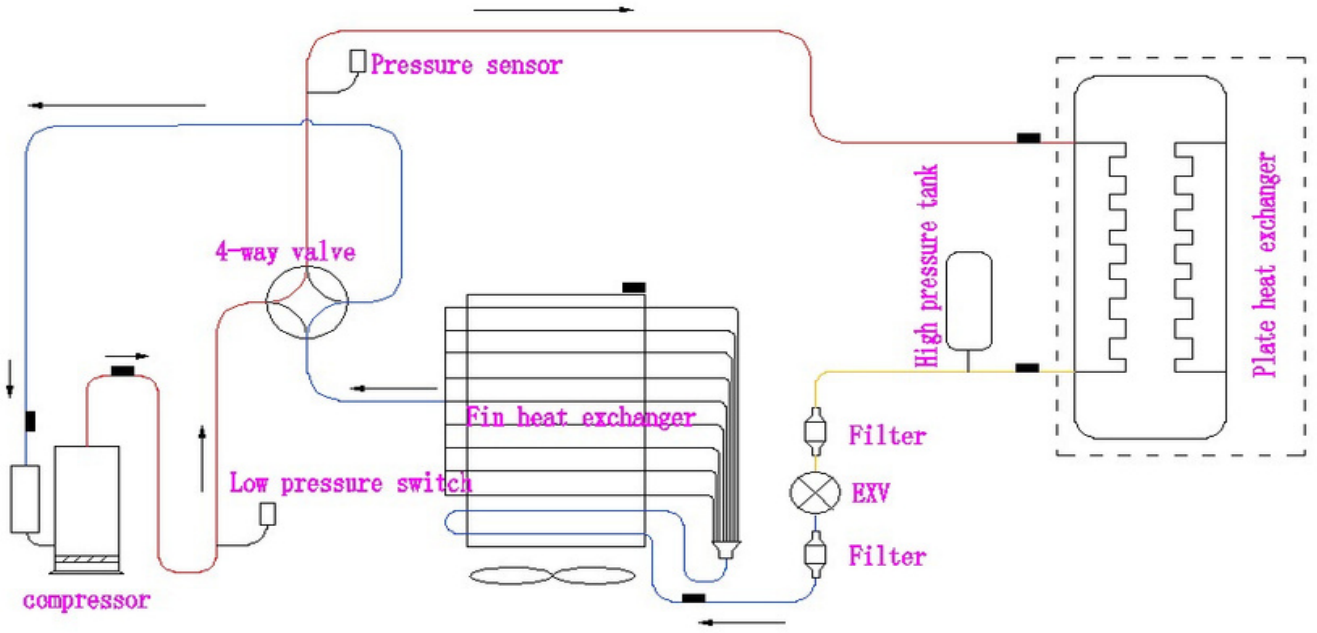
Heating and hot water operation

Figure2-2.1:Refrigerantflowduringheatingordomestic hot water operation

High temperature, high pressure gas

High temperature, high pressure liquid

Low temperature, low pressure



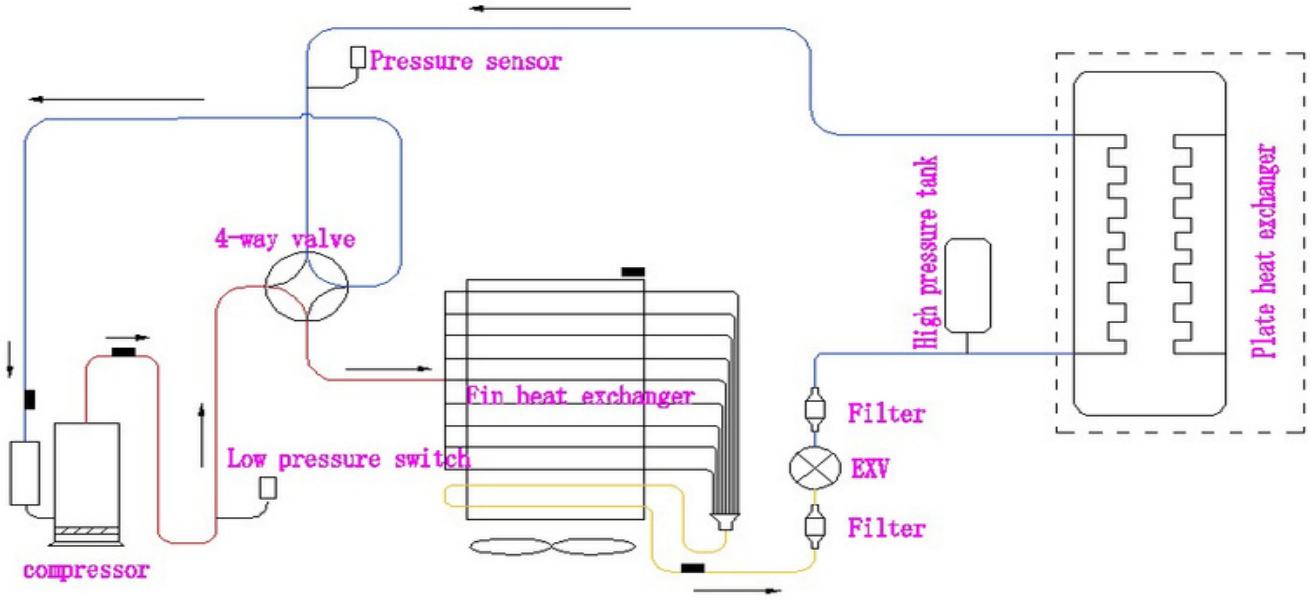
Cooling and defrosting operation

Figure2-2.2:Refrigerantflowduringcoolingand defrosting operations

High temperature, high pressure gas

High temperature, high pressure liquid

Low temperature, low pressure



Part 3 Control

1. Stop Operation

The stop operation occurs for one of the following reasons:

1. Abnormal shutdown: in order to protect the compressors, if an abnormal state occurs the system makes a stop with thermostat off operation and an err id is displayed on the user interface.

2. The system stops when the set temperature has been reached.

2. Standby Control

2.1 Self-preheat control

When the unit is powered on and in standby mode, the control board detects that the ambient temperature is lower than a certain value, and enters the self-preheating function. The PCB board energizes the compressor windings within a safe range (the lower the ambient temperature, the greater the current value), Heat generation and heat transfer to the inside of the compressor to ensure the reliability of the compressor starting at low temperature.

2.2 Water Pump Control

When the unit is in standby, the internal and external circulator pumps run continuously.

3. Startup Control

3.1 Compressor Startup Delay Control

In initial startup control and in restart control (except in oil return operation and defrosting operation), compressor startup is delayed such that a minimum of the set re-start delay time has elapsed since the compressor stopped, in order to prevent frequent compressor on/off and to equalize the pressure within the refrigerant system.

Figure3-3.1:compressorstartupprogram1 : Theinitialpower-onstartupandbeforestartup,thedetectedambienttemperatureisabove3°C



Notes:

1. Once the first, 40-second stage of the program is complete, the program proceeds to the subsequent stages in a step-by-step fashion and exits when the target rotation speed has been reached.

Figure 3-3.2: compressor startup program 2 : The compressor stops for a duration of ≥ 2 hours and the ambient temperature is detected to be ≤ 3°C before startup.

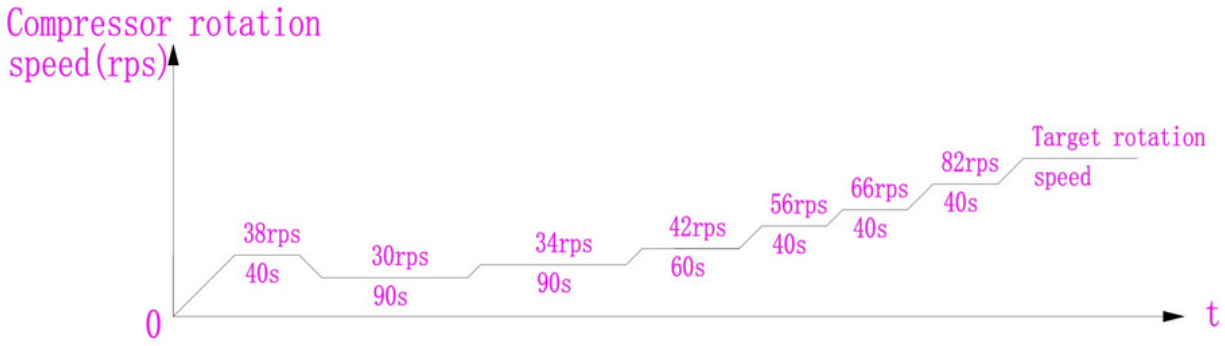
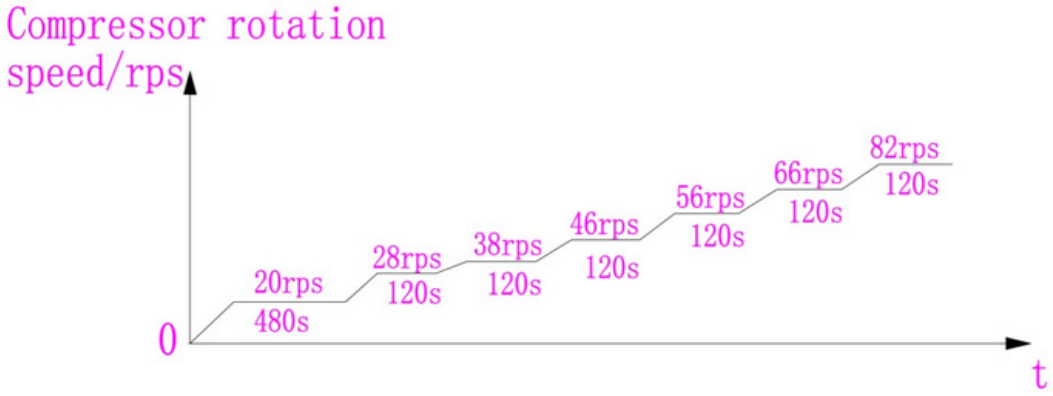


Figure 3-3.3: compressor startup program3 : When either condition one or condition two is met, the compressor will start in mode 3（Condition 1: Both of the following conditions must be met: 1) The heating/boiling water function is activated upon initial power-on; 2) Before startup, the external ambient temperature T is detected and it is confirmed that T ≤ -18；Condition 2: Both the compressor shutdown duration being ≥ 2 hours and the detection of the external loop temperature T outside the loop being ≤ -18℃ before startup must be met.）.



Notes:

1. Once the first, 40-second stage of the program is complete, the program proceeds to the subsequent stages in a step-by-step fashion and exits when the target rotation speed has been reached.

3.2 Startup Control for Heating and Domestic Hot Water Operation

Table 3-3.1: Component control during startup in heating and domestic hot water modes

Component	Wiring diagram label 4-16kW		Control functions and states
Inverter compressor	COMP	●	Determine the start-up operating frequency according to the room load (ambient temperature difference or water temperature difference)，and compressor startup program selected according to ambient temperature[1]
DC fan motor	FAN	●	After fan run at middle speed at 60s, determine the start-up operating wind speed according to the frequency of the compressor and the outdoor ambient temperature2
Electronic expansion valve	EXV	●	After maintaining for 30s with the starting opening 380P, its initial opening is determined by outdoor ambient temperature and inlet water temperature
Four-way valve	4-WAY	●	Off

Notes:

1.RefertoPart 3, 3.1 "Compressor Startup Program".

2.RefertoTable 3-4.3 in Part 3, 4.6 "Outdoor Fan Control".

3.3 Startup Control for Cooling Operation

Table 3-3.2: Component control during startup in cooling mode

Component	Wiring diagram label	4-16kW	Control functions and states
Inverter compressor	COMP	●	Determine the start-up operating frequency according to the room load (ambient temperature difference or water temperature difference)，and compressor startup program selected according to ambient temperature[1]
DC fan motor	FAN	●	After fan run at maximum speed at 60s, determine the start-up operating wind speed according to the frequency of the compressor and the outdoor ambient temperature2
Electronic expansion valve	EXV	●	After maintaining for 30s with the starting opening 380P, its intial opening is determined by outdoor ambient temperature and inlet water temperature
Four-way valve	4-WAY	●	On

Notes:

1. Refer to Part 3, 3.1 "Compressor Startup Program".

2. Refer to Table 3-4.3 in Part 3, 4.6 "Outdoor Fan Control".

4. Normal Operation Control

4.1 Component Control during Normal Operation

Table 3-4.1: Component control during heating and domestic hot water operations

Component	Wiring diagram label	4-16kW	Control functions and states
Inverter compressor	COMP	●	Controlled according to load requirement from hydronic system
DC fan motor	FAN	●	Controlled according to outdoor heat exchanger pipe temperature
Electronic expansion valve	EXV	●	Position (steps) from 0 (fully closed) to 480 (fully open), controlled according to discharge overheat, suction overheat and compressor speed
Four-way valve	4-WAY	●	Off

4.2 Compressor Output Control

Table 3-4.2: Component control during cooling operation

Component	Wiring diagram label	4-16kW	Control functions and states
Inverter compressor	COMP	●	Controlled according to load requirement from hydronic system
DC fan motor	FAN	●	Controlled according to outdoor heat exchanger pipe temperature
Electronic expansion valve	EXV	●	Position (steps) from 0 (fully closed) to 480 (fully open), controlled according to discharge overheat, suction overheat and compressor speed
Four-way valve	4-WAY	●	On

The compressor rotation speed is controlled according to the load requirement. Before compressor startup, the Tri-thermal unit determines the compressor target speed according to outdoor ambient temperature, leaving water set temperature and actual leaving water temperature and then runs the appropriate compressor startup program. Once the startup program is complete, the compressor runs at the target rotation speed.

4.3 Compressor Step Control

The running speed of six-pole compressors in rotations per second (rps) is one third of the frequency (in Hz) of the electrical input to the compressor motor. The frequency of the electrical input to the compressor motors can be altered at a rate of 1Hz per second.

4.4 Four-way Valve Control

The four-way valve is used to change the direction of refrigerant flow through the water side heat exchanger in order to switch between cooling and heating/DHW operations. Refer to Part 2, 2 "Refrigerant Flow Diagrams" . During heating and DHW operations, the four-way valve is off; during cooling and defrosting operations, the four-way valve is on.

4.5 Electronic Expansion Valve Control

The position of the electronic expansion valve (EXV) is controlled in steps from 0 (fully closed) to 480 (fully open).

- At power-on:

After the unit is powered on again, the EXV first opens to 480, then completely closes, then opens to 480, and maintains this opening to wait for startup.

- After the EXV maintains the starting opening at 320P for 30s, the initial opening is determined according to the operating mode and the outdoor ambient temperature; within a period of time, the opening of the EXV is determined by the suction superheat and discharge temperature; after a few minutes, the opening degree of the EXV is determined by the change of suction superheat degree, discharge temperature and compressor frequency.

- When the unit is in standby:The EXV is at standby position.
- When the unit stops:The EXV first closes fully, then moves to the standby position.

4.6 Outdoor Fan Control

Table3-4.3:Fanspeedsettingsfordifferentmodels

Fan Speed Index	Fan speed			
	4/6kW	8/10kW	12/14kW	16kW
W1	200	200	200	200
W2	250	250	300	300
W3	300	300	400	400
W4	400	400	450	450
W5	450	450	500	500

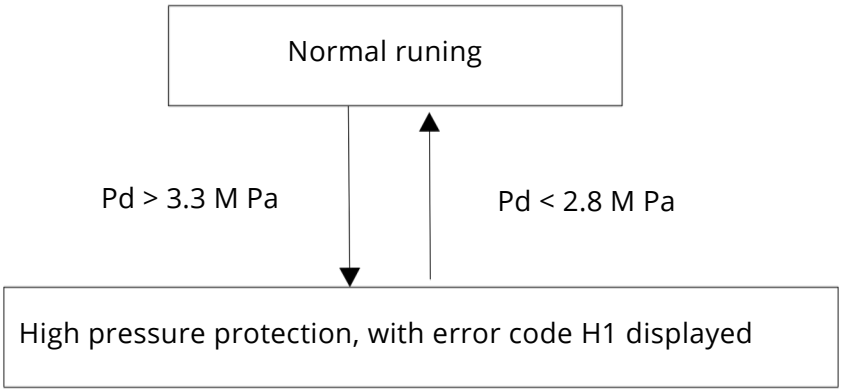
5. Protection Control

5.1 High Pressure Protection Control

This control protects the refrigerant system from abnormally high pressure and protects the compressor from transient spikes in pressure.

When the discharge pressure rises above 3.3MPa the system displays H1 protection and the unit stops running. When the discharge pressure drops below 2.8MPa, the compressor enters re-start control.

Figure 3-5.1: High pressure protection control



Notes:

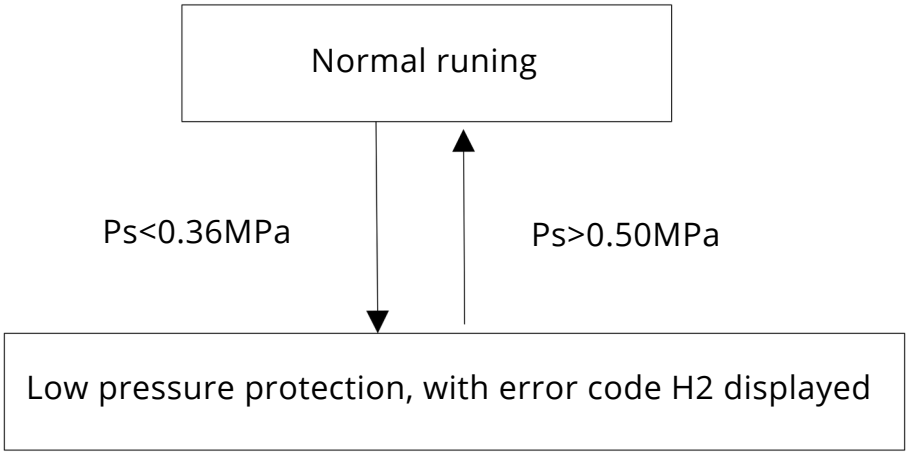
Pd - Discharge pressure.

5.2 Low Pressure Protection Control

This control protects the refrigerant system from abnormally low pressure and protects the compressor from transient drops in pressure.

When the suction pressure drops below 0.36MPa the system displays H2 protection and the unit stops running. When the suction pressure rises above 0.50MPa, the compressor enters re-start control.

Figure 3-5.2: Low pressure protection control

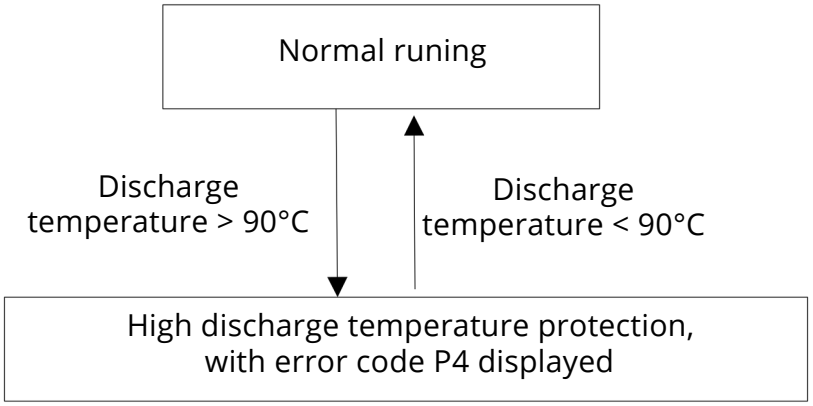


Notes: Ps - Suction pressure.

5.3 Discharge Temperature Protection Control

This control protects the compressor from abnormally high temperatures and transient spikes in temperature.

Figure 3-5.3: High discharge temperature protection control



Notes:

When the discharge temperature rises above 90°C the system displays P4 protection and the unit stops running. When the discharge temperature drops below 90°C, the compressor enters re-start control.

