R32

Commercial Air Conditioners

Service Manual

M-Thermal Split Series

CONTENTS

Part 1

General Information

1 Unit Capacities

1.1 Outdoor Unit Capacities

Table 1-1.1: Capacity range

Capacity	4kW	6kW	8kW	10kW
Model[1] (MHA-*/D2N8)	V4W	V6W	V8W	V10W

Notes:

1. The full model names can be obtained by substituting the asterisk in the model name format given in the left-hand column of the table above with the shortened model names given in the table. For example, the model name for the 10kW model is MHA-V10W/D2N8.

1.2 Hydronic Box Model

Table 1-1.2: Model

Model[1]	SMK-60/CGN8	SMK-80/CGN8
Compatible OU model	MHA-V4(6)W/D2N8	MHA-V8(10)W/D2N8

2 External Appearance

2.1 Outdoor Unit Appearance

Table 1-2.1: Outdoor unit appearance

MHA-V4(6)W/D2N8	MHA-V8(10)W/D2N8
	

2.2 Hydronic Box Appearance

Table 1-2.2: Hydronic box appearance

SMK-60/CGN8	SMK-80/CGN8
	

Part 2

Component Layout and Refrigerant Circuits

1 Layout of Functional Components

1.1 Outdoor Unit Layout

MHA-V4W/D2N8 / MHA-V6W/D2N8

Figure 2-1.1: MHA-V4(6)W/D2N8 top view

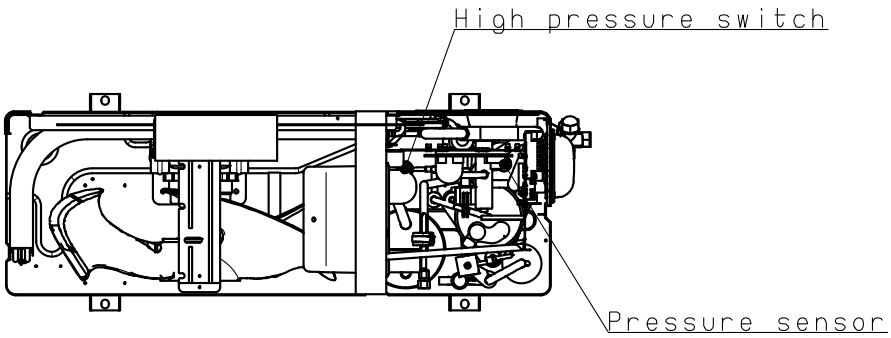
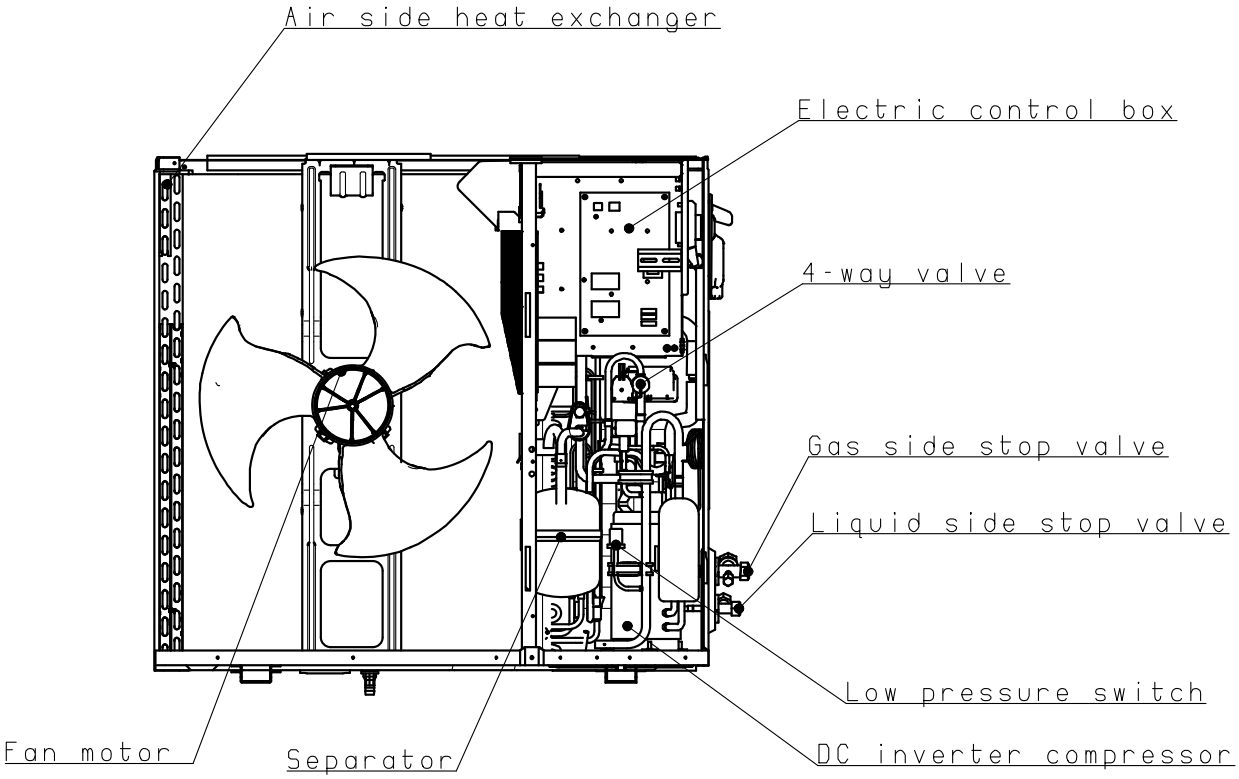


Figure 2-1.2: MHA-V4(6)W/D2N8 front view



MHA-V8W/D2N8 / MHA-V10W/D2N8

Figure 2-1.3: MHA-V8(10)W/D2N8 top view

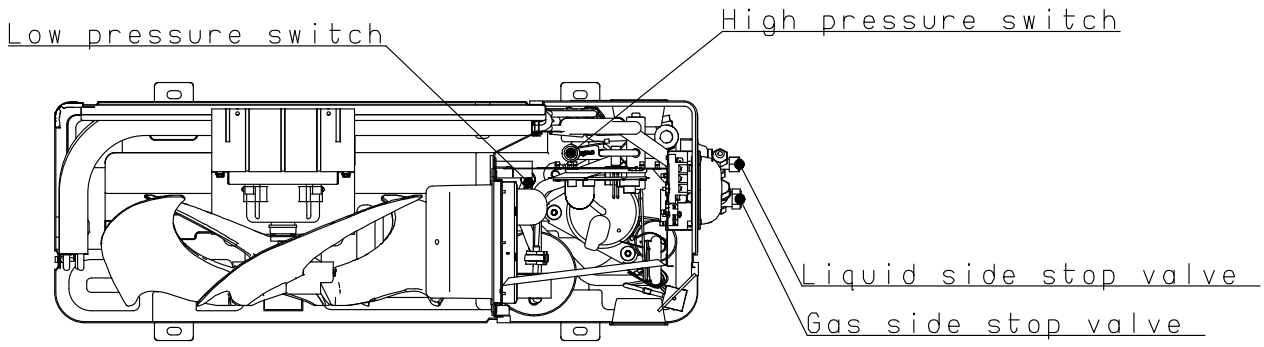
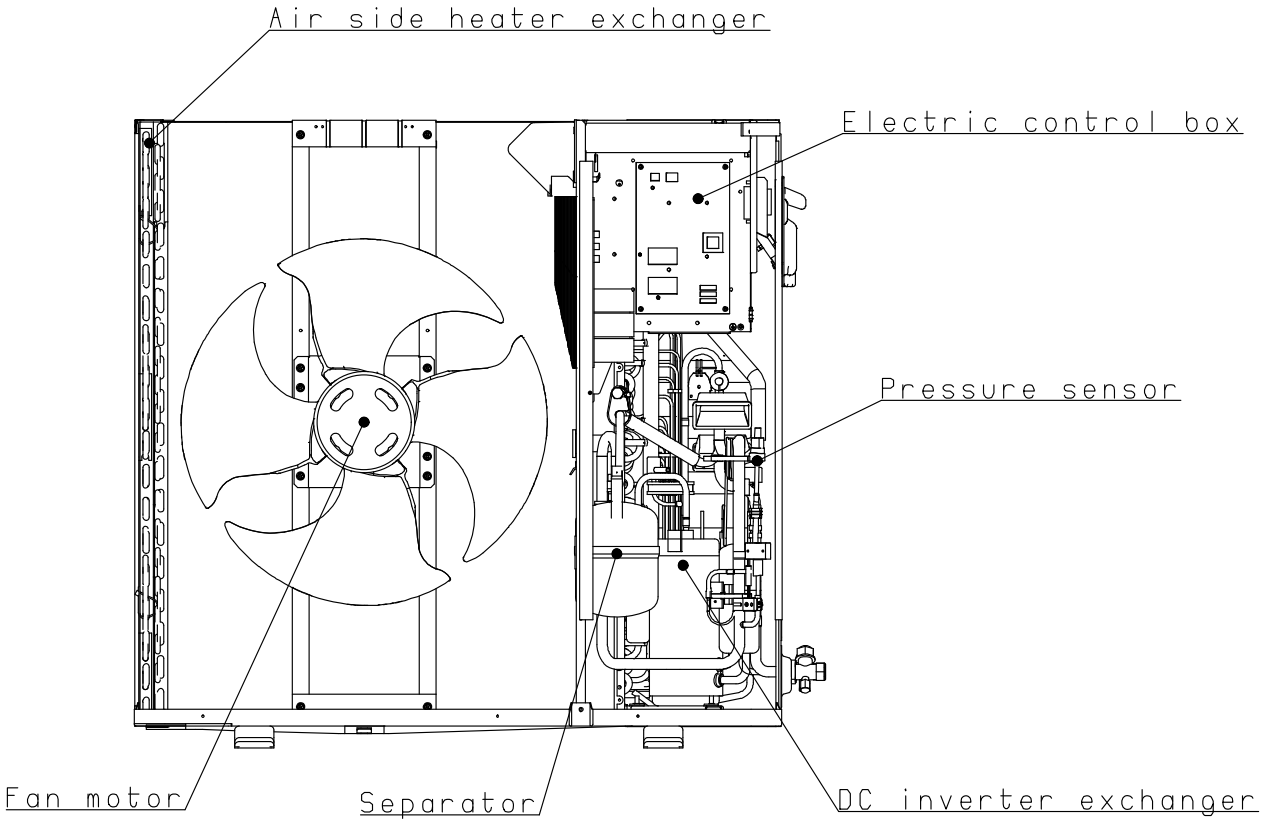
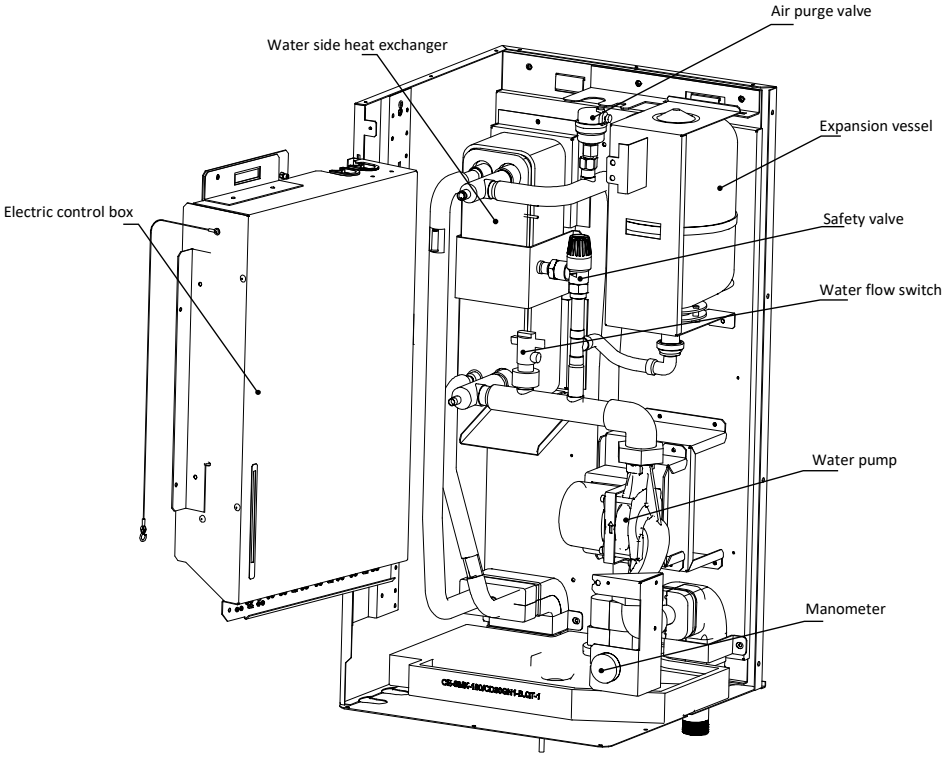


Figure 2-1.4: MHA-V8(10)W/D2N8 front view



1.2 Hydronic Box Layout

Figure 2-1.5: SMK-60/CGN8, SMK-80/CGN8 oblique view

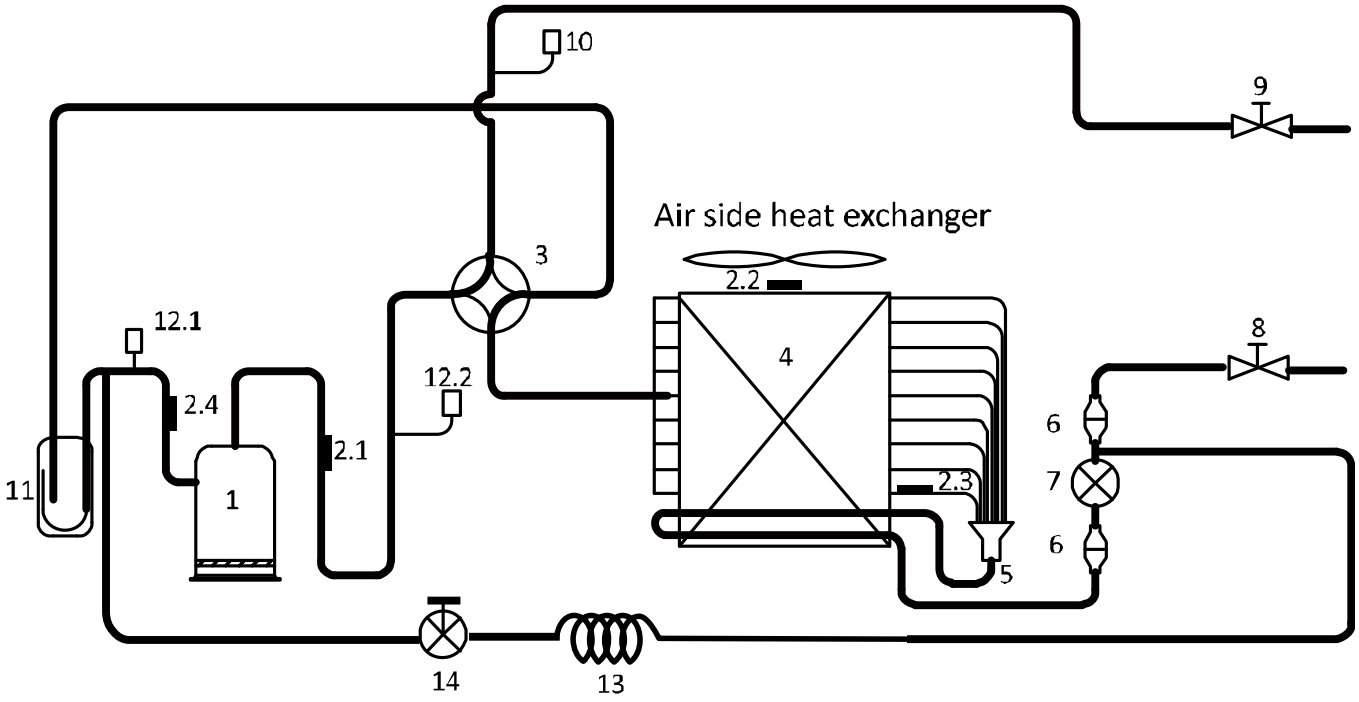


2 Piping Diagrams

2.1 Outdoor Unit Piping

MHA-V4W/D2N8 / MHA-V6W/D2N8 / MHA-V8W/D2N8 / MHA-V10W/D2N8

Figure 2-2.1: MHA-V4(6,8,10)W/D2N8 piping diagram



Legend			
1	Compressor	7	Electronic expansion valve
2.1	Discharge pipe temperature sensor	8	Stop valve (liquid side)
2.2	Outdoor ambient temperature sensor	9	Stop valve (gas side)
2.3	Air side heat exchanger refrigerant outlet temperature sensor	10	Pressure sensor
2.4	Suction pipe temperature sensor	11	Separator
3	4-way valve	12.1	Low pressure switch
4	Air side heat exchanger	12.2	High pressure switch
5	Distributor	13	Capillary
6	Filter	14	Solenoid valve

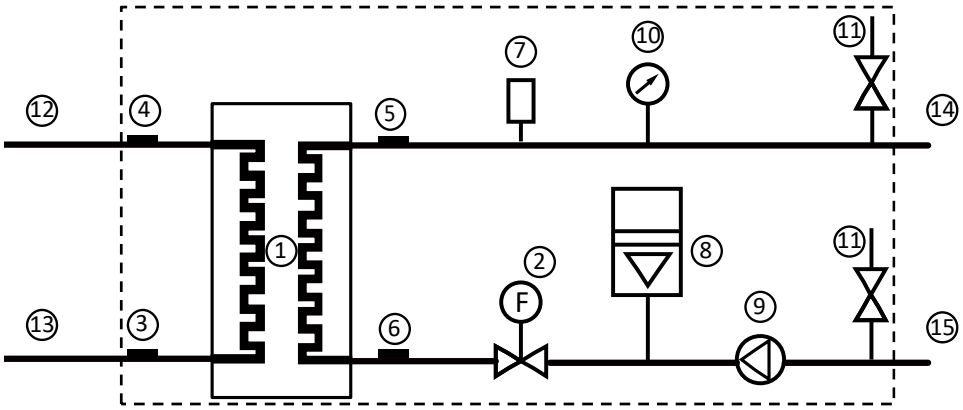
Key components:

1. **Electronic expansion valve (EXV):**
   Controls refrigerant flow and reduces refrigerant pressure.
2. **Four-way valve:**
   Controls refrigerant flow direction. Closed in cooling mode and open in heating mode. When closed, the air side heat exchanger functions as a condenser and water side heat exchanger functions as an evaporator; when open, the air side heat exchanger functions as an evaporator and water side heat exchanger function as a condenser.
3. **High and low pressure switches:**
   Regulate refrigerant system pressure. When refrigerant system pressure rises above the upper limit or falls below the lower limit, the high or low pressure switches turn off, stopping the compressor.
4. **Separator:**
   Separates liquid refrigerant from gas refrigerant to protect compressor from liquid hammering.

2.2 Hydronic box Piping

SMK-60/CGN8 / SMK-80/CGN8

Figure 2-2.2: SMK-60/CGN8 / SMK-80/CGN8 piping diagram



Legend			
1	Water side heat exchanger	9	Water pump
2	Water flow switch	10	Manometer
3	Refrigerant liquid line temperature sensor	11	Safety valve
4	Refrigerant gas line temperature sensor	12	Refrigerant gas side
5	Water outlet temperature sensor	13	Refrigerant liquid side
6	Water inlet temperature sensor	14	Water outlet
7	Air purge valve	15	Water inlet
8	Expansion vessel		

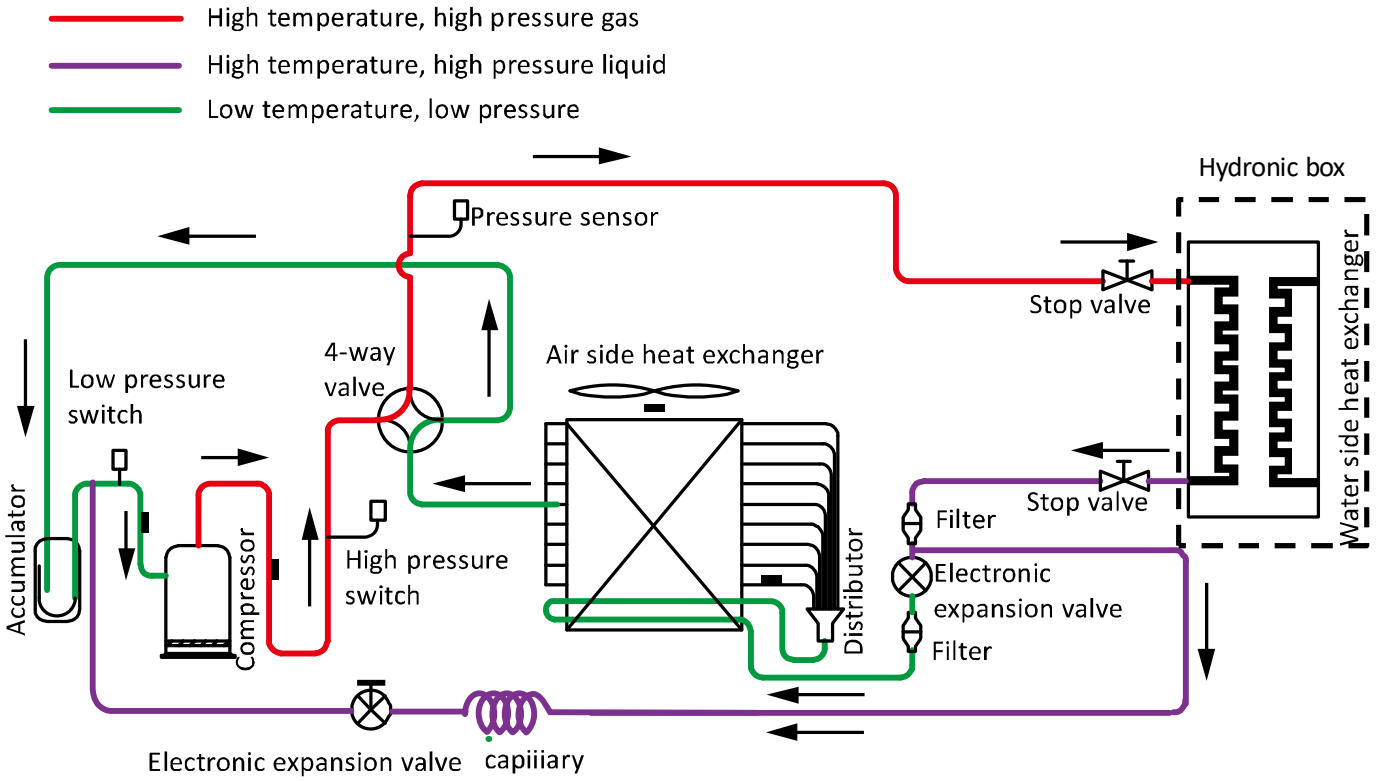
Key components:

1. **Air purge valve:**
   Automatically removes air from the water circuit.
2. **Safety valve:**
   Prevents excessive water pressure by opening at 43.5 psi (3 bar) and discharging water from the water circuit.
3. **Expansion vessel:**
   Balances water system pressure. (Expansion vessel volume: 3L.)
4. **Water flow switch:**
   Detects water flow rate to protect compressor and water pump in the event of insufficient water flow.
5. **Backup electric heater:**
   Provides additional heating capacity when the heating capacity of the heat pump is insufficient due to very low outdoor temperature. Also protects the external water piping from freezing.
6. **Manometer:**
   Provides water circuit pressure readout.
7. **Water pump:**
   Circulates water in the water circuit.

