R32

Commercial Air Conditioners

Service Manual

Atom T Mini Series VRF

Model:

220-240V~ 50Hz

MDVO-AtT80V2R8E

MDVO-AtT100V2R8E

MDVO-AtT120V2R8E

MDVO-AtT140V2R8E

MDVO-AtT160V2R8E

CONTENTS

Part 1 General Information 3

Part 2 Component Layout and Refrigerant Circuits 15

Part 3 Control 23

Part 4 Electrical Components and Wiring Diagrams 33

Part 5 Diagnosis and Troubleshooting 43

Part 1

General Information

1 Indoor and Outdoor Unit Capacities 4

2 External Appearance 5

3 Nomenclature 6

4 Combination Ratio 9

5 Selection Procedure 10

1 Indoor and Outdoor Unit Capacities

1.1 Indoor Units

Table 1-1.1: Indoor unit abbreviation codes

Abbreviation code	Type
Q4C	Compact Four-way Cassette
G	Wall-mounted

Abbreviation code	Type
T3	Arc Duct
T2	Medium Static Pressure Duct

Table 1-1.2: Indoor unit capacity range

Capacity			Capacity index	Q4C	T3	T2	G
kW	kBtu/h	HP					
1.5	5	0.5	15	15	15	—	15
1.8	6	0.6	18	—	—	—	—
2.2	7	0.8	22	22	22	—	22
2.8	9	1	28	28	28	—	28
3.6	12	1.25	36	36	36	—	36
4.5	15	1.6	45	45	45	—	45
5.6	19	2	56	56	56	—	56
6.3	21	2.25	63	63	—	—	—
7.1	24	2.5	71	—	71	—	—
8.0	27	3	80	—	—	80	—
9.0	30	3.2	90	—	—	90	—
10.0	34	3.6	100	—	—	—	—
11.2	38	4	112	—	—	112	—
12.5	43	4.5	125	—	—	125	
14.0	48	5	140	—	—	140	—
16.0	55	6	160	—	—	—	—

Note: Atom T can only available with V8 Atom indoor units. The indoor unit must be installed at a height of 1.8m or more.

1.2 Outdoor Units

Table 1-1.5: Outdoor unit capacity range

Capacity (kW)	Model Name
7.2	MDVO-AtT80V2R8E
9.0	MDVO-AtT100V2R8E
12.3	MDVO-AtT120V2R8E
14.0	MDVO-AtT140V2R8E
15.5	MDVO-AtT160V2R8E

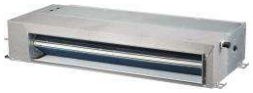
Notes:

1. Atom T Series outdoor units could not be combined.

2 External Appearance

2.1 Indoor Units

Table 1-2.1: Indoor unit appearance

Compact Four-way Cassette Q4C 	Arc Duct T3 
Wall-mounted G 	Medium Static Pressure Duct 
Hydraulic Module 	All in one hydraulic module* 
DHW Kit 	Tank 

*Note: *Integration of water tanks and hydronic modules into one module.*

2.2 Outdoor Units

Table 1-2.2: Outdoor unit appearance

8-10KW	12-16KW
	

3 Nomenclature

3.1 Indoor Units

3.1.1 Standard indoor units

V8 indoor units

MDV I 3 18 C1 V D

① ② ③ ④ ⑤ ⑥ ⑦

Legend		
No.	**Code**	**Remarks**
1	MDV	MDV
2	I	VRF indoor Inverter unit
3	H	Generatioon 3: Third Generation
4	22	Capacity index (the capacity in kW multiplied by 10)
5	C1	Indoor unit type C1: One-way Cassette C2: Two-way Cassette C4C: Compact Four-way Cassette C4: Four-way Cassette D1: Arc Duct D2: Medium Static Pressure Duct D3: High Static Pressure Duct WM: Wall-mounted CF:Ceiling & Floor CO: Floor Standing (Exposed/Concealed) FS: Floor Standing
6	V	DC Fan Motor
7	D	Power supply D: 1 phase, 220-240V, 50Hz

MDV ① I ② 3 ③ - At ④ 05 ⑤ WM ⑥ R12 ⑦ D ⑧

Legend		
No.	**Code**	**Remarks**
1	M	MDV
2	I	VRF indoor unit
3	3	The 3rd generation of indoor VRF
4	At	Atom series
5	05	Capacity index (the capacity in Btu/h)
6	WM	C4C: Compact Four-way Cassette WM: Wall-mounted D1: Arc Duct D2: Medium Static Pressure Duct
6	M	Series category (D: DC series)
7	R12	Refrigerant type (R12: R410A&R32)
8	D	Power supply D: 1 phase, 220-240V, 50Hz

3.1.2 Hydraulic Module

MDV ① K ② - At ③ 160 ④ R12 ⑤

Legend		
No.	**Code**	**Remarks**
1	MDV	Hydraulic Module
2	K	Hydraulic Module
3	At	Atom series
4	160	Capacity index (the capacity in kW multiplied by 10)
5	R12	Refrigerant type (R12: R32)

3.1.3 All in one hydraulic module

MDV KT - At 160 / 190 C G R12

① ② ③ ④ ⑤ ⑥ ⑦ ⑧

Legend		
No.	**Code**	**Remarks**
1	MDV	MDV
2	KT	All in one hydraulic module
3	At	Atom series
4	160	Capacity index (the capacity in kW multiplied by 10)
5	190	Tank water volume
6	C	Water cycle with water pump
7	G	Floor heating function
8	R12	Refrigerant type (R12: R32)

3.1.4 DHW Kit

MDV HWK - 120 H R12

① ② ③ ④ ⑤

Legend		
No.	**Code**	**Remarks**
1	MDV	MDV
2	MHWK	DHW Kit
3	120	Capacity index (the capacity in kW multiplied by 10)
4	H	Function code (H: Hot water)
5	R12	Refrigerant type (R12: R32)

3.2 Outdoor Units

MDV O - At T 80 V2 R8 E

① ② ③ ④ ⑤ ⑥ ⑦ ⑧

Legend		
No.	**Code**	**Remarks**
1	MDV	MDV
2	O	Outdoor unit
3	At	Atom series
4	T	Thermo series
5	80	Capacity index (the capacity in kW multiplied by 10)
6	V2	All DC inverter
7	R8	Refrigerant type (R8: R32)
8	E	Power supply E: 1 phase, 220-240V, 50Hz

4 Combination Ratio

$$\text{Combination ratio} = \frac{\text{Sum of capacity indexes of the indoor units}}{\text{Capacity index of the outdoor unit}}$$

Table 1-4.2: Combinations of outdoor and VRF indoor units

Outdoor unit capacity		Combination ratio	Sum of capacity indexes of connected indoor units (standard indoor units only)	Number of connected indoor units
kW	Capacity index			
7.2	72	50%~130%	36 to 93.6	1~4
9.0	90	50%~130%	45 to 117	1~6
12.3	123	50%~130%	61.5 to 159.9	1~7
14.0	140	50%~130%	70 to 182	1~8
15.5	155	50%~130%	77.5 to 201.5	1~9

Table 1-4.3: Combinations of outdoor units and VRF indoor units +DHW KIT (DHW kit cannot be independently connected with the ODU)

Outdoor unit capacity		Combination ratio of VRF indoor units	Sum of capacity indexes of connected indoor units (standard indoor units only)	Number of connected indoor units	Number of DHW kit(s)
kW	Capacity index				
12.3	123	50%~130%	61.5 to 159.9	2~7	1

Table 1-4.4: Combinations of outdoor units and VRF indoor units + hydraulic modules

Outdoor unit capacity		Combination ratio of VRF indoor units	Sum of capacity indexes of connected indoor units (standard indoor units only)	Number of connected indoor units	Number of hydraulic modules
kW	Capacity index				
7.2	72	50%~100%	36 to 72	2~4	1
9.0	90	50%~100%	45 to 90	2~6	1
12.3	123	50%~100%	61.5 to 123	2~7	1
14.0	140	50%~100%	70 to 140	2~8	1
15.5	155	50%~100%	77.5 to 155	2~9	1

Table 1-4.5: Combinations of outdoor units and hydraulic modules

Outdoor unit capacity		Number of hydraulic modules
kW	Capacity index	
7.2	72	1
9.0	90	1
12.3	123	1
14.0	140	1
15.5	155	1

5 Selection Procedure

5.1 Procedure

Step 1: Establish design conditions

Design temperature and humidity (indoor and outdoor)
Required heat load of each room
System peak load
Piping length, level differences
Indoor unit specifications (type and quantity)

Step 2: Select indoor units

Decide indoor unit safety factor

Select indoor unit models ensuring that:
Indoor unit capacity corrected for indoor air temperature WB[1] ≥ Required heat load × Indoor unit safety factor

Step 3: Select outdoor unit

Determine required total heat load on the outdoor unit

Use the sum of the peak load of each room

Use the system peak load

Provisionally select outdoor unit capacity based on combination ratio limitations

Confirm that the number of indoor units connected to the outdoor unit is within limitation

Correct cooling and heating capacities of the outdoor unit for the following items:
Outdoor air temperature / Indoor air temperature WB / Combination ratio / Piping length, level difference / Piping heat loss / Frost accumulation (for heating capacity only)

Is corrected outdoor unit capacity ≥ Required total heat load on outdoor unit?

No

Yes

VRF system selection is complete

Notes:

1. If the indoor design temperature falls between two temperatures listed in the indoor unit's capacity table, calculate the corrected capacity by interpolation. If the indoor unit selection is to be based on total heat load and sensible heat load, select indoor units which satisfy not only the total heat load requirements of each room but also the sensible heat load requirements of each room. As with total heat capacity, the sensible heat capacity of indoor units should be corrected for indoor temperature, interpolating where necessary. For the indoor unit capacity tables, refer to the indoor unit technical manuals.

5.2 Example

The following is a selection example based on total heat load for cooling.

Figure 1-5.1: Room plan

<table>
<tr><td rowspan="3">Room A</td><td>Room B</td><td>Room C</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Room D</td></tr>
</table>

Step 1: Establish design conditions

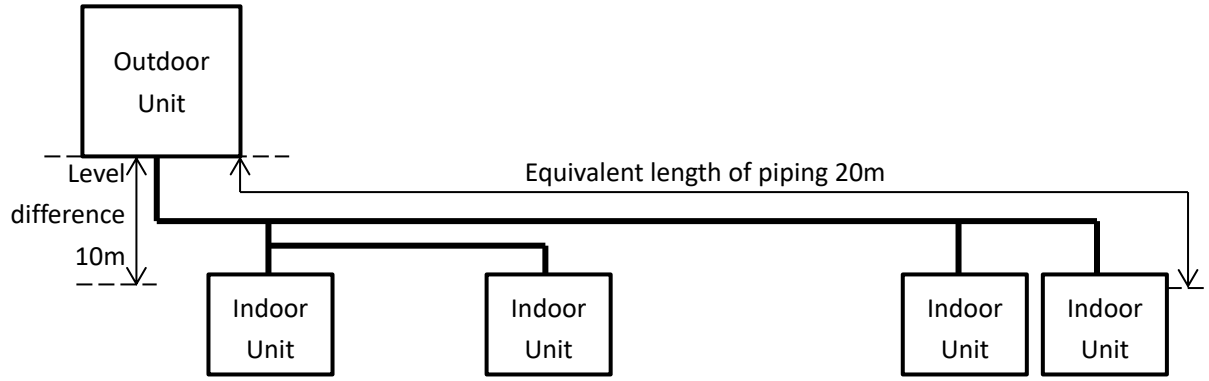
- Indoor air temperature 25°C DB, 18°C WB; outdoor air temperature 33°C DB.
- Determine peak load of each room and system peak load. As shown in Table 1-5.1, the system peak load is 10.5kW.

Table 1-5.1: Required heat load of each room (kW)

Time	Room A	Room B	Room C	Room D	Total
9:00	2.5	1.6	1.6	1.6	7.3
12:00	3.2	2.4	2.4	2.4	10.4
14:00	3.1	2.4	2.4	2.6	**10.5**
16:00	3.1	2.3	2.3	2.3	10

- The maximum piping lengths and level differences in this example are as given in Figure 1-5.2.

Figure 1-5.2: System diagram



- Indoor unit type for all rooms: Medium Static Pressure Duct (T2).

Step 2: Select indoor units

- In this example, a safety factor is not used (i.e. the safety factor is 1).
- Select indoor unit models using the medium static pressure duct cooling capacity table. Each indoor unit's corrected capacity needs to be greater than or equal to the peak load of the relevant room. The selected indoor units are shown in Table 1-5.3.

Table 1-5.2: Extract from medium static pressure duct (T2) cooling capacity table

Model	Capacity index		Indoor air temperature													
			14°C WB		16°C WB		18°C WB		19°C WB		20°C WB		22°C WB		24°C WB	
			20°C DB		23°C DB		26°C DB		27°C DB		28°C DB		30°C DB		32°C DB	
	kBtu/h	kW×10	TC	SHC	TC	SHC	TC	SHC	TC	SHC	TC	SHC	TC	SHC	TC	SHC
T2	7	22	1.5	1.4	1.8	1.5	2.1	1.6	2.2	1.6	2.3	1.7	2.4	1.5	2.4	1.5
	9	28	1.9	1.7	2.3	1.9	2.6	2.1	2.8	2.1	3.0	2.1	3.1	2.0	3.1	1.9
	12	36	2.5	2.1	2.9	2.3	3.4	2.5	3.6	2.6	3.8	2.7	4.2	2.8	3.9	2.3
	15	45	3.1	2.6	3.7	2.8	4.2	3.1	4.5	3.2	4.8	3.2	4.9	3.1	5.1	2.9
	18	56	3.9	3.0	4.6	3.3	5.3	3.6	5.6	3.7	5.9	3.8	6.2	3.7	6.2	3.4
	24	71	4.9	3.9	5.8	4.3	6.7	4.7	7.1	4.9	7.5	4.8	7.8	4.6	7.8	4.3
	28	80	5.5	4.4	6.6	4.9	7.5	5.3	8.0	5.5	8.4	5.5	8.8	5.2	8.8	4.8
	32	90	6.2	5.3	7.3	5.8	8.4	6.3	9.0	6.4	9.6	6.5	9.9	6.1	9.9	5.7
	40	112	7.7	6.4	9.1	7.1	10.5	7.7	11.2	7.8	11.9	8.1	12.5	7.8	12.5	7.4
	48	140	9.7	7.8	11.3	8.6	13.2	9.6	14.0	9.8	14.8	9.8	15.7	9.7	15.4	8.8

Abbreviations:

TC: Total capacity (kW); SHC: Sensible heat capacity (kW)

Table 1-5.3: Selected indoor units

	Room A	Room B	Room C	Room D
Peak heat load (kW)	3.1	2.4	2.4	2.6
Selected indoor unit	MDVI3-36D2VR12D	MDVI3-28D2VR12D	MDVI3-28D2VR12D	MDVI3-28D2VR12D
Corrected TC (kW)	3.6	2.8	2.8	2.8

Step 3: Select outdoor unit

- Determine the required total heat load from the indoor units to the outdoor unit based on either the sum of the peak loads of each room or the system peak load. In this example, it is determined based on the system peak load. Therefore, the required heat load is 10.5kW.
- Provisionally select an outdoor unit using the sum of the capacity indexes (CIs) of the selected indoor units (as shown in Table 1-5.4), ensuring that the combination ratio is between 45% and 130%. Refer to Table 1-5.5. As the sum of CIs of the indoor units is 120, all outdoor units are potentially suitable except 8kW. Start from the smaller, which is the 10kW unit.