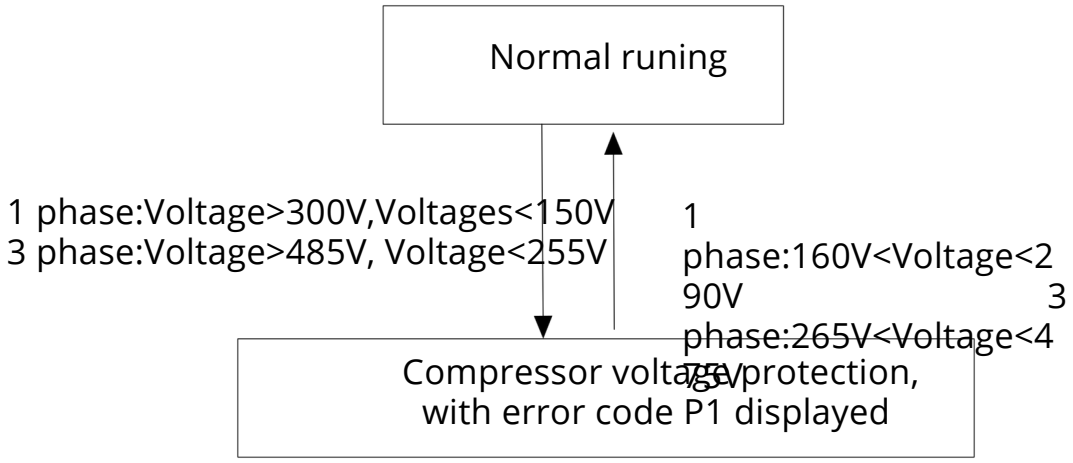
5.4 AC Current Protection Control

This control protects the system from abnormally high currents.
When the AC current rises above $Current_{max}$ the system displays P2 protection and the unit stops running. When the compressor current drops below $Current_{max}$ the compressor enters re-start control.
Figure 3-5.4: AC current protection control

Model name	4~6kw	8~10kw	12~16kw 1ph	12~16kw 3ph
$Current_{max}$	16	21	32	18

5.5 AC Voltage Protection Control

This control protects the Tri-thermal Ultra Mono from abnormally high or abnormally AC low voltages.
Figure 3-5.5: AC voltage protection control.



Notes:
1 Phase as an example, When the phase voltage of AC power supply is at or above 300V , the system displays P1 protection and the unit stops running. When the phase voltage drops below 290V , the refrigerant system restarts once the compressor re-start delay has elapsed. When the phase voltage is below 150V, the system displays P1 protection and the unit stops running. When the DC bus voltage rises to more than 160V, the refrigerant system restarts once the compressor re-start delay has elapsed.

5.6 Water Side Heat Exchanger Anti-freeze Protection Control

This control protects the water side heat exchanger from ice formation.
Standby anti-freeze protection of the unit: when the water outlet temperature is less than 8℃, the unit starts the water pump to operate for anti - freeze protection. After the water pump has run for the anti-freeze interval time, the water temperature is detected again. If the water outlet temperature is still less than 8℃, the unit activates the electric heater and the heating mode for anti-freeze protection.
Unit startup anti-freeze protection: When the ambient temperature is less than 4℃ and the time of reaching the set temperature and stopping the unit reaches the anti-freeze interval time, the unit starts the water pump to operate for anti-freeze protection. After the water pump has run for the anti-freeze interval time, the water temperature is detected. If the water outlet temperature is less than 8℃, the unit activates the electric heater and the heating mode for anti-freeze protection.
When the water temperature rises to a specific value, the unit automatically exits the anti - freeze protection.

6. Special Control

6.1 Oil Return Operation

In order to prevent the compressor from running out of oil, the oil return operation is conducted to recover oil that has flowed out of the compressor and into the refrigerant piping.
The oil return operation starts when the following condition occurs:

- When the compressor cumulative operating time reaches 6 hours.
- The oil return operation ceases when any one of the following three conditions occurs:
- Oil return operation duration reaches 3 minutes.
- Compressor stops.

Tables3-6.1showcomponentcontrolduringoil returnoperation incoolingmode.

Component	Wiring diagram label	4-16kW	Control functions and states
Inverter compressor	COMP	●	Runs at oil return operation rotation speed
DC fan motor	FAN	●	Controlled according to cooling mode
Electronic expansion valve	EXV	●	400 (steps)
Four-way valve	4-WAY	●	On

Tables 3-6.2 show component control during oil return operation in heating&DHW modes.

Component	Wiring diagram label	4-16kW	Control functions and states
Inverter compressor	COMP	●	Runs at oil return operation rotation speed
DC fan motor	FAN	●	Controlled according to heating mode
Electronic expansion valve	EXV	●	380 (steps)
Four-wayvalve	4-WAY	●	Off

6.2 Defrost Control

When the heating/DHW mode is operated under low temperature conditions, the unit will form a frost on the surface of the air-side heat exchanger, which will affect the heat exchange capacity. In order to clear the frost layer and restore the heating capacity, defrost control is carried out. Defrost control is performed according to the running time, outdoor ambient temperature, and refrigerant outlet temperature of the air-side heat exchanger.
Tables 3-6.3 show component control during defrost control

Component	Wiring diagram label	4-16kW	Control functions and states
Inverter compressor	COMP	●	Run according to defrosting frequency
DC fan motor	FAN	●	Stop
Electronic expansion valve	EXV	●	When the compressor is turned on, the electronic expansion valve opens to 380P, and gradually increases the opening
Four-wayvalve	4-WAY	●	On

6.3 Fast DHW Operation

Fast DHW operation is used to quickly meet a requirement for domestic hot water when DHW priority has been set on the user interface.
Domestic hot water demand priority can be ended by changing the switch on controller from "on" to "off".
Table3-6.4:Component controlduringfastDHW operation

Component	Wiring diagram label	4-16kW	Control functions and states
Inverter compressor	COMP	●	Controlled according to load requirement

DC fan motor	FAN	●	Controlled according to outdoor heat exchanger pipe temperature
Electronic expansion valve	EXV	●	Position (steps) from 0 (fully closed) to 480 (fully open), controlled according to discharge overheat
Four-way valve	4-WAY	●	Off
Tank electric heater	TBH	●	On

6.4 Buffer Hot Water Tank

After equipped with a buffer water tank, the switch of the unit is controlled by the temperature sensor of the buffer water tank. The buffer water tank is used as a water storage container to store water while meeting the needs of space heating, space cooling and domestic hot water.

6.5 OTA Update

After the product is connected to the network through WIFI, you can use the "TSmart" app to upgrade the programs of the WiFi module, wire controller, unit and outdoor unit to improve product performance or repair abnormalities.

6.6 Dry Contact M1M2 Control

M1 and M2 can be configured on the wired controller with the following options:
NO: Disable;
HP: Heat pump on/off control;
AHS: AHS on/off control.
The remote control type can be selected on the wired controller with the following options:
ON - Normally open;
OFF - Normally close.
1. When ON is selected:
①For heat pump on/off control
When the dry contact is disconnected for 1 second, the heat pump stops (a shutdown command is sent). When the dry contact is closed for 5 seconds, the heat pump starts up, and the heat pump is started or stopped according to the settings of the wire controller or the room thermostat.
When the dry contact is disconnected:
When the wire controller shows "On", the dry contact takes precedence. When the dry contact is disconnected (shutdown), the unit shuts down; when the dry contact is closed, the unit starts up. When the wire controller shows "OFF", the wire controller takes precedence. Whether the dry contact is disconnected or closed, the unit shuts down.
②For TBH control
If [Hot water function] is set to valid, the following actions will be performed:
when the dry contact is closed, and Thwt<70℃ ; then TBH opens until water tank temperature reaches 75℃.
③For AHS control
In Heat mode, the setting of AHS is “Heat”, AHS on/off is only controlled by M1M2.
In DHW mode, the setting of AHS is “Heat”or “Heat & DHW”,M1M2 control does not affect AHS on/off.

2. When OFF is selected:
①For heat pump on/off control
When the dry contact is closed for 1 second, the heat pump stops (a shutdown command is sent). When the dry contact is disconnected for 5 seconds, the heat pump starts up, and the heat pump is started or stopped according to the settings of the wire controller or the room thermostat.
When the wire controller shows "On", the dry contact takes precedence. When the dry contact is disconnected (shutdown), the unit shuts down; when the dry contact is closed, the unit starts up. When the wire controller shows

"OFF", the wire controller takes precedence. Whether the dry contact is disconnected or closed, the unit shuts down.

For TBH and AHS control, it’s same as normally open type

6.7 Smart Grid Control

The unit adjusts the operating status according to different power supply signals and grid signals to achieve energy saving. The logic is as follows:

1. When the unit detects the EVU power supply signal [LDIevu] and the SG power grid signal [LDIsg] , it is in the free power consumption state(Ⅰ), with the following logic:

The unit is forced to run in "strong" mode;

If [Hot water function] is set to "valid", the following actions will be performed:

The hot water is forced to start, and the hot water is forced to be given priority;

The target temperature of hot water energy adjustment is automatically set to 75°C;

DHW Water tank electric heater action:

When the TDHW is less than 74°C, turn on the electric heating of the domestic water tank;

When the TDHW is ≥75°C, turn off the electric heating of the domestic water tank.

2. When the unit does not detects the EVU power supply signal [LDIevu] and detect the SG grid signal [LDIsg] , it is in the free power consumption state (Ⅱ), with the following logic:

The unit is forced to run in "strong" mode;

If the hot water is turned on and the unit is running to make hot water, the following actions will be performed:

The unit is forced to give priority to hot water

DHW Water tank electric heater H domestic Water tank electric heater action is as follows:

TDHW < T set_5-2°C, turn on the electric heating of the domestic water tank;

TDHW≥ T set_5 +3℃, turn off the electric heater of domestic water tank.

3. When neither the EVU power supply signal [LDIevu] nor the SG power grid signal [LDIsg] is detected by the unit it is in a low-valley power consumption state, and the unit is forced to run "Standard" mode;

4. When the unit detect the EVU power supply signal , and does not detects the SG power grid signal , it is in a peak power consumption state, with the following logic:

- The unit is forced to run in "energy-saving" mode;
- Forcibly cancel the hot water demand, and the unit is prohibited from running the hot water mode;
- The electric heating of the living water tank remains off;
- Timed sterilization function is invalid;
- The maximum cooling (or heating) running time of the unit is 0min.

6.8 Three Zones Control

The unit can be controlled by three zones to control the temperature of each zone separately to meet different types of terminal work requirements and user comfort requirements. Zone A can realize space heating and space cooling, and can be equipped with three types of terminals (floor heating, fan coil, radiator); Zone B is permitted to have space heating/cooling, and can only be equipped with one type of terminal (floor heating/cooling); Zone C is only allowed to use one type of terminal (using a wired controller to select whether it is the swimming pool or floor heating/cooling). In the cooling/heating mode, when a zone reaches the set temperature, the zone will unload, and the water pump in the corresponding zone will be turned off.

7. Role of Temperature Sensors in Control Functions

Figure 3-7.1: Location of the temperature sensors on Tri-thermal Ultra Mono systems

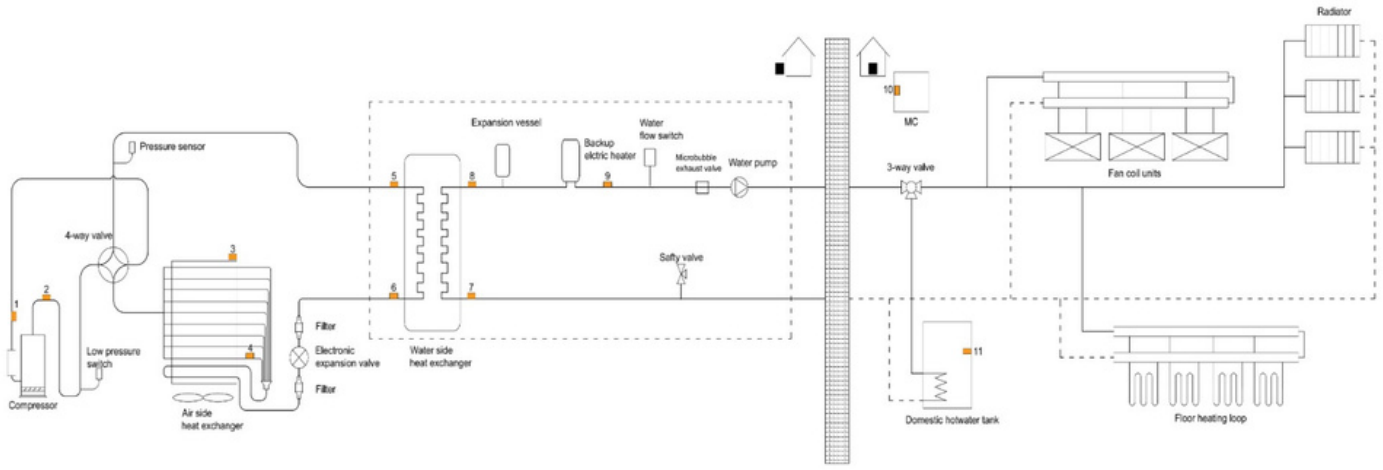


Table 3-7.1: Names of the temperature sensors

Number	Sensor name	Sensor code
1	Compressor suction temperature sensor	Xq
2	Compressor discharge temperature sensor	Pq
3	Outdoor ambient temperature sensor	OA
4	Air side heat exchanger refrigerant outlet temperature sensor	Cp
5	Water side heat exchanger refrigerant inlet (gas pipe) temperature sensor	TGRT
6	Water side heat exchanger refrigerant outlet (liquid pipe) temperature sensor	TLRT TIWT
7	Water side heat exchanger water inlet temperature sensor	TOWT
8	Water side heat exchanger water outlet temperature sensor	TTOWT
9	Total water outlet temperature sensor	Tr Thwt
10	Room temperature sensor (built in wired controller)	
11	Domestic hot water tank temperature sensor	

Part 4 Diagnosis and Troubleshooting

1. Electric Control Box Layout

1.1 Unit Electric Control Box Layout

Figure 4-1.1: THM4(6)DF3dB

Electric control box

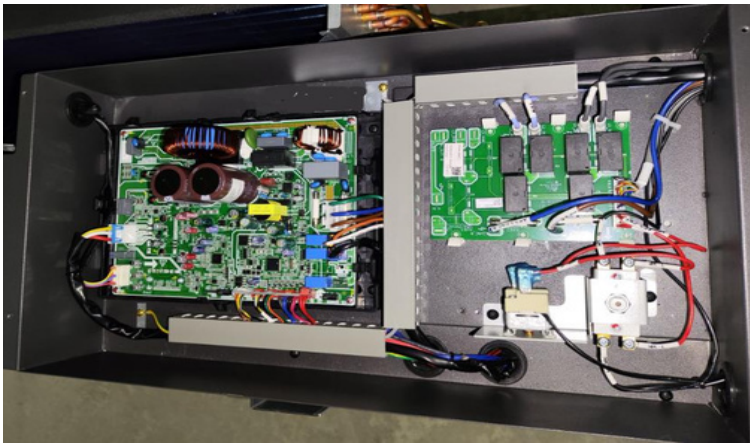
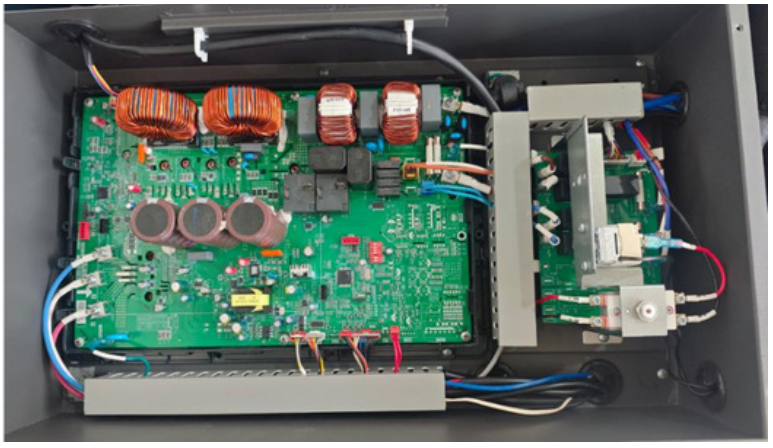




Figure 4-1.2: THM8D(10)F3dC, THM12(14, 16)DF3dC

Electric control box



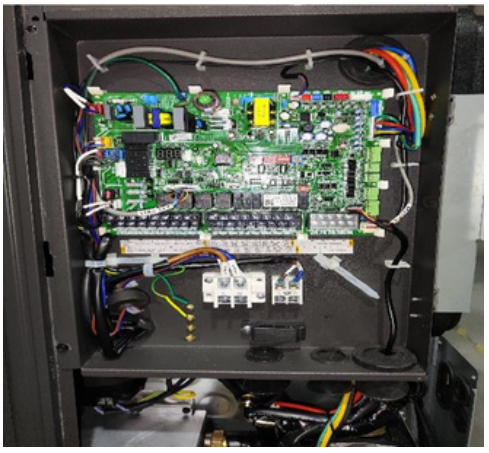


Figure 4-1.3: THM12(14,16)SF9dC, THM12(14,16)SFC electric control box

Electric control box

To Be Determined

2. PCBs

2.1 Main Control Board for Water System

Figure 4-2.1: Main control board

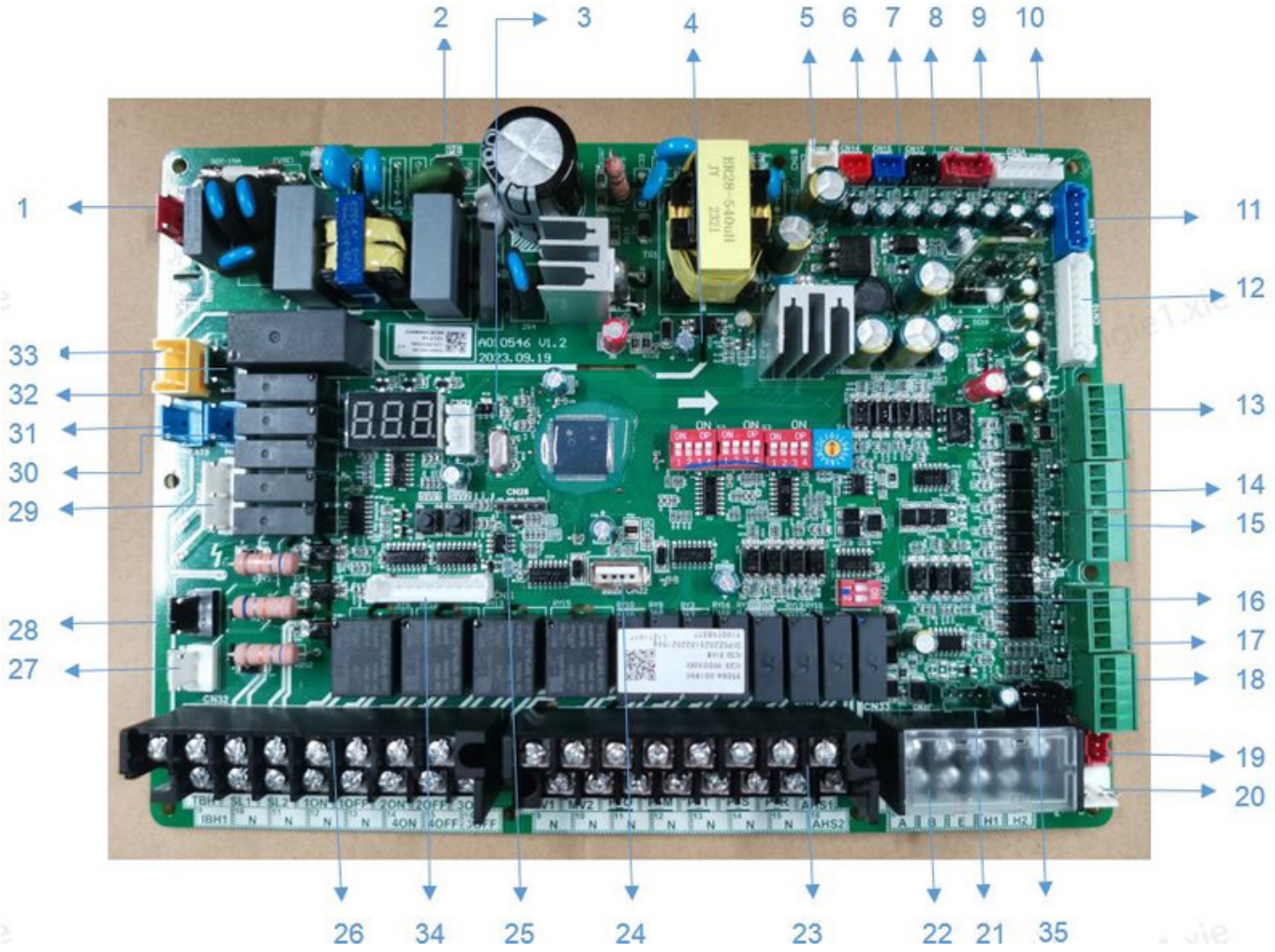


Table 4-2.1: Main control board

Label in Figure 4-2.1	Code	Content	Voltage
1	CN8	Power port	220VAC
2	PE	Ground port	/
3	CN21	IC program port	5VDC
4	S1、S2、S3、S4	dip switch	5VDC
5	CN18	flow switch port	12VDC
6	CN14	Solar panel temperature sensor port	5VDC
7	CN15	Water tank temperature sensor port	5VDC
8	CN17	The final outlet water temperature sensor of the system (AHS)	5VDC
9	CN2	Balance tank upper water temperature sensor port	5VDC
		Balance tank lower water temperature sensor port	5VDC
10	CN34	Zone 1 room temperature sensor port	5VDC
		Zone 2 room temperature sensor port	5VDC
		Zone 3 room temperature sensor port	5VDC
11	CN9	Zone 1 inlet water temperature sensor port	5VDC
		Zone 2 inlet water temperature sensor port	5VDC
		Zone 3 inlet water temperature sensor port	5VDC
12	CN10	Plate heat exchanger inlet water temperature sensor port	5VDC
		Plate heat exchanger outlet water temperature sensor port	5VDC
		The total outlet water temperature sensor port	5VDC