3 Refrigerant Flow Diagrams

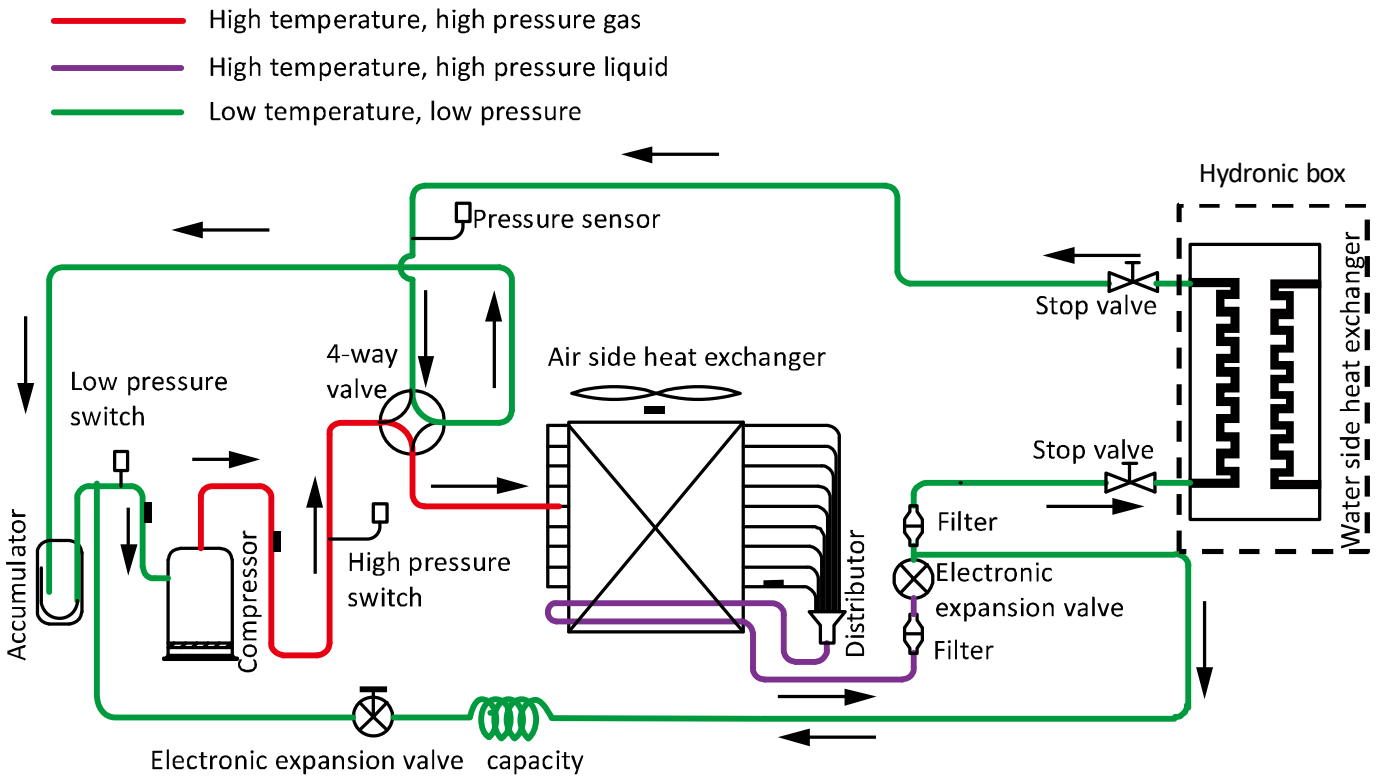
Heating and domestic hot water operation

Figure 2-3.1: Refrigerant flow during heating or domestic hot water operation



Cooling and defrosting operation

Figure 2-3.2: Refrigerant flow during cooling and defrosting operations



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 thermo off operation and an error code is displayed on the outdoor unit PCB digital displays and on the user interface.
2. The system stops when the set temperature has been reached.

2 Standby Control

2.1 Crankcase Heater Control

The crankcase heater is used to prevent refrigerant from mixing with compressor oil when the compressors are stopped. The crankcase heater is controlled according to outdoor ambient temperature and the compressor on/off state. When the outdoor ambient temperature is above 8°C or the compressor is running, the crankcase heater is off; when the outdoor ambient temperature is at or below 8°C and either the compressor has been stopped for more than 3 hours or the unit has just been powered-on (either manually or when the power has returned following a power outage), the crankcase heater turns on.

2.2 Water Pump Control

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

3 Startup Control

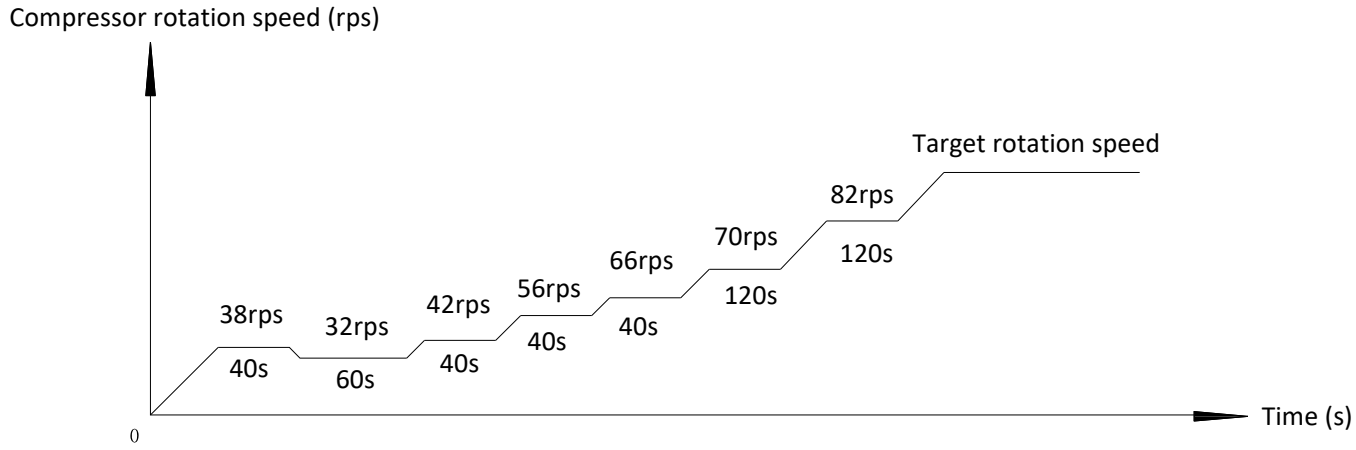
3.1 Compressor Startup Delay Control

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. The compressor re-start delays for cooling and heating modes are set on the user interface. Refer to the M-Thermal Split Engineering Data Book Part 3, 8.5 “COOL MODE SETTING Menu” and Part 3, 8.6 “HEAT MODE SETTING Menu”.

3.2 Compressor Startup Program

In initial startup control and in re-start control, compressor startup is controlled according to outdoor ambient temperature. Compressor startup follows one of two startup programs until the target rotation speed is reached. Refer to Figure 3-3.1, Figure 3-3.2.

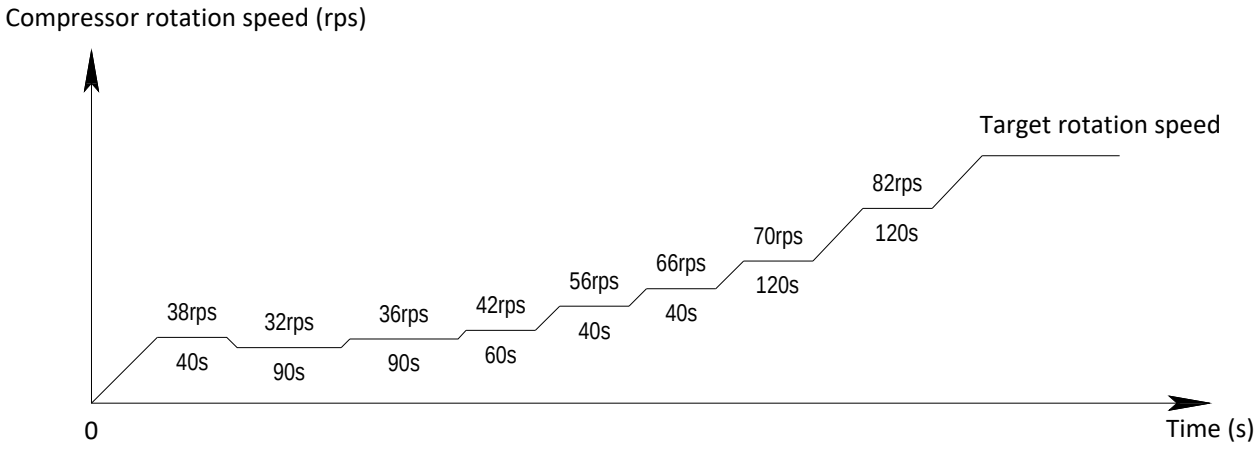
Figure 3-3.1: MHA-V4(6, 8,10)W/D2N8 compressor startup program[1] when ambient temperature is above 3°C



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: MHA-V4(6, 8,10)W/D2N8 compressor startup program[1] when ambient temperature is at or below 3°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.

3.3 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	4-10kW	Control functions and states
Inverter compressor	COMP	●	Compressor startup program selected according to ambient temperature[1]
DC fan motor	FAN	●	Fan run at maximum speed[2]
Electronic expansion valve	EXV	●	Position (steps) from 0 (fully closed) to 480 (fully open), controlled according to outdoor ambient temperature, discharge temperature, suction superheat, compressor speed and refrigerant system pressure
Four-way valve	4-WAY	●	On

Notes:
1. Refer to Figure 3-3.1, Figure 3-3.2 in Part 3, 3.2 “Compressor Startup Program”.
2. Refer to Table 3-4.1 in Part 3, 4.6 “Outdoor Fan Control”.

3.4 Startup Control for Cooling Operation

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

Component	Wiring diagram label	4-10kW	Control functions and states
Inverter compressor	COMP	●	Compressor startup program selected according to ambient temperature[1]
DC fan motor	FAN	●	Fan run at maximum speed[2]
Electronic expansion valve	EXV	●	Position (steps) from 0 (fully closed) to 480 (fully open), controlled according to outdoor ambient temperature, discharge temperature, suction superheat, compressor speed and refrigerant system pressure
Four-way valve	4-WAY	●	Off

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	4-10kW	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 outdoor ambient temperature, discharge temperature, suction superheat, compressor speed and refrigerant system pressure
Four-way valve	4-WAY	●	On

Table 3-4.2: Component control during cooling operation

Component	Wiring diagram label	4-10kW	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 outdoor ambient temperature, discharge temperature, suction superheat, compressor speed and refrigerant system pressure
Four-way valve	4-WAY	•	Off

4.2 Compressor Output Control

The compressor rotation speed is controlled according to the load requirement. Before compressor startup, the M-Thermal Split outdoor 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. Refer to Part 3, 3.2 “Compressor Startup Program”. Once the startup program is complete, the compressor runs at the target rotation speed. During operation the compressor speed is controlled according to the rate of change in water temperature, the refrigerant system pressure and the refrigerant temperature.

4.3 Compressor Step Control

The running speed of six-pole compressors (used on 4-10kW models) 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 Figures 2-3.1 and 2-3.2 in Part 2, 3 “Refrigerant Flow Diagrams”.

During heating and DHW operations, the four-way valve is on; during cooling and defrosting operations, the four-way valve is off.

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:
  - The EXV first closes fully, then moves to the standby position (480 (steps)). After compressor runs at 38Hz for 40 seconds the EXV moves to an initial running position, which is determined according to outdoor ambient temperature. After a further 180 seconds, the EXV is controlled according to suction superheat and discharge temperature. Once a further 6 minutes have elapsed, the EXV is then controlled according to suction superheat, discharge temperature and compressor speed.
- When the outdoor unit is in standby:
  - The EXV is at position 480 (steps).
- When the outdoor unit stops:
  - The EXV first moves to 478 (steps) and remains for 30 seconds, then closes fully, then moves to the standby position (480 (steps)).

4.6 Outdoor Fan Control

The speed of the outdoor unit fan is adjusted in steps, as shown in Table 3-4.1.

Table 3-4.1: Component control during cooling operation

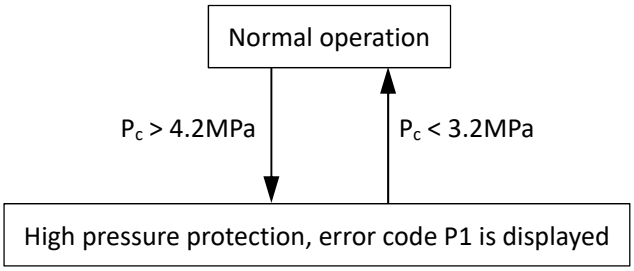
Fan speed index	Fan speed (rpm)			
	4kW	6kW	8kW	10kW
W1	300	300	300	300
W2	340	340	340	340
W3	400	400	400	400
W4	450	450	450	450
W5	520	520	520	520
W6	580	580	580	580
W7	630	630	630	630
W8	680	680	680	680
W9	730	730	730	730

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.

Figure 3-5.1: High pressure protection control



Notes:

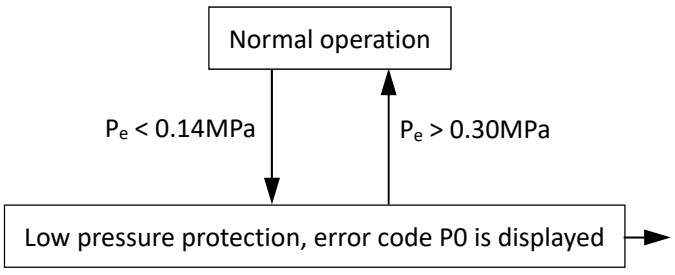
1. P_c: Discharge pressure

When the discharge pressure rises above 4.2MPa the system displays P1 protection and the unit stops running. When the discharge pressure drops below 3.2MPa, the compressor enters re-start control.

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.

Figure 3-5.2: Low pressure protection control



Notes:

1. P_e: Suction pressure

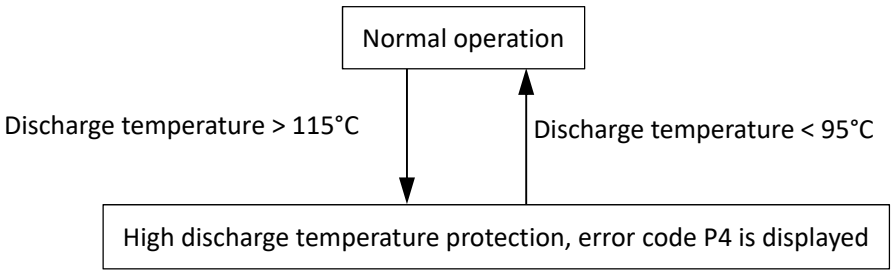
When P0 protection occurs 3 times in 60 minutes, the HP error is displayed. When an HP error occurs, a manual system restart is required before the system can resume operation.

When the suction pressure drops below 0.14MPa the system displays P0 protection and the unit stops running. When the suction pressure rises above 0.3MPa, the compressor enters re-start control.

5.3 Discharge Temperature Protection Control

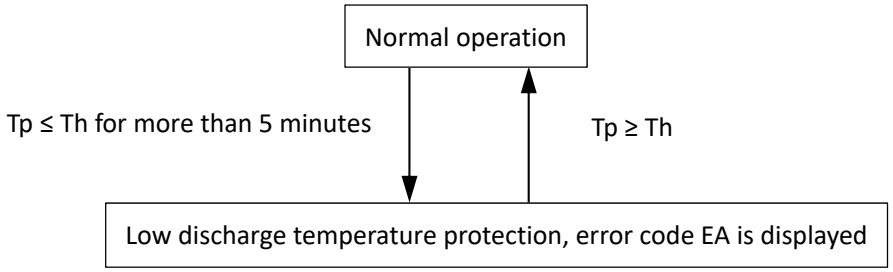
This control protects the compressor from abnormally high temperatures and transient spikes in temperature.

Figure 3-5.3: High discharge temperature protection control



When the discharge temperature rises above 115°C the system displays P4 protection and the unit stops running. When the discharge temperature drops below 95°C, the compressor enters re-start control.

Figure 3-5.4: Low discharge temperature protection control



When the discharge temperature(Tp) is below sunction temperature(Th) for more than 5 minutes after compressor operates for 15 minutes, the system displays EA protection and the unit stops running. When the discharge temperature rises to 27°C or higher, the compressor enters re-start control.

5.4 Compressor Current Protection Control

This control protects the compressor from abnormally high currents.

Figure 3-5.5: Compressor current protection control

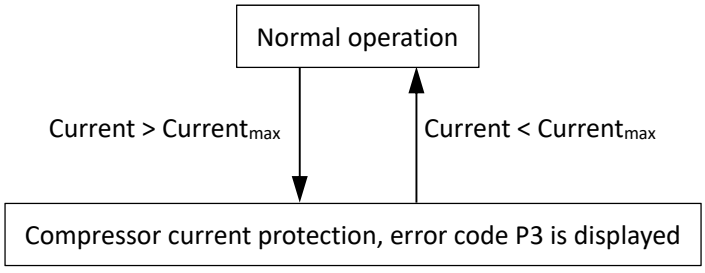


Table 3-5.1: Current limitation for compressors

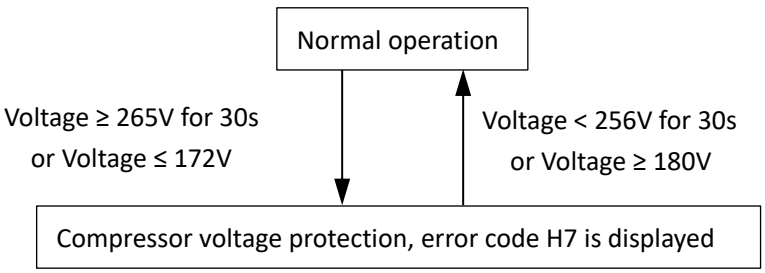
Model name	MHA-V4(6)W/D2N8	MHA-V8(10)W/D2N8
Compressor model	SVB172FNPMC-L	SVB220FLGMC-L
Current$_{max}$	18A	19A

When the compressor current rises above Current$_{max}$ the system displays P3 protection and the unit stops running. When the compressor current drops below Current$_{max}$, the compressor enters re-start control.

5.5 Voltage Protection Control

This control protects the M-Thermal Split from abnormally high or abnormally low voltages.

Figure 3-5.6: Compressor voltage protection control



When the phase voltage of AC power supply is at or above 265V for more than 30 seconds, the system displays H7 protection and the unit stops running. When the phase voltage drops below 265V for more than 30 seconds, the refrigerant system restarts once the compressor re-start delay has elapsed. When the phase voltage is below 172V, the system displays H7 protection and the unit stops running. When the AC voltage rises to more than 180V, the refrigerant system restarts once the compressor re-start delay has elapsed.

5.6 DC Fan Motor Protection Control

This control protects the DC fan motors from strong winds and abnormal power supply. DC fan motor protection occurs when any one of the following the following three sets of conditions are met:

- Outdoor ambient temperature is at or above 4°C and actual fan speed differs from target fan speed by 200rpm or more for more than 3 minutes.
- Outdoor ambient temperature is below 4°C and actual fan speed differs from target fan speed by 300rpm or more for more than 3 minutes.
- Actual fan speed is less than 150rpm for more than 20 seconds.

When DC fan motor protection control occurs the system displays the H6 error code and the unit stops running. After 3 minutes, the unit restarts automatically. When H6 protection occurs 10 times in 120 minutes, the HH error is displayed. When an HH error occurs, a manual system restart is required before the system can resume operation.

5.7 Water Side Heat Exchanger Anti-freeze Protection Control

This control protects the water side heat exchanger from ice formation. The water side heat exchanger electric heater is controlled according to outdoor ambient temperature, water side heat exchanger water inlet temperature and water side heat exchanger water outlet temperature.

In cooling mode, if inlet water temperature or leaving water temperature or auxiliary heat source leaving water temperature is below 4°C, the anti-freeze protection actions. In heating/DHW mode, if ambient temperature is below 3°C and inlet water temperature or leaving water temperature or auxiliary heat source leaving water temperature is below 5°C, the anti-freeze protection actions. In heating/DHW mode, leaving water temperature is below 2°C, the anti-freeze protection actions.

When water side heat exchanger anti-freeze protection occurs the system displays error code Pb and the unit stops running.

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. When the oil return operation is being conducted, the outdoor unit refrigerant system main PCB displays code d0.

The oil return operation starts when the following condition occurs:

- When the compressor cumulative operating time with running rotation speed less than 42rps reaches 6 hours.

The oil return operation ceases when any one of the following three conditions occurs:

- Oil return operation duration reaches 5 minutes.
- Compressor stops.

Tables 3-6.1 show component control during oil return operation in cooling mode.

Component	Wiring diagram label	4-10kW	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	●	304 (steps)
Four-way valve	4-WAY	●	Off

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

Component	Wiring diagram label	4-10kW	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	●	304 (steps)
Four-way valve	4-WAY	●	On

6.2 Defrosting Operation

In order to recover heating capacity, the defrosting operation is conducted when the outdoor unit air side heat exchanger is performing as a condenser. The defrosting operation is controlled according to outdoor ambient temperature, air side heat exchanger refrigerant outlet temperature and the compressor running time.

Table 3-6.3: Component control during defrosting operation

Component	Wiring diagram label	4-10kW	Control functions and states
Inverter compressor	COMP	●	Runs at defrosting operation rotation speed
DC fan motor	FAN	●	Off
Electronic expansion valve	EXV	●	Fully open
Four-way valve	4-WAY	●	Off

6.3 Force Cooling Operation

The force cooling operation helps the refrigerant recovering before removal the water side heat exchanger.

The force cool mode can be ended by pushing the button on the outdoor refrigerant system main PCB named “force-cool” for 5s or this mode will be ended automatic if the system has operated force cool mode for more than 30 minutes.

Table 3-6.4: Component control during force cool operation

Component	Wiring diagram label	4-10kW	Control functions and states
Inverter compressor	COMP	•	Runs at force cooling operation rotation speed
DC fan motor	FAN	•	Runs at force cooling operation speed
Electronic expansion valve	EXV	•	304 (steps)
Four-way valve	4-WAY	•	Off

6.4 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. Refer to the M-Thermal Split Engineering Data Book Part 3, 8.4 “DHW MODE SETTING Menu”.

Table 3-6.5: Component control during fast DHW operation

Component	Wiring diagram label	4-10kW	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 superheat
Four-way valve	4-WAY	•	On
Tank electric heater	TBH	•	On

6.5 Two zones control[1]

Two zones control function is used to control temperature of each zone separately, thus different type radiator will operate at its optimal temperature and water pump cycle time will be reduced to save energy.

In two zones control for cooling mode, when the setting temperature of a certain zones is reached, the zone and water pump of this zone will turn off.

In two zones control for heating mode, the on/off control of zone and water pump is same with cooling mode, but in addition, the mixing valve (3-way valve SV3) control function will be activated to adjust the water temperature of the low temperature zone by control the opening time and closing time of the valve. The mixing valve will only turn on when two zones control for heating is activated. On other conditions, the mixing valve will keep off.

When the valve initially turns on, the opening time and closing time is same and then the time is controlled according to the difference between water pipe temperature and setting water temperature of the controlling zone.

Note:

1. *M-Thermal units just have the controlling function, while the mixing valve, water pump of each zone need to be field supplied and connect to M-Thermal unit.*

6.6 Smart grid control

Unit adjusts the operation according to different electrical signals to realize energy saving.

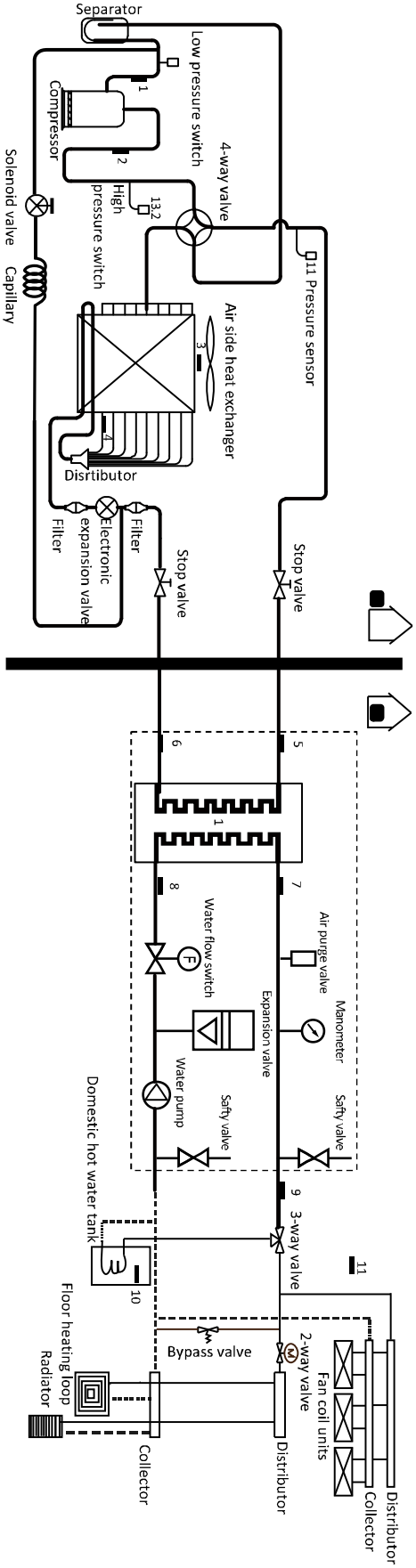
Free electric energy signal: DHW mode turn on, the setting temperature will be changed to 70℃ automatically, and the TBH operate as below:T5<69. the TBH is on, T5 ≥ 70, the TBH is off. The unit operate in cooling/heating mode as the normal logic.