Table 1-5.4: Sum of indoor unit capacity indexes

Model	Capacity Index	No. of units
MDVI3-28D2VR12D	36	1
MDVI3-36D2VR12D	28	3

Sum of CIs	120

Table 1-5.5: Combinations of Indoor and outdoor units

Outdoor unit capacity		Sum of capacity indexes of connected indoor units (standard indoor units only)
kBtu/h	Capacity index	
28	28	12.6 to 36.4
36	36	16.2 to 46.8
42	42	18.9 to 54.6
48	48	21.6 to 62.4
56	56	25.2 to 72.8

- The number of connected indoor units is 4 and the maximum number of connected indoor units on the 10kW outdoor unit is 6, so the number of connected indoor units is within the limitation.
- Calculate the corrected capacity of the outdoor unit:
  a) The sum of the indoor unit CIs is 120 and the CI of the 10kW outdoor unit is 100, so the combination ratio is 120 / 100 = 120%.
  b) Using the outdoor unit's cooling capacity table, interpolate to obtain the capacity ("B") corrected for outdoor air temperature, indoor air temperature, and combination ratio. Refer to Tables 1-5.6 and 1-5.7.

Table 1-5.6: Extract from Table 2-7.2 MDVO-AtT120V2R8E cooling capacity

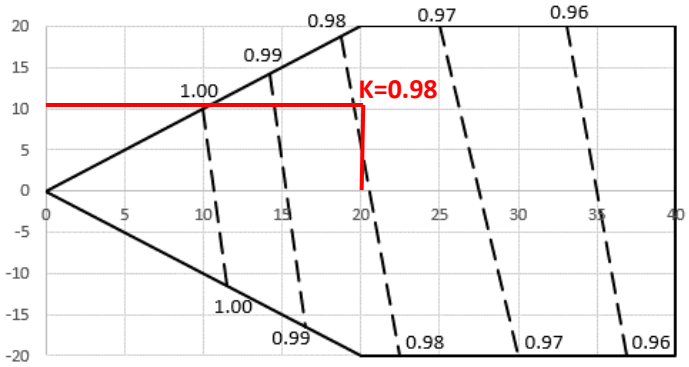
CR	Outdoor air temp. (°C DB)	Indoor air temp. (°C DB / °C WB) 25.8 / 18.0 TC kW	PI kW
120%	31	13.4	3.61
	33	13.1	3.74
	35	13.0	3.88
110%	31	13.1	3.58
	33	12.9	3.72
	35	12.7	3.85

Table 1-5.7: Cooling capacity calculated by interpolation

CR	Outdoor air temp. (°C DB)	Indoor air temp. (°C DB / °C WB) 25.8 / 18.0 TC kW	PI kW
120%			
	33	13.1	2.59
	B =13.1		
110%			
	33	12.9	2.57

c) Find the correction factor for piping length and level difference ("K1")

Figure 1-5.3: Atom rate of change in cooling capacity



d) Calculate the corrected capacity of MDVO-AtT120V2R8E ("C") by using K1:

$$C = B \times K1 = 13.1 \times 0.98 = 12.84kW$$

- The corrected capacity 12.84 kW is greater than required total heat load 10.5kW, so selection is complete.

Part 2

Component Layout and Refrigerant Circuits

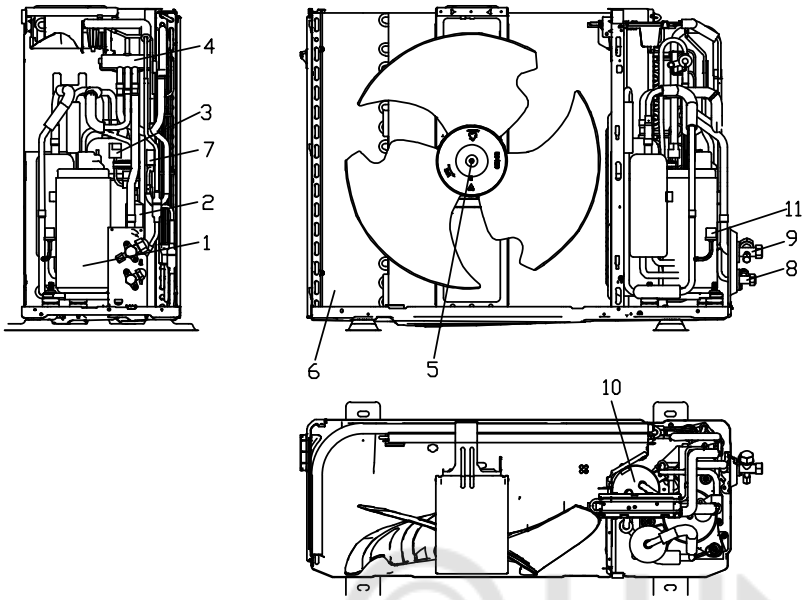
1 Piping Diagrams 16

2 Refrigerant Flow Diagrams 23

1 Layout of Functional Components

1.1 8kW layout of functional components

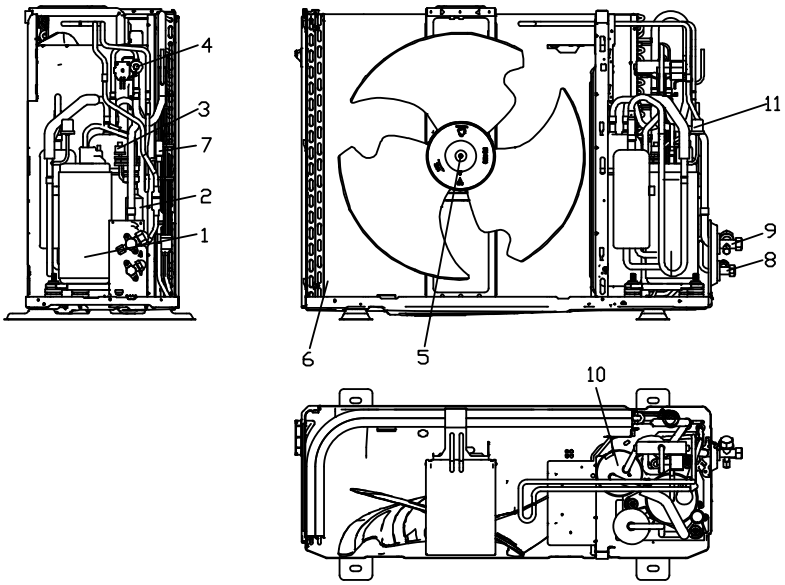
Figure 2-1.1: 8kW layout of functional components



Legend	
No.	**Parts name**
1	Compressor
2	Muffler
3	High pressure switch
4	Four-way valve (ST1)
5	Fan
6	Heat exchanger
7	Electronic expansion valve (EEVA)
8	Stop valve (liquid side)
9	Stop valve (gas side)
10	Gas-liquid separator
11	Low pressure switch

1.2 10kW layout of functional components

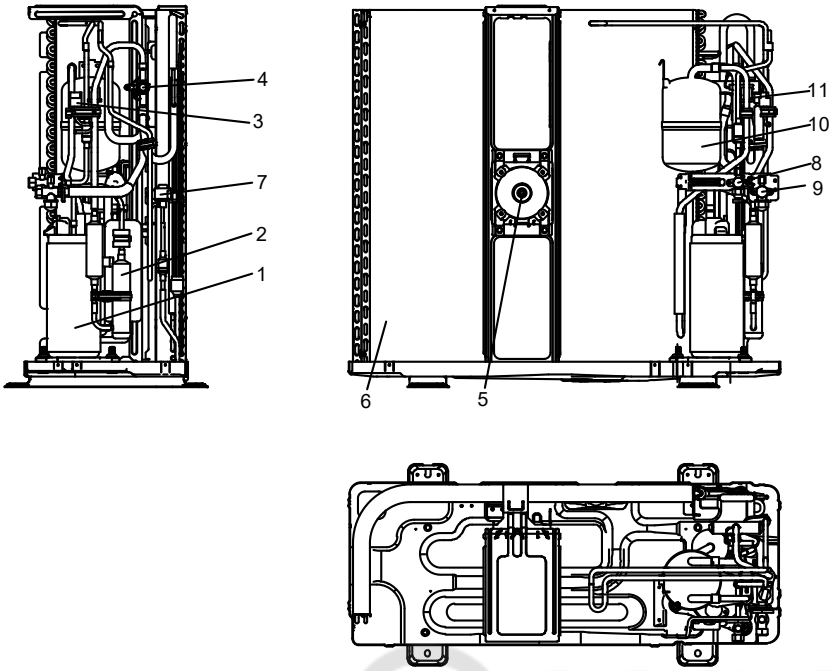
Figure 2-1.2: 10kW layout of functional components



Legend	
No.	**Parts name**
1	Compressor
2	Muffler
3	High pressure switch
4	Four-way valve (ST1)
5	Fan
6	Heat exchanger
7	Electronic expansion valve (EEVA)
8	Stop valve (liquid side)
9	Stop valve (gas side)
10	Gas-liquid separator
11	Low pressure switch

1.3 12kW layout of functional components

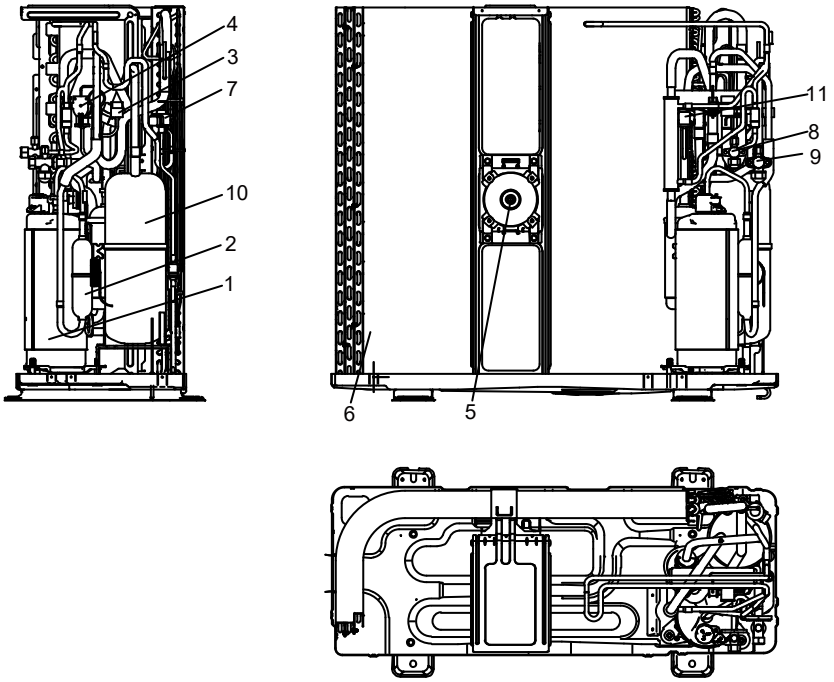
Figure 2-1.1: 12kW layout of functional components



Legend	
No.	**Parts name**
1	Compressor
2	Muffler
3	High pressure switch
4	Four-way valve (ST1)
5	Fan
6	Heat exchanger
7	Electronic expansion valve (EEVA)
8	Stop valve (liquid side)
9	Stop valve (gas side)
10	Gas-liquid separator
11	Low pressure switch

1.4 14-16kW layout of functional components

Figure 2-1.2: 14-16kW layout of functional components

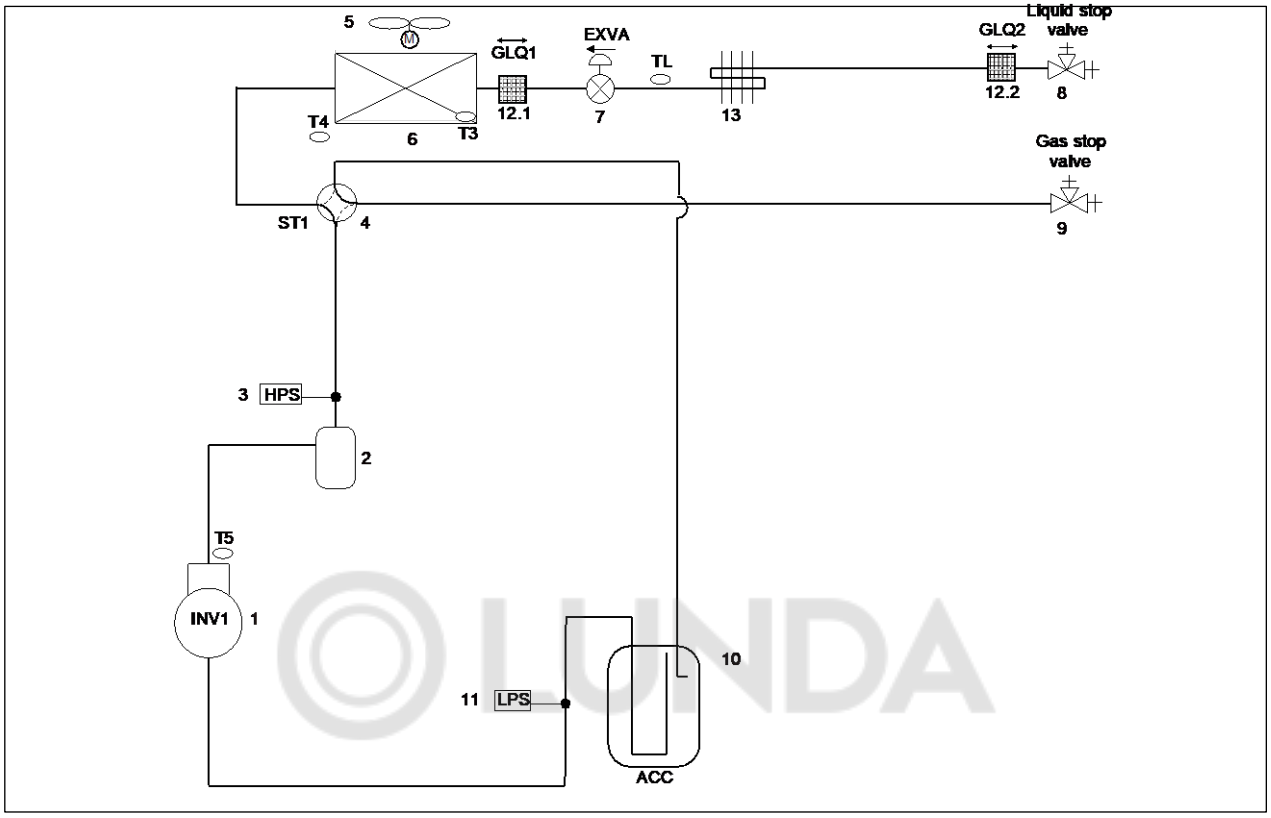


Legend	
No.	**Parts name**
1	Compressor
2	Oil separator
3	High pressure switch
4	Four-way valve (ST1)
5	Fan
6	Heat exchanger
7	Electronic expansion valve (EEVA)
8	Stop valve (liquid side)
9	Stop valve (gas side)
10	Gas-liquid separator
11	Low pressure switch