		Plate heat exchanger refrigerant outlet temperature sensor port	5VDC
		Plate heat exchanger refrigerant inlet temperature sensor port	5VDC
13	CN4	0-10V output port	0-10V
		0-10V output negative pole port	0-10V
		Room 1 thermostat control port (heating mode)	12VDC
		Room 1 thermostat power port	12VDC
		Room 1 Thermostat control Port (Cooling Mode)	12VDC
14	CN6	Room 2 thermostat control port (heating mode)	12VDC
		Room 2 thermostat power port	12VDC
		Room 2 Thermostat control Port (Cooling Mode)	12VDC
15	CN12	Room 3 thermostat control port (heating mode)	12VDC
		Room 3 thermostat power port	12VDC
		Room 3 Thermostat control Port (Cooling Mode)	12VDC
16	SW3	Dip switch(For cascade system)	5VDC
17	CN16	Smart grid port (photovoltaic signal)	12VDC
		Smart grid port (grid signal)	12VDC
18	CN20	Remote switch port(M1M2)	5VDC
		Modbus(XYE)	5VDC
19	CN38	RS485 communication Port	5VDC
20	CN19	Inverter water pump communication Port	12VDC
21	CN37	Port for communicate with wired controllers (for reserve)	12VDC
22	CN33	Wired controllers communication port(12V B1 A1 E1)	12VDC
		Main PCB 1/2 communication port(A B)	5VDC
		Port for cascade(H1H2)	5VDC
23	CN31	Electric mixing valve(MV1 MV2)	220VAC
		Zone 1 water pump(P_O)	220VAC
		Zone 2 water pump(P_M)	220VAC
		Zone 3 water pump(P_T)	220VAC
		Solar water pump(P_S)	220VAC
		DHW pump(P_R)	220VAC
		Auxiliary heat source(AHS1 AHS2)	220VAC
		USB burning port	5VDC
24	CN22	EEPROM	5VDC
25	CN28	Water tank electric heater	220VAC
26	CN32	Internal electric heater	220VAC
		Solar signal input(SL1 SL2)	220VAC
		Solar energy signal input	220VAC
		3 way valve 1(1ON 1OFF)	220VAC
		3 way valve 2(2ON 2OFF)	220VAC
		3 way valve 3(3ON 3OFF)	220VAC
		3 way valve 4(4ON 4OFF)	220VAC
		Internal electric heater feedback	220VAC
27	CN30	Water tank electric heater feedback	220VAC
28	CN29	Internal electric heater 1 control port	220VAC
29	CN23	Internal electric heater 2 control port	220VAC
		Water tank electric heater control port	220VAC

30	CN27	Control port for Antifreeze electric heating belt 2	220VAC
31	CN26	Control port for Antifreeze electric heating belt 1	220VAC
32	CN25	Backup heater port	220VAC
33	CN24	Inverter pump power input power	12VDC
34	CN11	Electric heating plate communication port	5VDC
35	CN39	Refrigerant gas leakage sensor	0-10V

2.2 Driving Board for Refrigerant System

Figure4-2.2:THM4(6)DF3dB,THM4(6)DFBdrivingboardforrefrigerantsystem



Table 4-2.2: THM4(6)DF3dB, THM4(6)DFB driving board for refrigerant system

Label in Figure 4-2.2	Code	Content	Voltage
1	DC_FAN	Fan motor	varying according to frequency
2	UVW	Compressor U、V、W ports	varying according to frequency
3	CN7	Electronic expansion valve	0-12V DC
4	RS485	485 communication	0-12V DC
5	SHP	Pressure Sensor	0-5V DC
6	CN2/CN1	Temperature sensor	0-5V DC
7	LP	Low pressure switch	0-5V DC
8	HEAT3	Drainage pipe electric heating	230V AC
9	4WAY	4 way valve	230V AC
10	HEAT1	Electric heating	230V AC
11	COM1	Power Supply	230V AC
12	IC8-W	EEPROM	/

Figure 4-2.3: THM8D(10)F3dC，THM8(10)DFC, THM12(14, 16)DF3dC, THM12(14, 16)DFC, driving board for refrigerant system



Table 4-2.3: THM8D(10)F3dC，THM8(10)DFC, THM12(14, 16)DF3dC, THM12(14, 16)DFC, driving board for refrigerant system

Label in Figure 4-2.3	Code	Content	Voltage
1	DC_FAN	Fan motor	varying according to frequency
2	U、V、W	Compressor U、V、W ports	varying according to frequency
3	EARTH-1	Ground terminal 2	/
4	RS485	485 communication	0-12V DC
5	CN7	Electronic expansion valve	0-12V DC
6	SHP	Pressure Sensor	0-5V DC
7	CN2/CN1	Temperature sensor	0-5V DC
8	CN17	EEPROM	/
9	HEAT1	Electric heating	230V AC
10	P8	4 way valve	230V AC
11	L2/AC_L	Live	230V AC
12	EARTH	Ground terminal 1	/
13	L1/AC_N	Neutral	230V AC

14	LP	Low pressure switch	0-5V DC
15	WAY-2	Drainage pipe electric heating	230V AC

Figure 4-2.4: THM12(14, 16)SF9dC, THM12(14, 16)SFC driving board for refrigerant system

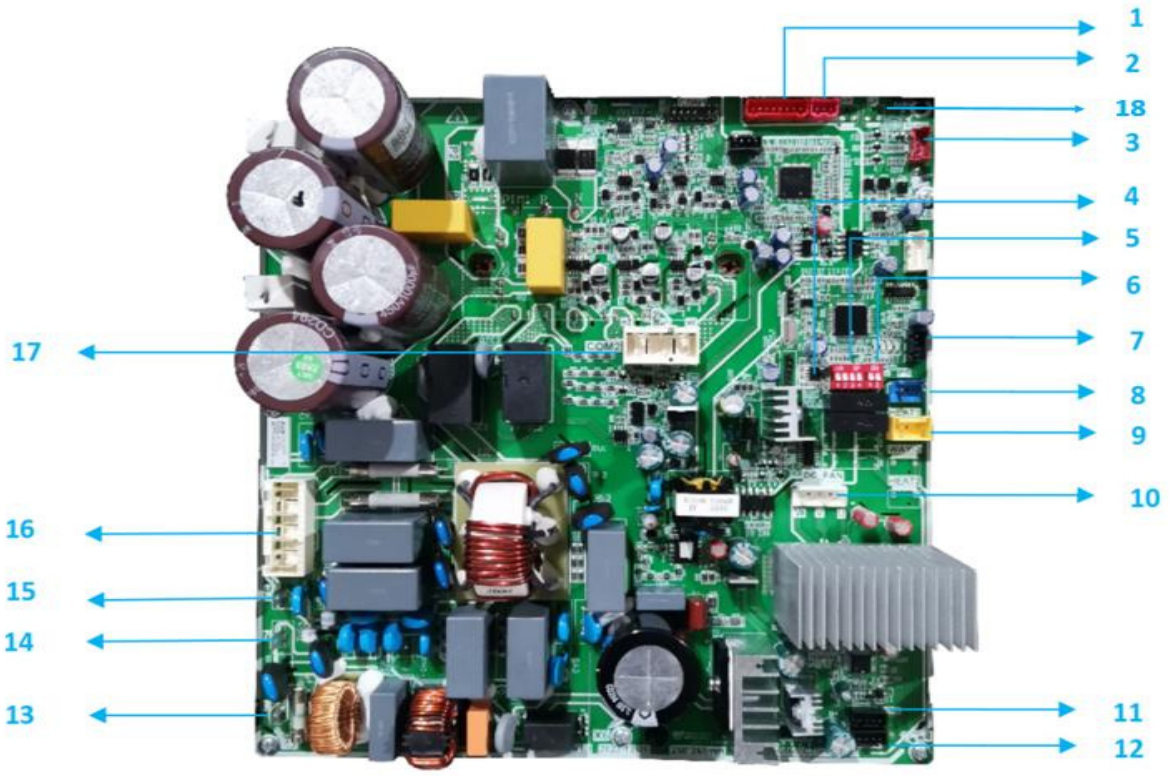


Table 4-2.4: THM12(14, 16)SF9(6)dC, THM12(14, 16)SFC driving board for refrigerant system

Label in Figure 4-2.4	Code	Content	Voltage
1	CN2/CN1	Outdoor ambient/outdoor pipe/exhaust temperature sensor	0-5V DC
2	SHP	Pressure Sensor	0-5V DC
3	RS485	485 communication terminal	0-12V DC
4	IC26	EEPROM	/
5	SW1	DIP switch SW1	/
6	SW2	DIP switch SW2	/
7	WATCH1	Reserve	/
8	P8	Four-way valve	230V AC
9	HEAT1	Electric chassis heating	230V AC
10	DC_FAN	Fan motor	varying according to frequency
11	CN2	Reserve	/
12	WATCH2	Reserve	/
13	L	Live	230V AC
14	N	Neutral	230V AC
15	PE	Ground wire	/
16	COM3	Three-phase power input	380V AC
17	COM2	Compressor terminal	varying according to frequency
18	LP	Low pressure switch	0-5V DC

2.3 Digital Display Output



（1）When there is a fault, the fault code is displayed, and when there are multiple faults, each fault displays 3s, and the cycle is switched

（2）When there is no fault, the default display is T. When operating the buttons, the display will be switched in turn according to the following table. After 5 seconds, no operation will resume and display T.

Table4-2.5:Digitaldisplayoutputin different operatingstates

Switch	The first time	The twice time	The third time	The fourth time	The fifth time
SW1	Inverter water pump rotating speed(÷10)	T_{IWT}	Electric heating gear (0/1/2/3)	TOWT	Cascaded address code
SW2	Compressor frequency	Discharge temperature	Fan rotating speed	Suction temperature	EXV

Note: The temperature value is displayed as an integer. When the temperature value is negative, the highest digit of the digital tube displays "-".

2.4 DIP switch setting and Modbus function

The rotating coded switch S3(0-F) on the main control board of hydraulic module is used for setting the modbus address. By default the units have this coded switch positioned=0, but this corresponds to the modbus address 16, while the others positions corresponds the number, e.g. pos=2 is address 2, pos=5 is address 5.

Figure 4-2.11: Connection

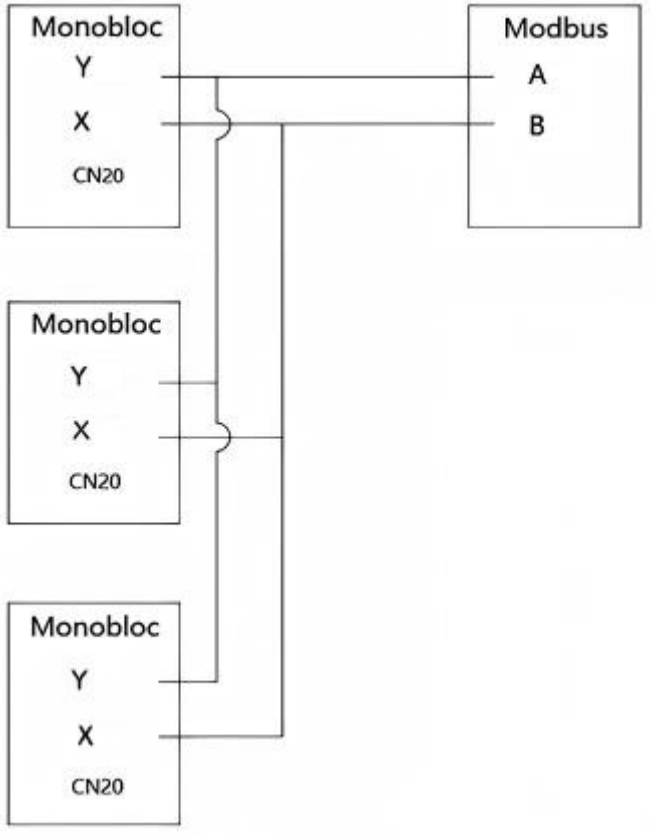


Table 4-2.6: Wiring table

Wire number	Input Voltage	Wiring size
1	13.5VAC	0.75mm²

3. Error ID Table

Table4-3.1:errorid table

Error code	Content[2]	Remarks
d1	Abnormal outlet water temperature after auxiliary heating	
d2	Abnormal temperature of plate heat exchange inlet water	
d3	Abnormal temperature of plate heat exchange outlet water	
d4	Plate heat exchanger refrigerant gas pipe is abnormal	
d5	Plate heat exchanger refrigerant liquid pipe is abnormal	
d6	Abnormal final outlet water temperature of the system	
d7	Zone 1 inlet water temperature abnormal	
d8	Zone 2 inlet water temperature abnormal	
d9	Zone 3 inlet water temperature abnormal	
dA	Zone 1 room temperature abnormal	
dB	Zone 2 room temperature abnormal	
dC	Zone 3 room temperature abnormal	
dF	Balance tank upper water temperature abnormal	
dH	Balance tank lower water temperature abnormal	
dj	Abnormal temperature of solar panel	
dn	Abnormal water tank temperature	
L1	The water temperature difference between plate heat exchanger inlet and outlet is too large	
L2	The water temperature difference between plate heat exchanger inlet and outlet is abnormal	
L3	Plate heat exchanger outlet water temperature is too low	
L4	Plate heat exchanger outlet water temperature is too high	
L5	Plate heat exchanger inlet water temperature is too low	
L6	Plate heat exchanger inlet water temperature is too high	
L7	Water side antifreeze	
L8	Insufficient water flow fault	
Lb	Auxiliary electric heating feedback failure	
LC	Water tank electric heating feedback failure	
LP	Main water pump failure	
C1	Multiple master control failure	
C7	WiFi communication failure	
E0	Communication failure between indoor unit and outdoor unit	
E3	Coil temperature sensor fault	
E4	Refrigerant leak fault	
E5	DIP abnormal	
E7	Outdoor temperature sensor failure	
E8	Discharge temperature sensor failure	
Eb	Communication error between the main controller and the wire controller	
EC	Communication failure between drive board and main PCB	
Ed	Indoor EEPROM failure	
EE	Outdoor EEPROM failure	
EF	Outdoor DC fan failure	
EH	Suction temperature sensor failure protection	
En	Module communication fault	

Ej	Thermostat communication fault	
En	Module communication fault	
F2	Outdoor discharge temperature sensor failure protection	
F3	Outdoor coil temperature sensor failure protection	
F5	PFC protection	
F6	Compressor loss/reverse phase protection	
F7	Module temperature protection	
F8	4 way valve reversing failure (heating mode)	
FA	Compressor phase current detection failure	
Fy	Lack of refrigerant	
H1	High pressure switch protection	
H2	Low pressure switch protection	
H3	High pressure sensor failure	
P0	IPM module protection	
P1	Overvoltage protection	
P2	AC input overcurrent	
P4	Discharge temperature too high protection	
P5	Refrigeration anti-overcooling failure	
P6	Refrigeration prevents overheating failure	
P7	Heating protection against overheating	
P8	Outdoor ambient temperature too high and too low protection	

Notes:

1. When the err id appears, the err id corresponding to the serial number can be obtained through the H1H2 port by using the host computer to query the wired controller register.

2. Sensor names in this service manual referring to refrigerant flow is named according refrigerant flow during cooling operation refer to Part 2, 3 "Refrigerant Flow Diagrams".

4. Troubleshooting

4.1 Warning

Warning

- All electrical work must be carried out by competent and suitably qualified, certified and accredited professionals and in accordance with all applicable legislation (all national, local and other laws, standards, codes, rules, regulations and other legislation that apply in a given situation).
- Power-off the units before connecting or disconnecting any connections or wiring, otherwise electric shock (which can cause physical injury or death) may occur or damage to components may occur.

4.2 L8 Troubleshooting

4.2.1 Digital display output



4.2.2 Description

Insufficient water flow fault.

When error occurs, a manual system restart is required before the system can resume operation.

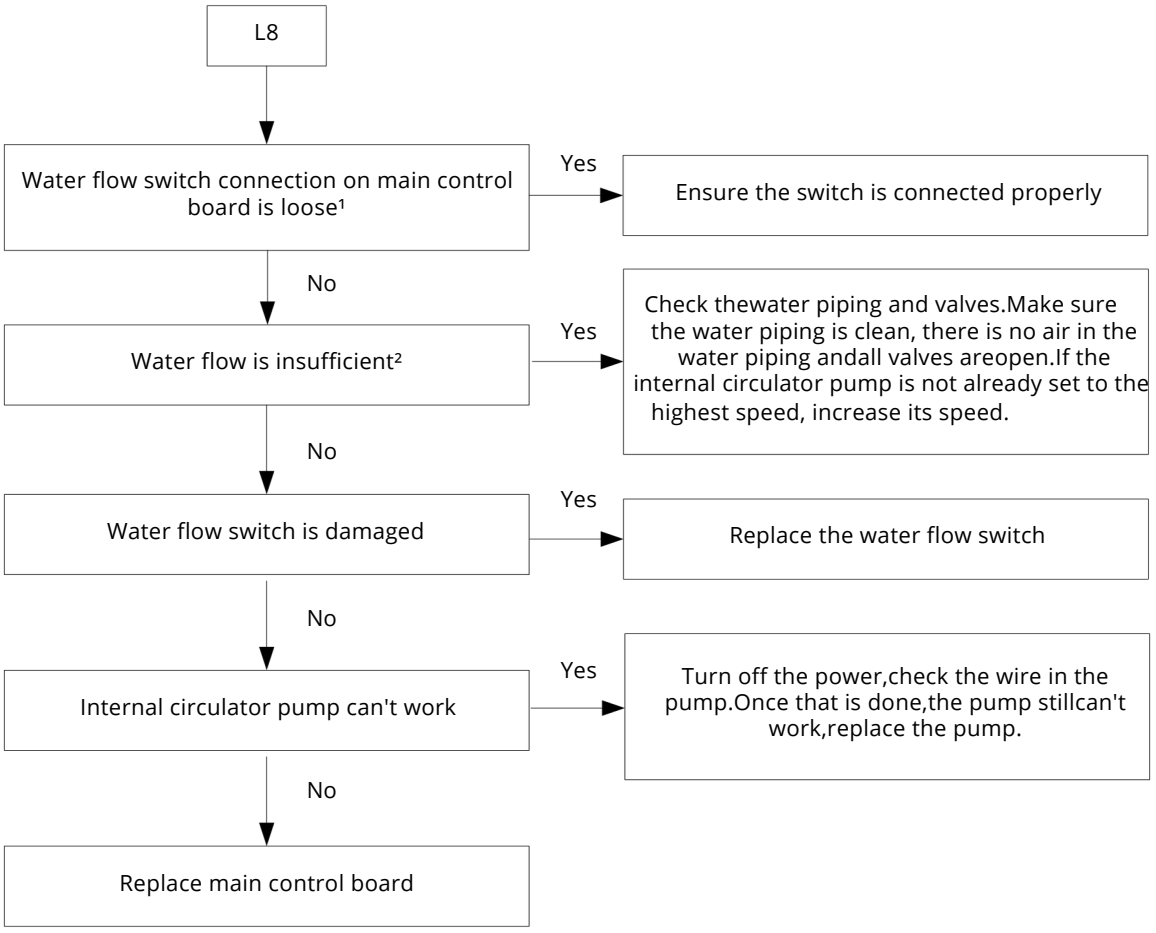
Tri-thermal Ultra Mono HP stops running.