Common electric energy signal: unit operates according to users' need.

Expensive electric energy signal: only available for cooling or heating mode and user can set the maximum operating time.

7 Role of Temperature Sensors in Control Functions

Figure 3-7.1: Location of the temperature sensors on M-Thermal Split systems



Notes:

1. The names and functions of the temperature sensors labelled 1 to 11 in this figure are detailed in Table 3-7.1.

Table 3-7.1: Names of the temperature sensors

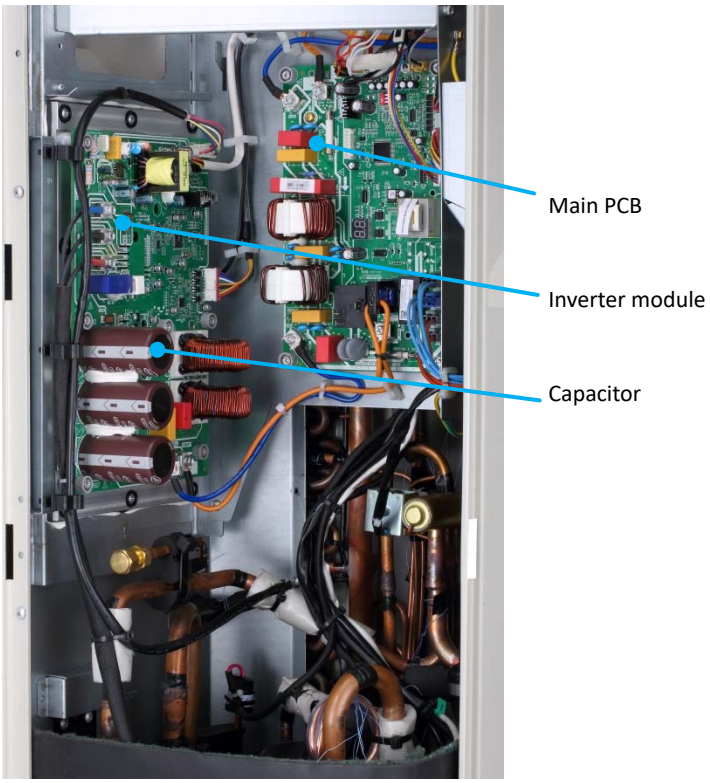
Number	Sensor name	Sensor code
1	Suction pipe temperature sensor	Th
2	Discharge pipe temperature sensor	Tp
3	Outdoor ambient temperature sensor	T4
4	Air side heat exchanger refrigerant outlet temperature sensor	T3
5	Water side heat exchanger refrigerant outlet (gas pipe) temperature sensor	T2B
6	Water side heat exchanger refrigerant outlet (liquid pipe) temperature sensor	T2
7	Water side heat exchanger water outlet temperature sensor	Tw_out
8	Water side heat exchanger water inlet temperature sensor	Tw_in
9	Auxiliary heat source water outlet temperature sensor	T1B
10	Domestic hot water tank temperature sensor	T5
11	Room temperature sensor	Ta

Part 4
Diagnosis and Troubleshooting

1 Electric Control Box Layout

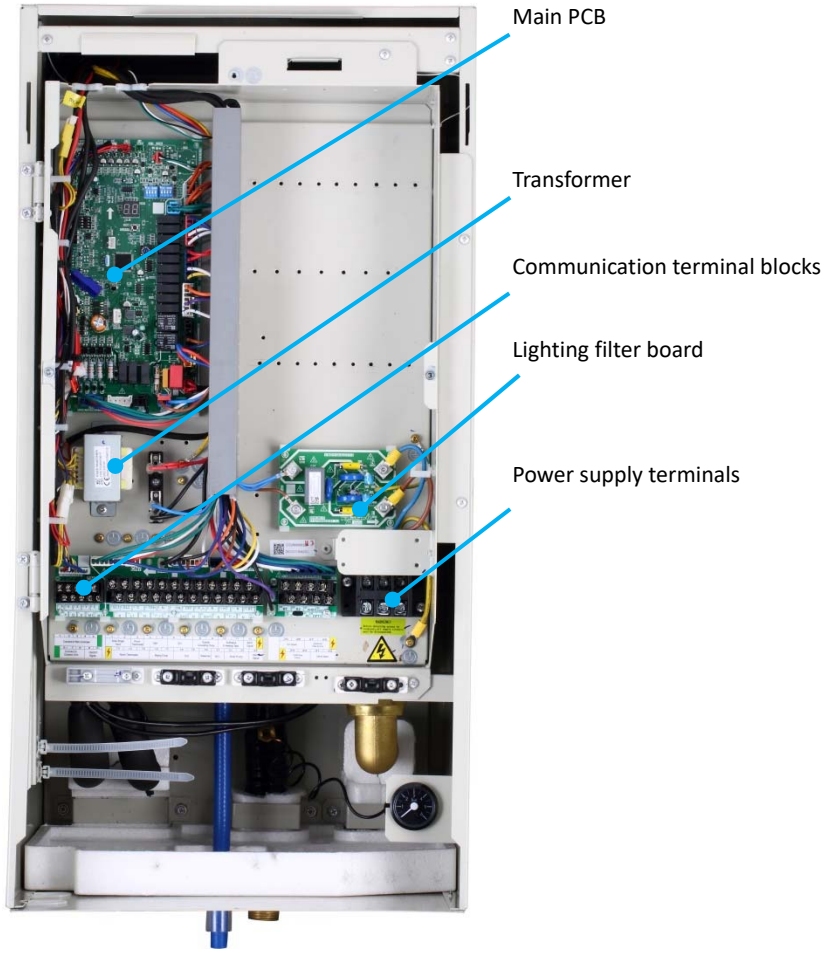
1.1 Outdoor Unit Electric Control Box Layout

Figure 4-1.1: MHA-V4(6, 8, 10)W/D2N8 electric control box



1.2 Hydronic Box Electric Control Box Layout

Figure 4-1.2: SMK-60(80)/CGN8



2 PCBs

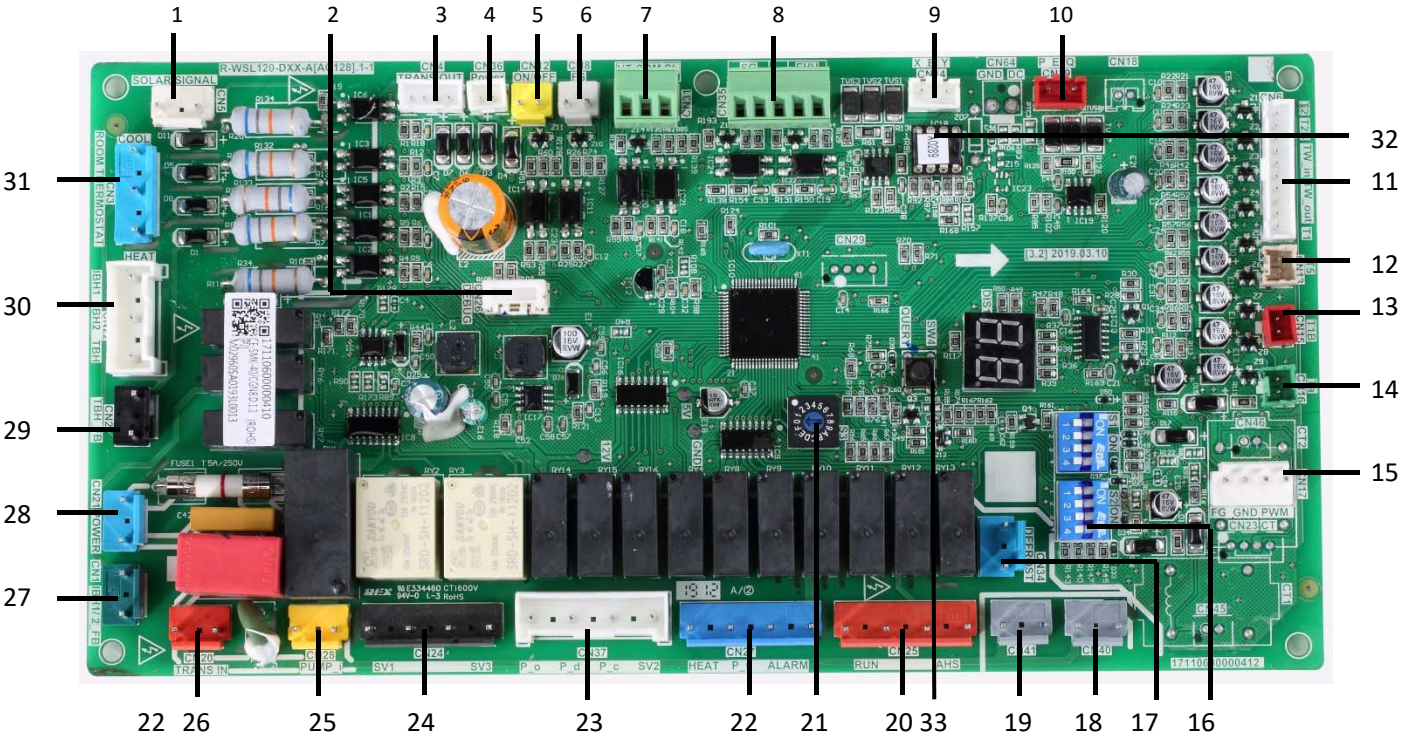
2.1 Outdoor Unit PCBs

There are one type of main PCB for the 4kW to 10kW models. In addition to the main PCB, all models have an inverter module.

The locations of each PCB in the outdoor unit electric control box are shown in Figures 4-1.1 in Part 4, 1.1 “Outdoor Unit Electric Control Box Layout”. The locations of each PCB in the hydronic box electric control box are shown in Figures 4-1.2 in Part 4, 1.2 “Hydronic Box Electric Control Box Layout”.

2.2 Main PCB for Hydronic System

Figure 4-2.1: MHA-V4(6, 8,10)W/D2N8 hydronic box main PCB [1]



Notes:

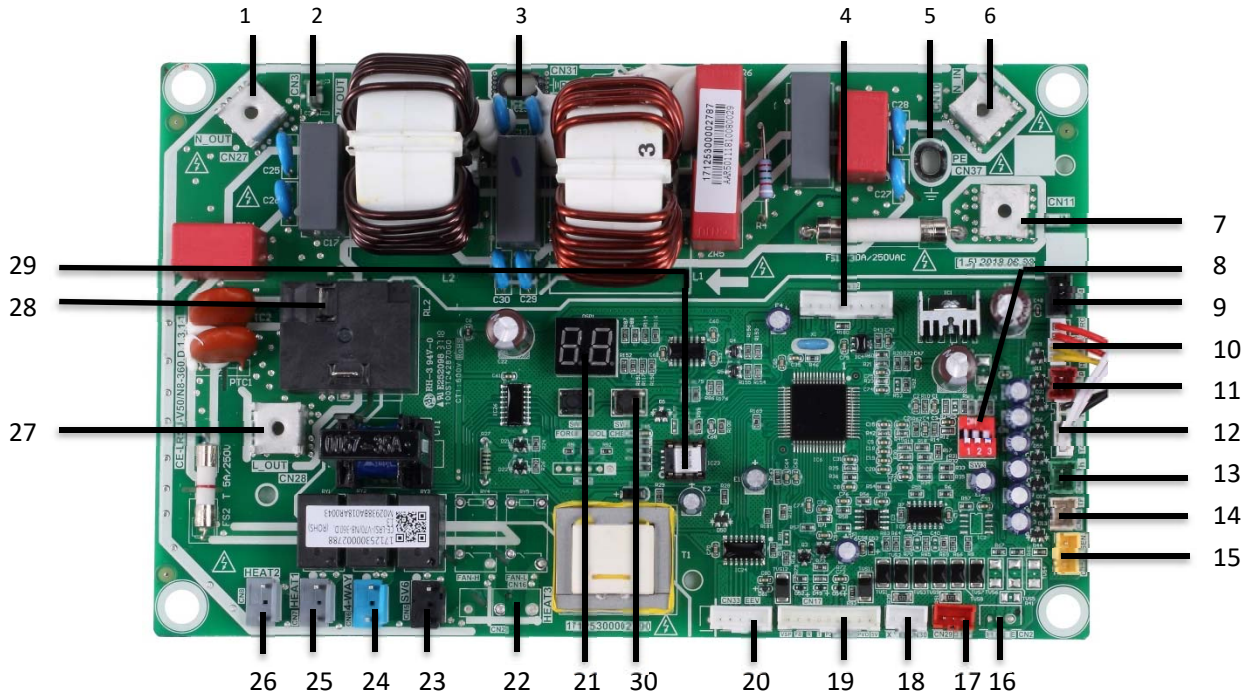
1. Label descriptions are given in Table 4-2.1.

Table 4-2.1: MHA-V4(6, 8,10)W/D2N8 hydronic box main PCB

Label in Figure 4-2.1	Code	Content
1	CN5	Input port for solar energy
2	CN26	Port for IC programming
3	CN4	Output port for transformer
4	CN36	Power supply port for user interface
5	CN12	Port for remote switch
6	CN8	Port for flow switch
7	CN31	Control port for room thermostat(low voltage)
8	CN35	Port for smart grid
9	CN14	Communicate port between indoor PCB and user interface
10	CN19	Communicate port between outdoor unit and indoor unit
11	CN6	Port for temperature sensors(Twout, Twin, T1, T2,T2B)
12	CN13	Port for temperature sensor(T5,Sanitary water temp.)
13	CN15	Port for temperature sensor(T1B, the final outlet temp.)
14	CN16	Port for temperature sensor(Ta, room temp.)
15	CN17	Port for internal pump
16	S1, S2	Dip switch
17	CN34	Output port for deforst
18	CN40	Port for anti-freeze eletric heating tape (internal)
19	CN41	Port for anti-freeze eletric heating tape (internal)
20	CN25	Output port for external heating source /operation output port
21	S3	Rotary dip switch
22	CN27	Port for anti-freeze eletric heating tape(external) /port for solar energy pump/output port for remote alarm
23	CN37	Port for external circulted pump/pipe pump/mix pump/2-way valve
24	CN24	Port for SV1(3-way valve) and SV3
25	CN28	Port for internal pump
26	CN20	Input port for transformer
27	CN1	Feedback port for temperature switch
28	CN21	Port for power supply
29	CN2	Feedback port for external temp. switch(shorted in default)
30	CN22	Control port for backup heater/booster heater
31	CN3	Control port for room thermostat(high voltage)
32	IC18	EEPROM
33	SW4	Check button

2.3 Main PCBs for Refrigerant System, Inverter Module

Figure 4-2.2: MHA-V4(6,8,10)W/D2N8 outdoor unit main PCB for refrigerant system[1]



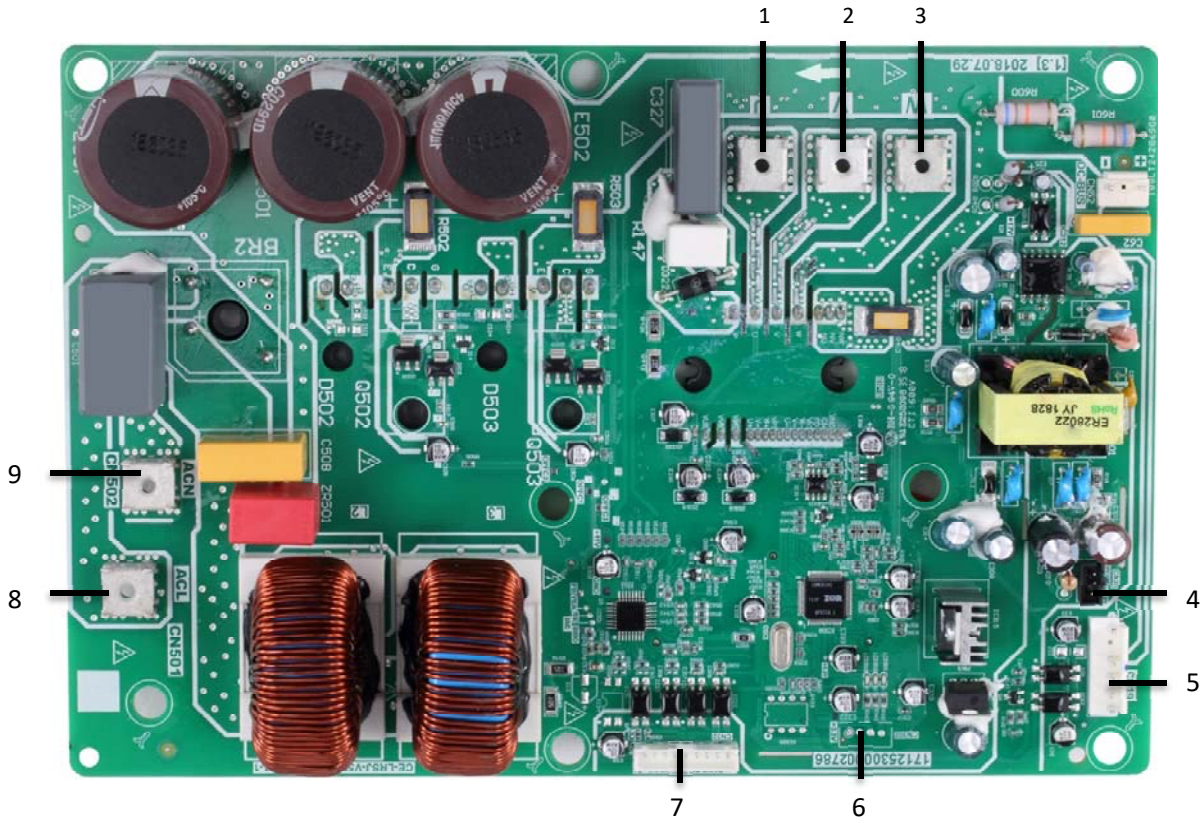
Notes:

1. Label descriptions are given in Table 4-2.2.

Table 4-2.2: MHA-V4(6,8,10)W/D2N8 outdoor unit main PCB for refrigerant system

Label in Figure 4-2.2	Code	Content
1	CN27	Output port N for invert module PCB
2	CN3	Output port N for hydro-box control board
3	CN31	Port for ground wire
4	CN32	Port for IC programming
5	CN37	Port for ground wire
6	CN10	Input port for neutral wire
7	CN11	Input port for live wire
8	SW3	DIP switch
9	CN24	Input port for +12V/5V
10	CN13	Port for low pressure switch and high pressure switch
11	CN8	Port for Tp temp. sensor
12	CN9	Port for outdoor ambient temp. sensor and condenser temp. sensor
13	CN1	Port for Th temp. sensor
14	CN14	Port for TF temp. sensor
15	CN4	Port for pressure sensor
16	CN2	Reserved
17	CN29	Port for communication with hydro-box control board
18	CN30	Reserved
19	CN17	Port for communication with invert module PCB
20	CN33	Port for electrical expansion value
21	DSP1	Digital display
22	CN6	Port for chassis electrical heating tape
23	CN5	Port for SV6 value
24	CN6	Port for 4-way value
25	CN7	Port for compressor electric heating tape1
26	CN8	Port for compressor electric heating tape2
27	CN28	Output port L for invert module PCB
28	RL2	Output port L for hydro-box control board
29	IC23	EEPROM
30	SW2	Check button

Figure 4-2.3: MHA-V4(6,8,10)W/D2N8 outdoor unit inverter module[1]



Notes:

1. Label descriptions are given in Table 4-2.3.

Table 4-2.3: MHA-V4(6,8,10)W/D2N8 outdoor unit inverter module

Label in Figure 4-2.3	Code	Content
1	U	Compressor connection port U
2	V	Compressor connection port V
3	W	Compressor connection port W
4	CN20	Output port for +12V/9.9V(CN20)
5	CN19	Port for fan
6	CN302	Reserved
7	CN32	Port for communication with PCB for refrigerant system
8	CN501	Input port L for rectifier bridge
9	CN502	Input port N for rectifier bridge

2.4 Check Buttons

2.4.1 Refrigerant system SW2 check button

Button SW2 is used to check the parameters of the refrigerant system. Refer to Table 4-2.2 First, press Button SW2 for 3 seconds and the first parameter (operating mode) will be displayed. Then, on each subsequent press, the next parameter is displayed.

Table 4-2.4: SW2 system check

Number	Parameters displayed on digital display	Remarks
1	Mode	0: standby; 2: cooling; 3: heating; 4 forced cooling.
2	Fan speed	The fan speed index is related to the fan speed in rpm as described in Table 3-4.1 in Part 3, 4.6 "Outdoor Fan Control".
3	Capacity requirements	Compressor frequency
4	Capacity requirements(Correct)	Compressor frequency
5	Frequency limit code	0: Without restriction 1: Compressor frequency restriction by outdoor ambient temperature 2: Compressor frequency restriction by condenser temperature 3: Compressor frequency restriction by actual current 4: Compressor frequency restriction by voltage AC 5: Compressor frequency restriction by radiator temperature 6: Compressor frequency restriction by Discharge temperature 7: Compressor frequency restriction by pressure
6	T3: Condenser temperature (°C)	▪ When no decimal point is displayed: Temperature is ≥ -9°C Actual value = value displayed ▪ When decimal point is displayed between the two digits: Temperature is ≤ -10°C Actual value = value displayed x -10 Example: "1.2" indicates -12°C
7	T4: Outdoor ambient temperature (°C)	
8	Tp: Discharge temperature (°C)	When the temperature < 100 °C, actual value = value displayed. When the temperature ⩾ 100 °C, actual value = value displayed × 10
9	Th: Suction temperature (°C)	▪ When no decimal point is displayed: Temperature is ≥ -9°C Actual value = value displayed ▪ When decimal point is displayed between the two digits: Temperature is ≤ -10°C Actual value = value displayed x -10 Example: "1.2" indicates -12°C
10	TF: Radiator temperature (°C)	Actual value = value displayed
11	Electric Expansive Valve	Steps = value displayed × 8
12	Actual current	Actual value = value displayed
13	Compressor current	Actual value = value displayed
14	Voltage AC	Actual value = value displayed × 10
15	Voltage DC	Actual value = value displayed × 10
16	Pressure	Actual value = value displayed
17	Software version	Version number
18	Last fault	"nn" is displayed if no error or protection events have occurred since start-up
19	--	

2.4.2 Hydronic system SW4 check button

Button SW4 is used to check the parameters of the hydronic system. Refer to Table 4-2.1. First, press Button SW4 for 3 seconds and the first parameter (operating mode) will be displayed. Then, on each subsequent press, the next parameter is displayed.