2 Piping Diagrams

2.1 8kW piping diagram

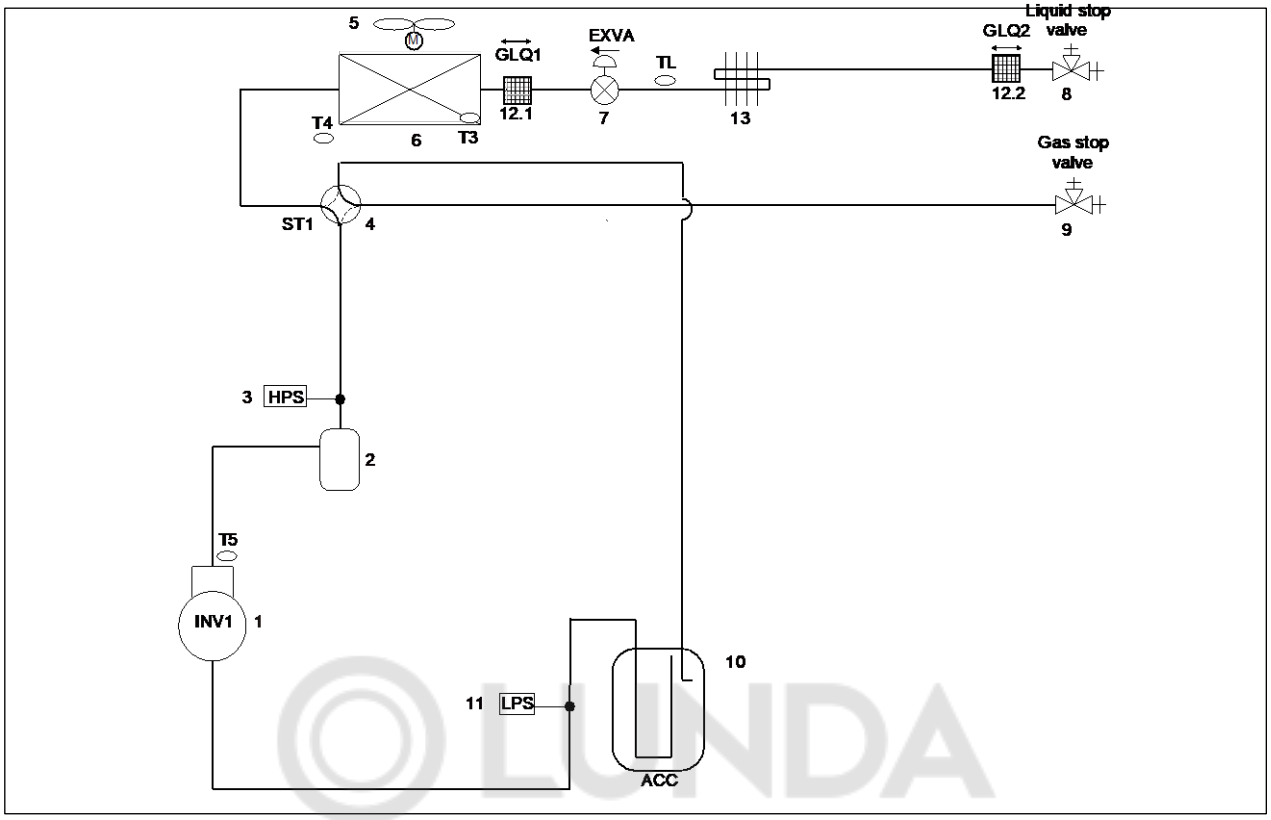
Figure 2-1.1: 8kW Piping diagram



Legend				
No.	**Parts name**		**No.**	**Parts name**
1	Compressor		10	Gas-liquid separator
2	Muffler		11	Low pressure switch
3	High pressure switch		12	Filter
4	Four-way valve (ST1)		13	Radiator
5	Fan		**Sensor Code**	**Description**
6	Heat exchanger		T3	Heat exchanger deicer temperature sensor
7	Electronic expansion valve (EEVA)		T4	Outdoor ambient temperature sensor
8	Stop valve (liquid side)		TL	Liquid pipe temperature sensor
9	Stop valve (gas side)		T5	Discharge temperature sensor

2.2 10kW piping diagram

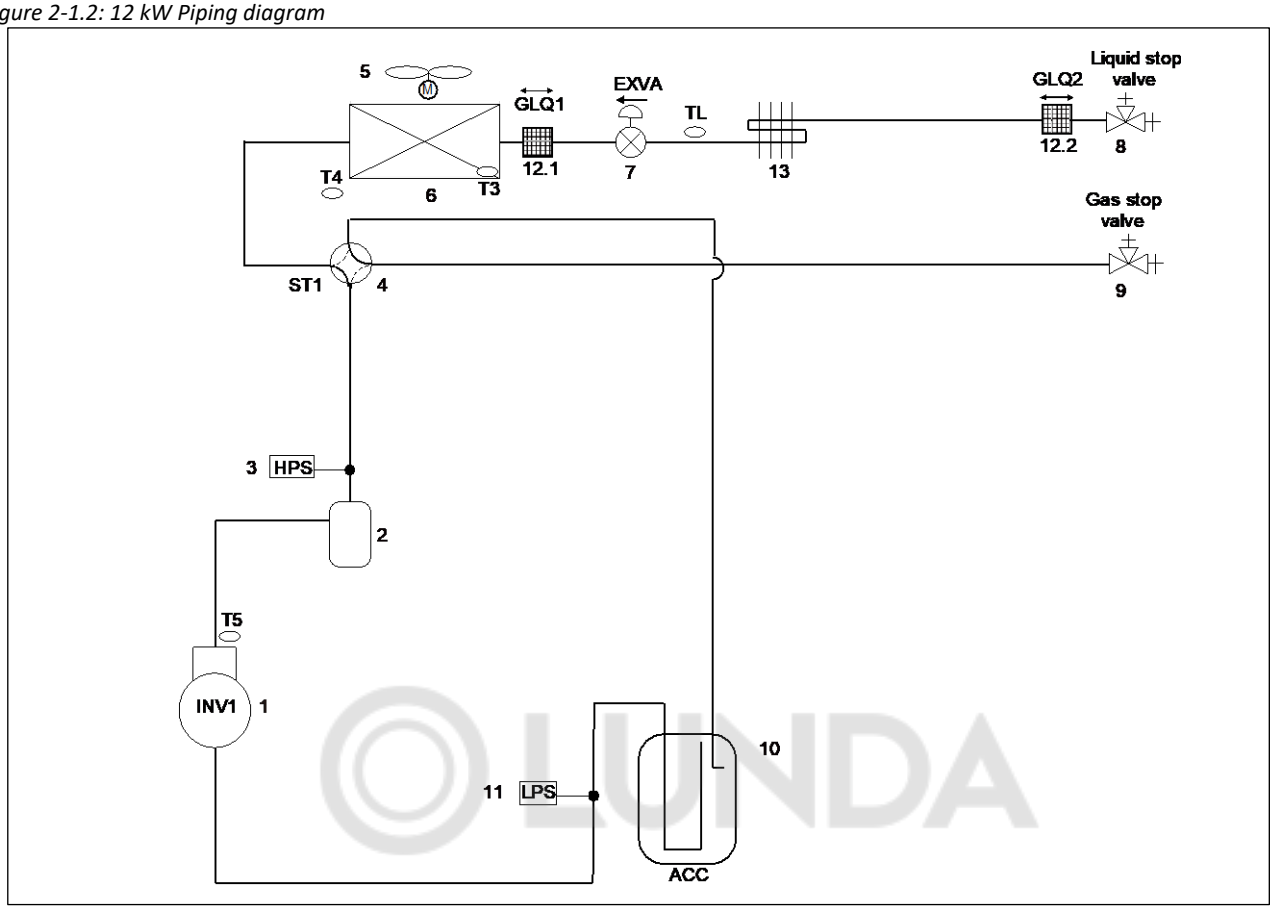
Figure 2-1.1: 10kW Piping diagram



Legend				
No.	**Parts name**		**No.**	**Parts name**
1	Compressor		10	Gas-liquid separator
2	Muffler		11	Low pressure switch
3	High pressure switch		12	Filter
4	Four-way valve (ST1)		13	Radiator
5	Fan		**Sensor Code**	**Description**
6	Heat exchanger		T3	Heat exchanger deicer temperature sensor
7	Electronic expansion valve (EEVA)		T4	Outdoor ambient temperature sensor
8	Stop valve (liquid side)		TL	Liquid pipe temperature sensor
9	Stop valve (gas side)		T5	Discharge temperature sensor

2.3 12kW piping diagram

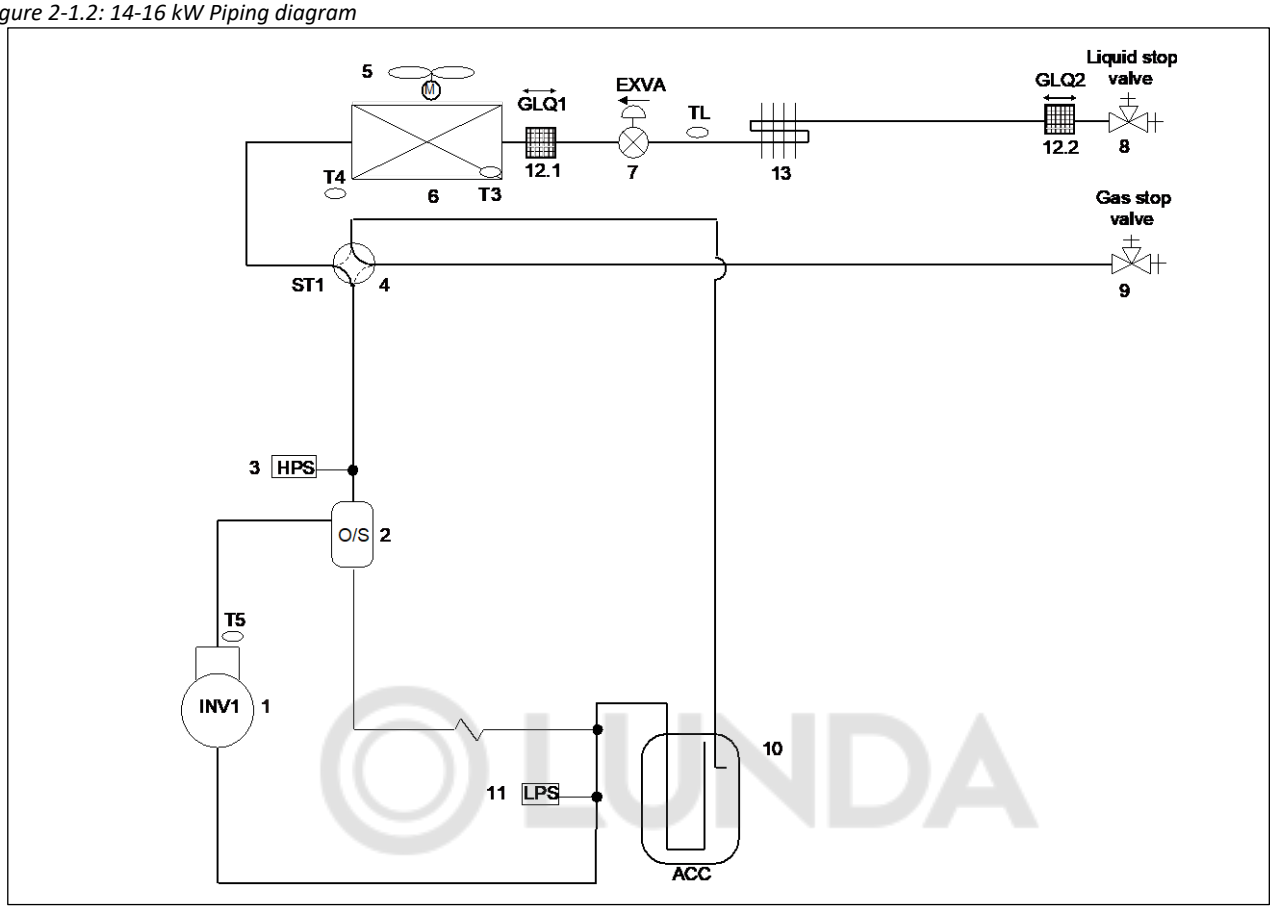
Figure 2-1.2: 12 kW Piping diagram



Legend				
No.	**Parts name**		**No.**	**Parts name**
1	Compressor		10	Gas-liquid separator
2	Muffler		11	Low pressure switch
3	High pressure switch		12	Filter
4	Four-way valve (ST1)		13	Radiator
5	Fan		**Sensor Code**	**Description**
6	Heat exchanger		T3	Heat exchanger deicer temperature sensor
7	Electronic expansion valve (EEVA)		T4	Outdoor ambient temperature sensor
8	Stop valve (liquid side)		TL	Liquid pipe temperature sensor
9	Stop valve (gas side)		T5	Discharge temperature sensor

2.4 14-16kW piping diagram

Figure 2-1.2: 14-16 kW Piping diagram



Legend				
No.	**Parts name**		**No.**	**Parts name**
1	Compressor		10	Gas-liquid separator
2	Oil separator		11	Low pressure switch
3	High pressure switch		12	Filter
4	Four-way valve (ST1)		13	Radiator
5	Fan		**Sensor Code**	**Description**
6	Heat exchanger		T3	Heat exchanger deicer temperature sensor
7	Electronic expansion valve (EEVA)		T4	Outdoor ambient temperature sensor
8	Stop valve (liquid side)		TL	Liquid pipe temperature sensor
9	Stop valve (gas side)		T5	Discharge temperature sensor