Error code is displayed on main control board and user interface.

4.2.3 Possible causes

- The wire circuit is short connected or open.
- Water flow rate is too low.
- Water flow switch damaged.

4.2.4 Procedure



Notes:

1. Water flow switch connection is port CN18 on the main control board .

2. Check water pressure on the manometer. If the water pressure is not > 1 bar, water flow is insufficient.

4.3 E0 Troubleshootingi

4.3.1 Digital display output



4.3.2 Description

Communication failure between indoor unit and outdoor unit.

Tri-thermal Ultra Mono HP stops running.

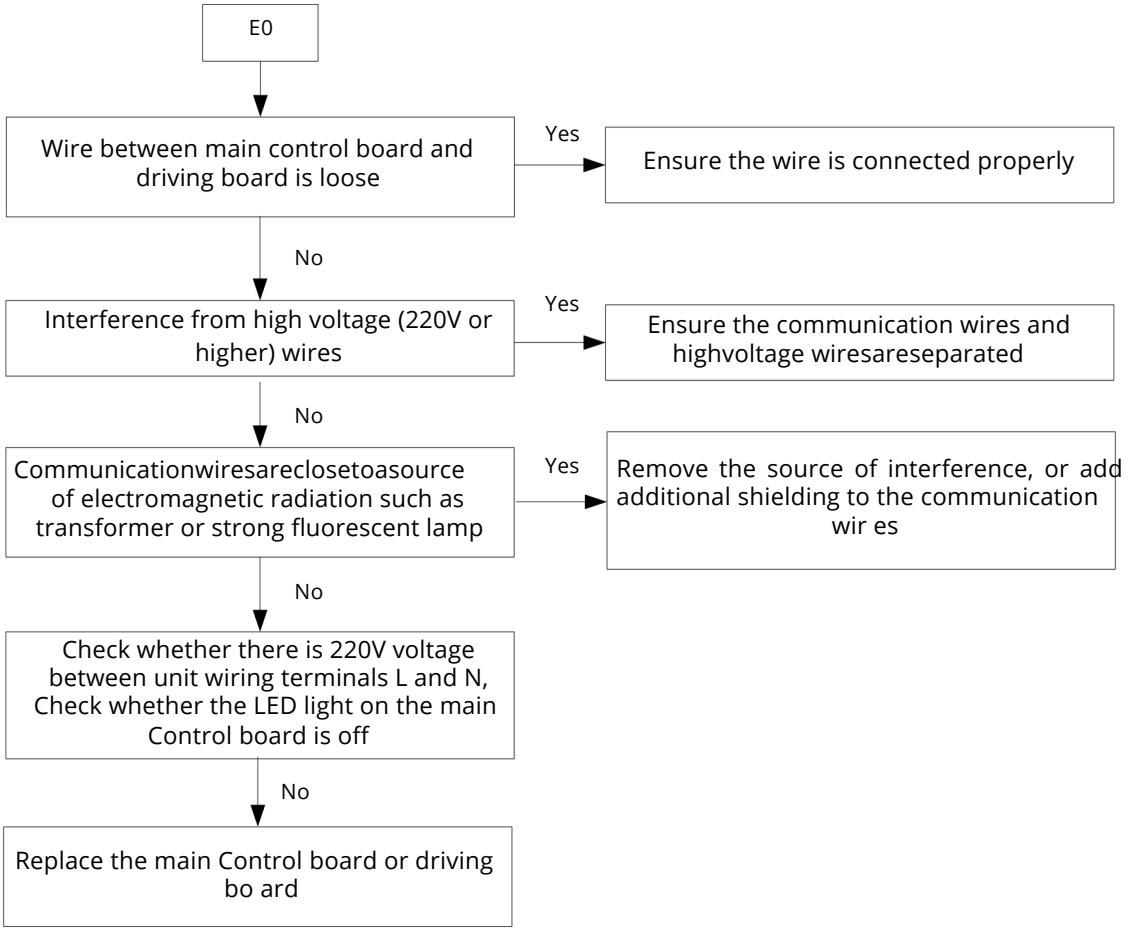
Error code is displayed on main control board and user interface.

4.3.3 Possible causes

- Communication wires between main control board and driving board not connected properly.
- Communication wiring terminals misconnected.
- Loosened wiring within electric control box.
- Interference from high voltage wires or other sources of electromagnetic radiation.

- Damaged main control board or electric control box communication terminals block.

4.3.4 Procedure



4.4 d1/dn/d6/d4/d5/d3/d2/dj/dH/dF/dA/db/dC/d7/d8/d9 Troubleshooting

4.4.1 Digital display output



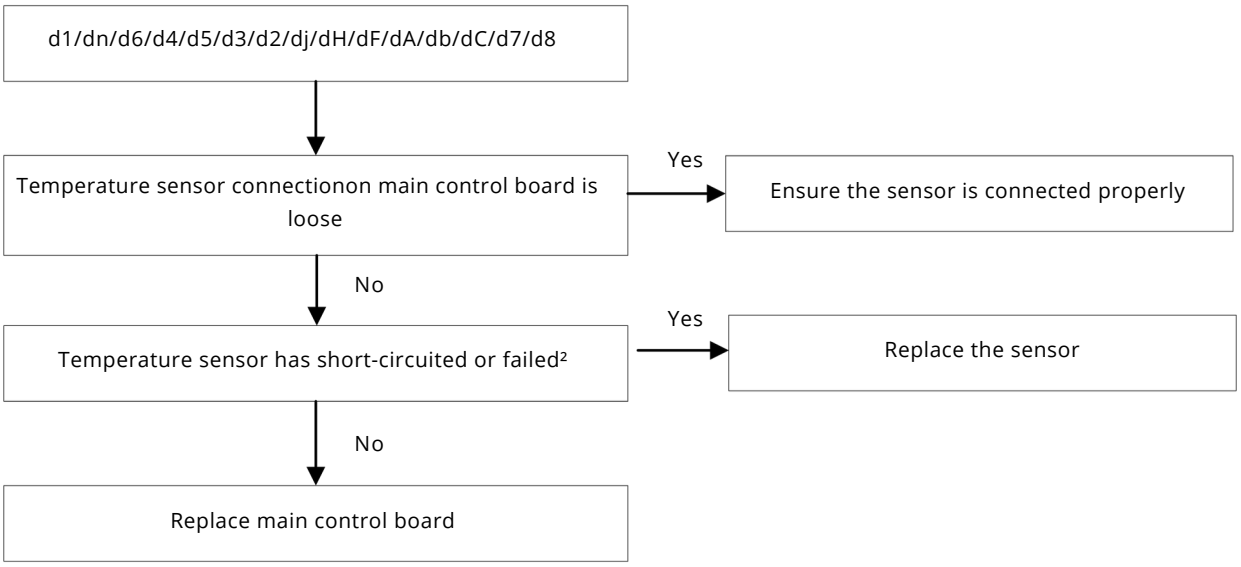
4.4.2 Description

- d1 indicates abnormal outlet water temperature after auxiliary heating. dn
- indicates abnormal water tank temperature.
- d6 indicates abnormal final outlet water temperature of the system.
- d4 indicates plate heat exchanger refrigerant gas pipe is abnormal.
- d5 indicates plate heat exchanger refrigerant liquid pipe is abnormal.
- d3 indicates abnormal temperature of plate heat exchange outlet water.
- d2 indicates abnormal temperature of plate heat exchange inlet water.
- dj indicates abnormal temperature of solar panel.
- dH indicates balance tank lower water temperature abnormal.
- dF indicates balance tank upper water temperature abnormal.
- dA indicates a room 1 temperature abnormal.
- db indicates a room 2 temperature abnormal.
- dC indicates a room 3 temperature abnormal.
- d7 indicates a zone 1 water inlet temperature abnormal.
- d8 indicates a zone 2 water inlet temperature abnormal.
- d9 indicates a zone 3 water inlet temperature abnormal.
- Tri-thermal Ultra Mono HP stops running.
- Error code is displayed on main control board and user interface.
-

4.4.3 Possible causes

- Temperature sensor not connectedproperly or has malfunctioned.
- Damaged main control board.

4.4.4 Procedure



Notes:

1. Refrigerant liquid side temperature (heating mode), Refrigerant gas side temperature sensor (cooling mode), Plate heat exchanger inlet water temperature sensor , Plate heat exchanger outlet water temperature sensor , Total outlet water temperature sensor CN10 port on the main control board .Total outlet water temperature sensor is port CN7 on the main control board.Zone 1/2/3 water temperature sensor respectively is ports CN9/11/13.Zone 1/2/3 room temperature sensor respectively is ports CN35/34/36.Domestic hot water tank temperature sensor connection is port CN15 on the main control board. Solar panel temperature sensor connection is port CN14 on the main control board Balance tank upper temperature sensor connection is port CN2 on the main control board Balance tank lower temperature sensor connection is port CN7 on the main control board

2.Measure sensor resistance. If the resistance is too low, the sensor has short-circuited.If the resistance is not consistent with the sensor's resistance characteristics table, the sensor has failed. Refer to Table 4-5.1, 4-5.2 or 4-5.3 in Part 4, 5.1 "Temperature Sensor Resistance Characteristics".

4.5 Troubleshooting

4.5.1 Digital display output



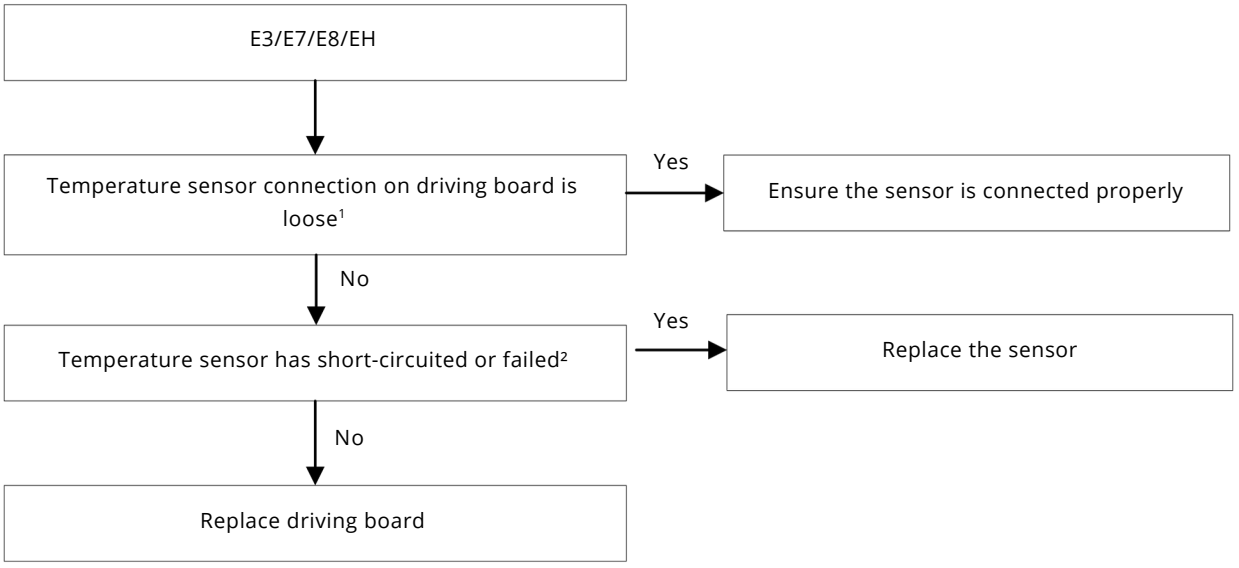
4.5.2 Description

- E7 indicates outdoor temperature sensor failure.
- E3 indicates coil temperature sensor fault.
- EH indicates suction temperature sensor failure protection.
- E8 indicates discharge temperature sensor failure.
- Tri-thermal Ultra Mono HP stops running.
- Error code is displayed on main control board and user interface.

4.5.3 Possible causes

- Temperature sensor not connected properly or has malfunctioned.
- Damaged driving board.

4.5.4 Procedure



Notes:

1. Outdoor ambient temperature sensor/ air side heat exchanger refrigerant outlet temperature sensor/compressor suction temperature sensor/compressor suction temperature sensor connections are port CN2/CN1 on the main driving board.

2. Measure sensor resistance. If the resistance is too low, the sensor has short-circuited. If the resistance is not consistent with the sensor's resistance characteristics table, the sensor has failed. Refer to Table 4-5.1, and to table in Part 4, 5.1 "Temperature Sensor Resistance Characteristics".

4.6 Troubleshooting

4.6.1 Digital display output



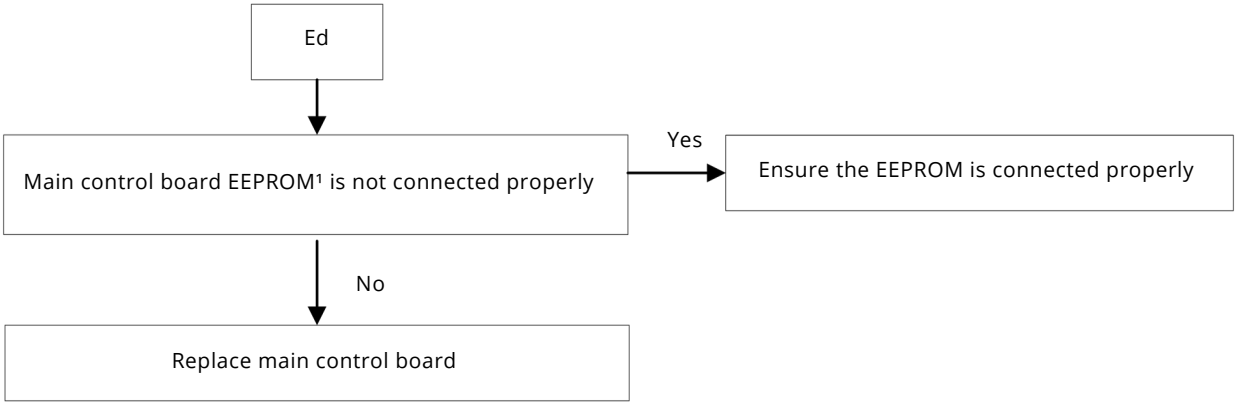
4.6.2 Description

- Indoor EEPROM failure.
- Tri-thermal Ultra Mono HP stops running.
- Error code is displayed on main control board and user interface.

4.6.3 Possible causes

- Indoor EEPROM is not connected properly.
- Damaged main control board .

4.6.4 Procedure



Notes:

1.Main controlboardEEPROM is designated CN28 on the main control board for water system.

4.7 EE Troubleshooting

4.7.1 Digital display output



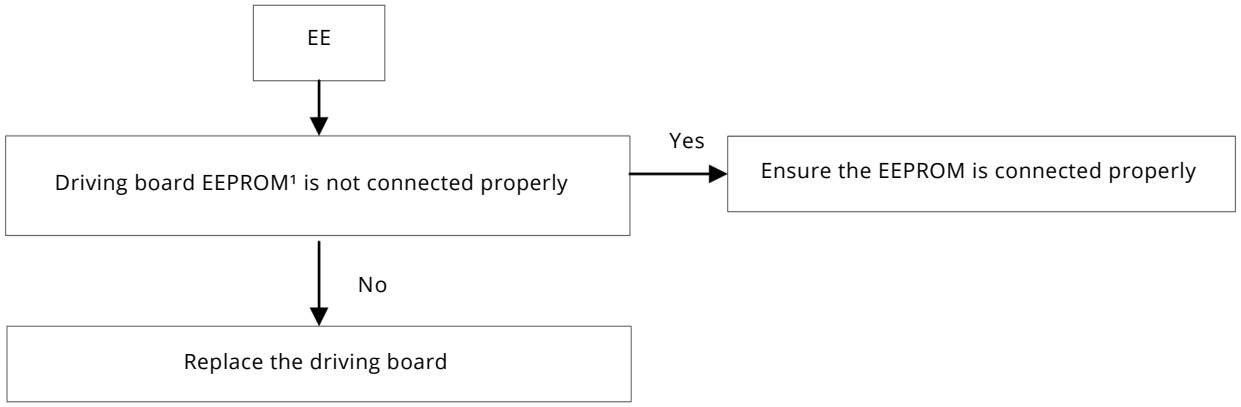
4.7.2 Description

- Outdoor EEPROM failure.
- Tri-thermal Ultra Mono HP stops running.
- Error code is displayed on main control board and user interface.

4.7.3 Possible causes

- Driving board EEPROM is not connected properly.
- Damaged driving board.

4.7.4 Procedure



Notes:

1.Driving board EEPROM is designated IC8-W/CN17/IC26 on the driving board for unit.

4.8 EC Troubleshooting

4.8.1 Digital display output



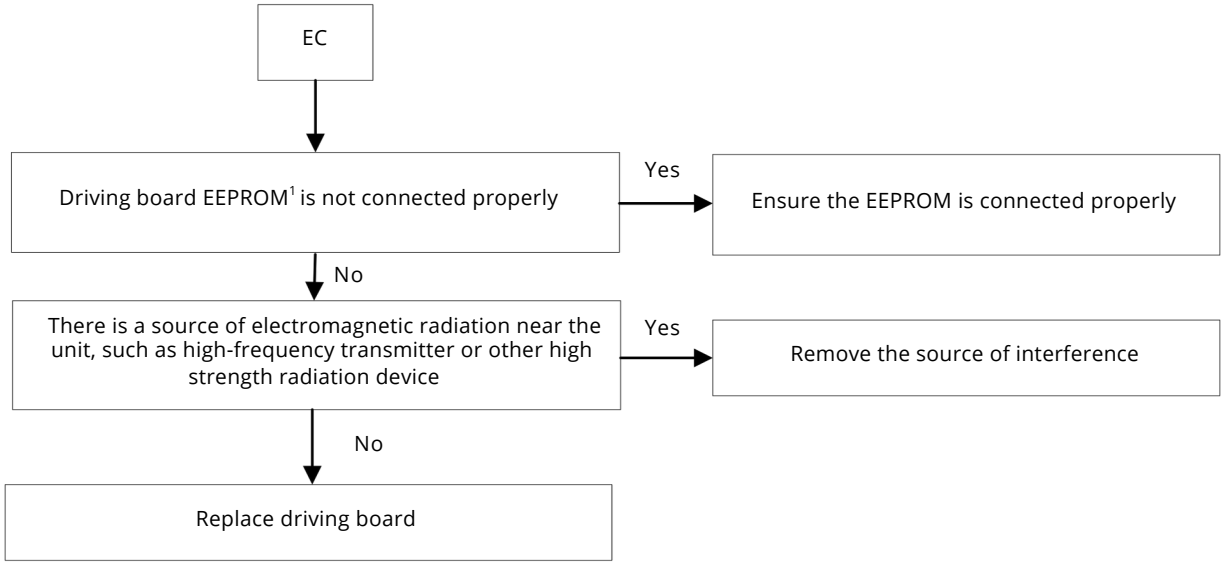
4.8.2 Description

- Communication failure between drive board and main PCB.
- Tri-thermal Ultra Mono HP stops running.
- Error code is displayed on main control board and user interface.