Table 4-2.5: SW4 system check

Number	Parameters displayed on digital display	Remarks
1	Mode	0: off; 2: cooling; 3: heating; 5: DHW.
2	Capacity Requirements	Actual value = value displayed
3	Capacity Requirements (Correct)	Actual value = value displayed
4	T1: Backup electric heater exchanger water outlet temperature	▪ When no decimal point is displayed: Temperature is ≥ -9°C, Actual value = value displayed ▪ When decimal point is displayed between the two digits: Temperature is ≤ -10°C, Actual value = value displayed x -10 Example: "1.2" indicates -12°C
5	T1B: Leaving water temperature of region 2	
6	T1S: Target leaving water temperature of region 1 calculated from climate-related curves (°C)	Actual value = value displayed
7	T1S2: Target leaving water temperature of region 2 calculated from climate-related curves (°C)	Actual value = value displayed
8	Ta: Room temperature (°C)	Actual value = value displayed (If Ta is used)
9	T5: DHW tank temperature (°C)	▪ When no decimal point is displayed: Temperature is ≥ -9°C, Actual value = value displayed ▪ When decimal point is displayed between the two digits: Temperature is ≤ -10°C, Actual value = value displayed x -10 Example: "1.2" indicates -12°C
10	T2: Water side heat exchanger refrigerant inlet (liquid pipe) temperature	
11	T2B: Water side heat exchanger refrigerant outlet (gas pipe) temperature	
12	Tw_out: Water side heat exchanger water outlet temperature (°C)	
13	Tw_in: Water side heat exchanger water inlet temperature (°C)	
14	T4: Outdoor ambient temperature (°C)	
15	Current (Reserved)	--
16	Current (Reserved)	--
17	Last failure	"--" is displayed if no error or protection events have occurred since start-up
18	Last second failure	"--" is displayed if no error or protection events have occurred since start-up
19	Last third failure	"--" is displayed if no error or protection events have occurred since start-up
20	Software version	Version number
21	--	

2.4.3 Digital Display Output

Table 4-2.6: Digital display output in different operating states

M-Thermal Split system state	Parameters displayed on outdoor unit main PCB DSP1	Parameters displayed on hydronic box main PCB DSP1	
On standby	0	0	
Normal operation	Running speed of the compressor in rotations per second	Leaving water temperature (°C)	
Error or protection	Error or protection code	Error or protection code	
System check	Refer to Table 4-2.4	Refer to Table 4-2.5	

2.5 DIP switch setting and wire connecting for 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 4-2.4: Rotating switch

Figure 4-2.5: Connection

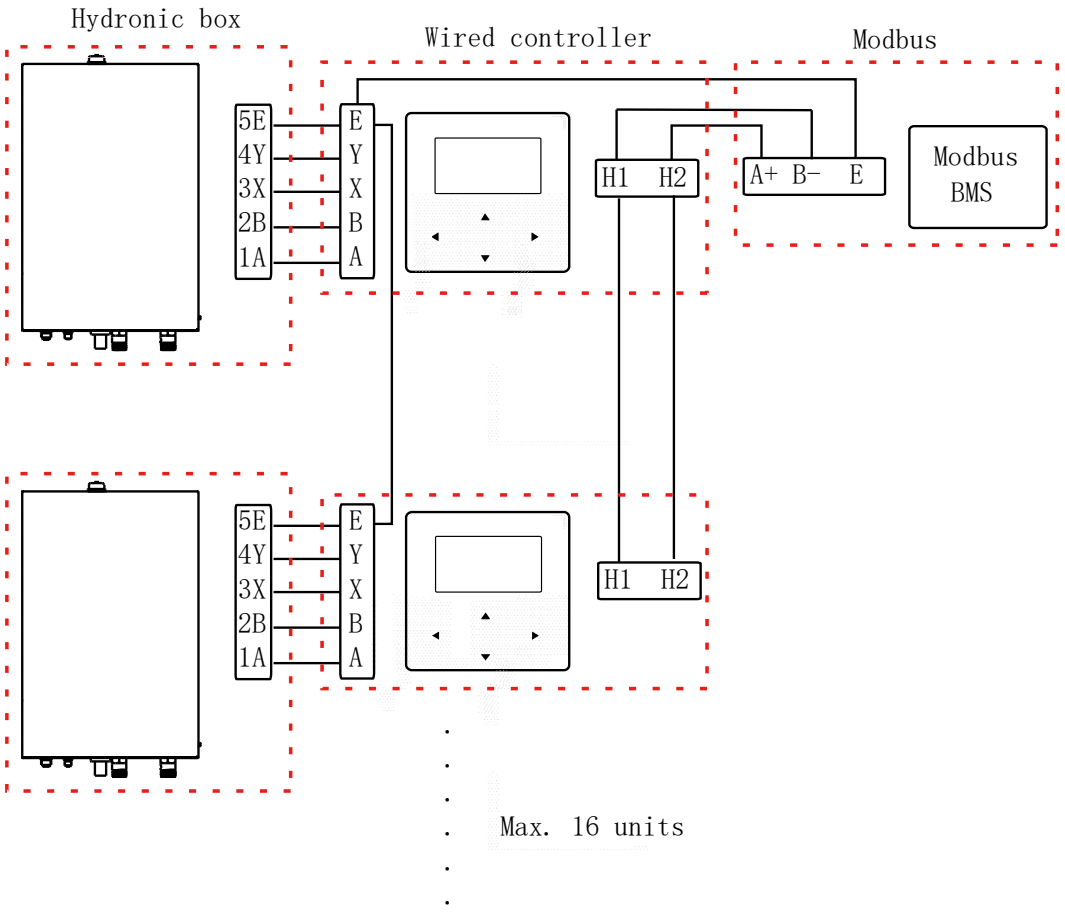
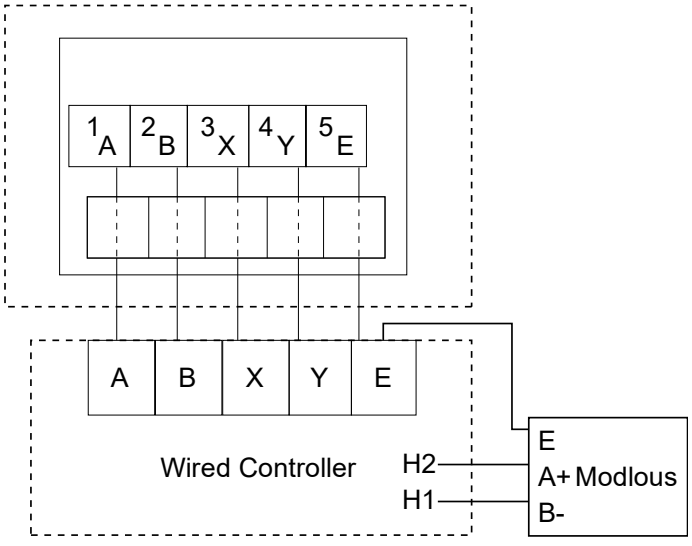


Figure 4-2.6: Wiring



Input Voltage(A/B)	13.5VAC
Wiring size	0.75mm²

3 Error Code Table

Table 4-3.1: Error code table

Error code	Serial Number[1]	Content[2]	Displayed on	Remarks
C7	65	Transducer module temperature too high protect	User interface and refrigerant system main PCB	Contact your local dealer
E0, E8	1 9	Water flow failure	User interface and hydronic box main PCB	
E1	2	Phase sequence error	User interface and outdoor unit main PCB	Only applies to 3-phase models
E2	3	Communicatin error between the main control board of hydraulic module and user interface	User interface and hydronic box main PCB	
E3	4	Backup electric heater exchanger water outlet temperature sensor error	User interface and hydronic box main PCB	Sensor T1
E4	5	Domestic hot water tank temperature sensor error	User interface and hydronic box main PCB	Sensor T5
E5	6	Air side heat exchanger refrigerant outlet temperature sensor error	User interface and outdoor unit main PCB	Sensor T3
E6	7	Outdoor ambient temperature sensor error	User interface and outdoor unit main PCB	Sensor T4
E9	10	Suction pipe temperature sensor error	User interface and outdoor unit main PCB	Sensor Th
EA	11	Discharge pipe temperature sensor error	User interface and outdoor unit main PCB	Sensor Tp
Ed	14	Water side heat exchanger water inlet temperature sensor error	User interface and hydronic box main PCB	Sensor Tw_in
EE	15	Hydronic box EEPROM error	User interface and hydronic box main PCB	
F1	116	DC generatrix voltage is too low	User interface and refrigerant system main PCB	
H0	39	Communication error between outdoor unit main control chip and hydronic box main control chip	User interface, outdoor unit main PCB and hydronic box main PCB	
H1	40	Communication error between outdoor unit main control chip and inverter driver chip	User interface and outdoor unit main PCB	
H2	41	Water side heat exchanger refrigerant outlet (gas pipe) temperature sensor error	User interface and hydronic box main PCB	Sensor T2B
H3	42	Water side heat exchanger refrigerant inlet (liquid pipe) temperature sensor error	User interface and hydronic box main PCB	Sensor T2
H5	44	Room temperature sensor error	User interface and hydronic box main PCB	Sensor Ta
H6, HH	45 55	DC fan error	User interface and outdoor unit main PCB	
H7	46	Abnormal main circuit voltage	User interface and outdoor unit main PCB	

Table continued on next page …

Table 4-3.1: Error code table *(continued)*

H8	47	Pressure sensor error	User interface and outdoor unit main PCB	
H9	48	Circuit 2 water outlet temperature sensor error	User interface and hydronic box main PCB	Sensor T1B
HA	49	Water side heat exchanger water outlet temperature sensor error	User interface and hydronic box main PCB	Sensor Tw_out
HF	54	Refrigerant system EEPROM error	User interface and refrigerant system main PCB	
P0, HP	20 57	Low pressure protection	User interface and refrigerant system main PCB	
P1	21	High pressure protection	User interface and refrigerant system main PCB	
P3	23	Compressor current protection	User interface and outdoor unit main PCB	
P4	24	Discharge temperature protection	User interface and outdoor unit main PCB	
P5	25	High temperature difference between water side heat exchanger water inlet and water outlet temperatures protection	User interface and hydronic box main PCB	
P6 H4	26 43	Inverter module protection	User interface	Displayed on user interface when any of L0, L1, L2, L4, L5, L7, L8 or L9 occur
L0	-	Inverter module protection	Outdoor unit main PCB	
L1	-	DC bus low voltage protection	Outdoor unit main PCB	
L2	-	DC bus high voltage protection	Outdoor unit main PCB	
L4	-	MCE error	Outdoor unit main PCB	
L5	-	Zero speed protection	Outdoor unit main PCB	
L7	-	Phase sequence error	Outdoor unit main PCB	
L8	-	Compressor frequency variation greater than 15Hz within one second protection	Outdoor unit main PCB	
L9	-	Actual compressor frequency differs from target frequency by more than 15Hz protection	Outdoor unit main PCB	
Pb	31	Water side heat exchanger anti-freeze	Hydronic box main PCB	
Pd	33	High temperature protection of refrigerant outlet temperature of condenser in cooling mode	User interface and outdoor unit main PCB	
PP Hb	38 50	Water side heat exchanger inlet temperature is higher than outlet temperature in heating mode	User interface and hydronic box main PCB	

Notes:

1. When the error code appears, the error code 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 outdoor 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 E0, E8 Troubleshooting

4.2.1 Digital display output

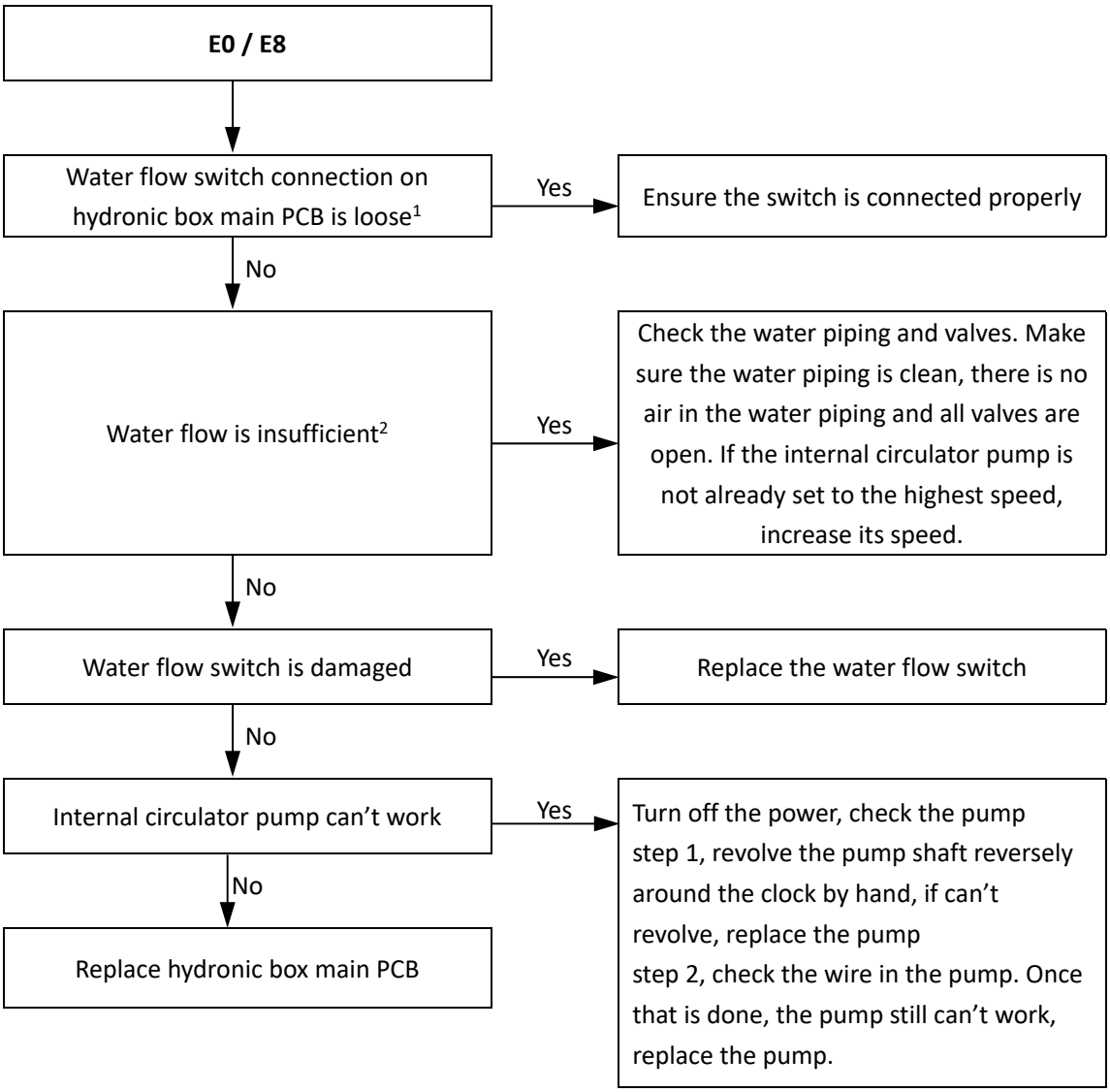

4.2.2 Description

- Water flow failure.
- E0 indicates E8 has displayed 3 times. When an E0 error occurs, a manual system restart is required before the system can resume operation.
- M-Thermal Split stops running.
- Error code is displayed on hydronic box main PCB 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 CN8 on the main PCB for hydronic box (labeled 6 in Figure 4-2.1 in Part4, 2.2 "Main PCB for Hydronic System").
2. Check water pressure on the manometer. If the water pressure is not > 1 bar, water flow is insufficient. Refer to Figure 2-1.6 in Part 2, 1 "Hydronic Box Layout".
3. Revolve the pump shaft reversely around the clock, check the wire in the pump.

4.3 E2 Troubleshooting

4.3.1 Digital display output

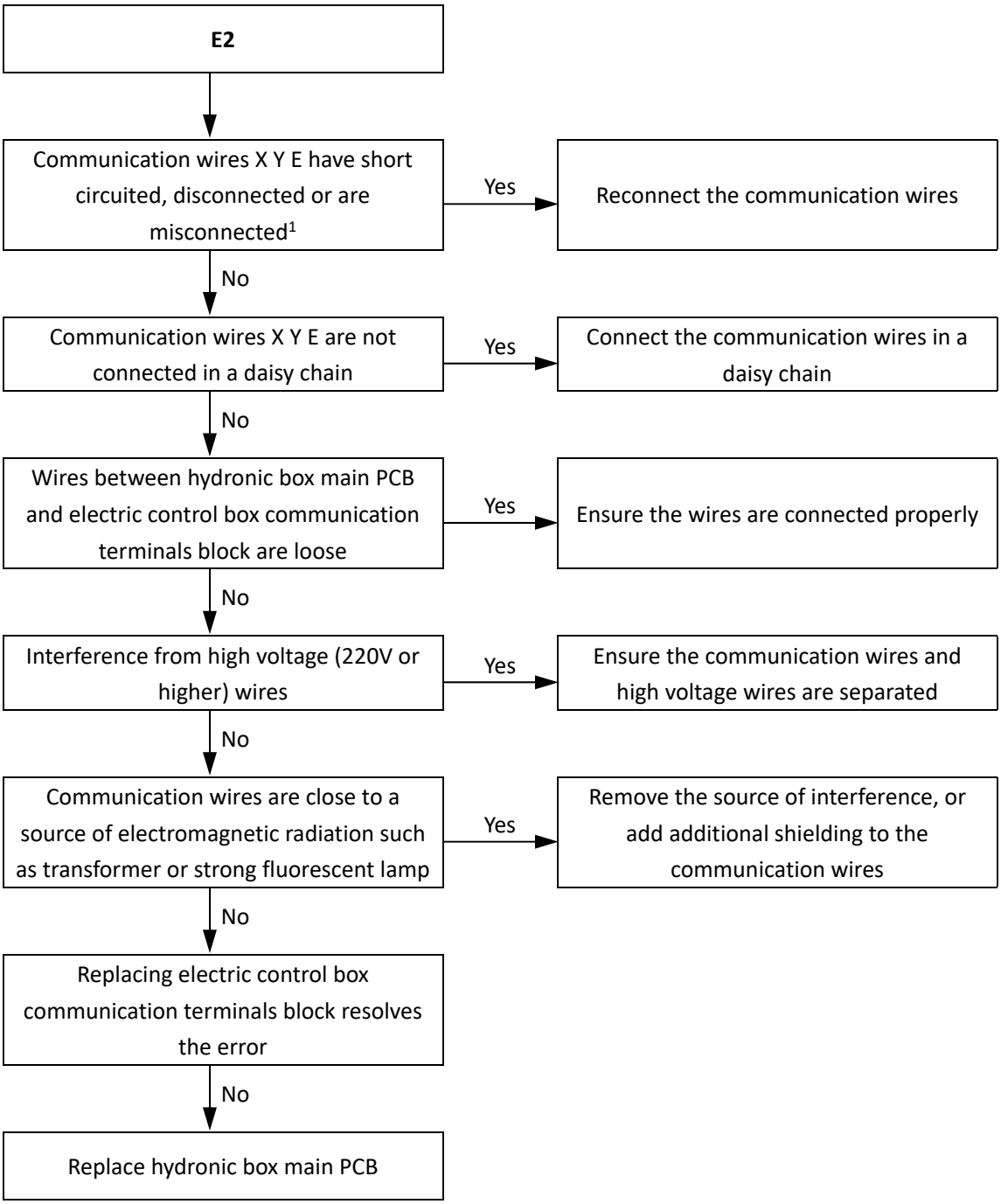
4.3.2 Description

- Communication error between hydronic box and user interface.
- M-Thermal Split stops running.
- Error code is displayed on hydronic box main PCB and user interface.

4.3.3 Possible causes

- Communication wires between hydronic box and user interface not connected properly.
- Communication wiring X Y E terminals misconnected.
- Loosened wiring within electric control box.
- Interference from high voltage wires or other sources of electromagnetic radiation.
- Damaged main PCB or electric control box communication terminals block.

4.3.4 Procedure

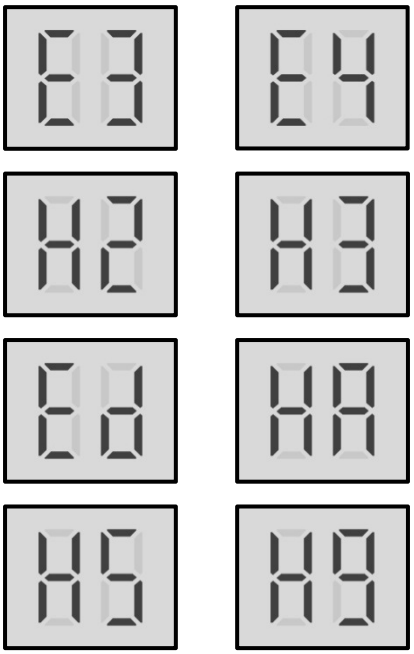


Notes:

1. Measure the resistance among X, Y and E. The normal resistance between P and Q is 120Ω, between P and E is infinite, between Y and E is infinite. Communication wiring has polarity. Ensure that the X wire is connected to X terminals and the Y wire is connected to Y terminals.

4.4 E3, E4, H2, H3, Ed, HA, H5, H9 Troubleshooting

4.4.1 Digital display output



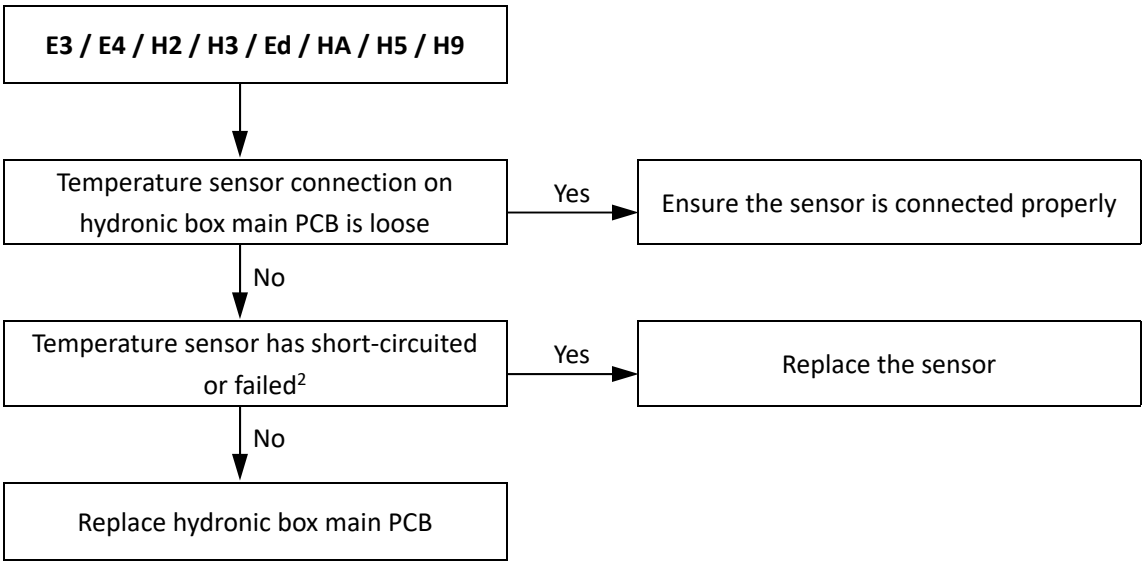
4.4.2 Description

- E3 indicates a backup electric heater water outlet temperature sensor error.
- E4 indicates a domestic hot water tank temperature sensor error.
- H2 indicates a water side heat exchanger refrigerant outlet (gas pipe) temperature sensor error.
- H3 indicates a water side heat exchanger refrigerant inlet (liquid pipe) temperature sensor error.
- Ed indicates a water side heat exchanger water inlet temperature sensor error.
- HA indicates a water side heat exchanger water outlet temperature sensor error.
- H5 indicates a room temperature sensor error.
- H9 indicates a circuit 2 water outlet temperature sensor error.
- M-Thermal Split stops running.
- Error code is displayed on hydronic box main PCB and user interface.

4.4.3 Possible causes

- Temperature sensor not connected properly or has malfunctioned.
- Damaged hydronic box main PCB.