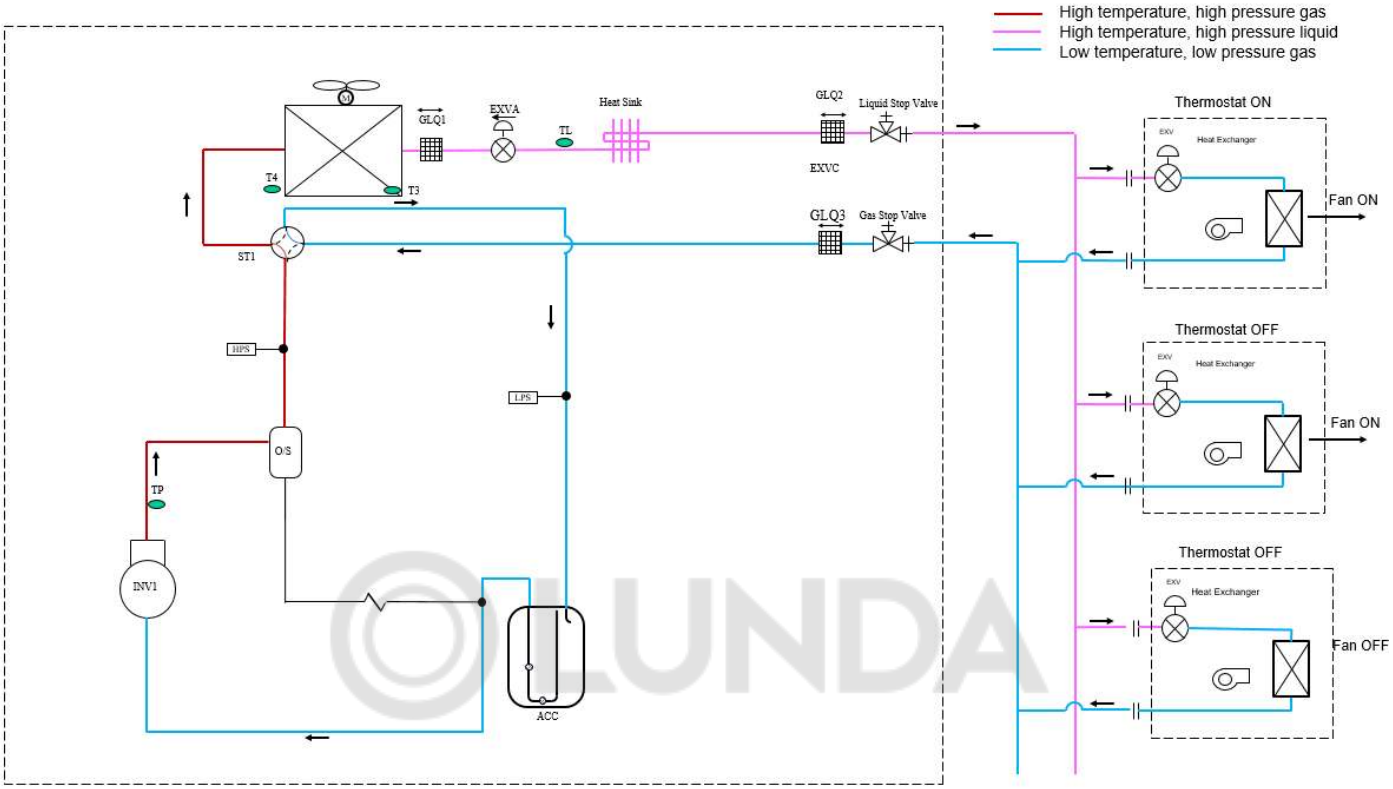
Key components:

1. **Oil separator:**
   Separates oil from gas refrigerant pumped out of the compressor and quickly returns it to the compressor. Separation efficiency is up to 99%.
2. **Gas-liquid separator:**
   Stores liquid refrigerant and oil to protect compressor from liquid hammering.
3. **Electronic expansion valve (EEV):**
   Controls refrigerant flow and reduces refrigerant pressure.
4. **Four-way valve(ST1):**
   Controls refrigerant flow direction. Closed in cooling mode and open in heating mode. When closed, the heat exchanger functions as a condenser; when open, the heat exchanger functions as an evaporator.
5. **High and low pressure switches:**
   Regulate system pressure. When system pressure rises above the upper limit or falls below the lower limit, the high or low pressure switches turn off, stopping the compressor. After 5 minutes, the compressor restarts.

3 Refrigerant Flow Diagrams

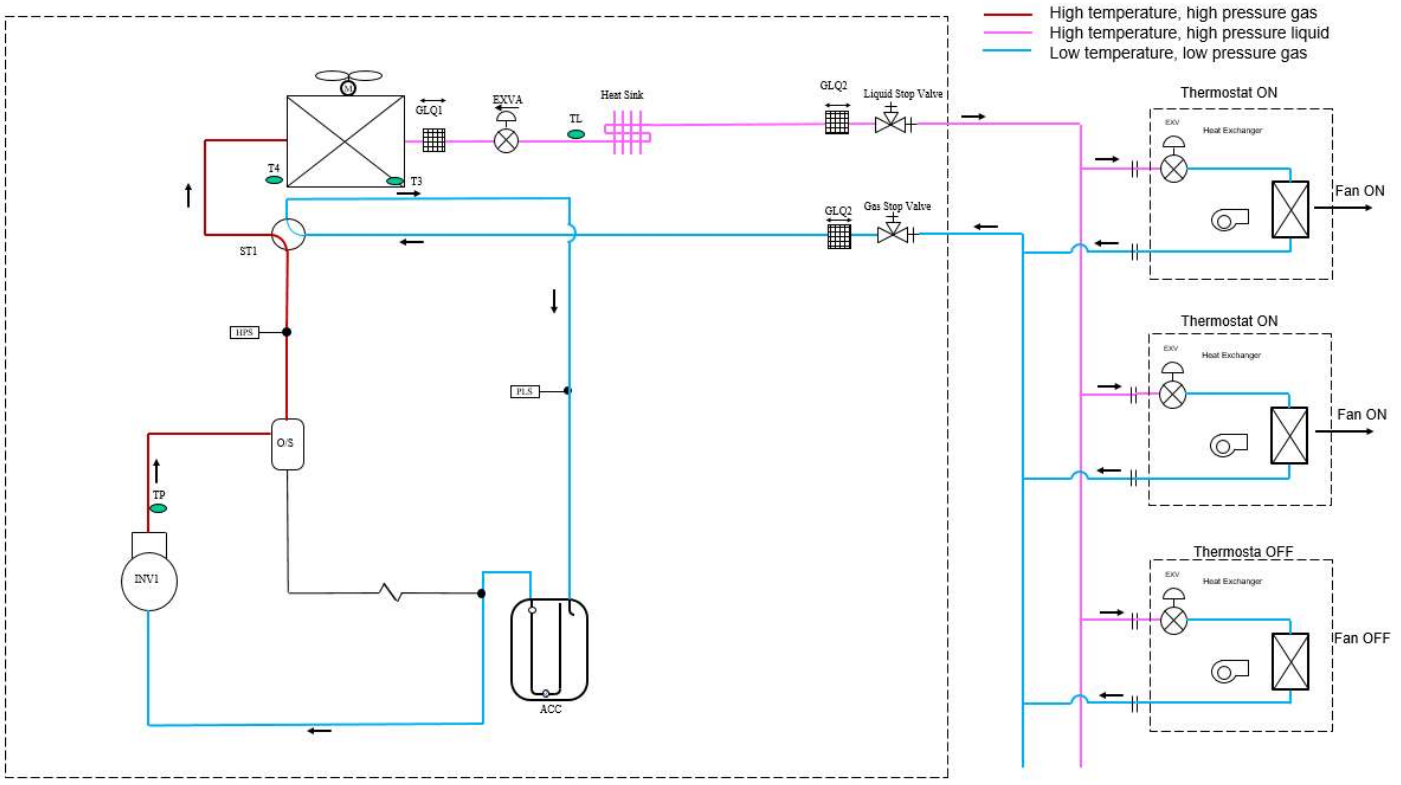
3.1 Cooling operation

Figure 2-3.1: Refrigerant flow during cooling operation



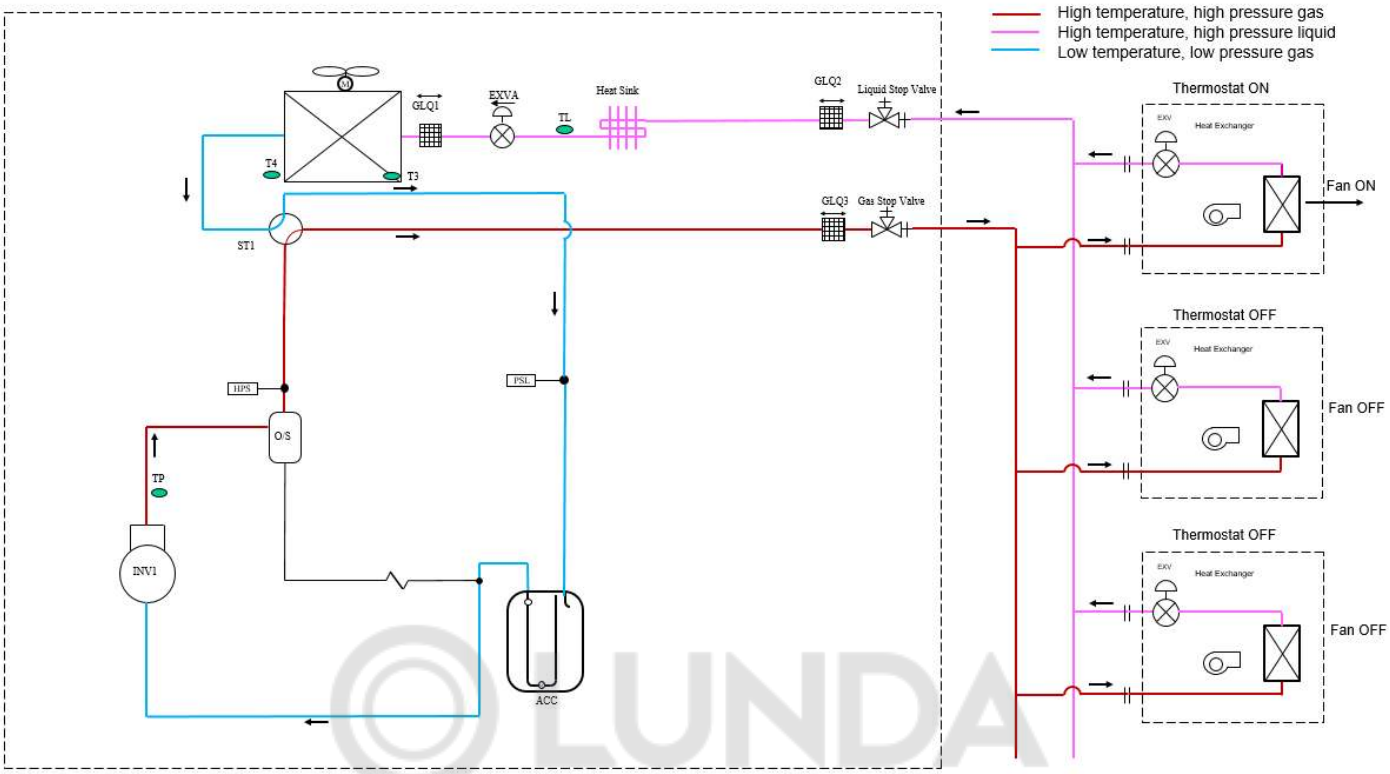
3.2 Oil return operation in cooling mode

Figure 2-3.4: Refrigerant flow during oil return operation in cooling mode



3.3 Heating operation

Figure 2-3.7: Refrigerant flow during heating operation



3.4 Oil return operation in heating mode

Figure 2-3.10: Refrigerant flow during oil return operation in heating mode (4-way Valve Keep in the same direction)