4.8.3 Possible causes

- Power supply abnormal.
- Interference from a source of electromagnetic radiation.
- Damaged driving board.

4.8.4 Procedure



4.9 EF Troubleshooting

4.9.1 Digital display output



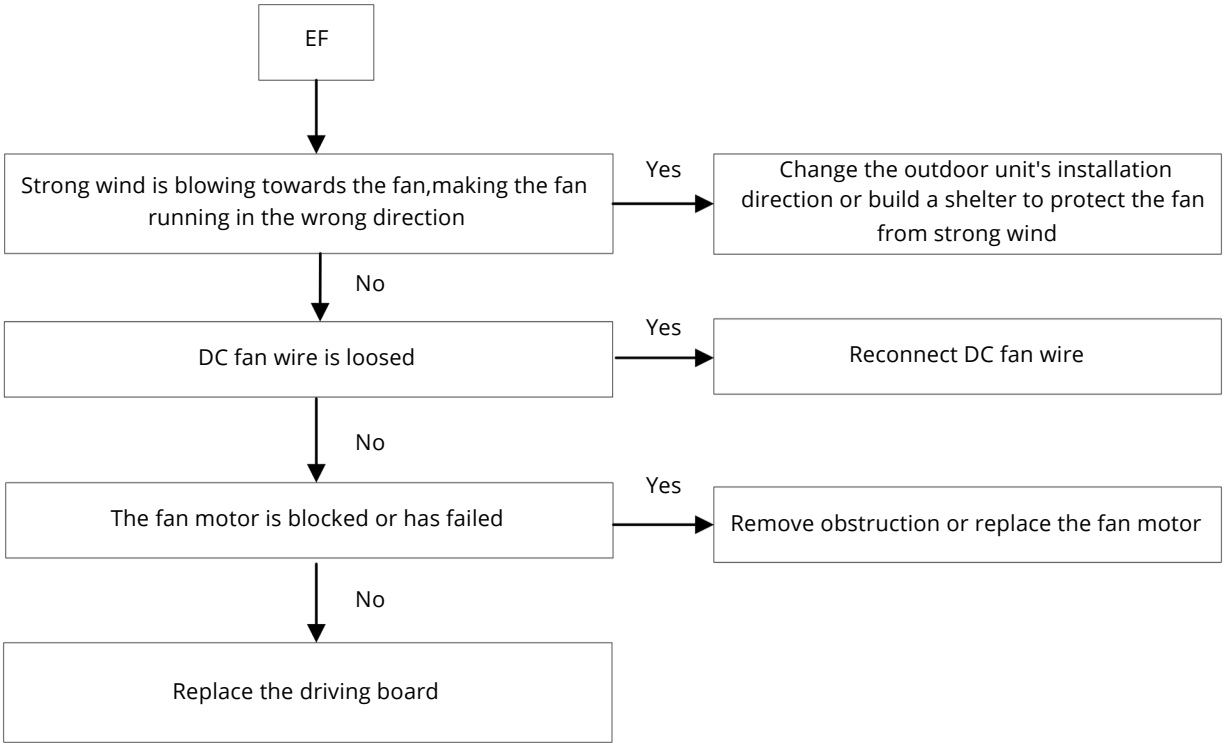
4.9.2 Description

- Outdoor DC fan failure.
- Tri-thermal Ultra Mono HP stops running.
- Error code is displayed on main control board and user interface.

4.9.3 Possible causes

- DC fan wire is loosed.
- High wind speed.
- Fan motor blocked or has failed.
- Inverter module damaged.
- Damaged driving board.

4.9.4 Procedure



Notes:

1. Measure the voltage between the DC fan motor power supply's white and black wires. The normal voltage is 15V when the unit is in standby. If the voltage is significantly different from 15V, the IGBT module on the inverter module is damaged. DC fan connection are port 'FAN 1' on the driving board.

4.10 H3 Troubleshooting

4.10.1 Digital display output



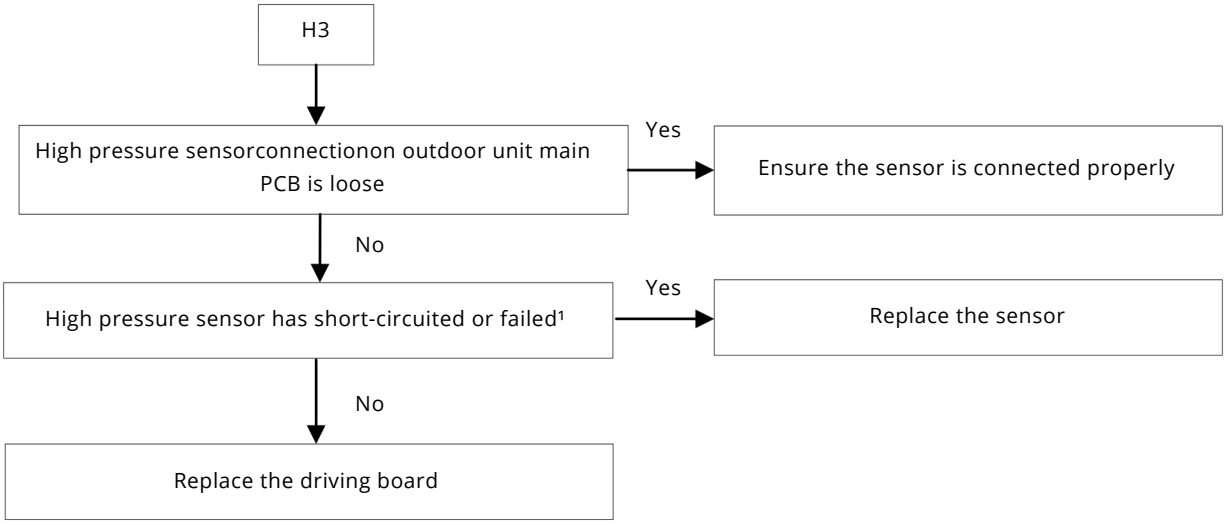
4.10.2 Description

- High pressure sensor failure.
- Tri-thermal Ultra Mono HP stops running.
- Error code is displayed on main control board and user interface.

4.10.3 Possible causes

- Pressure sensor not connected properly or has malfunctioned.
- Damaged driving board.

4.10.4 Procedure



Notes:

1. Measure the resistance among the three terminals of the pressure sensor. If the resistance is of the order of mega Ohms or infinite, the pressure sensor has failed. The pressure sensor connection are port SHP on the driving board.

4.11 H2 Troubleshooting

4.11.1 Digital display output



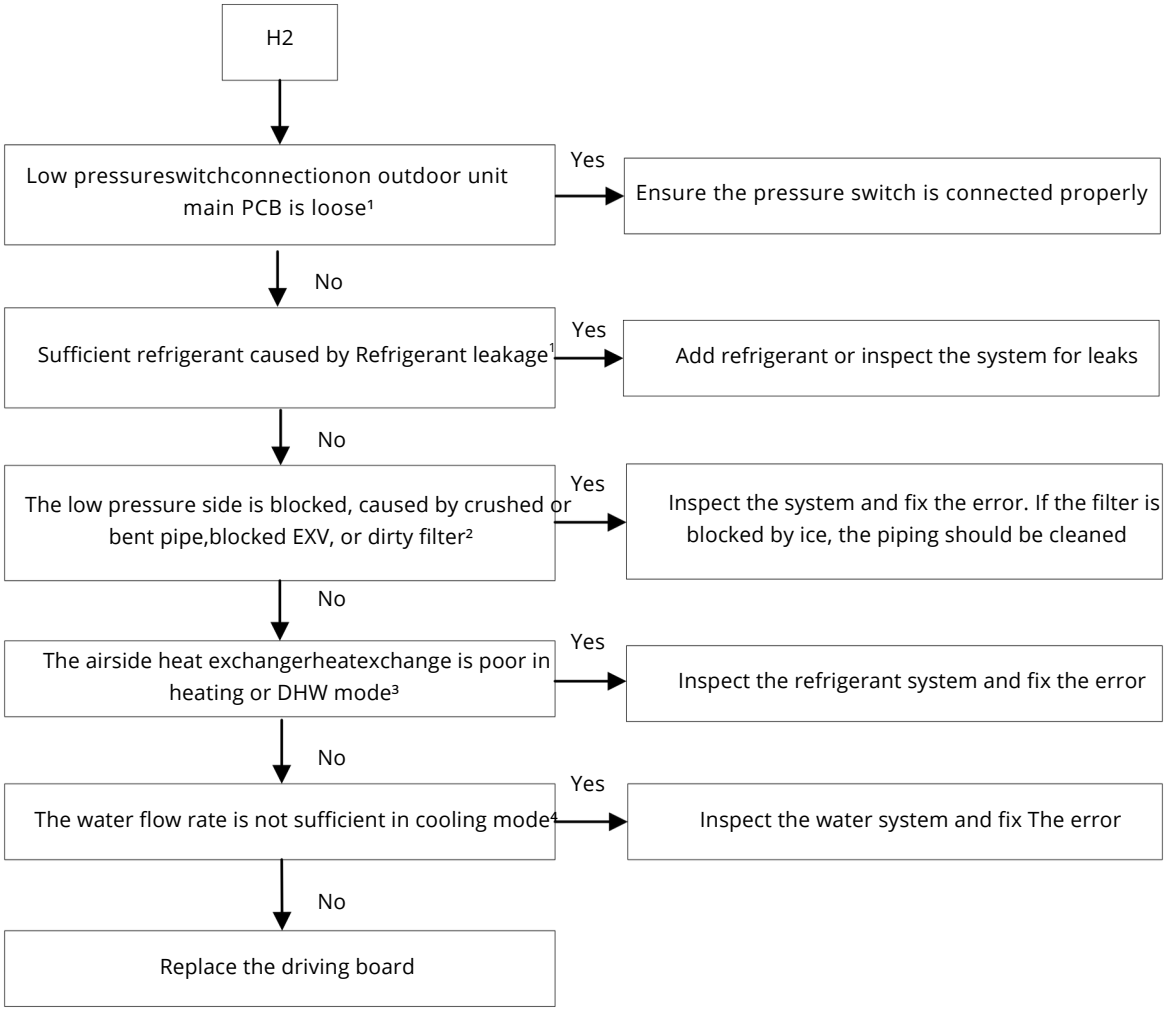
4.11.2 Description

- H2 indicates low pressure protection. When the suction pressure falls below 0.6MPa, the system displays H2 protection and Tri-thermal Ultra Mono HP stops running. When the pressure rises above 0.9MPa, H2 is removed and normal operation resumes.
- Error code is displayed on main control board and user interface.

4.11.3 Possible causes

- Pressure switch not connected properly or has malfunctioned.
- Insufficient refrigerant.
- Low pressure side blockage.
- Poor evaporator heat exchange in heating mode or DHW mode.
- Insufficient water flow in cooling mode.
- Damaged driving board.

4.11.4 Procedure



Notes:

1. To check for insufficient refrigerant:

An insufficiency of refrigerant causes compressor discharge temperature to be higher than normal, discharge and suction pressures to be lower than normal and compressor current to be lower than normal, and may cause frosting to occur on the suction pipe. These issues disappear once sufficient refrigerant has been charged into the system.

2. A low pressure side blockage causes compressor discharge temperature to be higher than normal, suction pressure to be lower than normal and compressor current to be lower than normal, and may cause frosting to occur on the suction pipe. For normal system parameters.

3. Check air side heat exchanger, fan and air outlets for dirt/blockages.

4. Check water side heat exchanger, water piping, circulator pumps and water flow switch for dirt/blockages.

4.12 H1 Troubleshooting

4.12.1 Digital display output



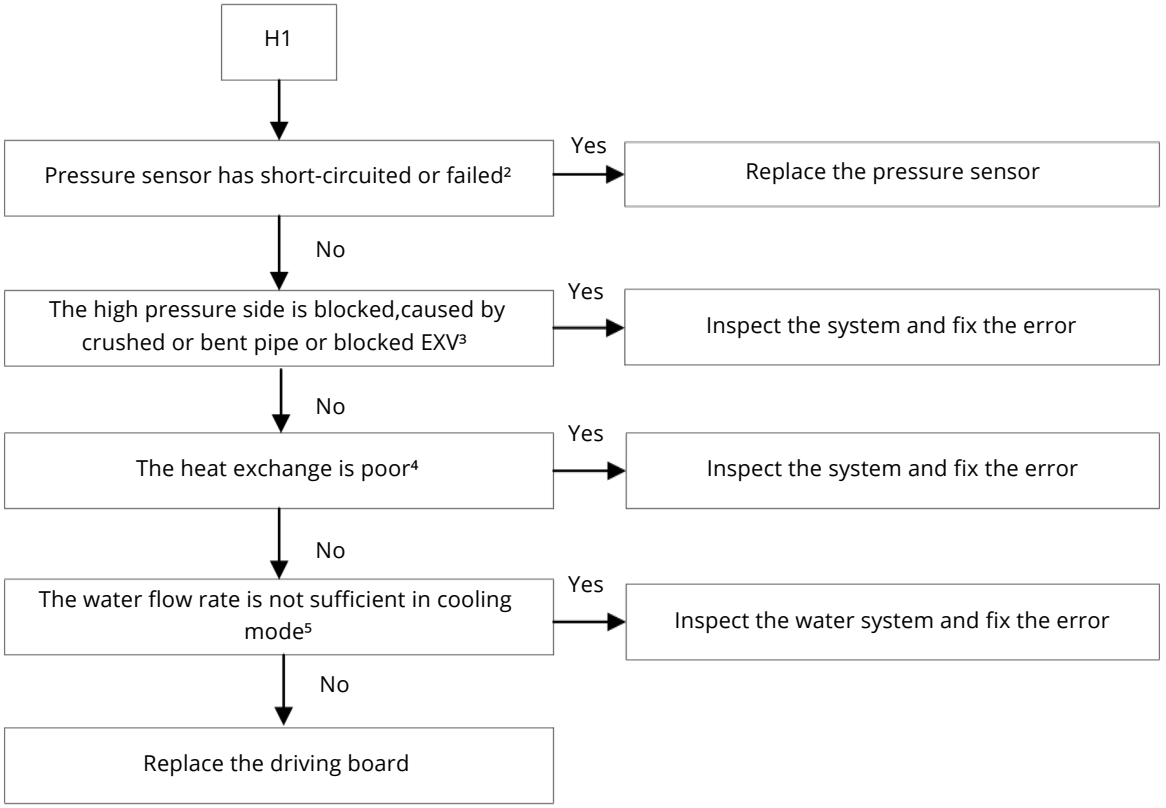
4.12.2 Description

- High pressure protection. When the discharge pressure rises above 3.1 MPa, the system displays H1 protection and Tri-thermal Ultra Mono HP stops running. When the discharge pressure falls below 2.4MPa, H1 is removed and normal operation resumes.
- Error code is displayed on main control board and user interface.

4.12.3 Possible causes

- Excess refrigerant.
- System contains air or nitrogen.
- High pressure side blockage.
- Poor condenser heat exchange.
- Damaged driving board.

4.12.4 Procedure



Notes:

1. Pressure sensor connection is port SHP on the driving board.

2.Measuretheresistanceamongthethreeterminalsofthepressuresensor.Iftheresistanceisoftheorder of mega Ohms or infinite, the pressure sensor has failed.

3.Highpressuresideblockagecausesdischargetemperaturetobehigherthannormal,dischargepressure to be higher than normal and suction pressure to be lower than normal.

4.Inheatingmodecheckwatersideheatexchanger,waterpiping,circulatorpumpsandwaterflowswitch for dirt/blockages. In cooling mode check air side heat exchanger, fan(s) and air outlets for dirt/blockages.

5.Checkwaterpressureonthemanometer.Ifthewaterpressureisnot>1bar,waterflowisinsufficient.

4.13 FA Troubleshooting

4.13.1 Digital display output



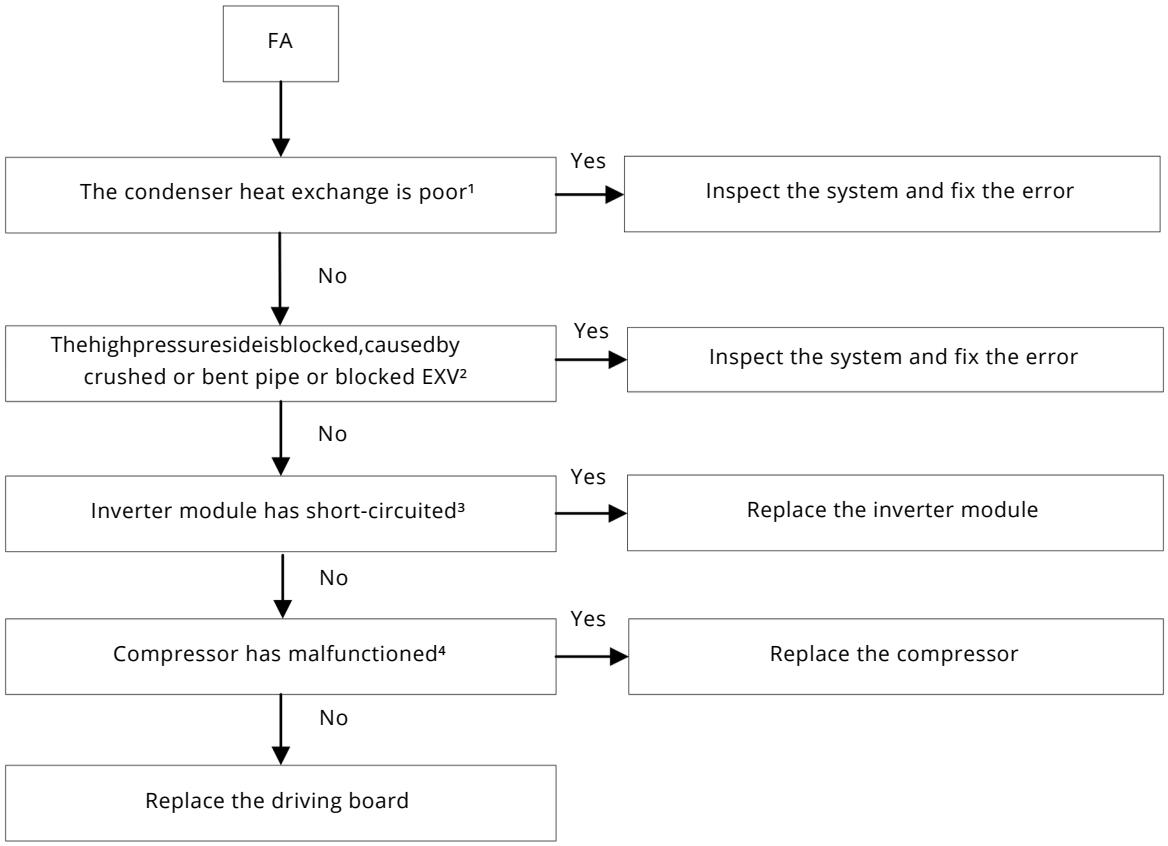
4.13.2 Description

- Compressor phase current detection failure.
- When the compressor current rises above the protection value , the system displays protection and Tri-thermal Ultra Mono HP stops running. When the current returns to the normal range, is removed and normal operation resumes.
- Error code is displayed on main control board and user interface.