4.4.4 Procedure

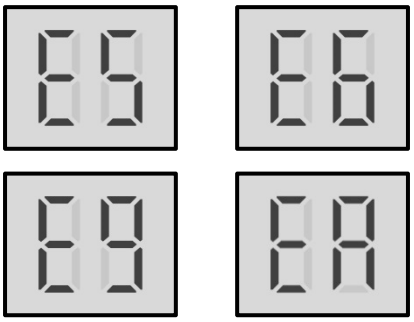


Notes:

1. Backup electric heater water outlet temperature sensor, water side heat exchanger refrigerant inlet (liquid pipe) temperature sensor, water side heat exchanger refrigerant outlet (gas pipe) temperature sensor, water side heat exchanger water inlet temperature sensor and water side heat exchanger water outlet temperature sensor connections are port CN6 on the hydronic box main PCB (labeled 11 in Figure 4-2.1 in Part4, 2.2 "Main PCB for Hydronic System"). Domestic hot water tank temperature sensor connection is port CN13 on the hydronic box main PCB (labeled 12 in Figure 4-2.1 in Part4, 2.2 "Main PCB for Hydronic System"). Circuit 2 water outlet temperature sensor connection is port CN15 on the hydronic box main PCB (labeled 13 in Figure 4-2.1 in Part4, 2.2 "Main PCB for Hydronic System"). Room temperature sensor connection is port CN16 on the hydronic box main PCB (labeled 14 in Figure 4-2.1 in Part4, 2.2 "Main PCB for Hydronic System").
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 or 4-5.3 in Part 4, 5.1 "Temperature Sensor Resistance Characteristics".

4.5 E5, E6, E9, EA Troubleshooting

4.5.1 Digital display output



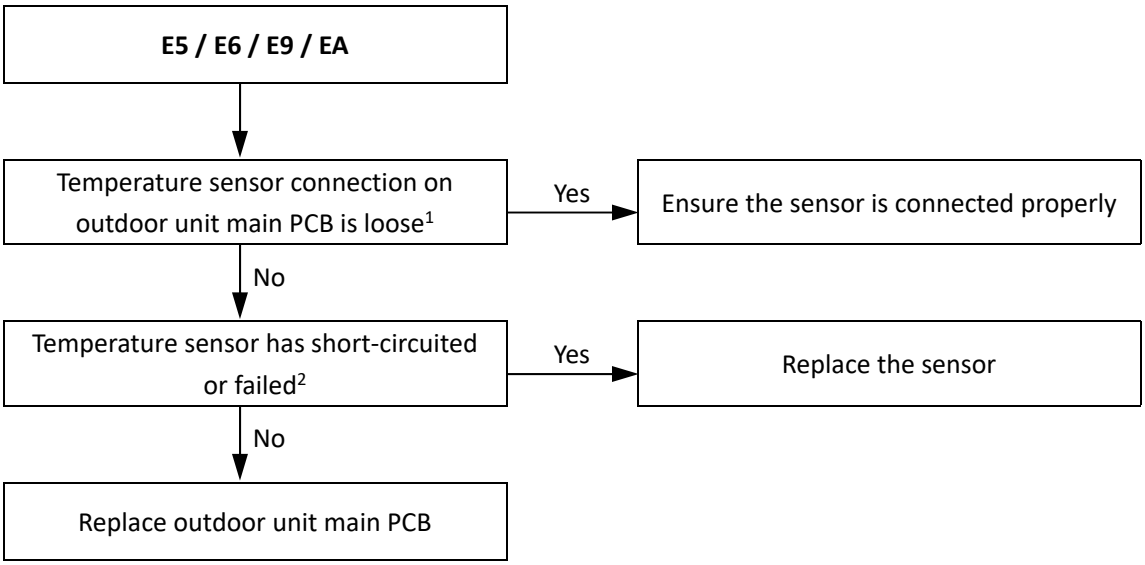
4.5.2 Description

- E5 indicates an air side heat exchanger refrigerant outlet temperature sensor error.
- E6 indicates an outdoor ambient temperature sensor error.
- E9 indicates a suction pipe temperature sensor error.
- EA indicates a discharge temperature sensor error.
- M-Thermal Split stops running.
- Error code is displayed on outdoor unit main PCB and user interface.

4.5.3 Possible causes

- Temperature sensor not connected properly or has malfunctioned.
- Damaged outdoor unit main PCB.

4.5.4 Procedure



Notes:

1. Air side heat exchanger refrigerant outlet temperature sensor and outdoor ambient temperature sensor connections are port CN9 on the outdoor unit main PCB (labeled 12 in Figure 4-2.2 in Part4, 2.3 "Main PCBs for Refrigerant System, Inverter Module". Discharge pipe temperature sensor connection is port CN8 on the refrigerant system main PCBs (labeled 11 in Figure 4-2.2 in Part4, 2.3 "Main PCBs for Refrigerant System, Inverter Module"). Suction pipe temperature sensor connection is port CN1 on the main control board (labeled 13 in Figure 4-2.2 in Part4, 2.3 "Main PCBs for Refrigerant System, Inverter Module").
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 Table 4-5.2 in Part 4, 5.1 "Temperature Sensor Resistance Characteristics".

4.6 EE Troubleshooting

4.6.1 Digital display output

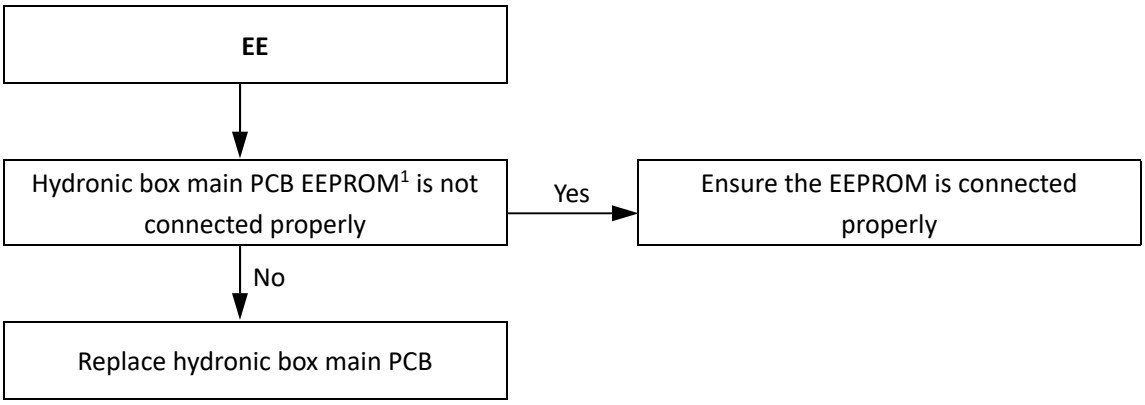
4.6.2 Description

- Hydronic box main PCB EEPROM error.
- M-Thermal Split stops running.
- Error code is displayed on hydronic box main PCB and user interface.

4.6.3 Possible causes

- Hydronic box main PCB EEPROM is not connected properly.
- Hydronic box main PCB damaged.

4.6.4 Procedure



Notes:

1. Hydronic box main PCB EEPROM is designated IC18 on the main PCB for hydronic box (labeled 32 in Figure 4-2.1 in Part4, 2.2 "Main PCB for Hydronic System").

4.7 F1 Troubleshooting

4.7.1 Digital display output

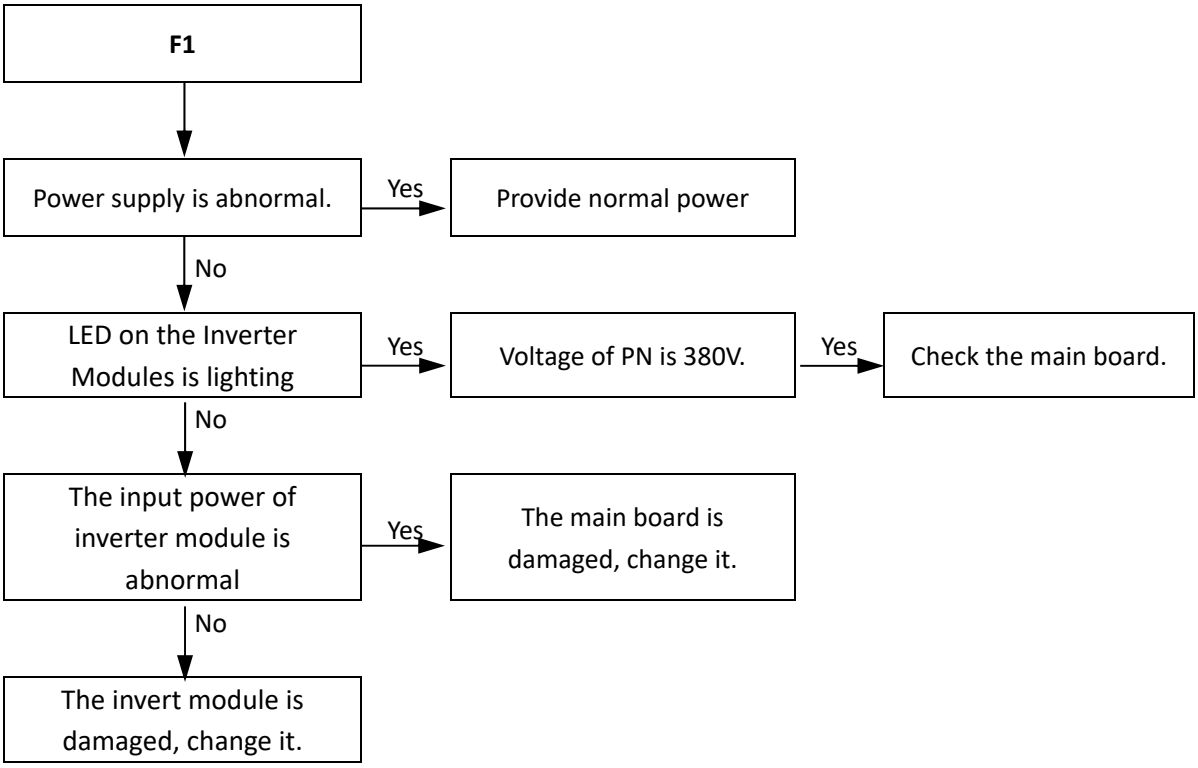
4.7.2 Description

- Low DC generatrix voltage.
- M-Thermal Split stops running.
- Error code is displayed on hydronic system main PCB and user interface.

4.7.3 Possible causes

- The DC generatrix voltage is too low.

4.7.4 Procedure



4.8 HF Troubleshooting

4.8.1 Digital display output

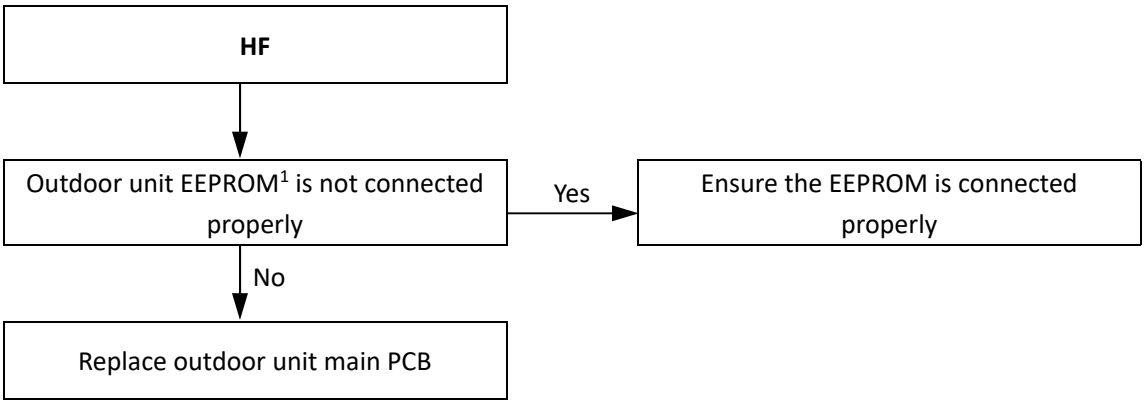
4.8.2 Description

- Outdoor unit main PCB EEPROM error.
- M-Thermal Split stops running.
- Error code is displayed on outdoor unit main PCB and user interface.

4.8.3 Possible causes

- Outdoor unit main PCB EEPROM is not connected properly.
- Outdoor unit main PCB damaged.

4.8.4 Procedure



Notes:

1. Outdoor unit EEPROM is designated IC23 on the outdoor unit main PCB (labeled 29 in Figure 4-2.2 in Part4, 2.3 "Main PCBs for Refrigerant System, Inverter Module").

4.9 H0 Troubleshooting

4.9.1 Digital display output

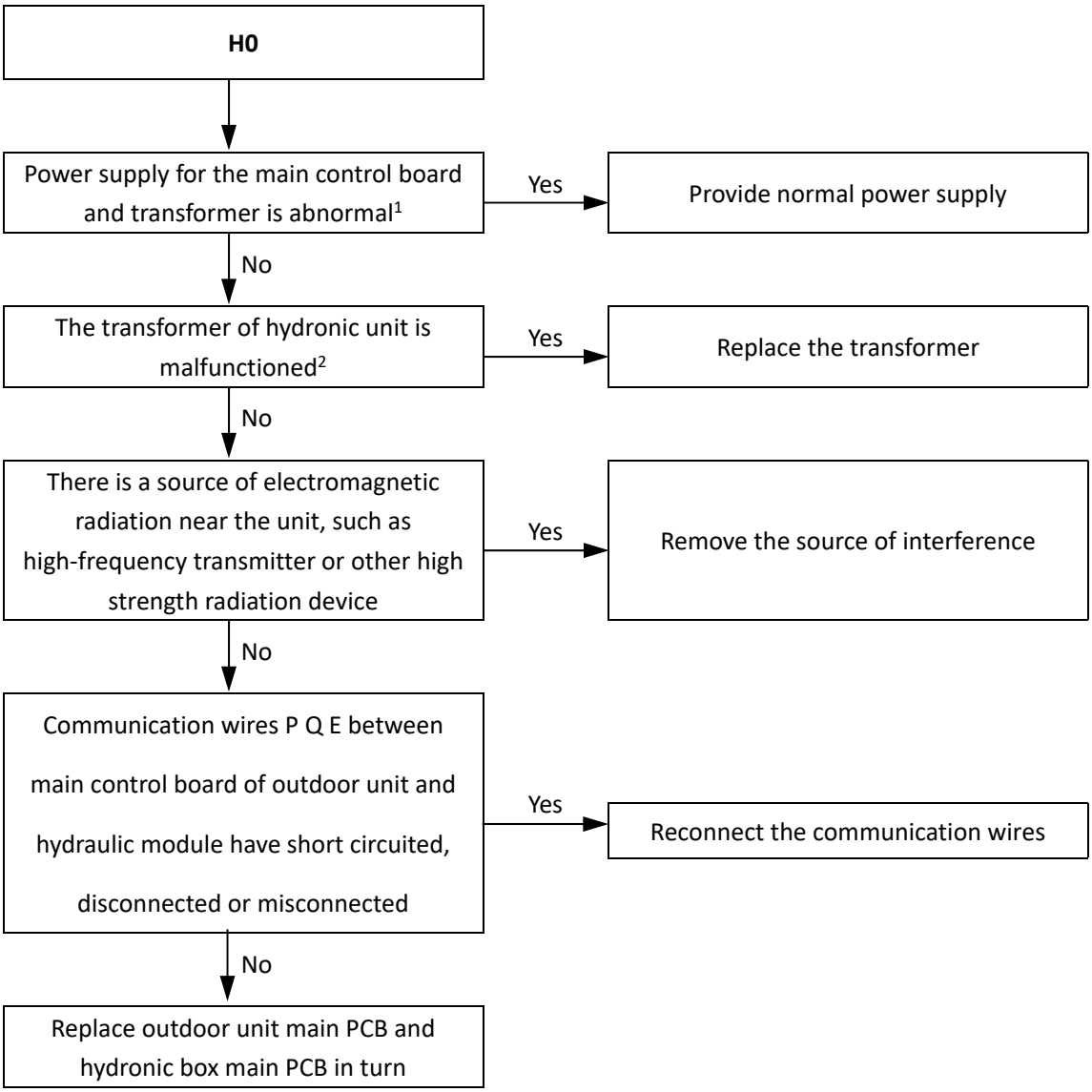
4.9.2 Description

- Communication error between outdoor unit and hydronic box.
- M-Thermal Split stops running.
- Error code is displayed on hydronic box main PCB, outdoor unit main PCB and user interface.

4.9.3 Possible causes

- Power supply abnormal.
- Transformer malfunction.
- Interference from a source of electromagnetic radiation.
- Outdoor unit main PCB or hydronic box main PCB damaged.

4.9.4 Procedure

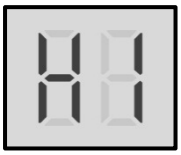


Notes:

1. Measure the voltages of transformer input port and out port. The input voltage of transformer is 220V AC, output voltage of transformer is 13.5V AC. If any voltages is abnormal, the power supply for the main control board of hydraulic module and transformer will be abnormal.
2. Measure the voltages of transformer output port ports. If the voltages are not normal, the transformer has malfunctioned.

4.10 H1 Troubleshooting

4.10.1 Digital display output



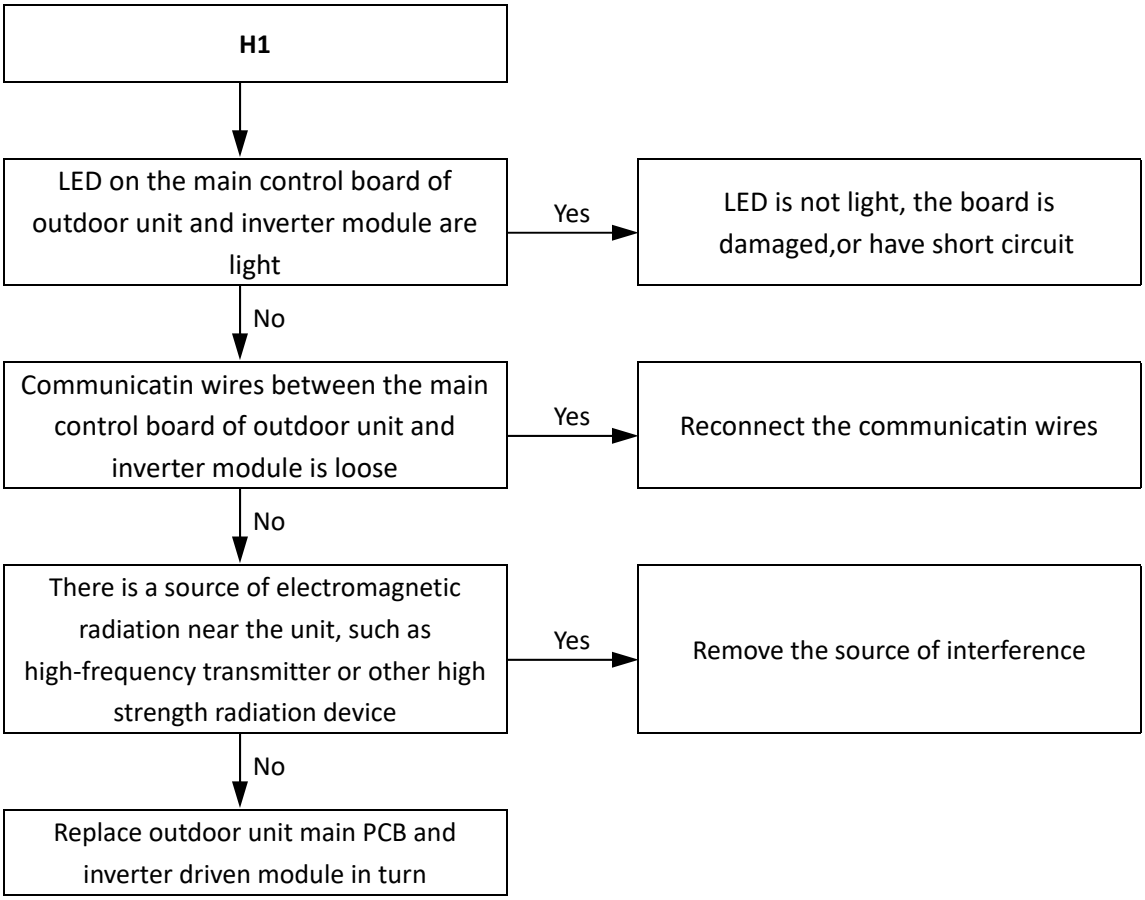
4.10.2 Description

- Communication error between outdoor unit main control board and inverter module.
- M-Thermal Split stops running.
- Error code is displayed on outdoor unit main PCB and user interface.

4.10.3 Possible causes

- Power supply abnormal.
- Interference from a source of electromagnetic radiation.
- Outdoor unit main PCB or inverter driven module damaged.

4.10.4 Procedure



4.11 H6, HH Troubleshooting

4.11.1 Digital display output

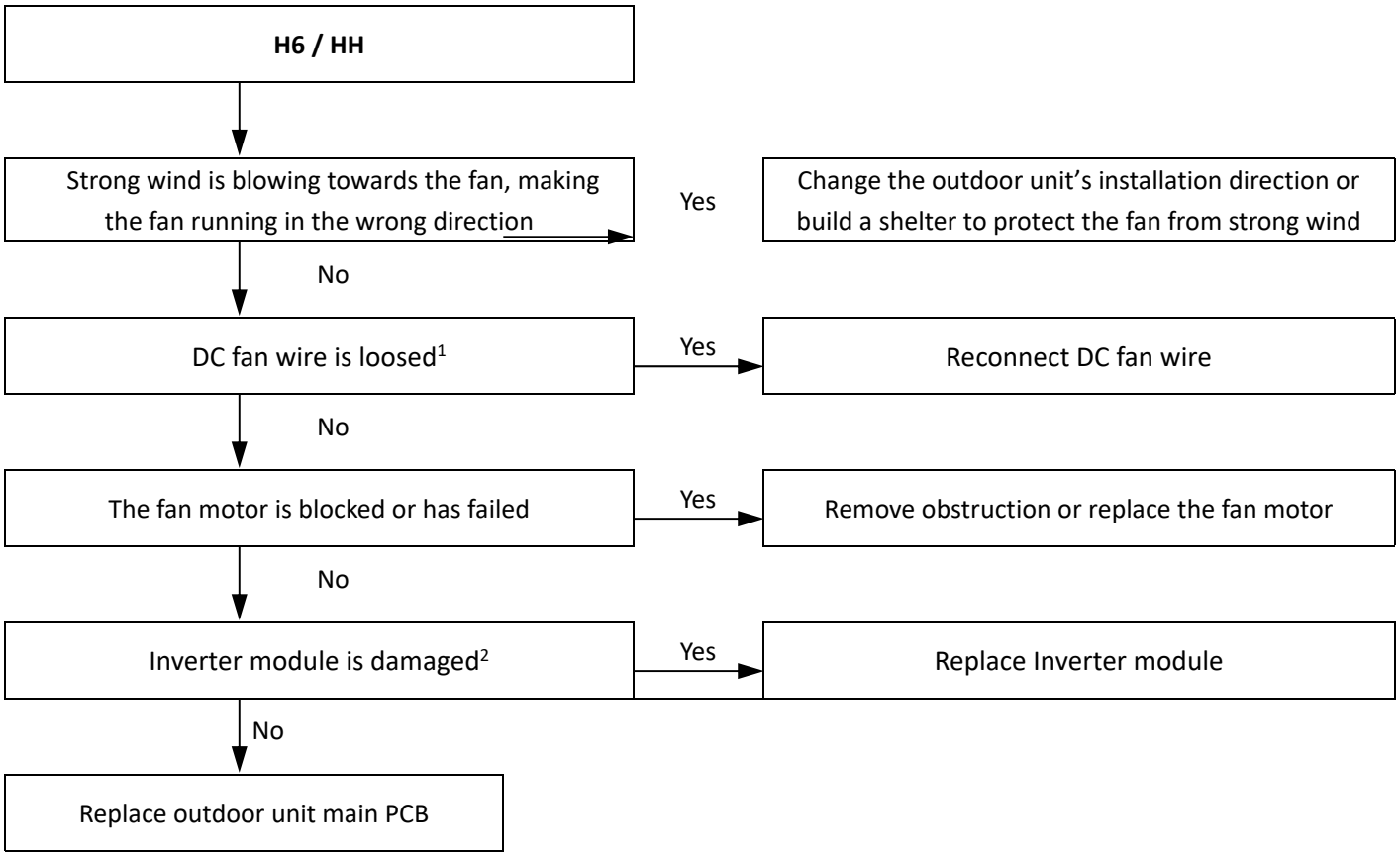

4.11.2 Description

- H6 indicates a DC fan error.
- HH indicates that H6 protection has occurred 10 times in 2 hours. When HH error occurs, a manual system restart is required before the system can resume operation. The cause of HH error should be addressed promptly in order to avoid system damage.
- M-Thermal Split stops running.
- Error code is displayed on outdoor unit main PCB and user interface.