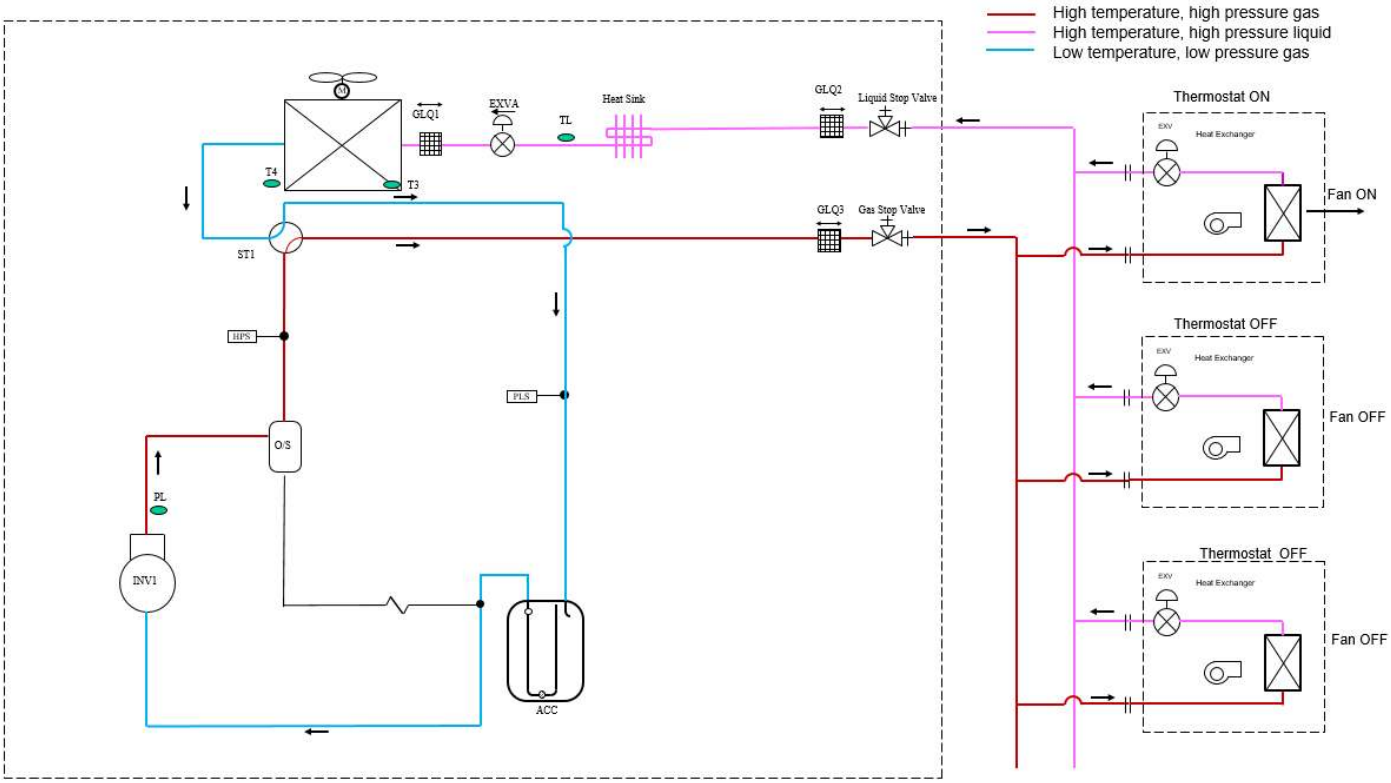
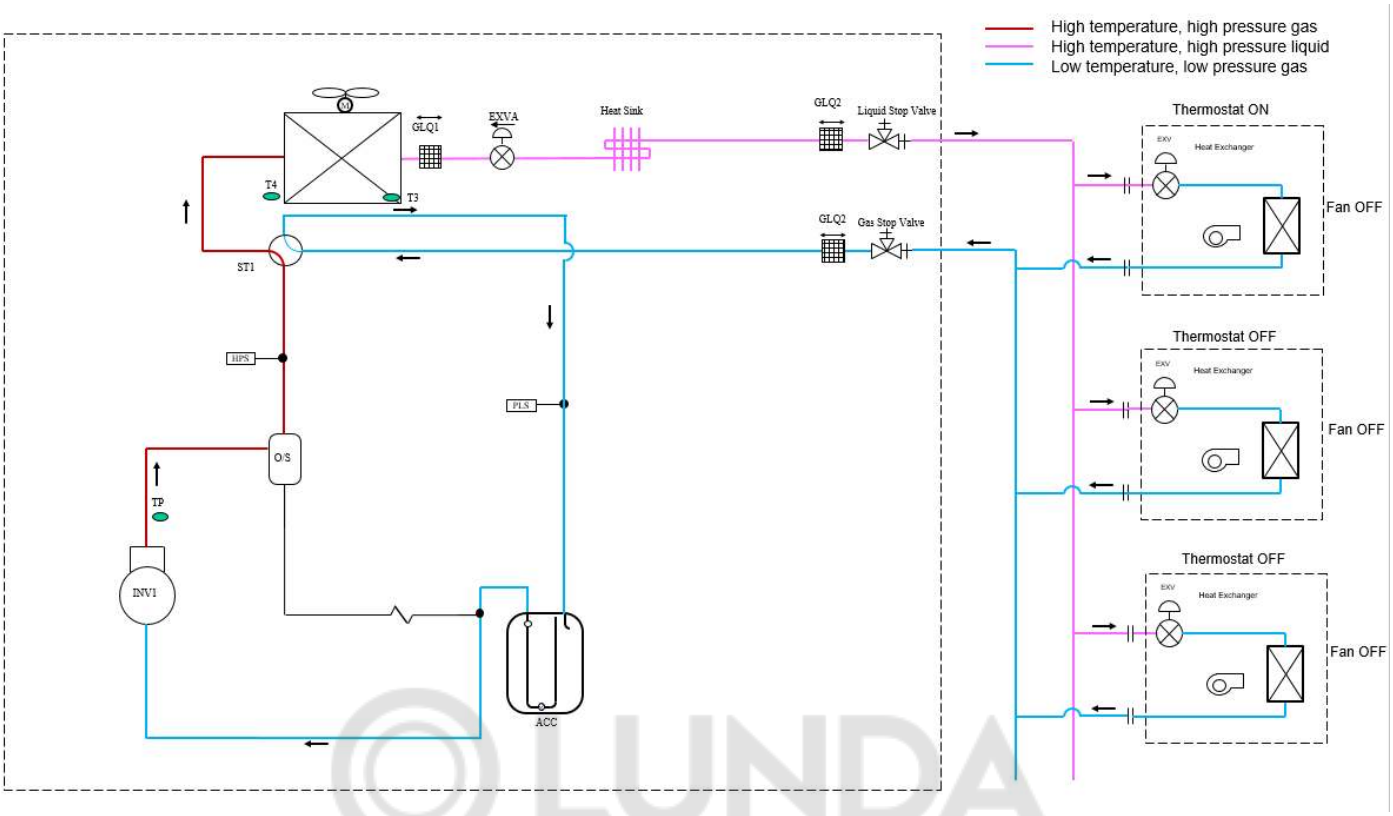
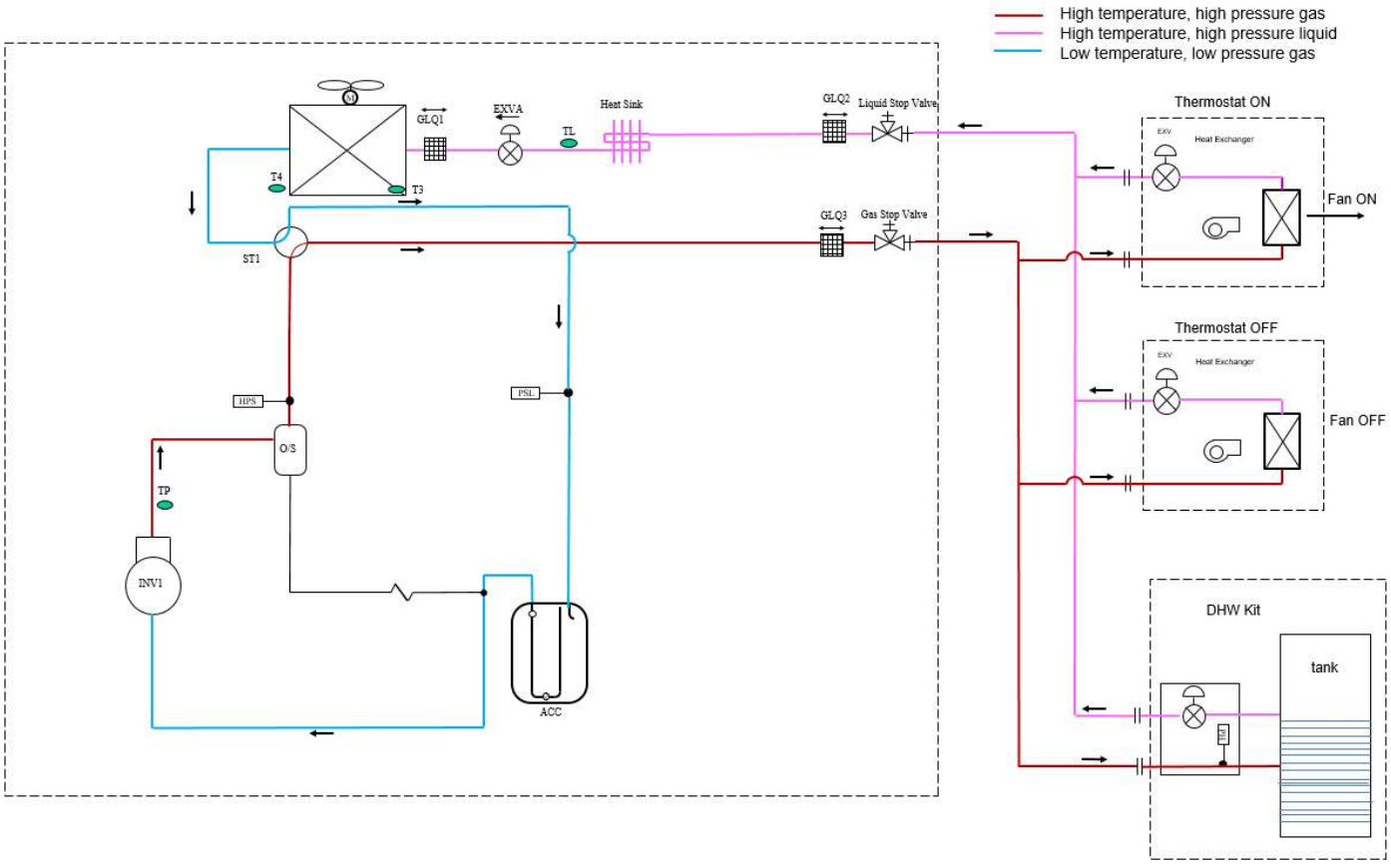


Figure 2-3.10: Refrigerant flow during oil return operation in heating mode (4-way Valve change direction)



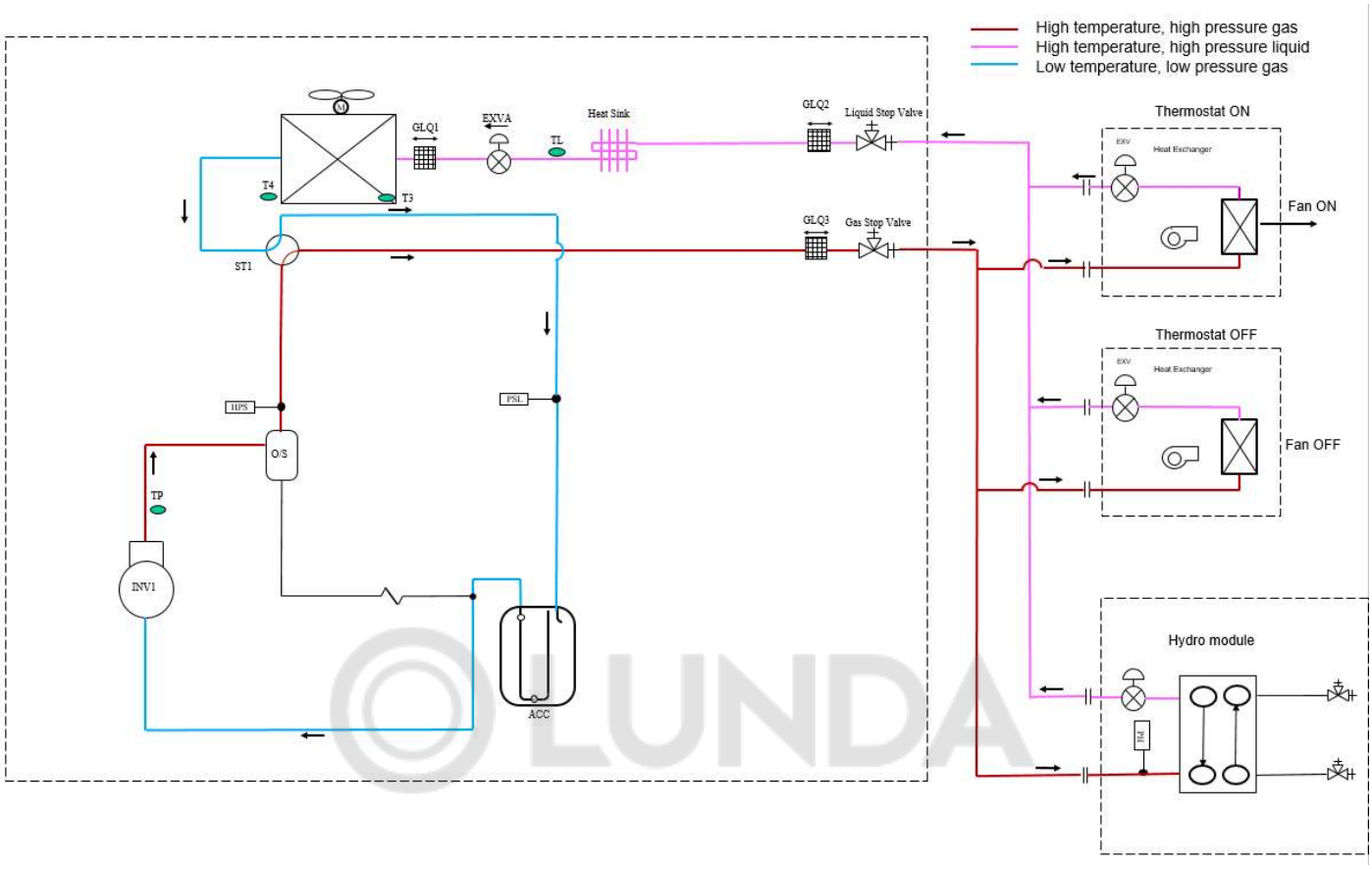
3.5 Kit hot water Operation

Figure 2-3.13: Refrigerant flow during hot water operation



3.6 Hydraulic module hot water Operation

Figure 2-3.13: Refrigerant flow during hot water operation



Part 3

Control

1 General Control Scheme Flowchart 24

2 Stop Operation 25

3 Standby Control 25

4 Startup Control 26

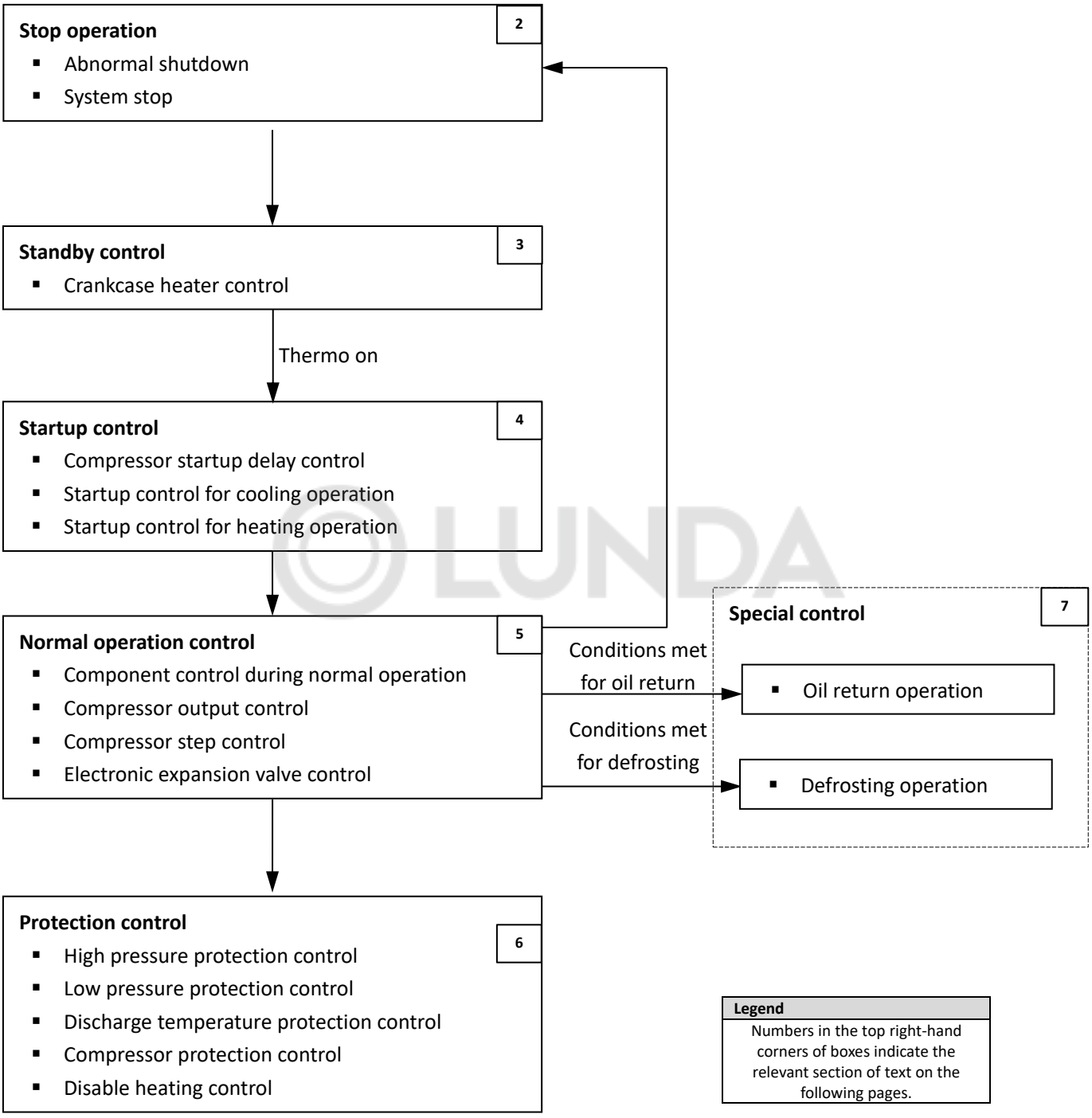
5 Normal Operation Control 27

6 Protection Control 28

7 Special Control 30

1 General Control Scheme Flowchart

Sections 3-2 to 3-7 on the following pages detail when each of the controls in the flowchart below is activated.



2 Stop Operation

The stop operation occurs for one of the two 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 digital displays.
2. The system stops when the set temperature has been reached.

3 Standby Control

3.1 Crankcase Heater Control

The crankcase heater is used to prevent refrigerant from mixing with compressor oil when the compressor is stopped. The crankcase heater is controlled according to outdoor ambient temperature and the compressor on/off state. When the outdoor ambient temperature is above 3°C or the compressor is running, the crankcase heater is off; when the outdoor ambient temperature is at or below 3°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.

4 Startup Control

4.1 Compressor Startup Delay Control

When the ODU is powered on again and the compressor delays about 7 minutes to start. After the compressor stops running, it takes about 4 minutes to restart, in order to prevent frequent compressor on/off and to equalize the pressure within the refrigerant system.