4.13.3 Possible causes

- Poor condenser heat exchange.
- High pressure side blockage.
- Inverter module damaged.
- Compressor damaged.
- Damaged driving board.

4.13.4 Procedure



Notes:

1. In heating mode check water side heat exchanger, water piping, circulator pumps and water flow switch for dirt/blockages. In cooling mode check air side heat exchanger, fan and air outlets for dirt/blockages.

2. High pressure side blockage causes discharge temperature to be higher than normal, discharge pressure to be higher than normal and suction pressure to be lower than normal.

3. Set a multi-meter to buzzer mode and test any two terminals of P N and U V W of the inverter module. If the buzzer sounds, the inverter module has short-circuited.

4. The normal resistances of the inverter compressor are 0.7-1.5Ω among U V W and infinite between each of U V W and ground. If any of the resistances differ from these specifications, the compressor has malfunctioned.

4.14 P1 Troubleshooting

4.14.1 Digital display output



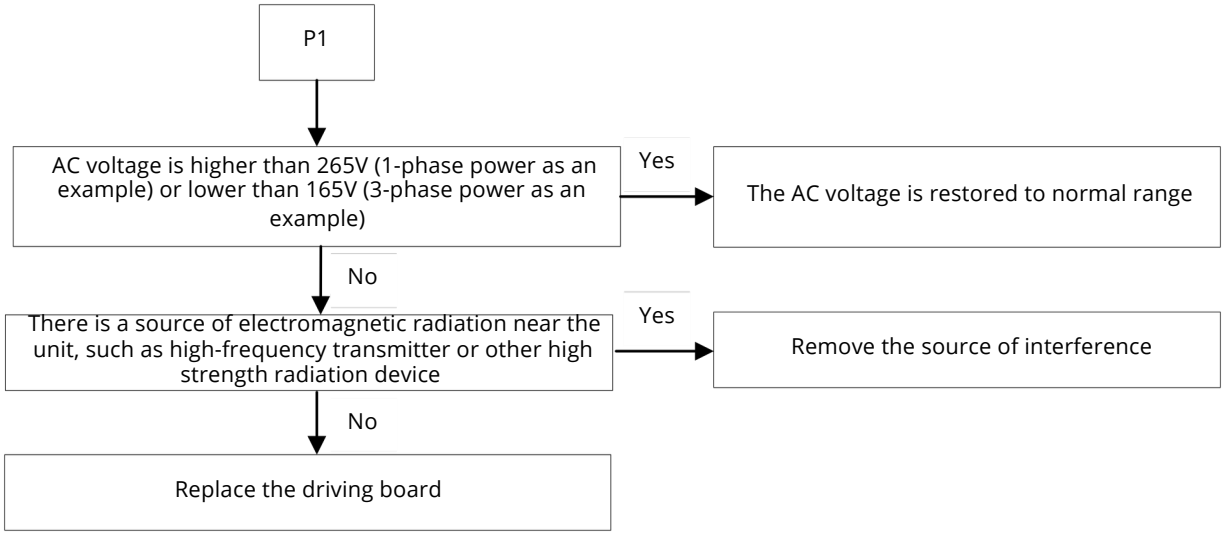
4.14.2 Description

- Power AC voltage is too low.
- Tri-thermal Ultra Mono HP stops running.
- Error code is displayed on main control board and user interface.

4.14.3 Possible causes

- Power supply abnormal.
- Interference from a source of electromagnetic radiation.
- Damaged driving board.

4.14.4 Procedure



4.15 P6 Troubleshooting

4.15.1 Digital display output



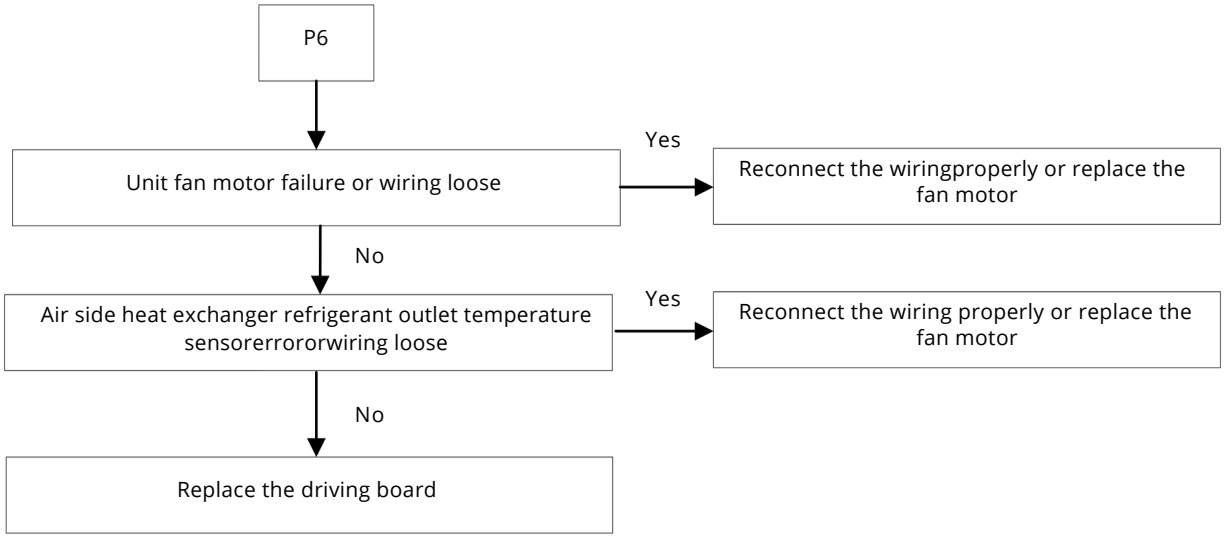
4.15.2 Description

- Refrigeration anti-overheating failure.
- Tri-thermal Ultra Mono HP stops running.
- Error code is displayed on main control board and user interface.

4.15.3 Possible causes

- Unit fan motor failure or wiring loose.
- Air side heat exchanger refrigerant outlet temperature sensor error or wiring loose.
- Damaged driving board.

4.15.4 Procedure



4.16 P7 Troubleshooting

4.16.1 Digital display output



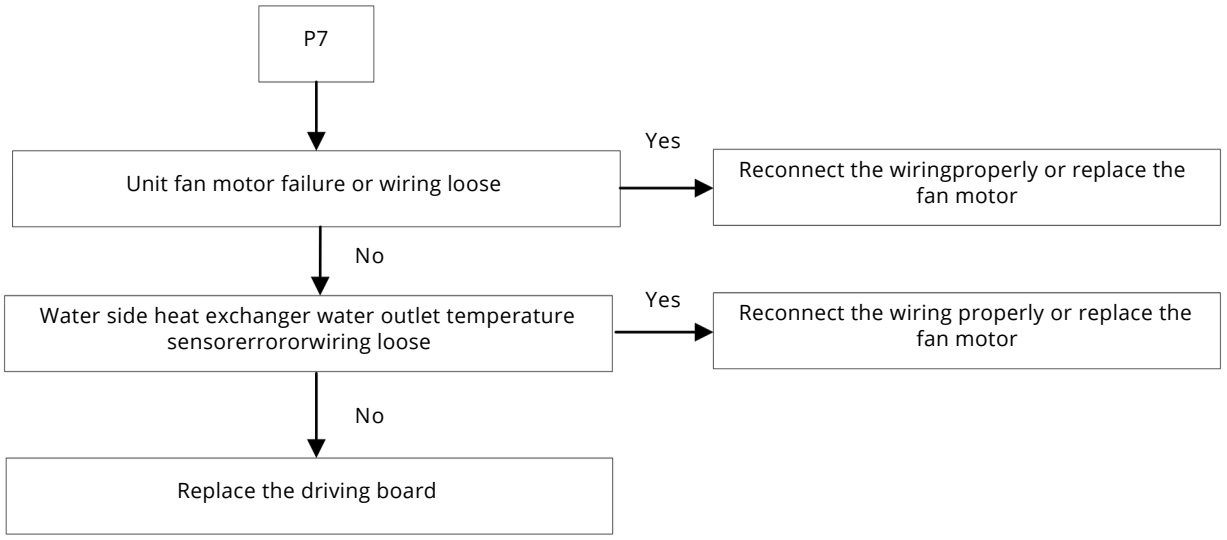
4.16.2 Description

- Heating protection against overheating.
- Tri-thermal Ultra Mono HP stops running.
- Error code is displayed on main control board and user interface.

4.16.3 Possible causes

- Unit fan motor failure or wiring loose.
- Water side heat exchanger water outlet temperature sensor error or wiring loose.
- Damaged driving board.

4.16.4 Procedure



4.17 P8 Troubleshooting

4.17.1 Digital display output



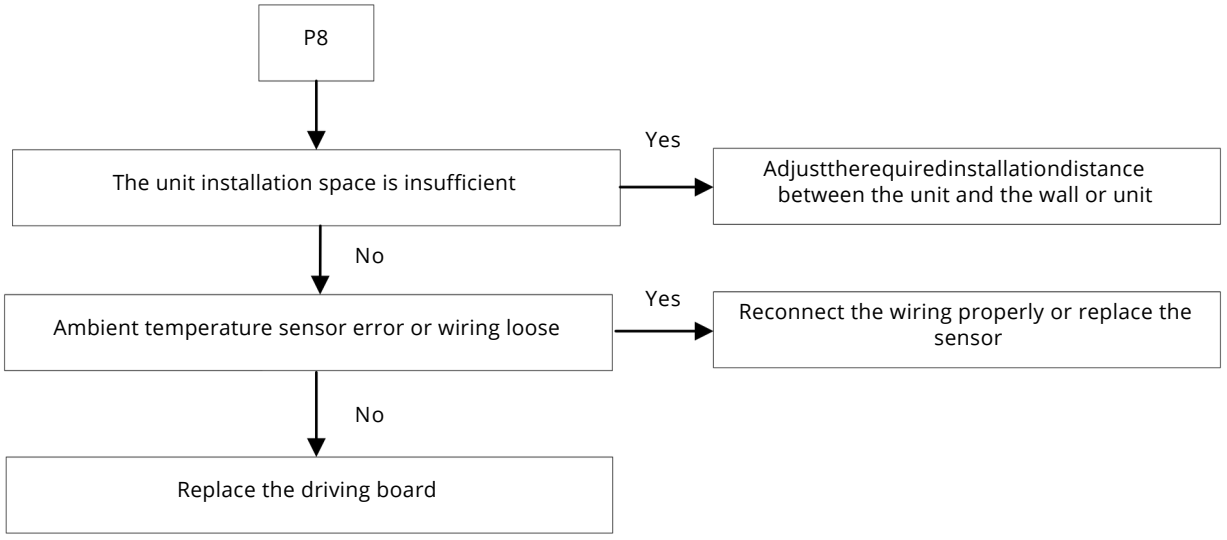
4.17.2 Description

- Ambient temperature too high or too low protection.
- Compressor stops running.
- Error code is displayed on main control board and user interface.

4.17.3 Possible causes

- The unit installation space is insufficient.
- Ambient temperature sensor error or wiring loose.
- Damaged driving board.

4.17.4 Procedure



4.18 F6 Troubleshooting

4.18.1 Digital display output



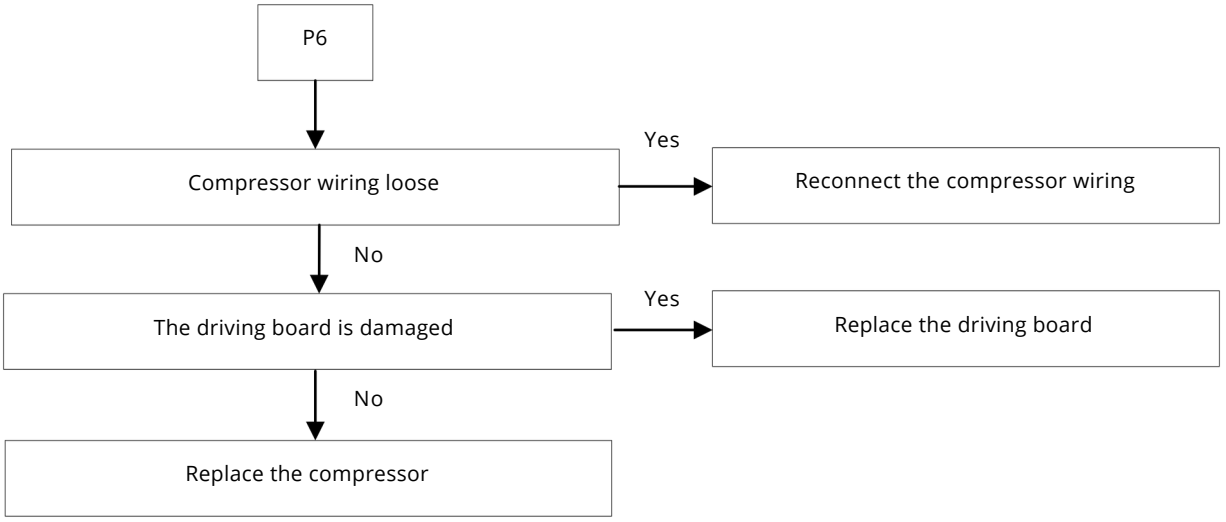
4.18.2 Description

- Compressor loss/reverse phase protection.
- Tri-thermal Ultra Mono HP stops running.
- Error code is displayed on main control board and user interface.

4.18.3 Possible causes

- Compressor wiring loose.
- Damaged driving board.
- Compressor failure.

4.18.4 Procedure



4.19 F7 Troubleshooting

4.19.1 Digital display output



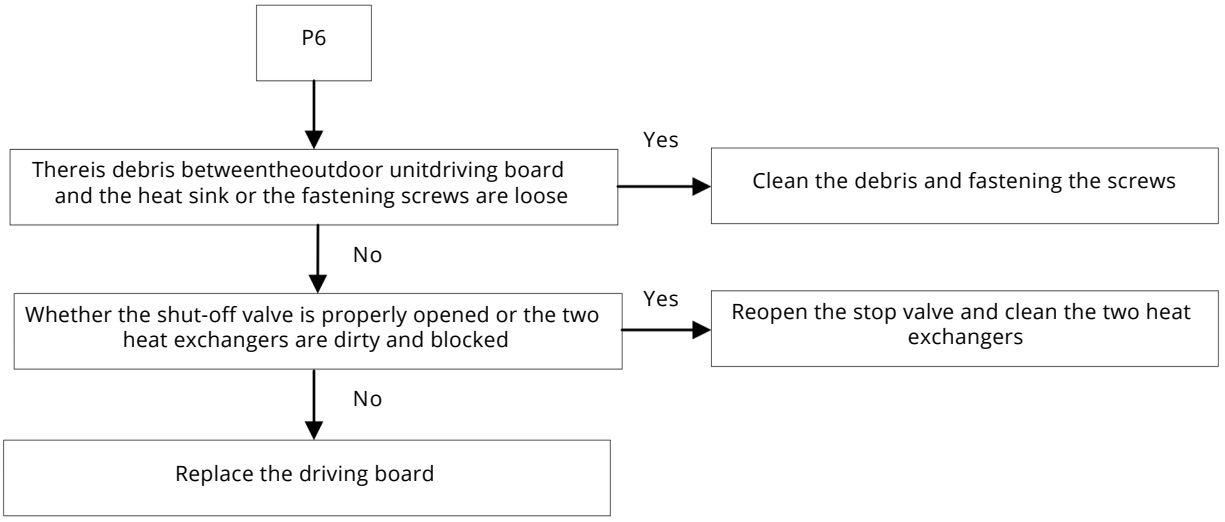
4.19.2 Description

- IPM module temperature protection.
- Tri-thermal Ultra Mono HP stops running.
- Error code is displayed on main control board and user interface.

4.19.3 Possible causes

- There is debris between the outdoor unit driving board and the heat sink or the fastening screws are loose.
- The compressor current is too large and the system pressure is abnormal.
- Outdoor unit driving board damaged.

4.19.4 Procedure



4.20 F8 Troubleshooting

4.20.1 Digital display output



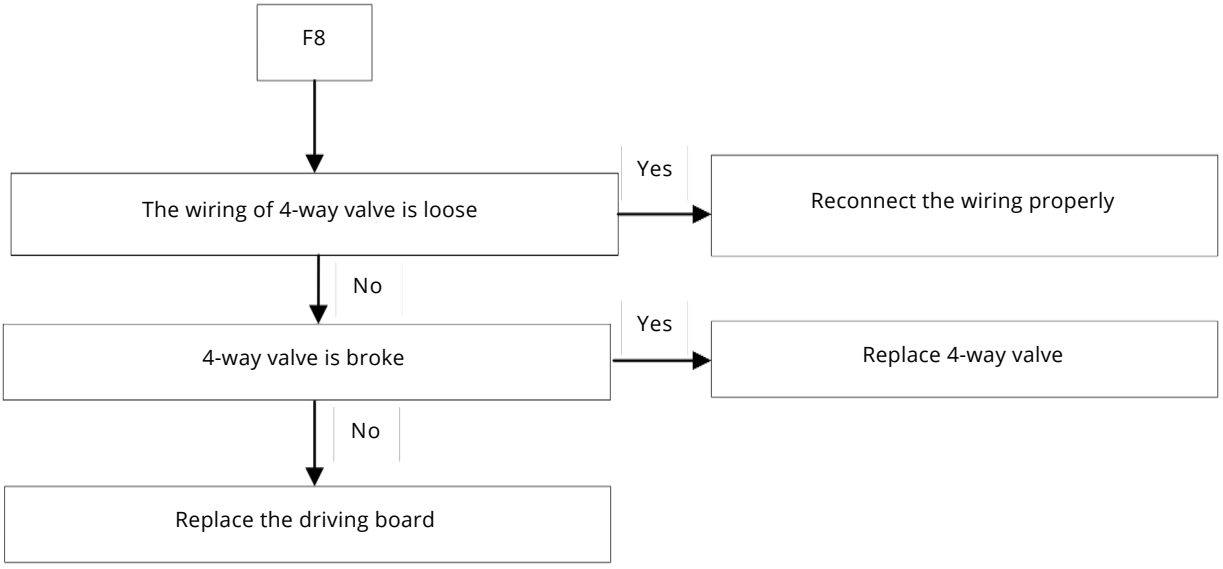
4.20.2 Description

- 4-way valve reversing failure (heating mode).
- Tri-thermal Ultra Mono HP stops running.
- Error code is displayed on main control board and user interface.

4.20.3 Possible causes

- The wiring of 4-way valve is loose.
- 4-way valve is broke.
- Damaged driving board.

4.20.4 Procedure



4.21 P2 Troubleshooting

4.21.1 Digital display output



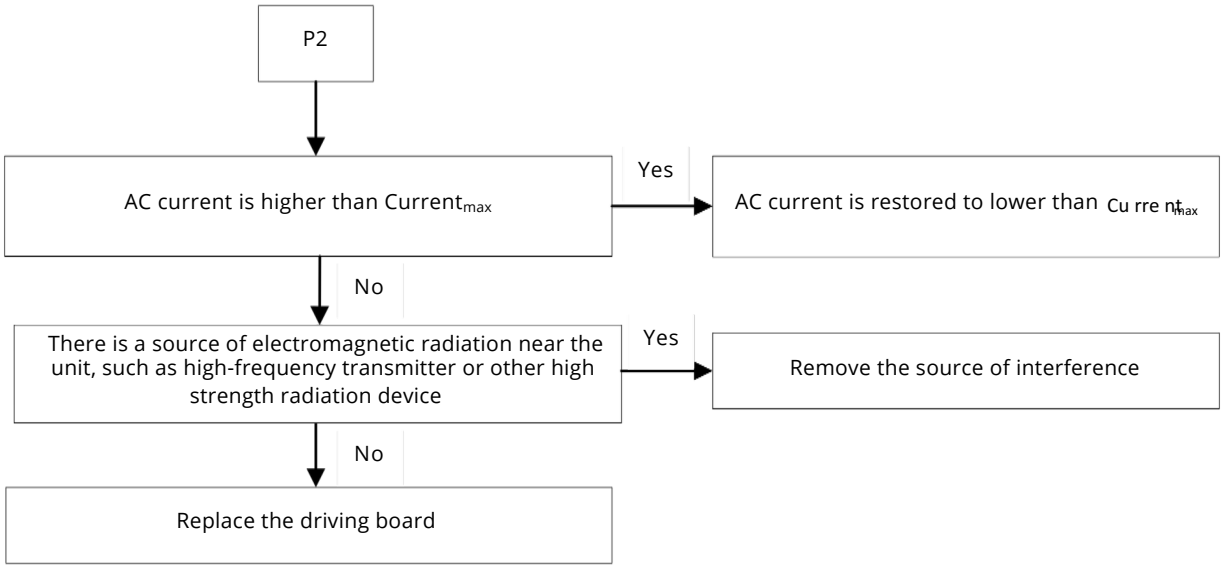
4.21.2 Description

- AC input overcurrent.
- Tri-thermal Ultra Mono HP stops running.
- Error code is displayed on main control board and user interface.