4.11.3 Possible causes

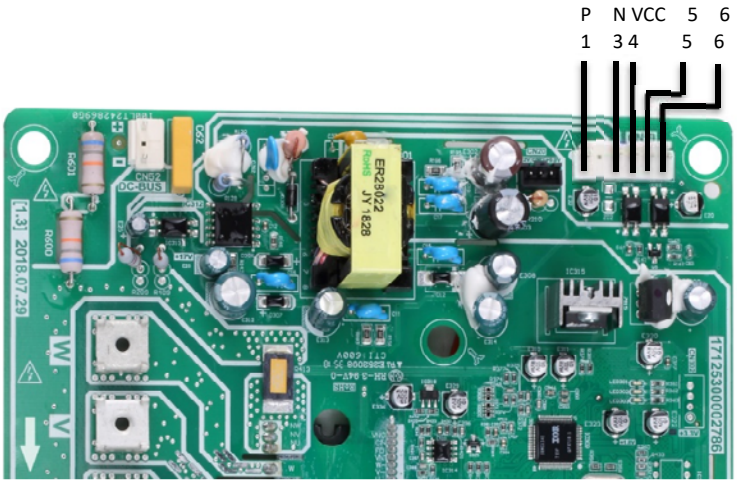
- DC fan wire is loosed.
- High wind speed.
- Fan motor blocked or has failed.
- Invert module damaged.
- Main PCB is damaged.

4.11.4 Procedure



Notes:

1. Refer to Figures 4-1.1 to 4-1.6 in Part 4, 1.1 "Outdoor Unit Electric Control Box Layout" and to the M-Thermal Split Engineering Data Book, Part 2, 5 "Wiring Diagrams".
2. Only applies to single-phase power supply models. Check the voltage between "+" and "-" terminals on the PFC module on the inverter module. The normal range is 277V to 354V. If the voltage is outside this range, the PFC module is damaged.



3. 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 IPM module on the inverter module is damaged. The DC fan connection CN19 on the inverter module labelled 5 in Figure 4-2.2 in Part4, 2.3 "Main PCBs for Refrigerant System, Inverter Module"

4.12 H7 Troubleshooting

4.12.1 Digital display output

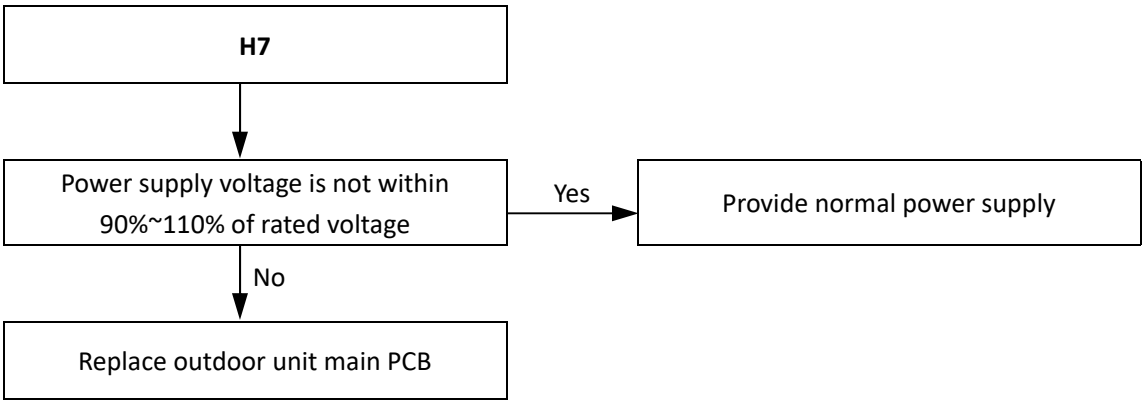
4.12.2 Description

- Abnormal main circuit voltage.
- M-Thermal Split stops running.
- Error code is displayed on outdoor unit main PCB and user interface.

4.12.3 Possible causes

- Power supply voltage not within 90%~110% of rated voltage.
- Outdoor unit main PCB is damaged.

4.12.4 Procedure



4.13 H8 Troubleshooting

4.13.1 Digital display output

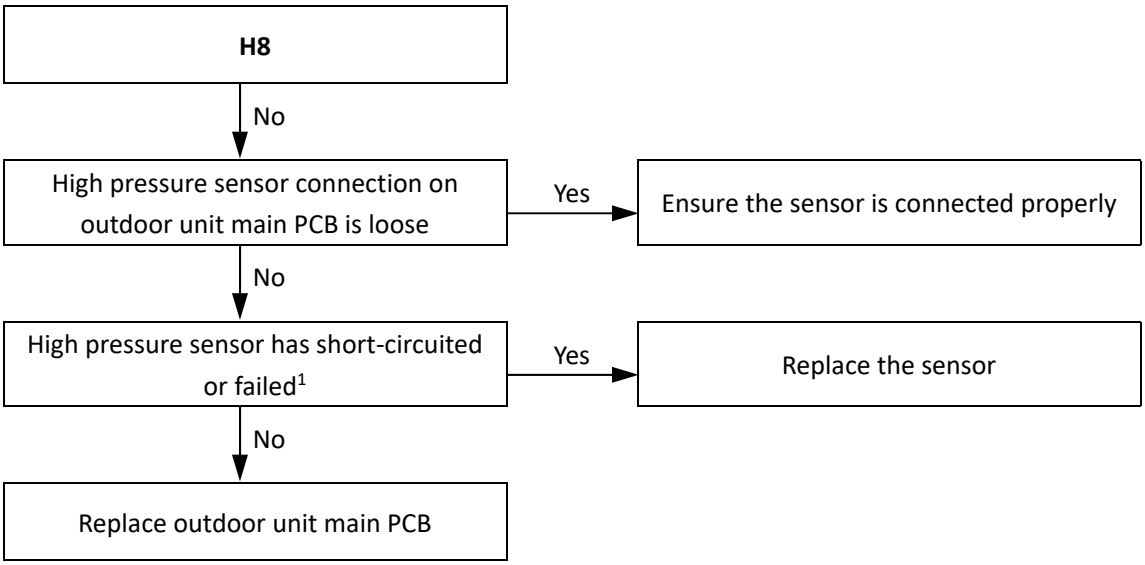
4.13.2 Description

- Pressure sensor error.
- M-Thermal Split stops running.
- Error code is displayed on outdoor unit main PCB and user interface.

4.13.3 Possible causes

- Pressure sensor not connected properly or has malfunctioned.
- Outdoor unit main PCB is damaged.

4.13.4 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 on each type of outdoor unit main PCB is labeled in Figure 4-2.2 in Part4, 2.3 "Main PCBs for Refrigerant System, Inverter Module".

4.14 P0, HP Troubleshooting

4.14.1 Digital display output

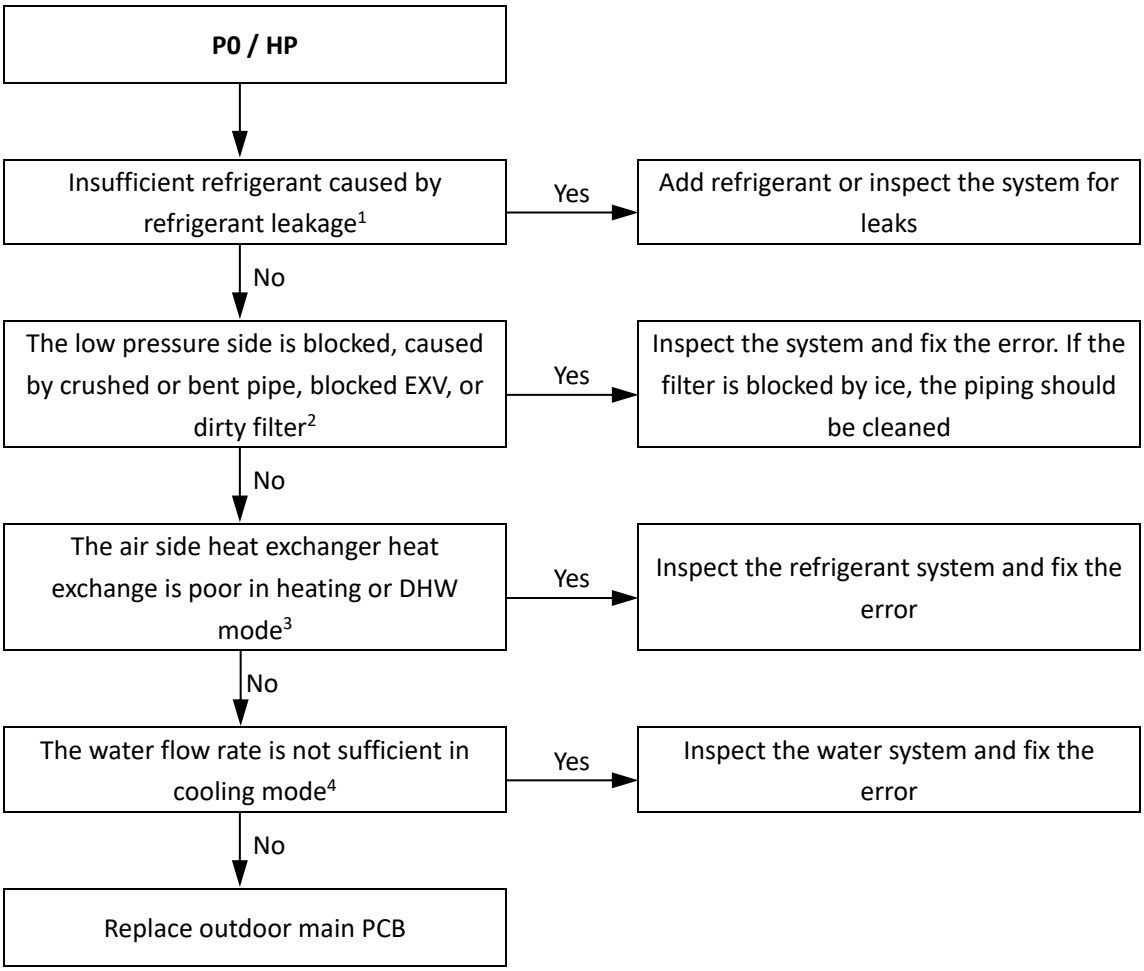

4.14.2 Description

- P0 indicates suction pipe low pressure protection. When the suction pressure falls below 0.14MPa, the system displays P0 protection and M-Thermal Split stops running. When the pressure rises above 0.3MPa, P0 is removed and normal operation resumes.
- HP indicates P0 protection has occurred 3 times in 60 minutes. When an HP error occurs, a manual system restart is required before the system can resume operation.
- Error code is displayed on outdoor unit main PCB and user interface.

4.14.3 Possible causes

- Low 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.
- Outdoor unit main PCB damaged.

4.14.4 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.

4.15 P1 Troubleshooting

4.15.1 Digital display output

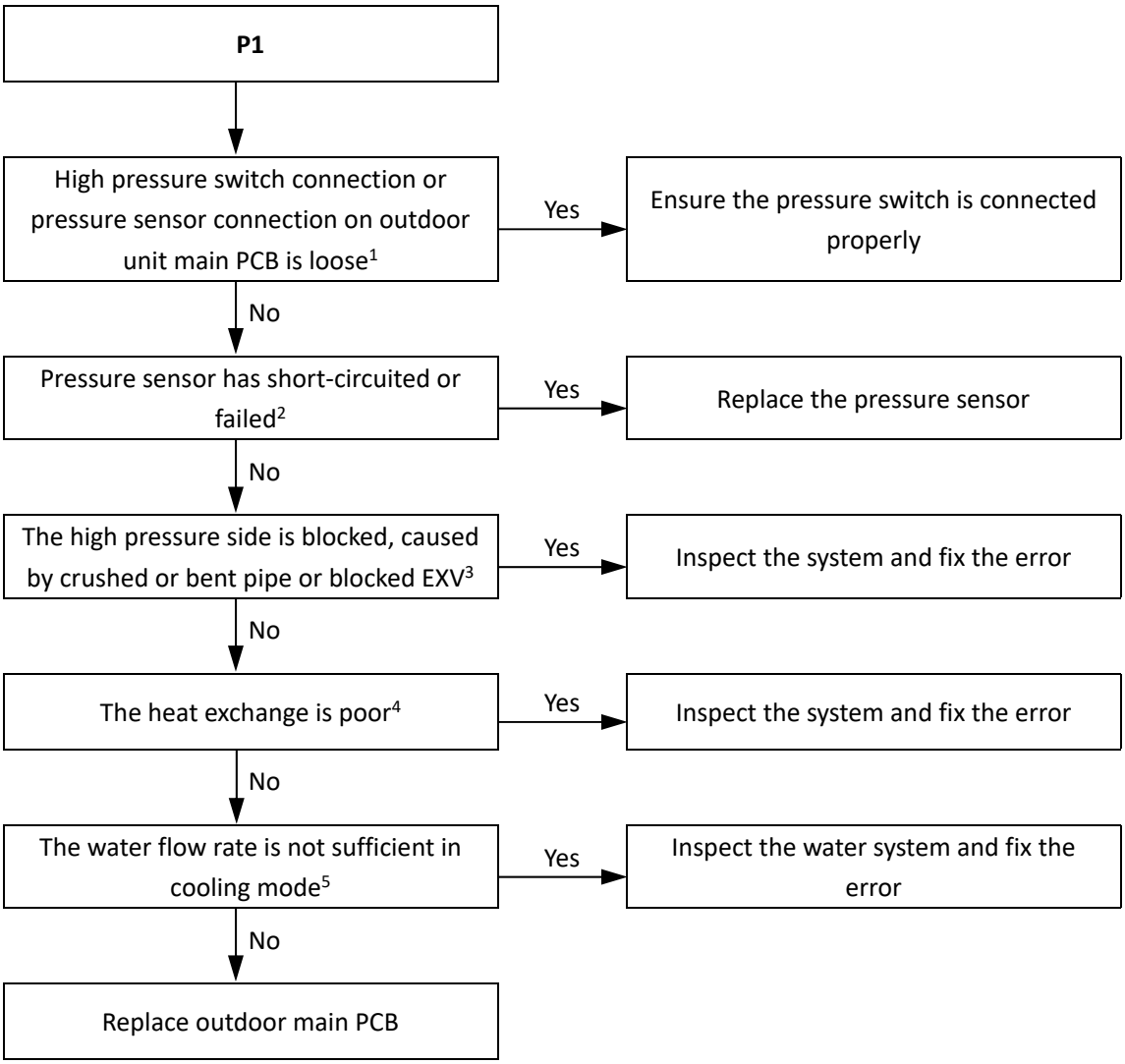
4.15.2 Description

- Discharge pipe high pressure protection. When the discharge pressure rises above 4.2MPa, the system displays P1 protection and M-Thermal Split stops running. When the discharge pressure falls below 3.2MPa, P1 is removed and normal operation resumes.
- Error code is displayed on outdoor unit main PCB and user interface.

4.15.3 Possible causes

- Pressure sensor/switch not connected properly or has malfunctioned.
- Excess refrigerant.
- System contains air or nitrogen.
- High pressure side blockage.
- Poor condenser heat exchange.
- Outdoor unit main PCB damaged.

4.15.4 Procedure

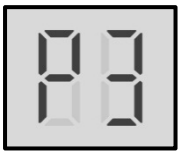


Notes:

1. High pressure switch connection is port CN13 on the main control board of outdoor unit (labeled 10 in Figure 4-2.2 in Part4, 2.3 "Main PCBs for Refrigerant System, Inverter Module". Pressure sensor connectin is port CN4 on the main control board of outdoor unit (labeled 15 in Figure 4-2.2 in Part4, 2.3 "Main PCBs for Refrigerant System, Inverter Module"
2. 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.
3. 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.
4. 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(s) and air outlets for dirt/blockages.
5. Check water pressure on the manometer. If the water pressure is not > 1 bar, water flow is insufficient. Refer to Figure 2-1.6 and 2-1.7 in Part 2, 1.2 “Hydronic Box Layout”.

4.16 P3 Troubleshooting

4.16.1 Digital display output



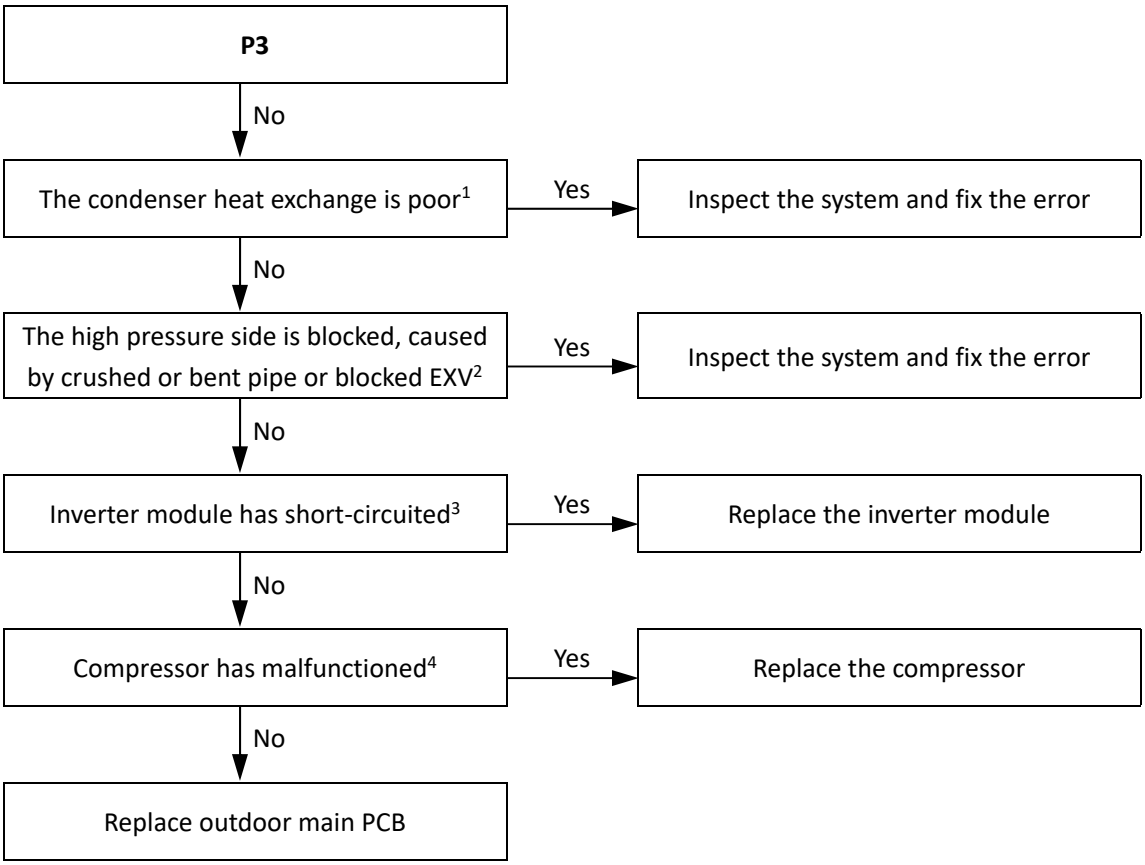
4.16.2 Description

- Compressor current protection.
- When the compressor current rises above the protection value (4/6kW models 18A, 8/10kW model 19A), the system displays P3 protection and M-Thermal Split stops running. When the current returns to the normal range, P3 is removed and normal operation resumes.
- Error code is displayed on refrigerant system main PCB and user interface.

4.16.3 Possible causes

- Poor condenser heat exchange.
- High pressure side blockage.
- Inverter module damaged.
- Compressor damaged.
- Outdoor unit main PCB damaged.

4.16.4 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.

4.17 P4 Troubleshooting

4.17.1 Digital display output

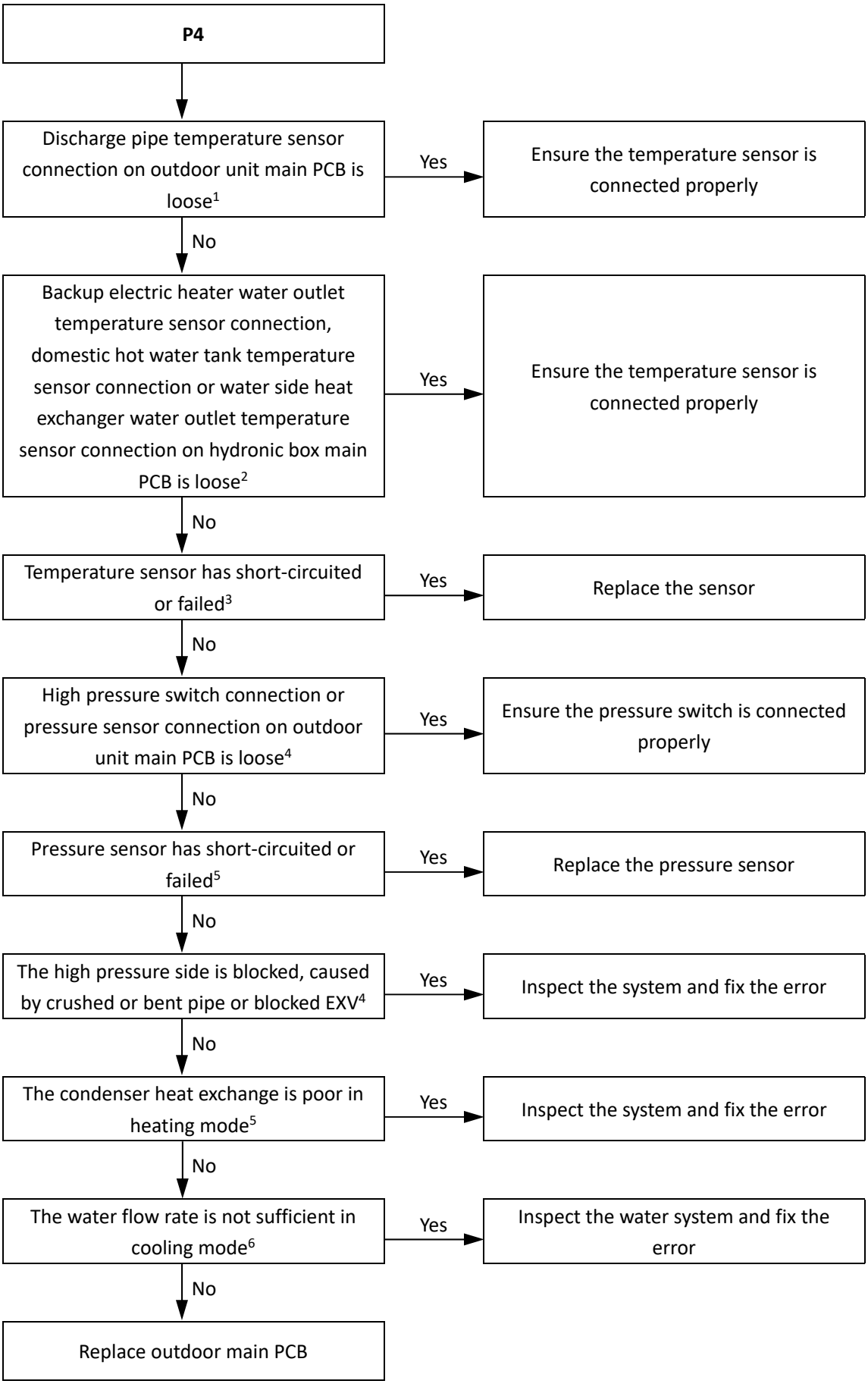
4.17.2 Description

- Discharge temperature protection.
- When the compressor the discharge temperature rises above 115°C, the system displays P4 protection and M-Thermal Split stops running. When the discharge temperature falls below 90°C, P4 is removed and normal operation resumes.
- Error code is displayed on refrigerant system main PCB and user interface.

4.17.3 Possible causes

- Temperature sensor error
- High pressure side blockage.
- Poor condenser heat exchange.
- Outdoor unit main PCB damaged.

4.17.4 Procedure



Notes:

1. Discharge pipe temperature sensor connection is port CN8 on the outdoor unit main PCBs (labeled 11 in Figure 4-2.2 in Part4, 2.3 "Main PCBs for

Refrigerant System, Inverter Module").