4.2 Startup Control for Cooling Operation

Table 3-4.1: Component control during startup in cooling mode

Component	Wiring diagram label	8~16kW	Control functions and states
Inverter compressor	COMP	•	Controlled according to load requirement, operating frequency increased by 1 step / sec
DC fan motor	FAN	•	The outdoor unit fan start by 7 gears for 20 seconds before compressor start, and then maintain the fan speed for another 20 seconds when compressor start, finally the fan speed controlled according to heat exchanger temperature (T3), outdoor ambient temperature (T4) ,discharge temperature (T5)and compressor frequency.
Electronic expansion valve	EEV	•	Maintain 304(step) for 3 minutes before compressor startup，then controlled according to discharge temperature
Four-way valve	ST1	•	Off

4.3 Startup Control for Heating Operation

Table 3-4.2: Component control during startup in heating mode

Component	Wiring diagram label	8~16kW	Control functions and states
Inverter compressor	COMP	•	Controlled according to load requirement, operating frequency increased by 1 step / sec
DC fan motor	FAN	•	The outdoor unit fan start by 7 gears for 20 seconds before compressor startup, and then maintain the fan speed for another 20 seconds when compressor start, finally the fan speed controlled according to heat exchanger temperature (T3), outdoor ambient temperature (T4) and compressor frequency.
Electronic expansion valve	EEV	•	Maintain 304(step) for 3 minutes before compressor startup，then controlled according to discharge temperature
Four-way valve	ST1	•	On

5 Normal Operation Control

5.1 Component Control during Normal Operation

Table 3-5.1: Component control during normal cooling operation

Component	Wiring diagram label	8~16kW	Control functions and states
Inverter compressor	COMP	•	Controlled according to load requirement
DC fan motor	FAN	•	Fan speed controlled according to heat exchanger temperature (T3), outdoor ambient temperature (T4),discharge temperature (T5)and compressor frequency.
Electronic expansion valve	EEV	•	Controlled according to discharge temperature
Four-way valve	ST1	•	Off

Table 3-5.2: Component control during heating operation

Component	Wiring diagram label	8~16kW	Control functions and states
Inverter compressor	COMP	•	Controlled according to load requirement
DC fan motor	FAN	•	Fan speed controlled according to outdoor unit heat exchanger refrigerant temperature (T3),outdoor ambient temperature (T4) and compressor frequency.
Electronic expansion valve	EEV	•	Controlled according to discharge temperature
Four-way valve	ST1	•	On

5.2 Compressor Output Control

The compressor rotation speed is controlled according to the load requirement. Before compressor startup, the outdoor unit first estimates the indoor unit load requirement according to the nominal capacity of indoor units currently running, and then correct for ambient temperature. The compressors then start up according to the corrected load requirement.

During operation the compressors are controlled according to the nominal capacity of indoor units currently running and the indoor unit heat exchanger temperatures.

5.3 Compressor Step Control

The running speed of the compressors in rotations per second (rps) is one third of the frequency (in Hz) of the electrical input to the compressor motors. The compressor speed can be altered in increments of 1 rps.

5.4 Electronic Expansion Valve Control

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

In cooling mode:

- When the outdoor unit is in standby:
  - EEV is at position 304 (steps).
- When the outdoor unit is running:
  - EEV is controlled according to discharge temperature.

In heating mode:

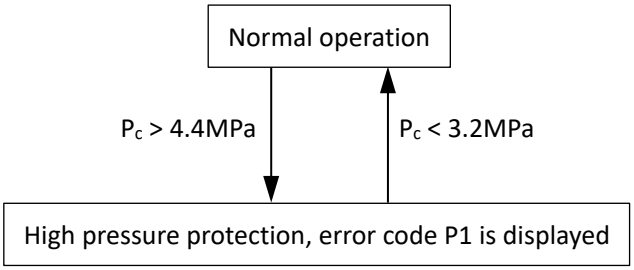
- When the outdoor unit is in standby:
  - EEV is at position 304 (steps).
- When the outdoor unit is running:
  - EEV is controlled according to discharge temperature.

6 Protection Control

6.1 High Pressure Protection Control

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

Figure 3-6.1: High pressure protection control



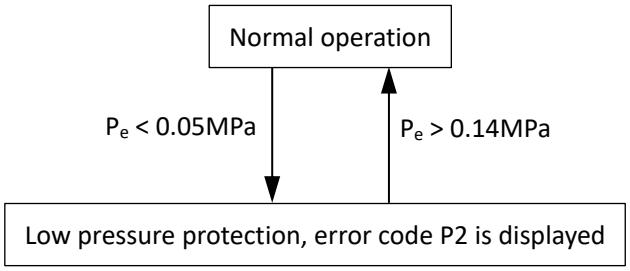
Notes:
1. P_c: Discharge pressure

When the discharge pressure rises above 4.4MPa the system displays P1 protection and the unit stops running. When the discharge pressure drops below 3.2MPa, the compressor enters re-start control.

6.2 Low Pressure Protection Control

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

Figure 3-6.2: Low pressure protection control



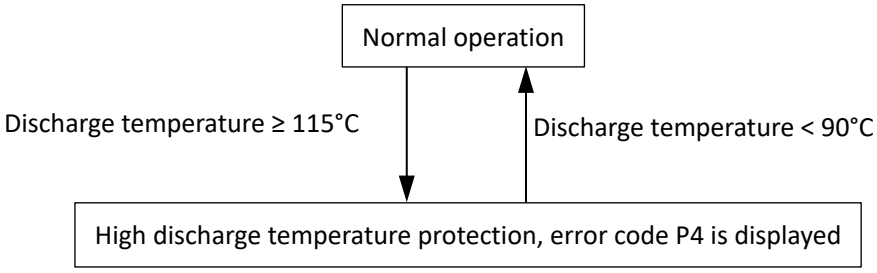
Notes:
1. P_e: Suction pressure

When suction pipe pressure drops blow 0.05MPa the system displays P2 protection and the unit stops running. When the suction pipe pressure rises above 0.14MPa, the compressor enters re-start control.

6.3 Discharge Temperature Protection Control

This control protects the compressors from abnormally high temperatures and transient spikes in temperature. It is performed for each compressor.

Figure 3-6.3: High discharge temperature protection control

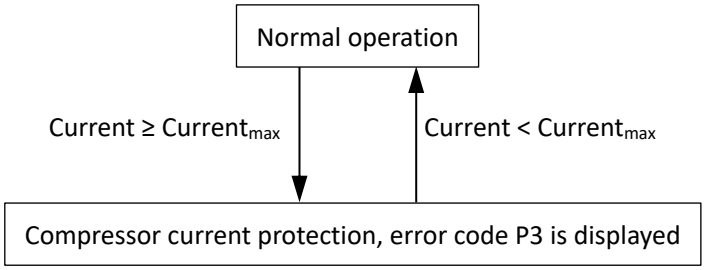


When the discharge temperature rises above or equal to 115°C the system displays P4 protection and the unit stops running. When the discharge temperature drops below 90°C, the compressor enters re-start control.

6.4 Compressor and Inverter Module Protection Control

This control protects the compressors from abnormally high currents and protects the inverter modules from abnormally high temperatures.

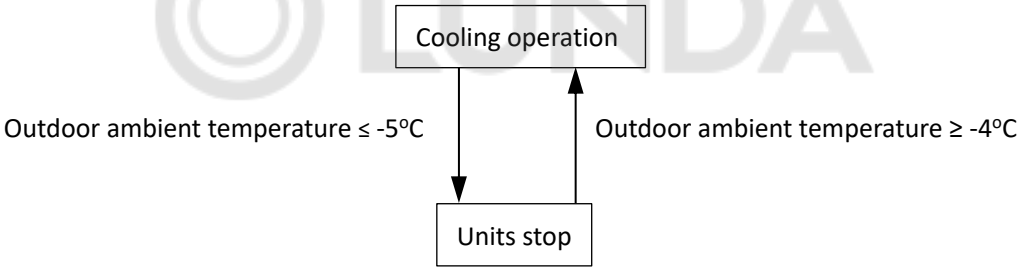
Figure 3-6.4: Compressor current protection control



6.5 Disable Cooling Control

When the outdoor ambient temperature drops below or equal to -5°C， cooling mode is disabled to prevent low compression ratios which can result in insufficient compressor internal oil lubrication, and prevent humid compressed in low superheat of compressor bottom conditions. When the outdoor ambient temperature rises above or equal to -4°C, the compressor enters re-start control.

Figure 3-6.6: Disable heating control



7 Special Control

7.1 Oil Return Operation

In order to prevent compressors from running out of oil, the oil return operation is conducted to recover oil that has flowed out of the compressor(s) and into the piping system. This operation is performed for all units including units that are in standby.

Timing of oil return operation:

- When the initial cumulative operating time reaches every 8 hours.

Tables 3-7.1 and 3-7.2 show component control during oil return operation in cooling mode.

Table 3-7.1: Outdoor unit component control during oil return operation in cooling mode

Component	Wiring diagram label	8~16kW	Control functions and states
Inverter compressor	COMP	•	Fixed frequency
DC fan motor	FAN	•	Normal control as cooling operation
Electronic expansion valve	EEV1	•	Position 300 (steps)
Four-way valve	ST1	•	Off

Table 3-7.2: Indoor unit component control during oil return operation in cooling mode

Component	Unit state	Control functions and states
Fan	Thermo on	Remote controller setting
	Standby	Remote controller setting
	Thermo off	Off
Electronic expansion valve	Thermo on	Normal control
	Standby	300 (steps)
	Thermo off	300 (steps)

Tables 3-7.3 and 3-7.4 show component control during oil return operation in heating mode.

Table 3-7.3: Outdoor unit component control during oil return operation in heating mode

Component	Wiring diagram label	8~16kW	Control functions and states
Inverter compressor	COMP	•	Fixed frequency
DC fan motor	FAN	•	Fan speed controlled according to heat exchanger temperature (T3) and outdoor ambient temperature (T4)
Electronic expansion valve	EEV1	•	Position 300 (steps)
Four-way valve	ST1	•	Off

Table 3-7.4: Indoor unit component control during oil return operation in heating mode

Component	Unit state	Control functions and states
Fan	Thermo on	Operate on setting fan speed (Prevent cold wind priority)
	Standby	Operate on setting fan speed (Prevent cold wind priority)
	Thermo off	Off
Electronic expansion valve	Thermo on	Normal control
	Standby	480 (steps)
	Thermo off	480 (steps)

Note：Prevent cold wind：It's only valid in heating operation, and this control is priority to other controls (including heating oil return and defrost), Which determine the conversion between setting fan speed with low fan speed and turn off the fan according to the evaporator coil temperature T2.

7.2 Defrosting Operation

In order to recover heating capacity, the defrosting operation is conducted when the outdoor unit heat exchanger is performing as an evaporator. The defrosting operation is controlled according to outdoor ambient temperature, outdoor heat exchanger temperature, indoor heat exchanger temperature and outdoor unit running time. When the outdoor unit is running in defrosting, the digital display on outdoor main PCB will display “df”.

Table 3-7.5: Outdoor unit component control during defrosting operation

Component	Wiring diagram label	8~16kW	Control functions and states
Inverter compressor	COMP	●	Fixed frequency
DC fan motor	FAN	●	Fan speed controlled according to outdoor ambient temperature (T4) before running in defrosting
Electronic expansion valve	EEV1	●	Position 480 (steps)
Four-way valve	ST1	●	Off

Table 3-7.6: Indoor unit component control during defrosting operation

Component	Unit state	Control functions and states
Fan	Thermo on	Operate on setting fan speed (Prevent cold wind priority)
	Standby	Operate on setting fan speed (Prevent cold wind priority)
	Thermo off	Off
Electronic expansion valve	Thermo on	480 (steps)
	Standby	480 (steps)
	Thermo off	480 (steps)

Note：Prevent cold wind：It’s only valid in heating operation, and this control is priority to other controls (including heating oil return and defrost), Which determine the conversion between setting fan speed with low fan speed and turn off the fan according to the evaporator coil temperature T2.

Part 4

Electrical Components and Wiring Diagrams

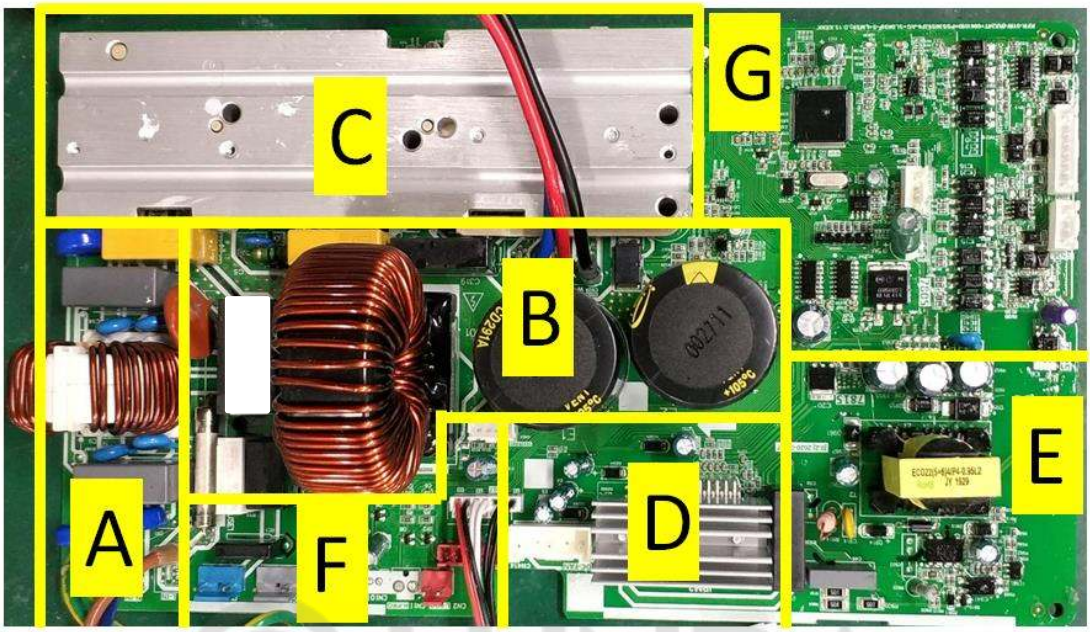
1 Outdoor Unit Electric Control Box Layout 34