4.21.3 Possible causes

- Power supply abnormal.
- Interference from a source of electromagnetic radiation.
- Damaged driving board.

4.21.4 Procedure



4.22 P4 Troubleshooting

4.22.1 Digital display output



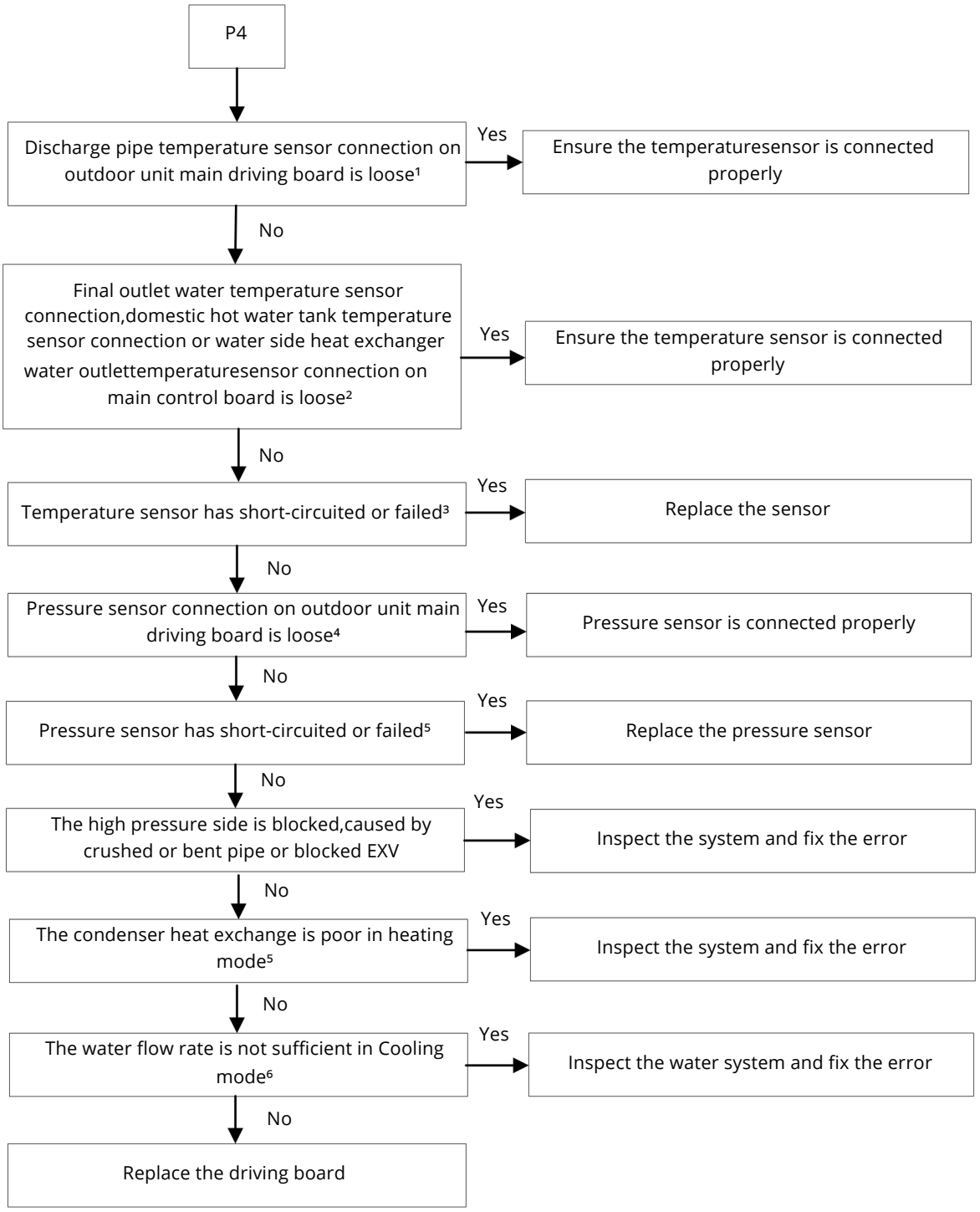
4.22.2 Description

- Discharge temperature too high protection.
- When the compressor the discharge temperature rises above 115°C, the system displays P4 protection and Tri-thermal Ultra Mono HP stops running. When the discharge temperature falls below 90°C, P4 is removed and normal operation resumes.
- Error code is displayed on main control board and user interface.

4.22.3 Possible causes

- Temperature sensor error.
- High pressure side blockage.
- Poor condenser heat exchange.
- Damaged driving board.

4.22.4 Procedure



Notes:

1. Discharge pipe temperature sensor connection is port CN2/CN1 on the driving board.

2. Final outlet water temperature sensor and Domestic hot water tank temperature sensor connections are port CN15 on the main control board .Water side heat exchanger water outlet temperature sensor connection is port CN10 on the main control board.

3. Measure sensor resistance. If the resistance is too low, the sensor has short-circuited. If the resistance is not consistent with the sensor's resistance characteristics table, the sensor has failed. Refer to Table 4-5.1 , 4-5.2 or 4-5.3 in Part 4, 5.1"Temperature Sensor Resistance Characteristics".

4. High pressure sensor connection is port SHP on the driving board.

5. Measure the resistance among the three terminals of the pressure sensor. If the resistance is of the order of mega Ohms or infinite, the pressure sensor has failed.

6. High pressure side blockage causes discharge temperature to be higher than normal, discharge pressure to be higher than normal and suction pressure to be lower than normal.

7. Check air side heat exchanger, fan and air outlets for dirt/blockages.

8. Check the water side heat exchanger, water piping, circulator pumps and water flow switch for dirt/blockages.

4.23 P0 Troubleshooting

4.23.1 Digital display output



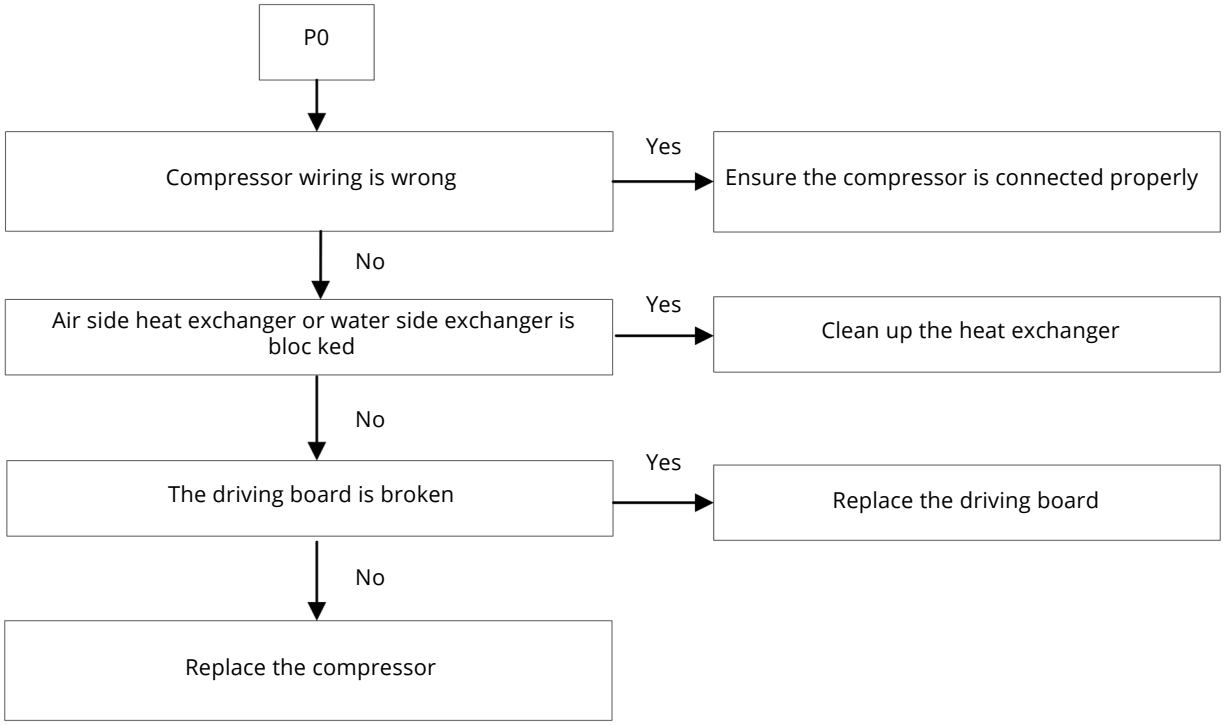
4.23.2 Description

- IPM module protection.
- Tri-thermal Ultra Mono HP stops running.
- Error code is displayed on main control board and user interface.

4.23.3 Possible causes

- Compressor wiring is abnormal.
- Abnormal operation of fan motor.
- Air side heat exchanger or water side exchanger is blocked.
- Damaged driving board.

4.23.4 Procedure



4.24 L1/L2/L3/L4/L5/L6 Troubleshooting

4.24.1 Digital display output



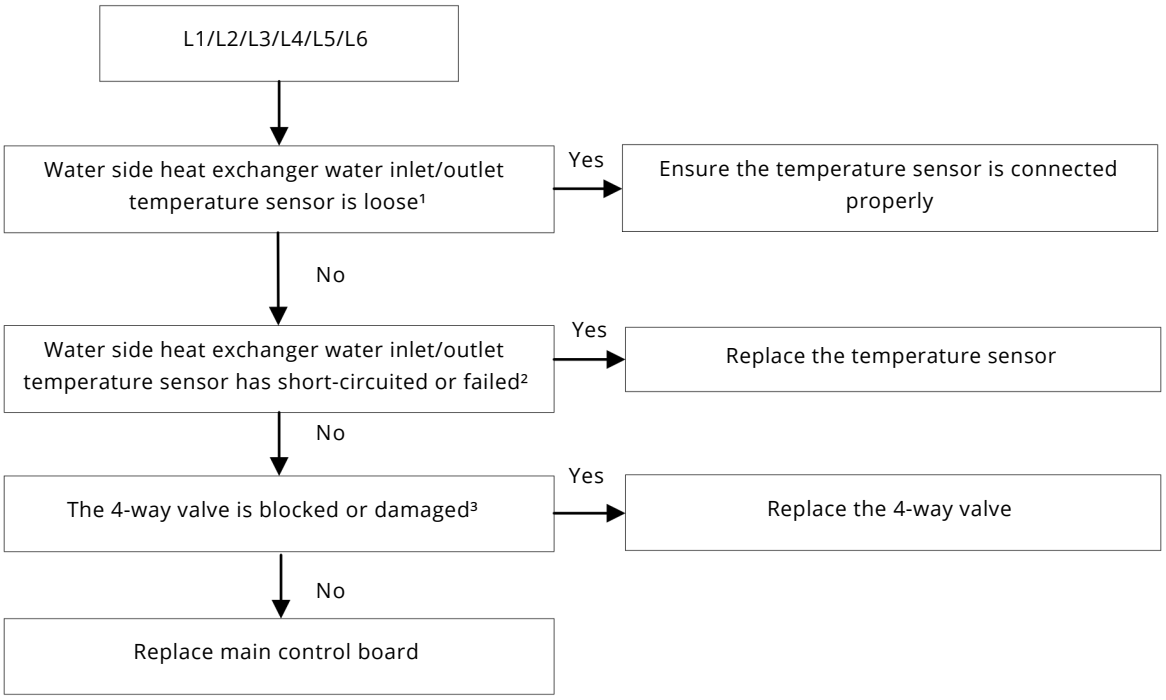
4.24.2 Description

- 'L1': The water temperature difference between plate heat exchanger inlet and outlet is too large.
- 'L2': The water temperature difference between plate heat exchanger inlet and outlet is abnormal.
- 'L3': Plate heat exchanger outlet water temperature is too low.
- 'L4': Plate heat exchanger outlet water temperature is too high.
- 'L5': Plate heat exchanger inlet water temperature is too low.
- 'L6': Plate heat exchanger inlet water temperature is too high
- Tri-thermal Ultra Mono HP stops running.
- Error code is displayed on main control board and user interface.

4.24.3 Possible causes

- Power supply voltage of the unit is low.
- The space between the units is too narrow for heat exchanger.
- Heat exchanger is dirty or something is block on the surface.
- Fan is not running.
- Water flow rate is low.
- Water outlet temperature sensorisloosen or broken.

4.24.4 Procedure



Notes:

1. Water side heat exchanger water inlet temperature sensor and water side heat exchanger water outlet temperature sensor connections are port CN10 on the main control board.

2. Measure sensor resistance. If the resistance is too low, the sensor has short-circuited. If the resistance is not consistent with the sensor's resistance characteristics table, the sensor has failed. Refer to Table 4-5.1 in Part 4, 5.1"Temperature Sensor Resistance Characteristics".

3. Check water pressure on the manometer. If the water pressure is not > 1 bar, water flow is insufficient.

4.25 Lb/LC Troubleshooting

4.25.1 Digital display output



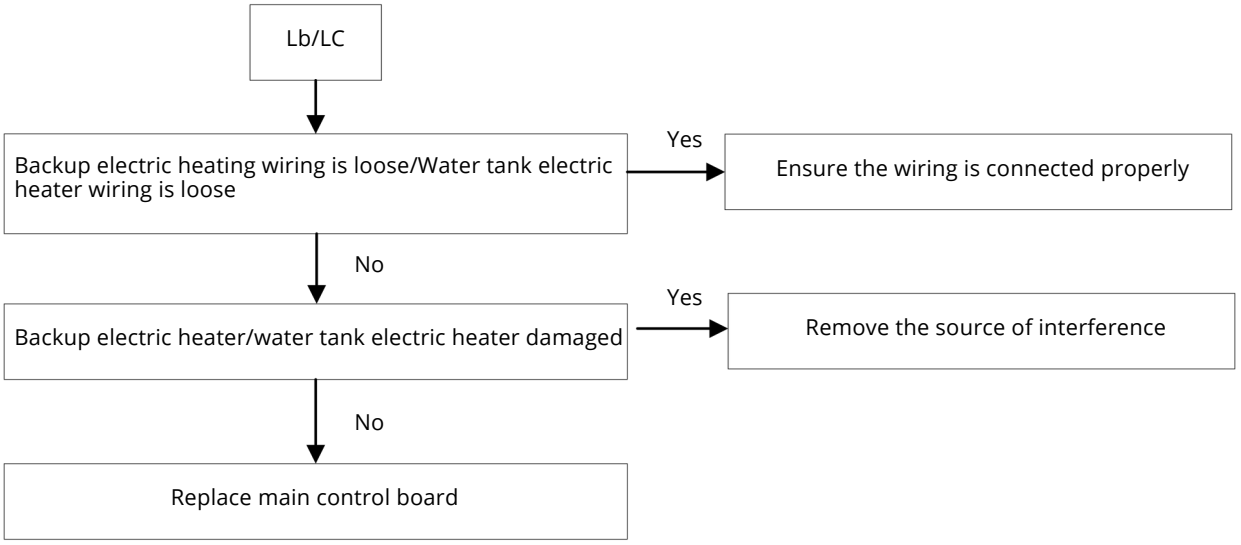
4.25.2 Description

- Lb: Auxiliary electric heating feedback failure.
- LC: Water tank electric heating feedback failure.
- Tri-thermal Ultra Mono HP stops running.
- Error code is displayed on main control board and user interface.

4.25.3 Possible causes

- Backup electric heating wiring is loose/Water tank electric heater wiring is loose.
- Damaged main control board.

4.25.4 Procedure



Notes:

1. Water side heat exchanger water inlet temperature sensor and water side heat exchanger water outlet temperature sensor connections are port CN10 on the main control board.

2. Measure sensor resistance. If the resistance is too low, the sensor has short-circuited. If the resistance is not consistent with the sensor's resistance characteristics table, the sensor has failed. Refer to Table 4-5.1 in Part 4, 5.1"Temperature Sensor Resistance Characteristics".

4.26 P5 Troubleshooting

4.26.1 Digital display output



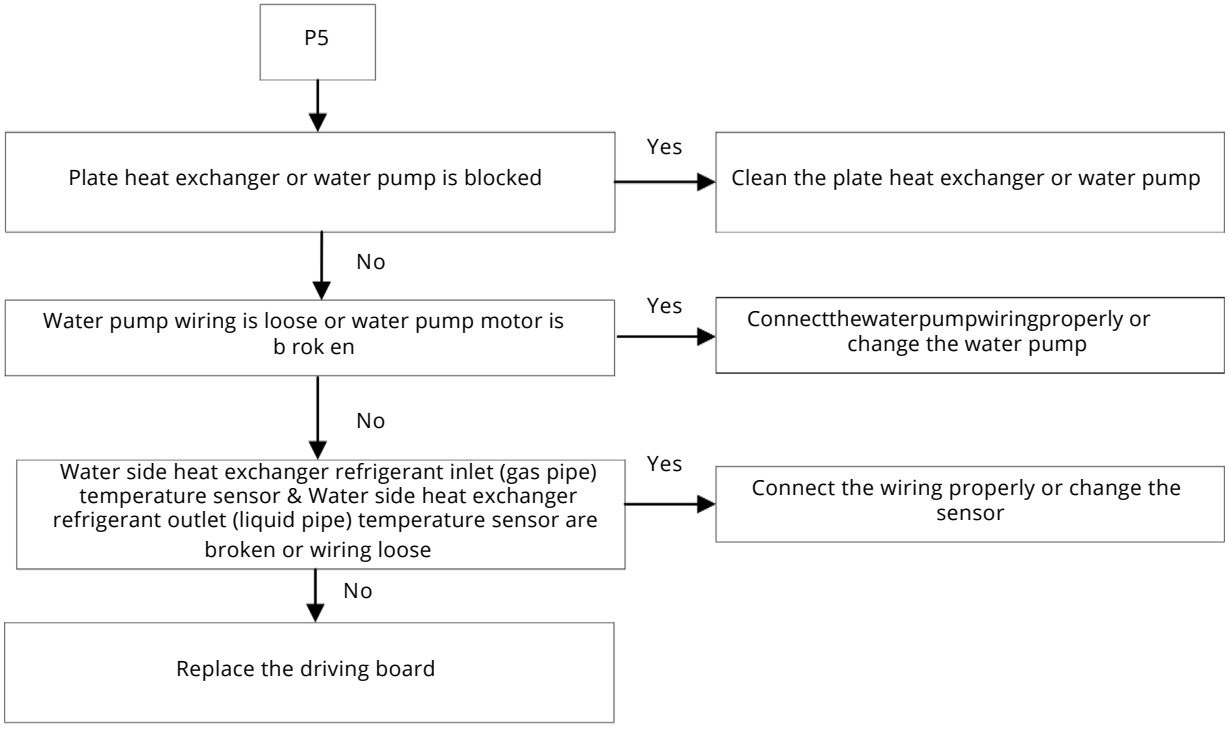
4.26.2 Description

- Refrigeration anti-overcooling failure.
- Tri-thermal Ultra Mono HP stops running.
- Error code is displayed on main control board and user interface.