2. Backup electric heater water outlet temperature sensor and water side heat exchanger water outlet temperature sensor connections are port CN6 on the hydronic box main PCB (labeled 11 in Figure 4-2.1 in Part4, 2.2 "Main PCB for Hydronic System"). Domestic hot water tank temperature sensor connection is port CN13 on hydronic box main PCB (labeled 12 in Figure 4-2.1 in Part4, 2.2 "Main PCB for Hydronic System").
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 Part 2, 1 "Layout of Functional Components" and to Table 5-5.1 or 5-5.2 in Part 5, 5.1 "Temperature Sensor Resistance Characteristics".
4. High pressure switch connection is port CN13 on the main PCB (labeled 10 in Figure 4-2.2 in Part4, 2.3 "Main PCBs for Refrigerant System, Inverter Module"). Pressure sensor connectin is port CN4 on the main control board (labeled 15 in Figure 4-2.2 in Part4, 2.3 "Main PCBs for Refrigerant System, Inverter Module")
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.

4.18 P5 Troubleshooting

4.18.1 Digital display output

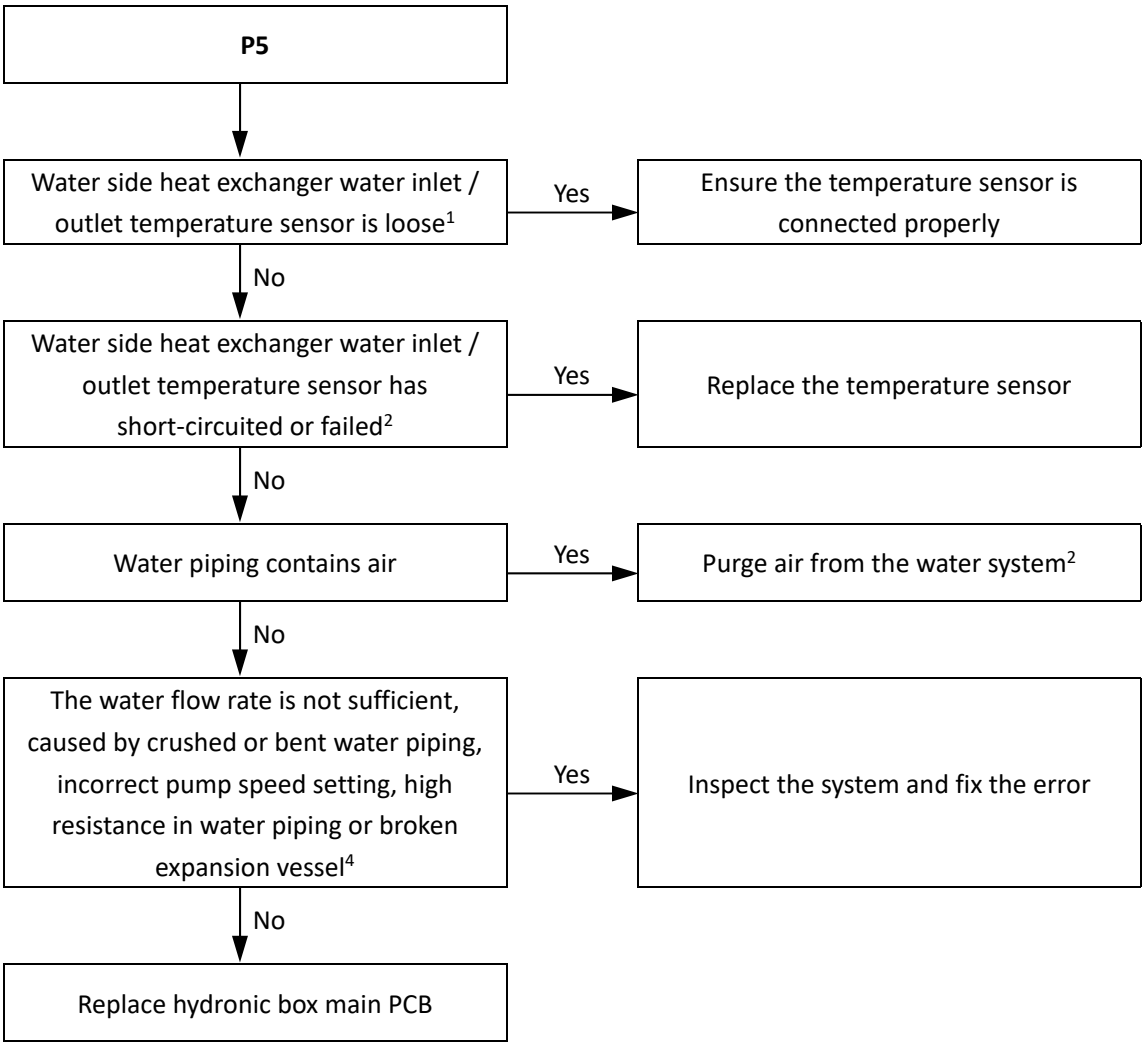
4.18.2 Description

- High temperature difference between water side heat exchanger water inlet and water outlet temperatures protection.
- M-Thermal Split stops running.
- Error code is displayed on hydronic box main PCB and user interface.

4.18.3 Possible causes

- Temperature sensor not connected properly or has malfunctioned.
- Water piping contains air.
- Insufficient water flow.
- Hydronic box main PCB damaged.

4.18.4 Procedure



Notes:

1. Water side heat exchanger water inlet temperature sensor and water side heat exchanger water outlet temperature sensor connections are port CN6 on the hydronic box main PCB (labeled11 in Figure 4-2.1 in Part4, 2.2 "Main PCB for Hydronic System").
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 Part 2, 1.2 "Hydronic Box Layout" and to Table 5-5.3 in Part 5, 5.1 "Temperature Sensor Resistance Characteristics".
3. Refer to the M-Thermal Split Engineering Data Book, Part 5, 15 "SPECIAL FUNCTIONS".
4. Check water pressure on the manometer. If the water pressure is not > 1 bar, water flow is insufficient. Refer to Figures 2-1.7 and 2-1.8 in Part 2, 1.2 "Hydronic Box Layout".

4.19 P6 Troubleshooting for single-phase models

4.19.1 Digital display output

4.19.2 Description

- Inverter module protection.
- M-Thermal Split stops running.
- Error code P6 is displayed on the user interface. Specific error code L0, L1, L2, L4, L5, L7, L8 or L9 is displayed on the outdoor unit main PCB.

4.19.3 Possible causes

- Inverter module protection.
- DC bus low or high voltage protection.
- MCE error.
- Zero speed protection.
- Phase sequence error.
- Excessive compressor frequency variation.
- Actual compressor frequency differs from target frequency.

4.19.4 Specific error codes for P6 inverter module protection

If a P6 error code is displayed on the user interface, one of the following specific error codes is displayed on the outdoor unit main PCB: L0, L1, L2, L4, L5, L7, L8, L9. Refer to Table 4-4.1.

Table 4-4.1: Specific error codes for error P6

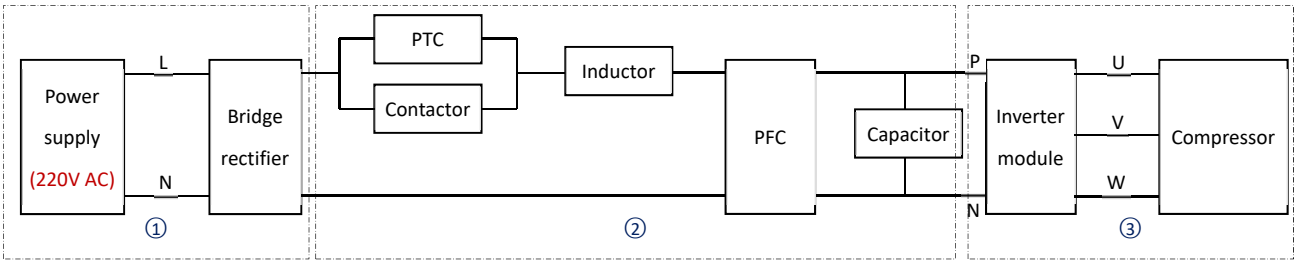
Specific error code	Content
L0	Inverter module protection
L1	DC bus low voltage protection
L2	DC bus high voltage protection
L4	MCE error
L5	Zero speed protection
L7	Phase sequence error
L8	Compressor frequency variation greater than 15Hz within one second protection
L9	Actual compressor frequency differs from target frequency by more than 15Hz protection

The specific error codes can also be obtained from the LED indicators LED1/LED2 on the inverter module. Refer to Figure 4-4.2 and Figure 4-2.4 or 4-2.6 in Part 4, 2.1 “Outdoor Unit PCBs”.

Table 4-4.2: Errors indicated on LED1/2

LED1/2 flashing pattern	Corresponding error
Flashes 8 times and stops for 1 second, then repeats	L0 - Inverter module protection
Flashes 9 times and stops for 1 second, then repeats	L1 - DC bus low voltage protection
Flashes 10 times and stops for 1 second, then repeats	L2 - DC bus high voltage protection
Flashes 12 times and stops for 1 second, then repeats	L4 - MCE error
Flashes 13 times and stops for 1 second, then repeats	L5 - Zero speed protection
Flashes 15 times and stops for 1 second, then repeats	L7 - Phase sequence error
Flashes 16 times and stops for 1 second, then repeats	L8 - Compressor frequency variation greater than 15Hz within one second protection
Flashes 17 times and stops for 1 second, then repeats	L9 - Actual compressor frequency differs from target frequency by more than 15Hz protection

4.19.5 Principle of DC inverter



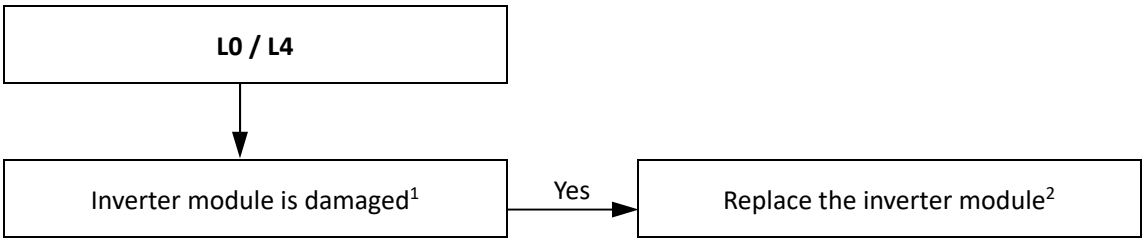
① 220V AC power supply change to DC power supply after bridge rectifier.

② Contactor is open, the current across the PTC to charge capacitor, after 5 seconds the contactor closed.

③The capacitor output steady power supply for inverter module P N terminals. In standby the voltage between P and N terminal on inverter module is 310V DC. When the fan motor is running, the voltage between P and N terminal on inverter module is 380V DC.

4.19.6 L0/L4 troubleshooting

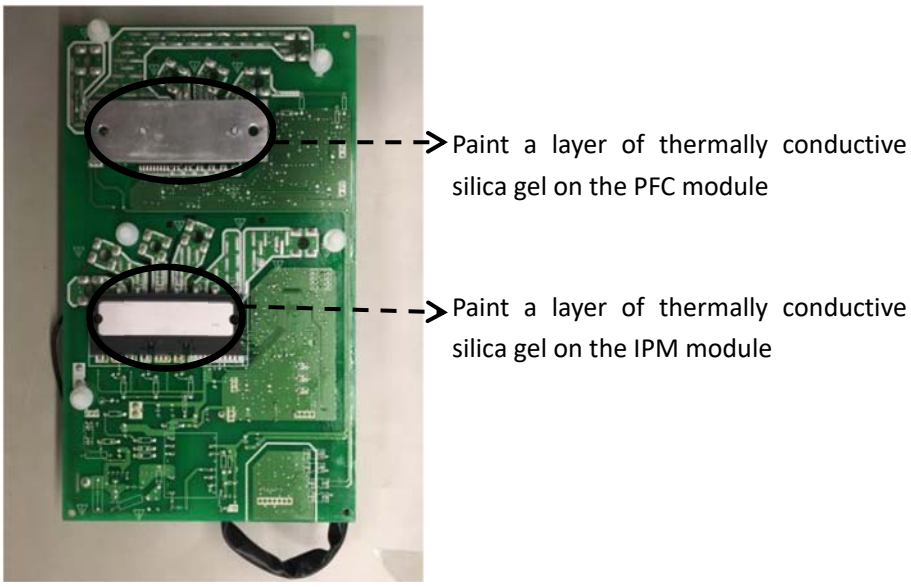
Situation 1: L0 or L4 error appears immediately after the outdoor unit is powered-on



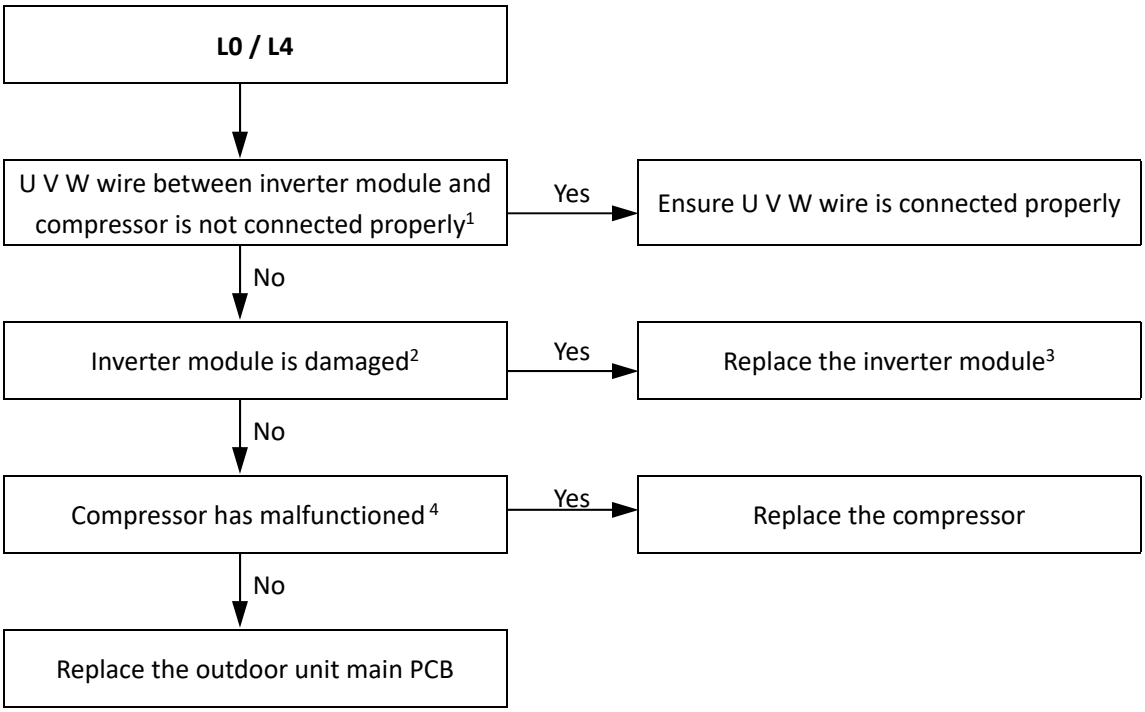
Notes:

1. Measure the resistance between each of U, V and W and each of P and N on the inverter module. All the resistances should be infinite. If any of them are not infinite, the inverter module is damaged and should be replaced. Refer to Figure 4-2.3 or 4-2.5 in Part 4, 2.1 “Outdoor Unit PCBs”.
2. When replacing an inverter module, a layer of thermally conductive silica gel should be painted on the IPM module, IGBT, diode, brigde rectifier (on the reverse side of the inverter module). Refer to Figure 4-4.1.

Figure 4-4.1: Replacing an inverter module



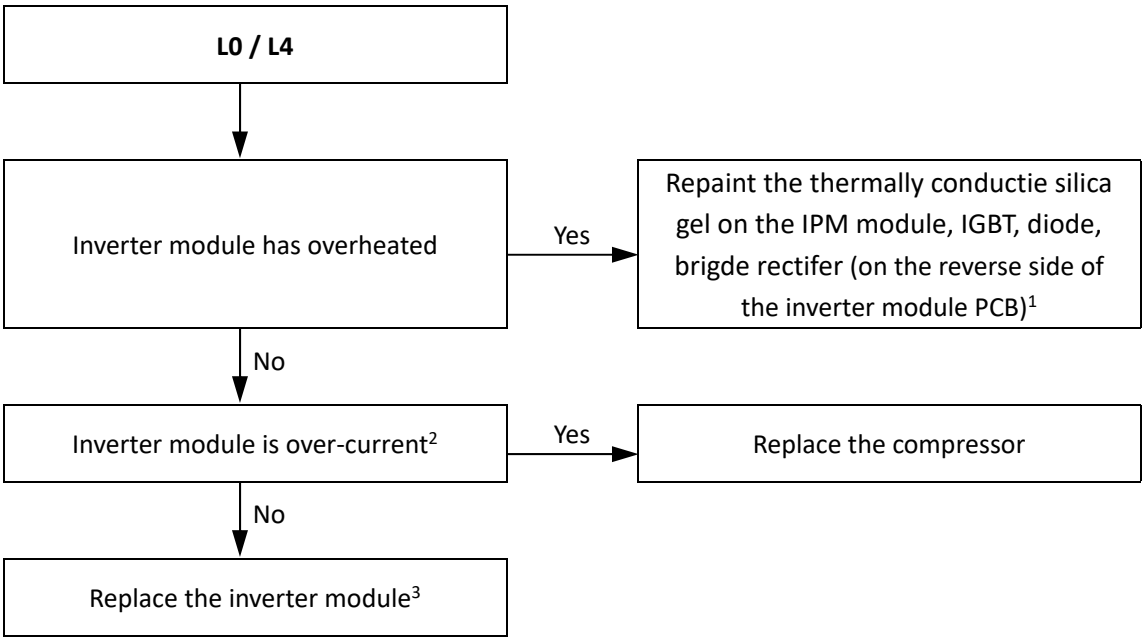
Situation 2: L0 or L4 error appears immediately after the compressor starts up



Notes:

1. Connect the U V W wire from the inverter module to the correct compressor terminals, as indicated by the labels on the compressor.
2. Measure the resistance between each of U, V and W and each of P and N on the inverter module. All the resistances should be infinite. If any of them are not infinite, the inverter module is damaged and should be replaced. Refer to Figure 4-2.2 or 4-2.4 in Part 4, 2.1 “Outdoor Unit PCBs”.
3. When replacing an inverter module, a layer of thermally conductive silica gel should be painted on the IPM module, IGBT, diode ,brigde rectifer (on the reverse side of the inverter module PCB). Refer to Figure 4-4.1.
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.

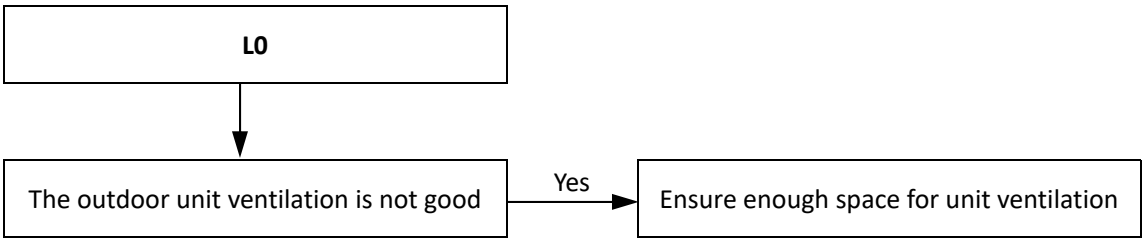
Situation 3: L0 or L4 error appears after the compressor has been running for a period of time and the compressor speed is over 60rps



Notes:

1. Refer to Figure 4-4.1.
2. Use clip-on ammeter to measure the compressor current, if the current is normal indicates the inverter module is failed, if the current is abnormal indicates the compressor is failed.
3. When replacing an inverter module, a layer of thermally conductive silica gel should be painted on the PFC and IPM modules (on the reverse side of the inverter module PCB). Refer to Figure 4-4.1.

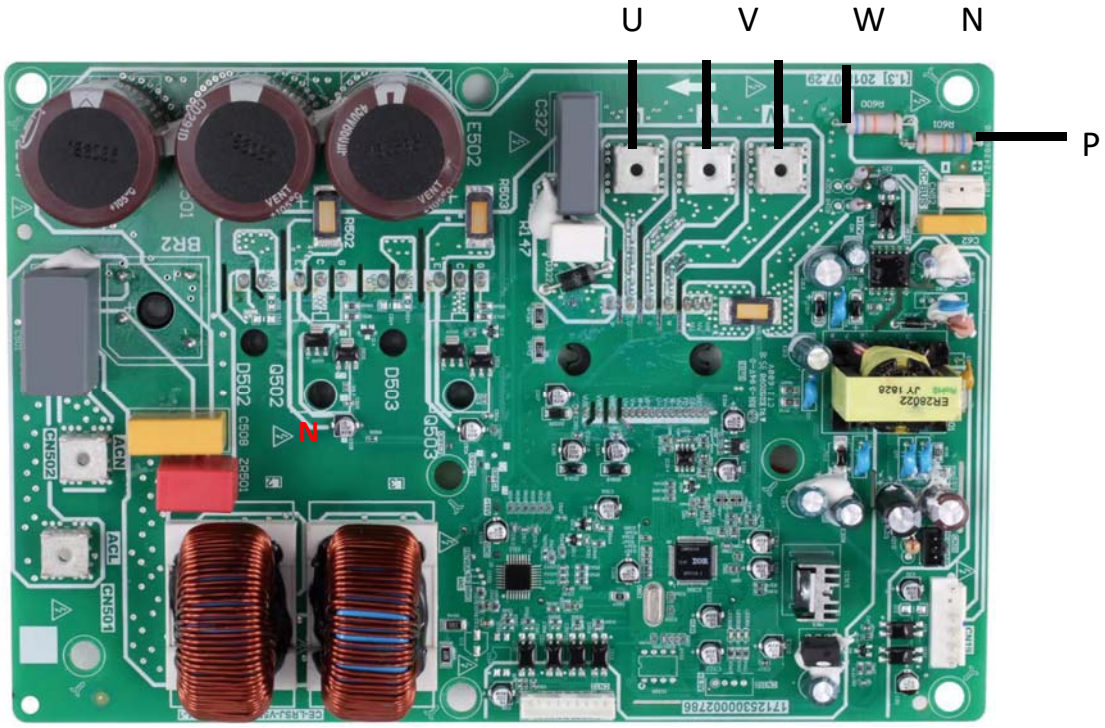
Situation 4: L0 error appears occasionally/irregularly



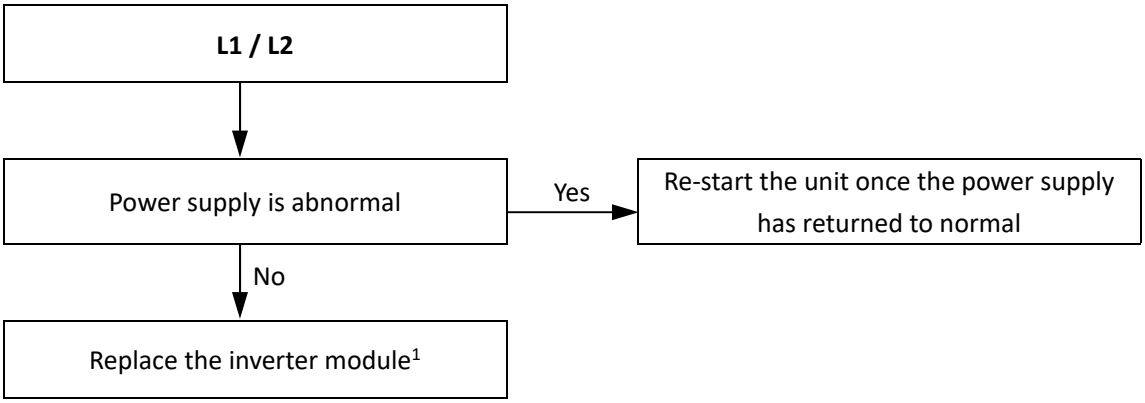
4.19.7 L1/L2 troubleshooting

The normal DC voltage between terminals P and N on inverter module is 310V in standby and 380V when the fan motor is running. If the voltage is lower or higher than the normal voltage, the unit displays an L1 or L2 error.