2 Outdoor Unit Main PCB 36

3 Wiring Diagrams 41

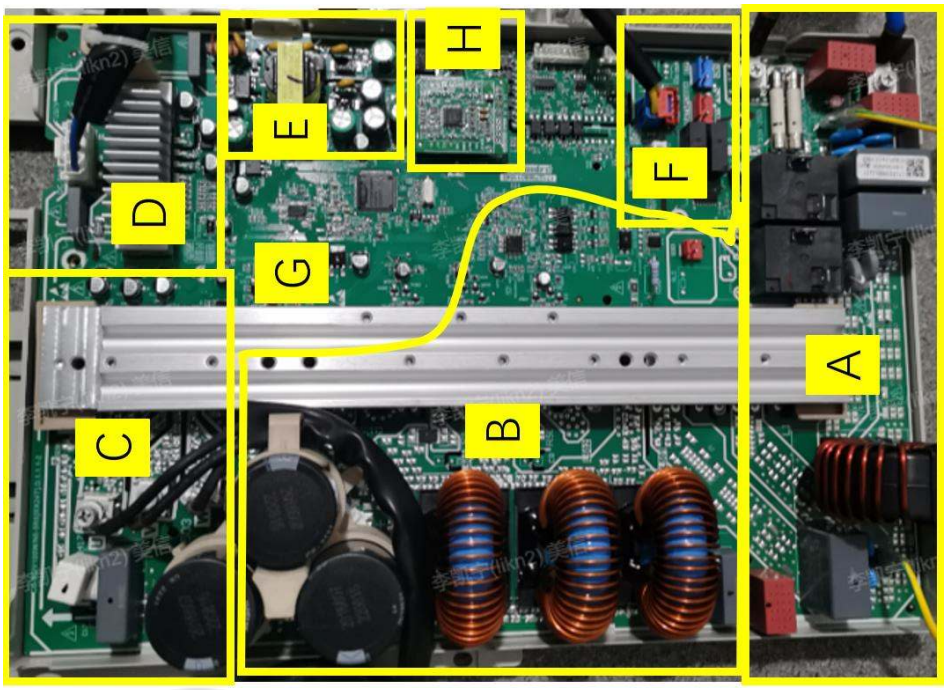
1 Outdoor Unit Electric Control Box Layout

Figure 4-1.1: 8kW electric control box (compressor & fan drive board)



Part	Name	Description
A	Power input and power filter	Filter and rectify AC power into DC power to supply DC bus, DC fan and switching power supply on the board.
B	PFC inductor	Increase grid utilization and adjust DC bus voltage: Standby to operation: 310V->350 (mains 220VAC) Fault shutdown: 350>310V (mains 220VAC)
C	IPM module	IPM converts the DC bus voltage to AC output to the UVW with adjustable frequency and amplitude. The inverter driver chip simultaneously detects various L-type errors and then notifies the main chip.
D	DC fan motor control module	IPM converts the DC bus voltage to AC output to the fan with adjustable frequency and amplitude.
E	Switching power supply	Switching power output: Output1：7VDC Output2：18VDC Output3：13VDC Output4：12VDC
F	Valve power supply and control module	Four-way valve, electric heater, electronic expansion valve control
G	Main control board	Detection function: all kinds of temperature sensors and high voltage switches, input current detection. Communication function: indoor and outdoor unit communication, centralized control gateway communication. Output control function: electric heater, four-way valve and electronic expansion valve, relay signal control

Figure 4-1.1: 10-16kW electric control box (compressor & fan drive board)

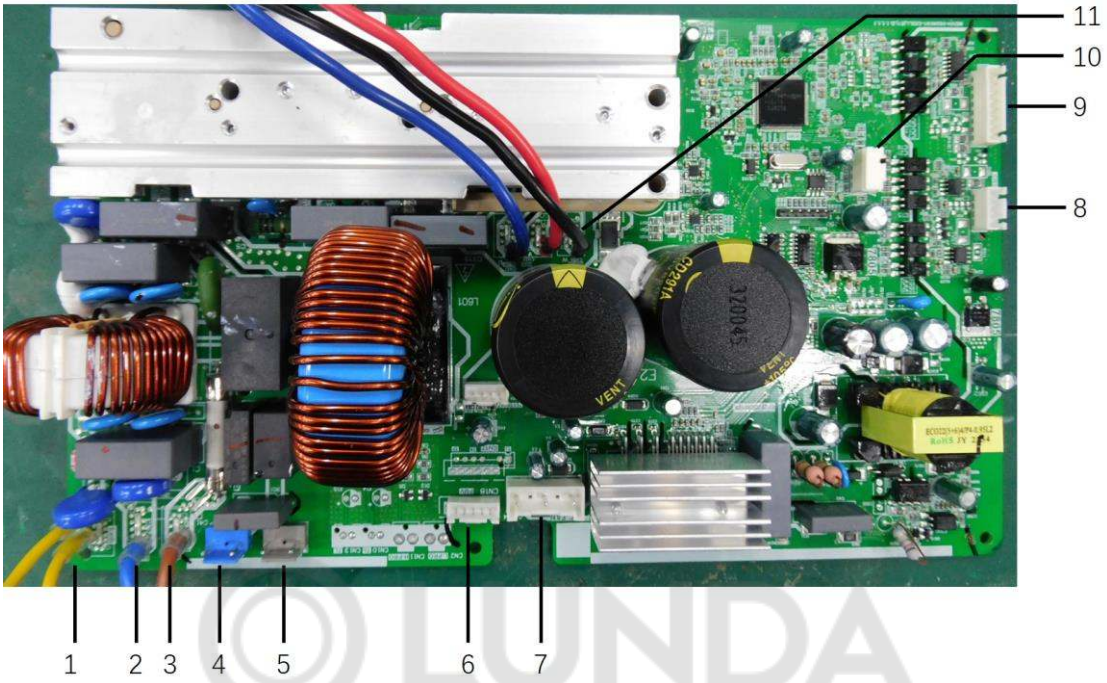


Part	Name	Description
A	Power input and power filter	Filter and rectify AC power into DC power to supply DC bus, DC fan and switching power supply on the board.
B	PFC inductor	Increase grid utilization and adjust DC bus voltage: Standby to operation: 310V->350 (mains 220VAC) Fault shutdown: 350>310V (mains 220VAC)
C	IPM module	IPM converts the DC bus voltage to AC output to the UVW with adjustable frequency and amplitude. The inverter driver chip simultaneously detects various L-type errors and then notifies the main chip.
D	DC fan motor control module	IPM converts the DC bus voltage to AC output to the fan with adjustable frequency and amplitude.
E	Switching power supply	Switching power output: Output1：7VDC Output2：18VDC Output3：13VDC Output4：12VDC
F	Valve power supply and control module	Four-way valve, electric heater, electronic expansion valve control
G	Main control board	Detection function: all kinds of temperature sensors and high voltage switches, input current detection. Communication function: indoor and outdoor unit communication, centralized control gateway communication. Output control function: electric heater, four-way valve and electronic expansion valve, relay signal control
H	PED module	Safety Diagnostic Module

2 Outdoor Unit Main PCB

2.1 Ports

Figure 4-1.1:8kW Outdoor unit main PCB ports



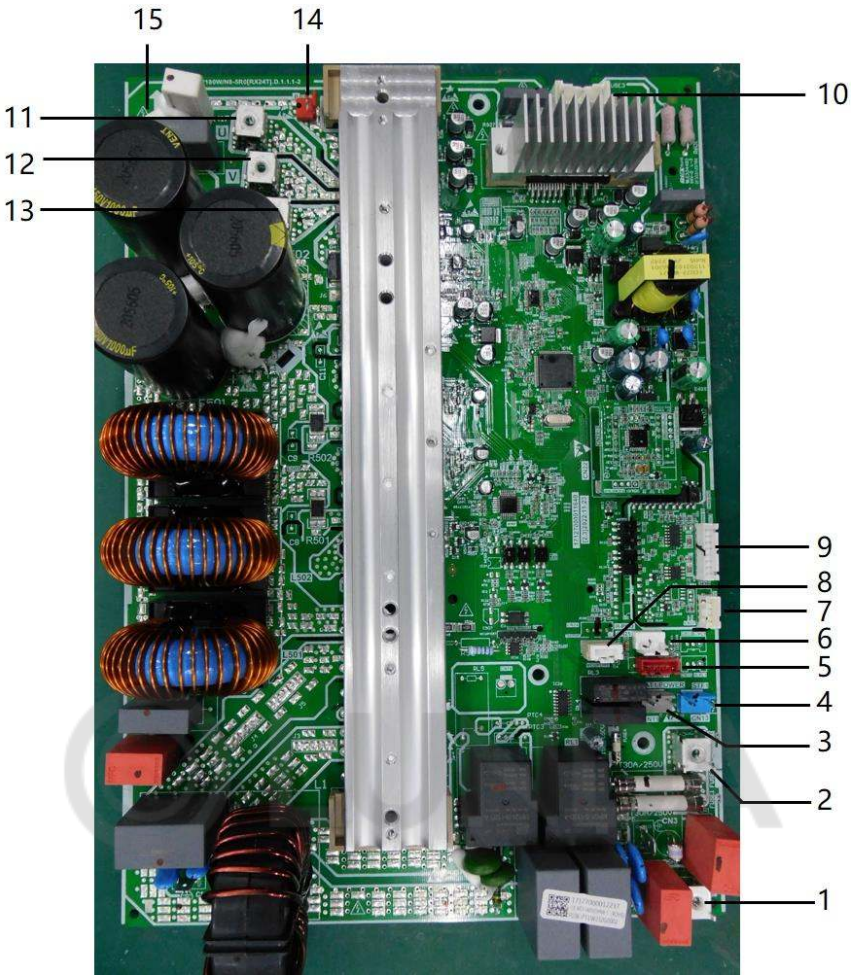
Notes:

1. Label descriptions are given in Table 4-1.1.

Table 4-1.1: Outdoor unit main PCB ports definition table

Label in Figure 4-1.1	Port code	Content	Port voltage
1	CN6/CN6-1	Ground wire	0
2	N-IN	Power input -N	AC 220V
3	L-IN	Power input -L	AC 220 V
4	CN60	Four-way valve port	AC 220 V
5	CN16	Electric heater port	AC 220 V
6	CN18	Electronic expansion valve port	Pin 1: DC 12V; Other pins: Dynamic change
7	CN414	Fan port	DC240-DC 350
8	CN30	Communication port between the main control board and Module board	DC 0~5V
9	CN3	Energy meter communication port	DC 2.5~5V
10	CN507	Chip burning port	DC 5V
11	U/V/W	Compressor U/V/W output	DC240-DC 350

Figure 4-1.1:10-16kW Outdoor unit main PCB ports



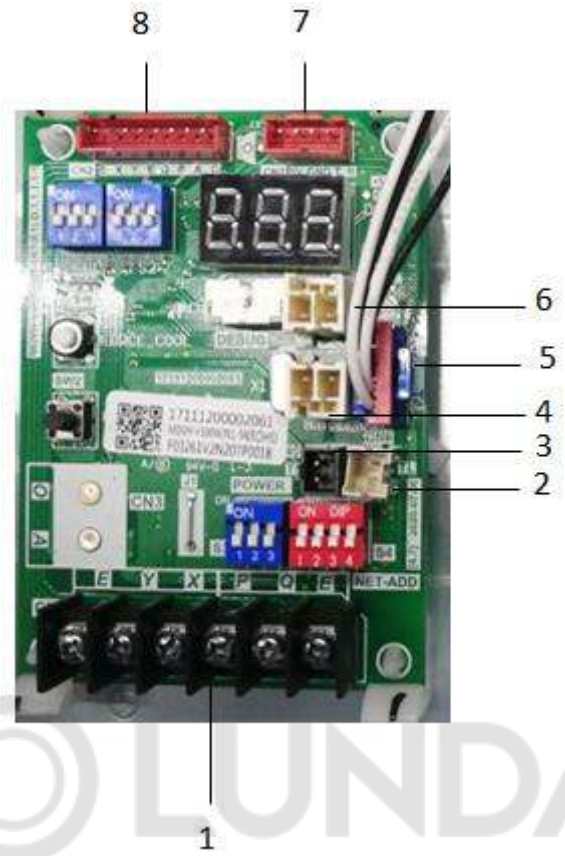
Notes:

2. Label descriptions are given in Table 4-1.1.

Table 4-1.1: Outdoor unit main PCB ports definition table

Label in Figure 4-1.1	Port code	Content	Port voltage
1	CN1	Power input -N	220VAC
2	CN2	Power input -L	220VAC
3	CN11	Electric heater port	220VAC
4	CN13	Four-way valve port	220VAC
5	CN23	Electronic expansion valve port	Pin 1: DC 12V; Other pins: Dynamic change
6	CN25	High voltage pressure switch connection port	220VAC
7	CN27	Communication port between the module board and the PCB	DC 0~5V
8	CN26	Chip burning port	5VDC
10	CN32	Inverter fan drive output	DC240-DC 350
11	U	Compressor U output	DC240-DC 350
12	V	Compressor V output	DC240-DC 350
13	W	Compressor W output	DC240-DC 350
14	CN17	For factory testing only, no market wiring	0-380VDC
15	CN18	For factory testing only, no market wiring	0-380VDC

Figure 4-1.3: Outdoor unit spot check board ports



Notes:

3. Label descriptions are given in Table 4-1.3.

Table 4-1.3: Outdoor unit spot check board ports definition table

Label in Figure 4-1.3	Port code	Content	Port voltage
1	CN4	Indoor and outdoor unit wiring controller communication port	DC 2.5~5V
2	CN6	Refrigerant radiator temperature sensor	DC 0~5V(Dynamic change)
3	CN5	Discharge temperature sensor	DC 0~5V(Dynamic change)
4	CN8	High voltage switch detection port	DC 0~5V(Dynamic change)
5	CN9	Outdoor condenser temperature sensor / Outdoor ambient temperature sensor	DC 0~5V(Dynamic change)
6	CN7	High pressure protection switch detection port	DC 0~5V(Dynamic change)
7	CN1	Communication port between the main control board and the spot check board	DC 0~5V(Dynamic change)
8	CN3, CN4	Energy meter communication port	DC 2.5~5V

2.2 Components

2.2.1 Digital display output

Outdoor unit state	Parameters displayed on DSP1	Picture
Standby	The number of indoor units in communication with the outdoor unit	
Normal operation	Compressor frequency	
Error or protection	Error or protection cod	
System check	Display system check code	

2.2.2 Function of buttons SW1 to SW2

Table 4-2.2: Function of buttons SW1 to SW2

Switch	Setting	Switch positions	Description	Picture
SW1	Forced cooling		Press SW1 to enter the forced cooling function; press it again to exit the forced cooling function	
SW2	Check		Spot check button	

2.2.3 System check button

Before pressing UP or DOWN button, allow the system to operate steadily for more than an hour. On pressing UP or DOWN button, the parameters listed in below table will be displayed in sequence.