4.26.3 Possible causes

- Plate heat exchanger or water pump is blocked.
- Water pump wiring is loose or water pump motor is broken.
- Water side heat exchanger refrigerant inlet (gas pipe) temperature sensor & Water side heat exchanger refrigerant outlet (liquid pipe) temperature sensor are broken or wiring loose .
- Damaged driving board.

4.26.4 Procedure



5. Appendix to Part 4

5.1TemperatureSensorResistance Characteristics

Table5-5.1:Resistancecharacteristicof room temperature sensor, floorheating temperaturesensor, DHW temperature sensor, buffer water tank temperature sensor, AHS temperature sensor, solar energy panel temperature sensor.

R25=10KΩ±1%, B25/50=4100K

T(℃)	Rmin(KΩ)	Rnom(KΩ)	Rmax(KΩ)	T(℃)	Rmin(KΩ)	Rnom(KΩ)	Rmax(KΩ)
-40	370.906	388.619	407.137	-3	39.418	40.376	41.352
-39	345.908	362.171	379.162	-2	37.371	38.259	39.163
-38	322.825	337.767	353.366	-1	35.442	36.264	37.102
-37	301.489	315.226	329.556	0	33.623	34.385	35.160
-36	281.749	294.386	307.558	1	31.907	32.613	33.330
-35	263.470	275.100	287.215	2	30.288	30.941	31.605
-34	246.528	257.238	268.386	3	28.759	29.364	29.979
-33	230.812	240.679	250.942	4	27.316	27.876	28.445
-32	216.222	225.317	234.770	5	25.953	26.471	26.998
-31	202.667	211.053	219.764	6	24.665	25.145	25.632
-30	190.063	197.799	205.830	7	23.448	23.892	24.342
-29	178.336	185.475	192.881	8	22.298	22.708	23.124
-28	167.416	174.007	180.840	9	21.210	21.590	21.974
-27	157.242	163.330	169.636	10	20.181	20.532	20.887
-26	147.757	153.381	159.202	11	19.207	19.532	19.859
-25	138.908	144.105	149.482	12	18.286	18.586	18.888
-24	130.648	135.452	140.419	13	17.414	17.690	17.969
-23	122.933	127.375	131.965	14	16.588	16.843	17.100
-22	115.724	119.832	124.074	15	15.806	16.041	16.278
-21	108.983	112.783	116.705	16	15.064	15.281	15.500
-20	102.676	106.193	109.819	17	14.362	14.562	14.763
-19	96.774	100.028	103.382	18	13.696	13.880	14.065
-18	91.246	94.259	97.361	19	13.065	13.234	13.404
-17	86.067	88.857	91.727	20	12.466	12.621	12.777
-16	81.213	83.796	86.453	21	11.898	12.041	12.184
-15	76.661	79.054	81.512	22	11.359	11.490	11.621
-14	72.391	74.607	76.882	23	10.847	10.967	11.087
-13	68.383	70.436	72.542	24	10.361	10.471	10.580
-12	64.620	66.521	68.472	25	9.900	10.000	10.100
-11	61.085	62.847	64.653	26	9.453	9.553	9.653
-10	57.763	59.396	61.068	27	9.029	9.128	9.228
-9	54.641	56.153	57.702	28	8.626	8.725	8.824
-8	51.704	53.106	54.540	29	8.243	8.342	8.440
-7	48.942	50.241	51.569	30	7.880	7.977	8.075
-6	46.342	47.546	48.776	31	7.534	7.631	7.728
-5	43.894	45.010	46.149	32	7.206	7.302	7.398
-4	41.589	42.623	43.678	33	6.894	6.988	7.084

T(℃)	Rmin(KΩ)	Rnom(KΩ)	Rmax(KΩ)	T(℃)	Rmin(KΩ)	Rnom(KΩ)	Rmax(KΩ)
34	6.597	6.690	6.785	71	1.540	1.585	1.630
35	6.315	6.407	6.500	72	1.487	1.530	1.575
36	6.046	6.137	6.229	73	1.436	1.478	1.522
37	5.790	5.880	5.970	74	1.387	1.428	1.471
38	5.547	5.635	5.724	75	1.340	1.380	1.422
39	5.315	5.402	5.489	76	1.294	1.334	1.375
40	5.094	5.179	5.266	77	1.251	1.289	1.329
41	4.884	4.968	5.053	78	1.209	1.247	1.286
42	4.683	4.766	4.849	79	1.169	1.206	1.244
43	4.492	4.573	4.655	80	1.130	1.166	1.203
44	4.310	4.390	4.470	81	1.093	1.128	1.164
45	4.136	4.215	4.294	82	1.057	1.091	1.127
46	3.971	4.047	4.125	83	1.022	1.056	1.091
47	3.813	3.888	3.964	84	0.989	1.022	1.056
48	3.662	3.736	3.810	85	0.957	0.990	1.023
49	3.518	3.590	3.663	86	0.926	0.958	0.991
50	3.381	3.451	3.523	87	0.897	0.928	0.960
51	3.249	3.318	3.389	88	0.868	0.899	0.930
52	3.124	3.192	3.260	89	0.841	0.870	0.901
53	3.004	3.070	3.138	90	0.814	0.843	0.873
54	2.889	2.954	3.020	91	0.789	0.817	0.846
55	2.779	2.843	2.908	92	0.764	0.792	0.820
56	2.674	2.737	2.800	93	0.741	0.768	0.796
57	2.574	2.635	2.697	94	0.718	0.744	0.772
58	2.478	2.538	2.598	95	0.696	0.722	0.748
59	2.386	2.444	2.504	96	0.675	0.700	0.726
60	2.298	2.355	2.413	97	0.654	0.679	0.704
61	2.214	2.269	2.326	98	0.635	0.659	0.684
62	2.133	2.187	2.243	99	0.615	0.639	0.663
63	2.055	2.109	2.163	100	0.597	0.620	0.644
64	1.981	2.033	2.087	101	0.579	0.602	0.625
65	1.910	1.961	2.013	102	0.562	0.584	0.607
66	1.842	1.892	1.943	103	0.546	0.567	0.590
67	1.776	1.825	1.875	104	0.530	0.551	0.573
68	1.714	1.761	1.810	105	0.514	0.535	0.556
69	1.653	1.700	1.748	106	0.499	0.520	0.540
70	1.596	1.641	1.688	107	0.485	0.505	0.525

Table 4-5.2:Resistance characteristic of inlet/outlet/total outlet water temperature sensor, water side heat exchanger refrigerant inlet / outlet (liquid / gas pipe) temperature sensor, outdoor ambient temperature sensor, outdoor unit coil temperature sensor, suction temperature sensor. R90=5KΩ±2%，B25/50=3470K±2%

T(℃)	Rmin(KΩ)	Rnom(KΩ)	Rmax(KΩ)	T(℃)	Rmin(KΩ)	Rnom(KΩ)	Rmax(KΩ)
-40	104.8311	113.8710	123.6409	-3	15.6366	16.3381	17.0642
-39	98.7962	107.1859	116.2415	-2	14.9383	15.5939	16.2718
-38	93.1767	100.9684	109.3679	-1	14.2751	14.8878	15.5206
-37	87.9368	95.1778	102.9739	0	13.6452	14.2178	14.8085
-36	83.0447	89.7780	97.0184	1	13.0469	13.5819	14.1332
-35	78.4723	84.7369	91.4650	2	12.4784	12.9783	13.4928
-34	74.1937	80.0251	86.2803	3	11.9382	12.4052	12.8854
-33	70.1860	75.6166	81.4348	4	11.4247	11.8610	12.3090
-32	66.4283	71.4879	76.9021	5	10.9365	11.3441	11.7621
-31	62.9018	67.6175	72.6576	6	10.4725	10.8532	11.2432
-30	59.5895	63.9862	68.6798	7	10.0313	10.3868	10.7506
-29	56.4759	60.5764	64.9487	8	9.6117	9.9436	10.2829
-28	53.5468	57.3723	61.4465	9	9.2126	9.5225	9.8389
-27	50.7894	54.3592	58.1566	10	8.8329	9.1222	9.4172
-26	48.1918	51.5238	55.0641	11	8.4716	8.7416	9.0166
-25	45.7434	48.8541	52.1555	12	8.1278	8.3798	8.6361
-24	43.4342	46.3389	49.4180	13	7.8007	8.0358	8.2747
-23	41.2552	43.9679	46.8403	14	7.4892	7.7085	7.9310
-22	39.1979	41.7318	44.4117	15	7.1927	7.3972	7.6045
-21	37.2547	39.6218	42.1225	16	6.9103	7.1010	7.2940
-20	35.4184	37.6300	39.9637	17	6.6415	6.8192	6.9989
-19	33.6824	35.7489	37.9270	18	6.3854	6.5510	6.7182
-18	32.0407	33.9718	36.0049	19	6.1414	6.2957	6.4513
-17	30.4874	32.2921	34.1900	20	5.9089	6.0526	6.1973
-16	29.0175	30.7042	32.4760	21	5.6874	5.8211	5.9556
-15	27.6258	29.2023	30.8565	22	5.4762	5.6007	5.7257
-14	26.3079	27.7815	29.3259	23	5.2749	5.3907	5.5068
-13	25.0596	26.4370	27.8790	24	5.0830	5.1906	5.2984
-12	23.8767	25.1643	26.5107	25	4.9000	5.0000	5.1000
-11	22.7557	23.9593	25.2165	26	4.6989	4.7987	4.8987
-10	21.6930	22.8181	23.9920	27	4.5088	4.6083	4.7081
-9	20.6854	21.7371	22.8332	28	4.3289	4.4280	4.5275
-8	19.7297	20.7128	21.7362	29	4.1586	4.2571	4.3562
-7	18.8232	19.7422	20.6978	30	3.9971	4.0950	4.1936
-6	17.9631	18.8221	19.7143	31	3.8438	3.9410	4.0390
-5	17.1468	17.9498	18.7829	32	3.6981	3.7945	3.8918
-4	16.3721	17.1226	17.9004	33	3.5596	3.6551	3.7516

T(℃)	Rmin(KΩ)	Rnom(KΩ)	Rmax(KΩ)	T(℃)	Rmin(KΩ)	Rnom(KΩ)	Rmax(KΩ)
34	3.4278	3.5223	3.6180	71	1.0010	1.0537	1.1088
35	3.3021	3.3957	3.4905	72	0.9705	1.0222	1.0763
36	3.1824	3.2749	3.3688	73	0.9410	0.9918	1.0449
37	3.0680	3.1595	3.2524	74	0.9126	0.9624	1.0145
38	2.9588	3.0492	3.1411	75	0.8850	0.9339	0.9851
39	2.8544	2.9437	3.0346	76	0.8583	0.9063	0.9565
40	2.7546	2.8427	2.9325	77	0.8326	0.8796	0.9289
41	2.6589	2.7459	2.8346	78	0.8077	0.8538	0.9022
42	2.5674	2.6532	2.7408	79	0.7835	0.8287	0.8762
43	2.4796	2.5642	2.6507	80	0.7601	0.8045	0.8511
44	2.3954	2.4788	2.5641	81	0.7375	0.7810	0.8268
45	2.3147	2.3969	2.4811	82	0.7156	0.7583	0.8032
46	2.2371	2.3181	2.4011	83	0.6944	0.7362	0.7803
47	2.1626	2.2424	2.3242	84	0.6739	0.7149	0.7581
48	2.0910	2.1696	2.2503	85	0.6540	0.6942	0.7366
49	2.0221	2.0995	2.1790	86	0.6348	0.6742	0.7158
50	1.9559	2.0321	2.1104	87	0.6161	0.6548	0.6956
51	1.8922	1.9672	2.0443	88	0.5981	0.6360	0.6760
52	1.8308	1.9046	1.9806	89	0.5806	0.6178	0.6571
53	1.7717	1.8443	1.9191	90	0.5637	0.6001	0.6386
54	1.7147	1.7861	1.8597	91	0.5473	0.5830	0.6208
55	1.6599	1.7301	1.8026	92	0.5314	0.5664	0.6034
56	1.6070	1.6760	1.7473	93	0.5161	0.5504	0.5867
57	1.5559	1.6238	1.6940	94	0.5012	0.5348	0.5704
58	1.5067	1.5734	1.6424	95	0.4869	0.5198	0.5548
59	1.4591	1.5247	1.5926	96	0.4729	0.5052	0.5395
60	1.4134	1.4778	1.5446	97	0.4594	0.4910	0.5246
61	1.3691	1.4324	1.4980	98	0.4463	0.4773	0.5103
62	1.3263	1.3885	1.4530	99	0.4336	0.4640	0.4963
63	1.2850	1.3461	1.4095	100	0.4213	0.4511	0.4828
64	1.2451	1.3051	1.3674	101	0.4094	0.4386	0.4697
65	1.2066	1.2655	1.3268	102	0.3979	0.4265	0.4570
66	1.1693	1.2272	1.2874	103	0.3868	0.4148	0.4447
67	1.1334	1.1902	1.2494	104	0.3759	0.4034	0.4327
68	1.0985	1.1543	1.2124	105	0.3655	0.3924	0.4211
69	1.0650	1.1197	1.1768	106	0.3553	0.3817	0.4099
70	1.0324	1.0861	1.1422	107	0.3454	0.3713	0.3989

Table 4-5.3:Resistance characteristic of compressor discharge temperature sensor.

R85=2.113KΩ±3% B25/85=4000K±2%

T(℃)	Rmin(KΩ)	Rnom(KΩ)	Rmax(KΩ)	T(℃)	Rmin(KΩ)	Rnom(KΩ)	Rmax(KΩ)
-30	302.8541	336.8998	374.4355	7	42.4556	45.8361	49.4413
-29	285.5608	317.3782	352.4232	8	40.4842	43.6761	47.0773
-28	269.3454	299.0896	331.8196	9	38.6146	41.6291	44.8386
-27	254.1355	281.9504	312.5281	10	36.8411	39.6887	42.7180
-26	239.8645	265.8833	294.4592	11	35.1582	37.8488	40.7086
-25	226.4700	250.8163	277.5299	12	33.5608	36.1036	38.8041
-24	213.8940	236.6824	261.6629	13	32.0444	34.4480	36.9986
-23	202.0830	223.4196	246.7867	14	30.6041	32.8767	35.2862
-22	190.9866	210.9701	232.8348	15	29.2361	31.3852	33.6620
-21	180.5583	199.2802	219.7454	16	27.9362	29.9690	32.1208
-20	170.7547	188.3000	207.4612	17	26.7007	28.6239	30.6580
-19	161.5355	177.9830	195.9286	18	25.5263	27.3461	29.2693
-18	152.8630	168.2860	185.0983	19	24.4094	26.1318	27.9506
-17	144.7023	159.1689	174.9242	20	23.3470	24.9775	26.6978
-16	137.0208	150.5942	165.3633	21	22.3363	23.8801	25.5076
-15	129.7877	142.5269	156.3756	22	21.3745	22.8365	24.3766
-14	122.9751	134.9348	147.9243	23	20.4589	21.8437	23.3013
-13	116.5564	127.7874	139.9746	24	19.5871	20.8991	22.2789
-12	110.5069	121.0567	132.4944	25	18.7568	20.0000	21.3064
-11	104.8035	114.7162	125.4535	26	17.9659	19.1441	20.3812
-10	99.4248	108.7415	118.8242	27	17.2123	18.3291	19.5008
-9	94.3508	103.1098	112.5805	28	16.4941	17.5529	18.6628
-8	89.5627	97.7996	106.6979	29	15.8094	16.8134	17.8650
-7	85.0431	92.7911	101.1539	30	15.1565	16.1087	17.1053
-6	80.7755	88.0657	95.9274	31	14.5338	15.4370	16.3816
-5	76.7447	83.6059	90.9985	32	13.9397	14.7966	15.6920
-4	72.9365	79.3956	86.3490	33	13.3729	14.1859	15.0348
-3	69.3373	75.4195	81.9615	34	12.8319	13.6035	14.4085
-2	65.9348	71.6636	77.8201	35	12.3153	13.0477	13.8112
-1	62.7172	68.1146	73.9099	36	11.8222	12.5174	13.2416
0	59.6736	64.7600	70.2167	37	11.3512	12.0113	12.6984
1	56.7938	61.5883	66.7274	38	10.9012	11.5280	12.1799
2	54.0681	58.5886	63.4299	39	10.4712	11.0665	11.6851
3	51.4875	55.7507	60.3126	40	10.0602	10.6257	11.2129
4	49.0436	53.0651	57.3647	41	9.6674	10.2046	10.7620
5	46.7285	50.5230	54.5764	42	9.2918	9.8022	10.3314
6	44.5348	48.1159	51.9382	43	8.9326	9.4176	9.9200

T(℃)	Rmin(KΩ)	Rnom(KΩ)	Rmax(KΩ)	T(℃)	Rmin(KΩ)	Rnom(KΩ)	Rmax(KΩ)
44	8.5889	9.0499	9.5270	81	2.3290	2.4057	2.4827
45	8.2602	8.6983	9.1514	82	2.2553	2.3284	2.4017
46	7.9455	8.3620	8.7924	83	2.1842	2.2539	2.3238
47	7.6443	8.0403	8.4492	84	2.1157	2.1822	2.2488
48	7.3560	7.7325	8.1210	85	2.0496	2.1130	2.1764
49	7.0799	7.4380	7.8071	86	1.9840	2.0463	2.1087
50	6.8155	7.1560	7.5068	87	1.9207	1.9820	2.0434
51	6.5663	6.8905	7.2242	88	1.8597	1.9200	1.9804
52	6.3276	6.6362	6.9536	89	1.8009	1.8602	1.9197
53	6.0987	6.3926	6.6946	90	1.7444	1.8026	1.8611
54	5.8792	6.1591	6.4465	91	1.6898	1.7470	1.8046
55	5.6687	5.9353	6.2088	92	1.6371	1.6933	1.7499
56	5.4668	5.7207	5.9810	93	1.5862	1.6415	1.6972
57	5.2729	5.5148	5.7626	94	1.5372	1.5915	1.6462
58	5.0870	5.3174	5.5533	95	1.4900	1.5433	1.5971
59	4.9084	5.1279	5.3524	96	1.4443	1.4967	1.5496
60	4.7369	4.9461	5.1599	97	1.4003	1.4518	1.5038
61	4.5721	4.7715	4.9751	98	1.3579	1.4084	1.4595
62	4.4139	4.6039	4.7977	99	1.3169	1.3665	1.4167
63	4.2618	4.4429	4.6275	100	1.2773	1.3260	1.3754
64	4.1157	4.2883	4.4641	101	1.2390	1.2869	1.3354
65	3.9752	4.1397	4.3071	102	1.2022	1.2492	1.2969
66	3.8402	3.9970	4.1565	103	1.1666	1.2127	1.2595
67	3.7102	3.8597	4.0116	104	1.1321	1.1774	1.2234
68	3.5853	3.7278	3.8725	105	1.0989	1.1434	1.1886
69	3.4651	3.6010	3.7388	106	1.0668	1.1105	1.1549
70	3.3496	3.4791	3.6104	107	1.0357	1.0786	1.1222
71	3.2382	3.3617	3.4868	108	1.0058	1.0479	1.0908
72	3.1312	3.2489	3.3680	109	0.9769	1.0182	1.0603
73	3.0280	3.1403	3.2538	110	0.9489	0.9894	1.0307
74	2.9288	3.0358	3.1439	111	0.9218	0.9616	1.0022
75	2.8332	2.9353	3.0383	112	0.8956	0.9347	0.9746
76	2.7412	2.8385	2.9366	113	0.8704	0.9087	0.9479
77	2.6525	2.7453	2.8388	114	0.8460	0.8836	0.9221
78	2.5670	2.6555	2.7446	115	0.8223	0.8592	0.8970
79	2.4847	2.5691	2.6539	116	0.7994	0.8357	0.8728
80	2.4055	2.4859	2.5667	117	0.7773	0.8129	0.8494