Figure 4-4.2: Inverter module terminals



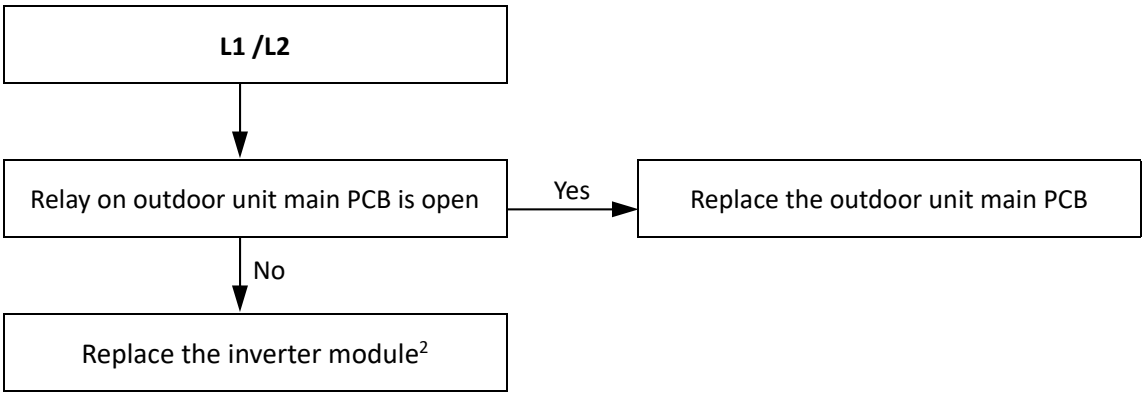
Situation 1: L1 or L2 error appears immediately after the outdoor unit is powered-on



Notes:

1. When replacing an inverter module, a layer of thermally conductive silica gel should be painted on the IPM module, IGBT, diode, brigde rectifer (on the reverse side of the inverter module PCB). Refer to Figure 4-4.1.

Situation 2: L1 or L2 error appears after the compressor has been running for a period of time and the compressor speed is over 20rps



Notes:

1. If the fan motor is running and the DC voltage between terminals P and N on inverter module declined, Relay on the main control board ofoutdoor unit is open.
2. When replacing an inverter module, a layer of thermally conductive silica gel should be painted on IPM module (on the reverse side of the inverter module PCB). Refer to Figure 4-4.1.

4.20 Pb Troubleshooting

4.20.1 Digital display output

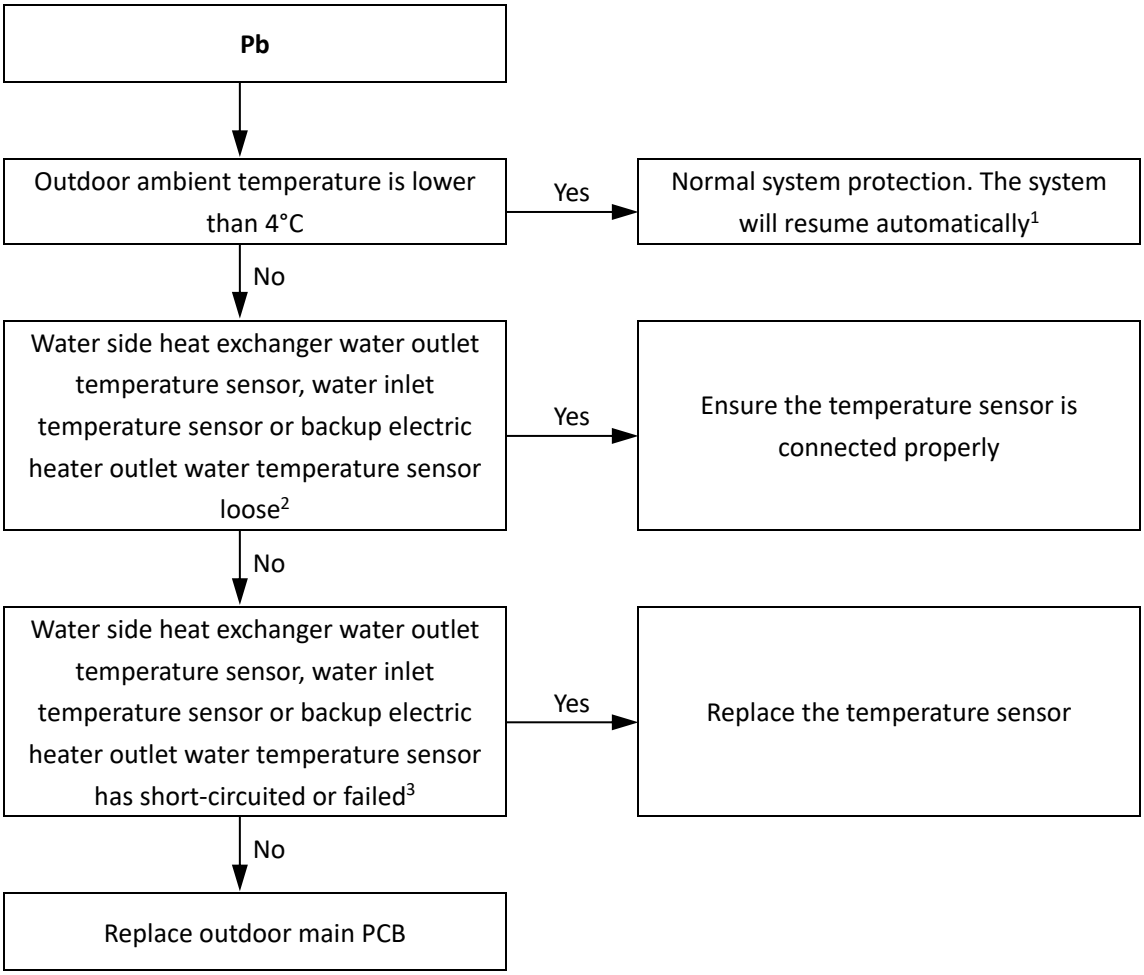
4.20.2 Description

- Water side heat exchanger anti-freeze protection.
- M-Thermal Split stops running.
- Error code is displayed on hydronic box main PCB and **ANTI.FREEZE** icon is displayed on user interface.

4.20.3 Possible causes

- Normal system protection.
- Temperature sensor not connected properly or has malfunctioned.
- Hydronic box main PCB damaged.

4.20.4 Procedure



Notes:

1. Refer to Part 3, 5.7 “Water Side Heat Exchanger Anti-freeze Protection Control”.
2. Backup electric heater water outlet temperature sensor, water side heat exchanger water inlet temperature sensor and water side heat exchanger water outlet temperature sensor connections are port CN6 on the hydronic box main PCB (labeled 11 in Figure 4-2.1 in Part4, 2.2 "Main PCB for Hydronic System").
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 Part 2, 1.2 “Hydronic Box Layout” and to Table 4-5.3 in Part 4, 5.1 “Temperature Sensor Resistance Characteristics”.

4.21 Pd Troubleshooting

4.21.1 Digital display output

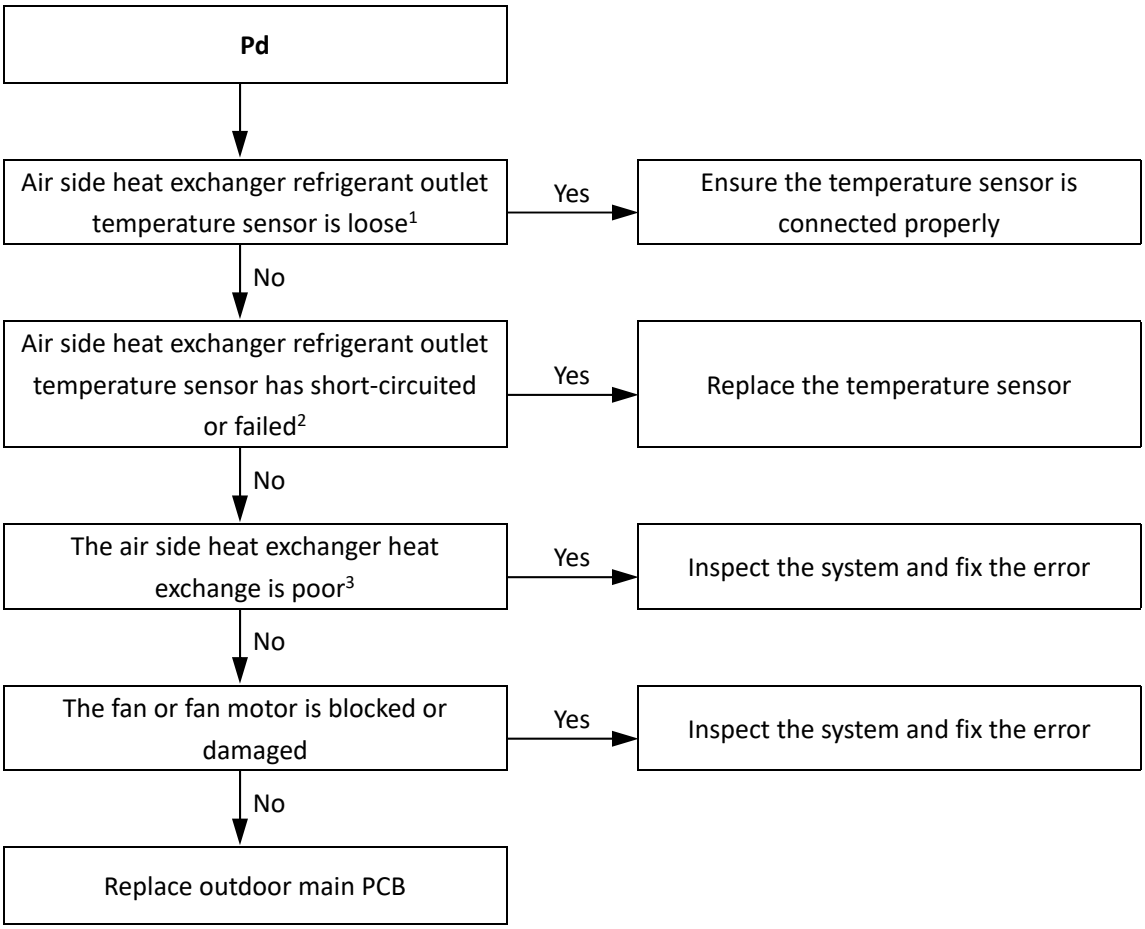
4.21.2 Description

- High temperature protection of air side heat exchanger refrigerant outlet in cooling mode. When the air side heat exchanger refrigerant outlet temperature is higher than 62°C for more than 3 seconds, the system displays Pd protection and M-Thermal Split stops running. When the air side heat exchanger refrigerant outlet temperature returns drops below 52°C, Pd is removed and normal operation resumes.
- M-Thermal Split stops running.
- Error code is displayed on outdoor unit main PCB and user interface.

4.21.3 Possible causes

- Temperature sensor not connected properly or has malfunctioned.
- Poor condenser heat exchange.
- Fan motor damaged.
- Hydronic box main PCB damaged.

4.21.4 Procedure



Notes:

1. Air side heat exchanger refrigerant outlet temperature sensor and outdoor ambient temperature sensor connection port are CN9 on the outdoor unit main PCB (labeled 12 in Figure 4-2.2 in Part4, 2.3 "Main PCBs for Refrigerant System, Inverter Module")..
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 Part 2, 1.1 "Outdoor Unit Layout" and to Table 4-5.1 in Part 4, 5.1 "Temperature Sensor Resistance Characteristics".
3. Check air side heat exchanger, fan and air outlets for dirt/blockages.

4.22 PP Troubleshooting

4.22.1 Digital display output

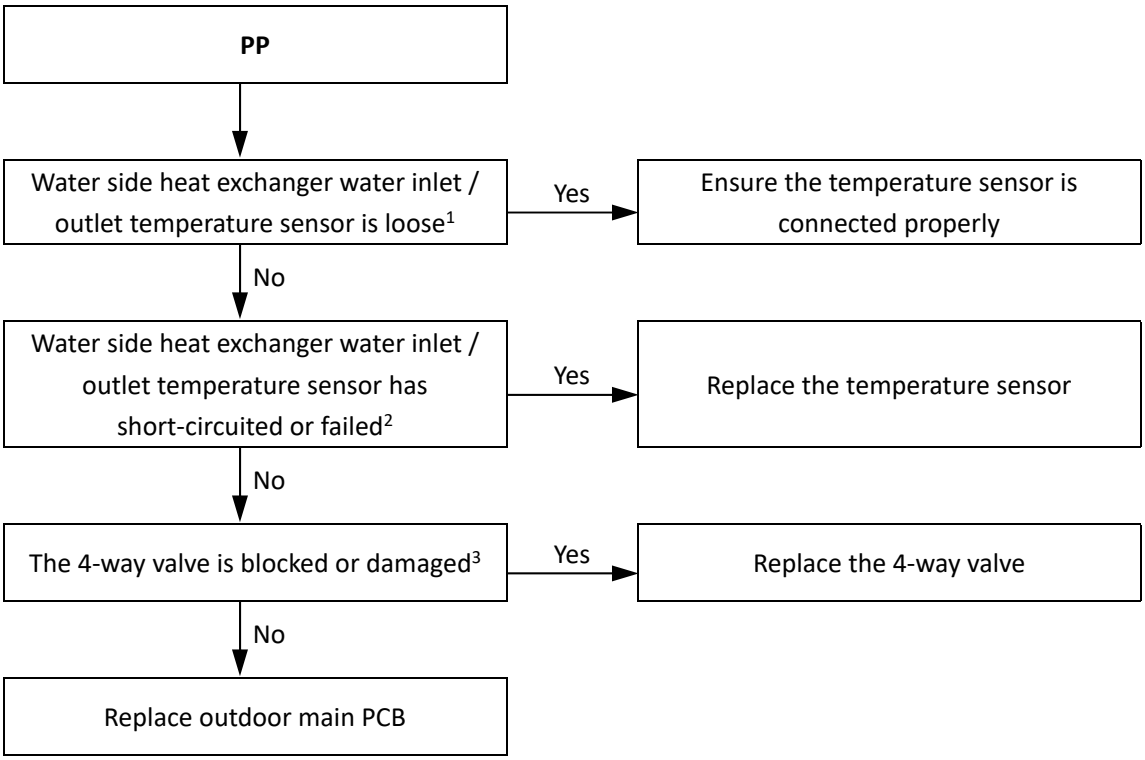
4.22.2 Description

- Water side heat exchanger inlet temperature is higher than outlet temperature in heating mode.
- M-Thermal Split stops running.
- Error code is displayed on hydronic box main PCB and user interface.
- Hb indicates PP has displayed 3 times.

4.22.3 Possible causes

- Temperature sensor not connected properly or has malfunctioned.
- 4-way valve is blocked or damaged.
- Hydronic box main PCB damaged.

4.22.4 Procedure



Notes:

1. water side heat exchanger water inlet temperature sensor and water side heat exchanger water outlet temperature sensor connections are port CN6 on the hydronic box main PCB (labeled 11 in Figure 4-2.1 in Part4, 2.2 "Main PCB for Hydronic System").
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 Part 2, 1.2 "Hydronic Box Layout" and to Table 4-5.1 to 4-5.2 in Part 4, 5.1 "Temperature Sensor Resistance Characteristics".
3. Restart the unit in cooling mode to change the refrigerant flow direction. If the unit does not operate normally, the 4-way valve is blocked or damaged.

5 Appendix to Part 4

5.1 Temperature Sensor Resistance Characteristics

Table 4-5.1: Outdoor ambient temperature sensor, water side heat exchanger refrigerant inlet / outlet (liquid / gas pipe) temperature sensor, air side heat exchanger refrigerant out temperature sensor and suction pipe temperature sensor resistance characteristics

Temperature (°C)	Resistance (kΩ)	Temperature (°C)	Resistance (kΩ)	Temperature (°C)	Resistance (kΩ)	Temperature (°C)	Resistance (kΩ)
-20	115.3	20	12.64	60	2.358	100	0.6297
-19	108.1	21	12.06	61	2.272	101	0.6115
-18	101.5	22	11.50	62	2.191	102	0.5939
-17	96.34	23	10.97	63	2.112	103	0.5768
-16	89.59	24	10.47	64	2.037	104	0.5604
-15	84.22	25	10.00	65	1.965	105	0.5445
-14	79.31	26	9.551	66	1.896	106	0.5291
-13	74.54	27	9.124	67	1.830	107	0.5143
-12	70.17	28	8.720	68	1.766	108	0.4999
-11	66.09	29	8.336	69	1.705	109	0.4860
-10	62.28	30	7.971	70	1.647	110	0.4726
-9	58.71	31	7.624	71	1.591	111	0.4596
-8	56.37	32	7.295	72	1.537	112	0.4470
-7	52.24	33	6.981	73	1.485	113	0.4348
-6	49.32	34	6.684	74	1.435	114	0.4230
-5	46.57	35	6.400	75	1.387	115	0.4116
-4	44.00	36	6.131	76	1.341	116	0.4006
-3	41.59	37	5.874	77	1.291	117	0.3899
-2	39.82	38	5.630	78	1.254	118	0.3796
-1	37.20	39	5.397	79	1.2133	119	0.3695
0	35.20	40	5.175	80	1.174	120	0.3598
1	33.33	41	4.964	81	1.136	121	0.3504
2	31.56	42	4.763	82	1.100	122	0.3413
3	29.91	43	4.571	83	1.064	123	0.3325
4	28.35	44	4.387	84	1.031	124	0.3239
5	26.88	45	4.213	85	0.9982	125	0.3156
6	25.50	46	4.046	86	0.9668	126	0.3075
7	24.19	47	3.887	87	0.9366	127	0.2997
8	22.57	48	3.735	88	0.9075	128	0.2922
9	21.81	49	3.590	89	0.8795	129	0.2848
10	20.72	50	3.451	90	0.8525	130	0.2777
11	19.69	51	3.318	91	0.8264	131	0.2708
12	18.72	52	3.192	92	0.8013	132	0.2641
13	17.80	53	3.071	93	0.7771	133	0.2576
14	16.93	54	2.959	94	0.7537	134	0.2513
15	16.12	55	2.844	95	0.7312	135	0.2451
16	15.34	56	2.738	96	0.7094	136	0.2392
17	14.62	57	2.637	97	0.6884	137	0.2334
18	13.92	58	2.540	98	0.6682	138	0.2278
19	13.26	59	2.447	99	0.6486	139	0.2223

Table 4-5.2: Compressor discharge pipe temperature sensor resistance characteristics

Temperature (°C)	Resistance (kΩ)	Temperature (°C)	Resistance (kΩ)	Temperature (°C)	Resistance (kΩ)	Temperature (°C)	Resistance (kΩ)
-20	542.7	**20**	68.66	**60**	13.59	**100**	3.702
-19	511.9	**21**	65.62	**61**	13.11	**101**	3.595
-18	483.0	**22**	62.73	**62**	12.65	**102**	3.492
-17	455.9	**23**	59.98	**63**	12.21	**103**	3.392
-16	430.5	**24**	57.37	**64**	11.79	**104**	3.296
-15	406.7	**25**	54.89	**65**	11.38	**105**	3.203
-14	384.3	**26**	52.53	**66**	10.99	**106**	3.113
-13	363.3	**27**	50.28	**67**	10.61	**107**	3.025
-12	343.6	**28**	48.14	**68**	10.25	**108**	2.941
-11	325.1	**29**	46.11	**69**	9.902	**109**	2.860
-10	307.7	**30**	44.17	**70**	9.569	**110**	2.781
-9	291.3	**31**	42.33	**71**	9.248	**111**	2.704
-8	275.9	**32**	40.57	**72**	8.940	**112**	2.630
-7	261.4	**33**	38.89	**73**	8.643	**113**	2.559
-6	247.8	**34**	37.30	**74**	8.358	**114**	2.489
-5	234.9	**35**	35.78	**75**	8.084	**115**	2.422
-4	222.8	**36**	34.32	**76**	7.820	**116**	2.357
-3	211.4	**37**	32.94	**77**	7.566	**117**	2.294
-2	200.7	**38**	31.62	**78**	7.321	**118**	2.233
-1	190.5	**39**	30.36	**79**	7.086	**119**	2.174
0	180.9	**40**	29.15	**80**	6.859	**120**	2.117
1	171.9	**41**	28.00	**81**	6.641	**121**	2.061
2	163.3	**42**	26.90	**82**	6.430	**122**	2.007
3	155.2	**43**	25.86	**83**	6.228	**123**	1.955
4	147.6	**44**	24.85	**84**	6.033	**124**	1.905
5	140.4	**45**	23.89	**85**	5.844	**125**	1.856
6	133.5	**46**	22.89	**86**	5.663	**126**	1.808
7	127.1	**47**	22.10	**87**	5.488	**127**	1.762
8	121.0	**48**	21.26	**88**	5.320	**128**	1.717
9	115.2	**49**	20.46	**89**	5.157	**129**	1.674
10	109.8	**50**	19.69	**90**	5.000	**130**	1.632
11	104.6	**51**	18.96	**91**	4.849		
12	99.69	**52**	18.26	**92**	4.703		
13	95.05	**53**	17.58	**93**	4.562		
14	90.66	**54**	16.94	**94**	4.426		
15	86.49	**55**	16.32	**95**	4.294		
16	82.54	**56**	15.73	**96**	4.167		
17	78.79	**57**	15.16	**97**	4.045		
18	75.24	**58**	14.62	**98**	3.927		
19	71.86	**59**	14.09	**99**	3.812		

Table 4-5.3: Water side *heat exchanger water inlet / outlet temperature sensor, backup heater exchanger outlet water temperature sensor and DHW temperature sensor resistance characteristics*

Temperature (°C)	Resistance (kΩ)	Temperature (°C)	Resistance (kΩ)	Temperature (°C)	Resistance (kΩ)	Temperature (°C)	Resistance (kΩ)
-30	867.29	10	98.227	50	17.600	90	4.4381
-29	815.80	11	93.634	51	16.943	91	4.3022
-28	767.68	12	89.278	52	16.315	92	4.1711
-27	722.68	13	85.146	53	15.713	93	4.0446
-26	680.54	14	81.225	54	15.136	94	3.9225
-25	641.07	15	77.504	55	14.583	95	3.8046
-24	604.08	16	73.972	56	14.054	96	3.6908
-23	569.39	17	70.619	57	13.546	97	3.5810
-22	536.85	18	67.434	58	13.059	98	3.4748
-21	506.33	19	64.409	59	12.592	99	3.3724
-20	477.69	20	61.535	60	12.144	100	3.2734
-19	450.81	21	58.804	61	11.715	101	3.1777
-18	425.59	22	56.209	62	11.302	102	3.0853
-17	401.91	23	53.742	63	10.906	103	2.9960
-16	379.69	24	51.396	64	10.526	104	2.9096
-15	358.83	25	49.165	65	10.161	105	2.8262
-14	339.24	26	47.043	66	9.8105		
-13	320.85	27	45.025	67	9.4736		
-12	303.56	28	43.104	68	9.1498		
-11	287.33	29	41.276	69	8.8387		
-10	272.06	30	39.535	70	8.5396		
-9	257.71	31	37.878	71	8.2520		
-8	244.21	32	36.299	72	7.9755		
-7	231.51	33	34.796	73	7.7094		
-6	219.55	34	33.363	74	7.4536		
-5	208.28	35	31.977	75	7.2073		
-4	197.67	36	30.695	76	6.9704		
-3	187.66	37	29.453	77	6.7423		
-2	178.22	38	28.269	78	6.5228		
-1	168.31	39	27.139	79	6.3114		
0	160.90	40	26.061	80	6.1078		
1	152.96	41	25.031	81	5.9117		
2	145.45	42	24.048	82	5.7228		
3	138.35	43	23.109	83	5.5409		
4	131.64	44	22.212	84	5.3655		
5	125.28	45	21.355	85	5.1965		
6	119.27	46	20.536	86	5.0336		
7	113.58	47	19.752	87	4.8765		
8	108.18	48	19.003	88	4.7251		
9	103.07	49	18.286	89	4.5790		

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