Table 4-3.1 system check list:

DSP1 content	Parameters displayed on DSP2	Remarks
----	Operating mode	
0.--	Operating fan speed	0
1.--	Total IDU capacity requirement	Actual value = value displayed (HP)
2.--	Total capacity requirement for the modified ODU	1
3.--	T3 condenser temperature	1~12
4.--	T4 outdoor ambient temperature	
5.--	T5 discharge temperature	Displacement frequency (1)
6.--	TF temperature	
7.--	TL refrigerant cooling tube temperature	Actual value = value displayed
8.--	Electronic expansion value opening *8	
9.--	Input current	0: OFF
	Comp. current	2: Cooling
	Input voltage	3: Heating
10.--	DC voltage	Actual value = value displayed
11.--	T2/T2B average temperature	
12.--	T2A condenser temperature	Actual value = value displayed
13.--	Total number of IDUs	Actual value = value displayed
14.--	Number of Operating IDUs	Actual value = value displayed
15.--	Model name	Actual value = value displayed
16.--	System address	Actual value = value displayed
17.--	Compressor error code	
18.--	Priority mode	Actual value = value displayed
19.--	Discharge pressure	Actual value = value displayed
20.--	Program version No.	
21.--	Operating mode	Actual value = value displayed
22.--	Operating fan speed	
23.--	Total IDU capacity requirement	Actual value = value displayed
24.--	Total capacity requirement for the modified ODU	Actual value = value displayed
25~34.--	Last 10 times error protection code	
35.--	Display “--”	Actual value = value displayed

Notes:

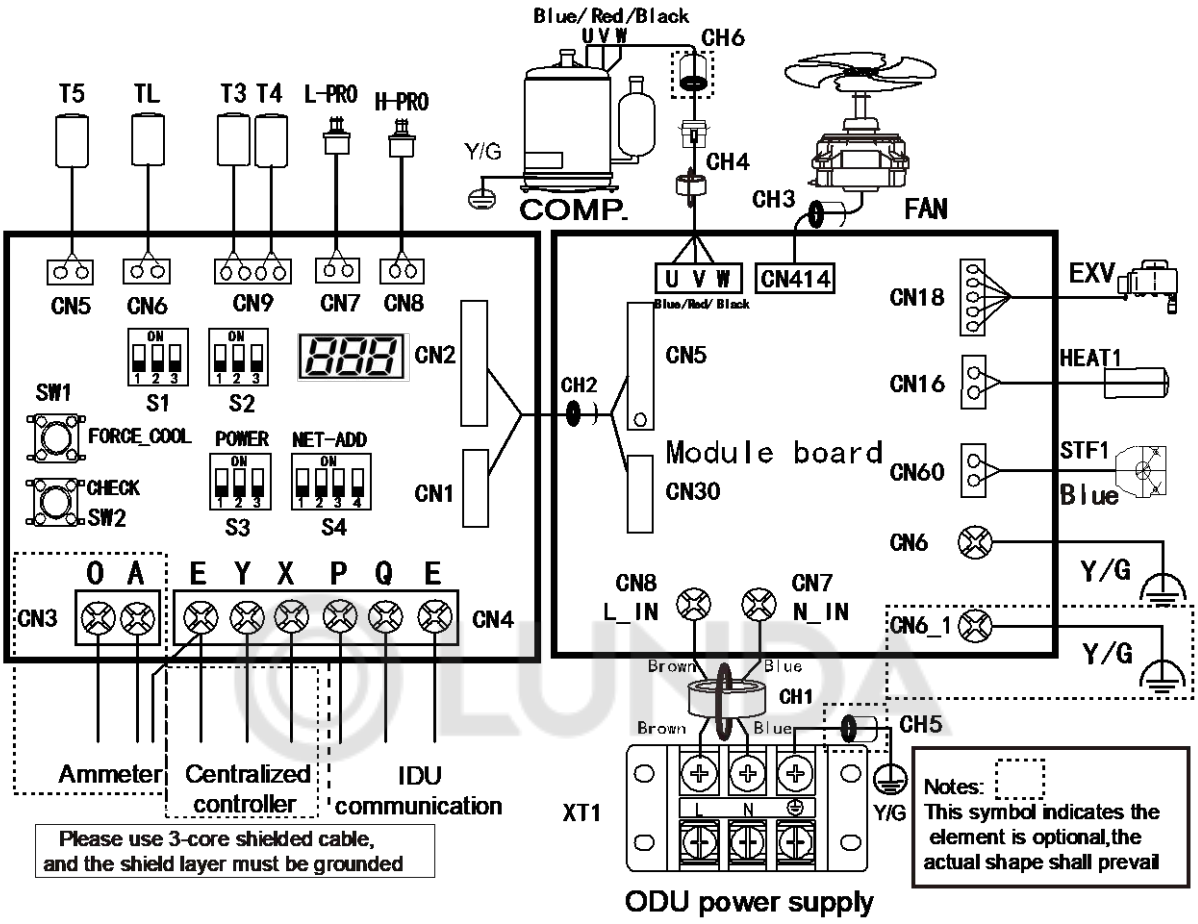
(1) Need to convert to current compressor output volume. For example: compressor output volume is 42, Target frequency = Actual frequency * 42 /60.

(2) Te: Low pressure equivalent saturation temperature (°C) Tes: Target Te value.

Tc: High pressure equivalent saturation temperature (°C) Tcs: Target Tc value.

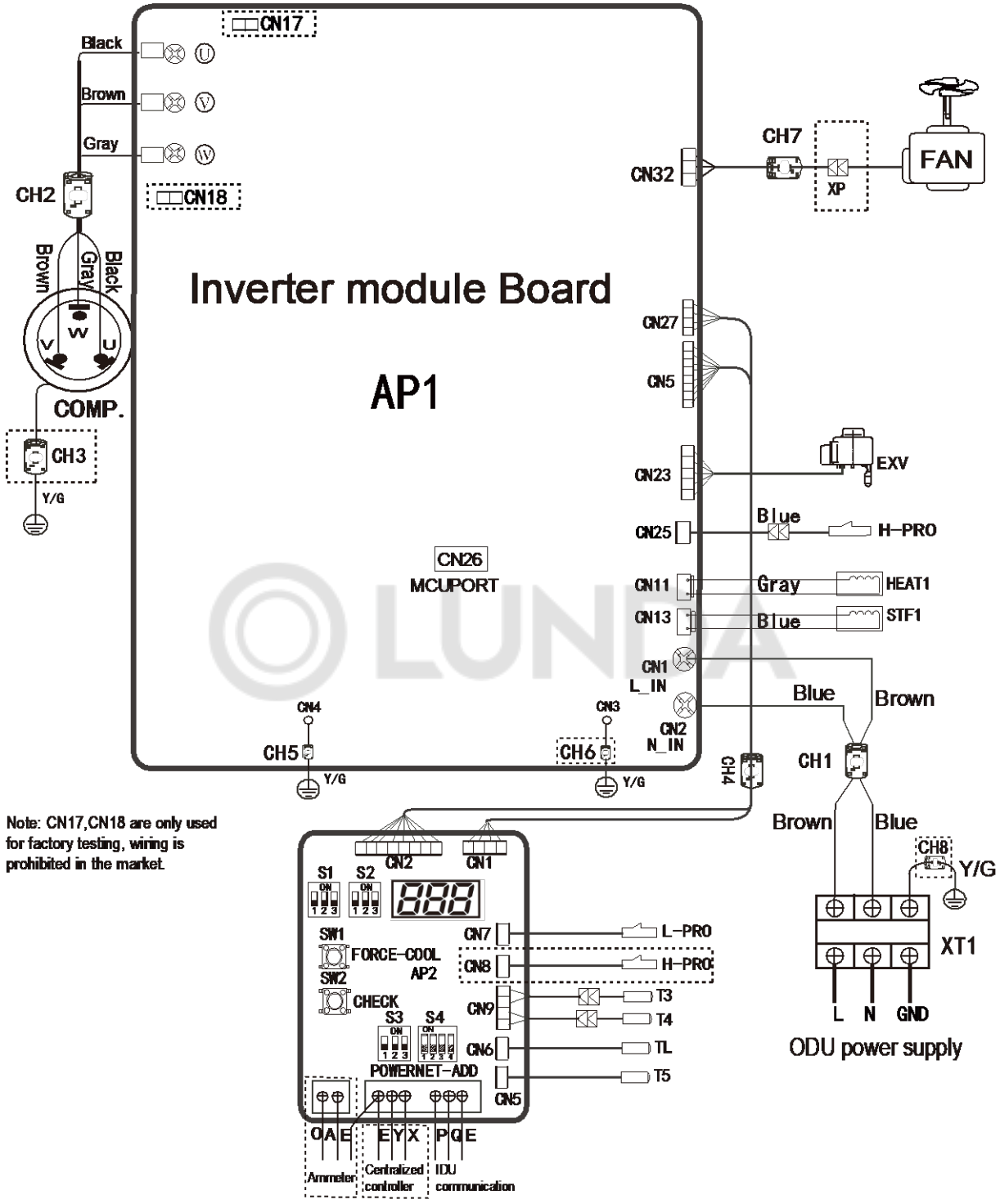
3 Wiring Diagrams

Figure 4-3.1: 8kW Outdoor units wiring diagram



Legend				
Code	**Name**		**Code**	**Name**
COMP	Compressor		CH1-CH5	Magnetic ring
EXV	Electronic expansion valve		T3	Heat exchanger temperature sensor
FAN	DC Fan		T4	Outdoor ambient temperature sensor
HEAT1	Heat sink		T5	Discharge temperature sensor
H-PRO	High pressure switch		TL	Refrigerant radiator temperature sensor
L-PRO	Low pressure switch		XT1	Power supply terminal
STF1	Four-way valve		XP	Connecting terminal

Figure 4-3.1: 10-16kW Outdoor units wiring diagram



Legend				
Code	**Name**		**Code**	**Name**
COMP	Compressor		T3	Heat exchanger temperature sensor
EXV	Electronic expansion valve		T4	Outdoor ambient temperature sensor
FAN	DC Fan		T5	Discharge temperature sensor
HEAT1	Heat sink		TL	Refrigerant radiator temperature sensor
H-PRO	High pressure switch		XT1	Power supply terminal
L-PRO	Low pressure switch		XP	Connecting terminal
STF1	Four-way valve		AP1	Main control board
CH1-CH5	Magnetic ring		AP2	Spot check board

Part 5 Diagnosis and Troubleshooting

1 Error Code Table 44

2 Troubleshooting 45

3 Appendix.....80

1 Error Code Table

1.1 Outdoor Error code table

Table 5-1.1 Outdoor Error code table

Error code	Error description	Manual re-start required
C0	Communication fault between Inverter module Board and communication terminals block	NO
U2	System combination error	NO
E2	Communication error between indoor and outdoor unit	NO
E4	T3 or T4 temperature sensor fault	NO
E5	Input voltage protection	NO
E6	DC fan protection	NO
Eb	E6 fault occurs more than six times in an hour.	YES
E9	EEPROM Error	YES
E.9.	Compressor parameters mismatch	YES
EF	PFC feedback resistance failure protection	YES
EH	Refrigerant radiator temperature sensor fault	NO
EP	Cooling ambient temperature lower than -16℃	NO
F1	DC bus voltage protection	NO
H4	L0 fault occurs three times in one hour.	NO
H7	The number of online indoor units have decreased/increased	NO
PL	Radiator surface temperature protection	NO
P1	System high pressure protection	NO
P2	System low pressure protection	NO
P3	Overcurrent protection	NO
P5	Outdoor condenser temperature T3 protection	NO
P9	Poor reversing of four-way valve	YES
PE	IDU evaporator temperature T2 protection	NO
Ph	Abnormal condensation protection	NO
Pd	Anti-condensation protection	YES
L0	IPM module protection	YES
L1	DC generatrix low voltage protection	YES
L2	DC generatrix high voltage protection	YES
L3	Other driving errors	YES
L4	Overcurrent、Loss speed protection	YES
L5	Zero speed protection	YES
L7	Compressor phase lost protection	YES

2 Troubleshooting

2.1 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.

2.2 C0: Communication fault between Inverter module Board and communication terminals block

2.2.1 Digital display output

2.2.2 Description

- Communication fault between Inverter module Board and communication terminals block.
- The system stops running.
- Error code is displayed on the outdoor unit PCB.

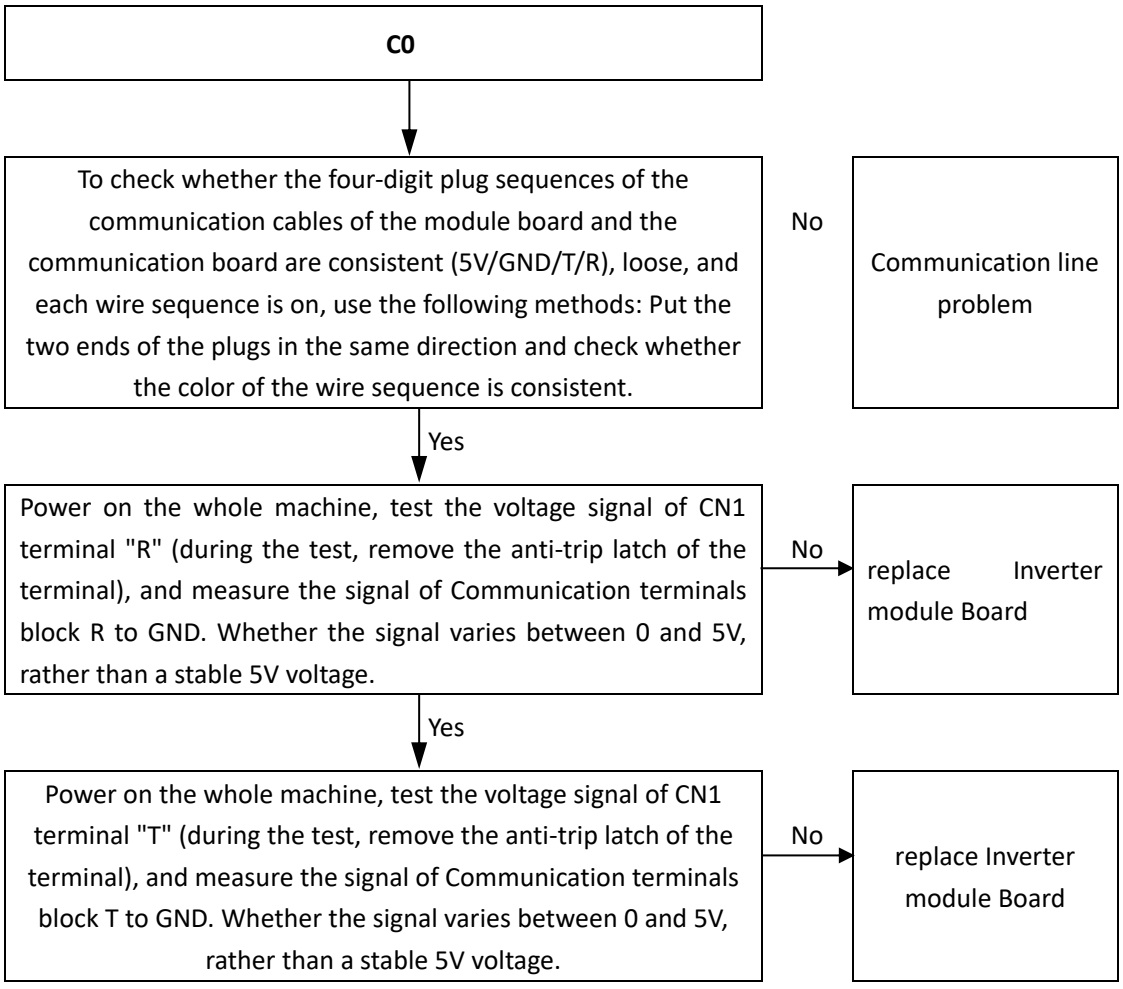
2.2.3 Trigger / recover condition

- Trigger condition: Communication terminals block and Inverter module board cannot communicate.
- Recover condition: Communication go back to normal.
- Reset method: Resume automatically.

2.2.4 Possible causes

- Interference from high voltage wires or other sources of electromagnetic radiation.
- Communication terminals block is damage.
- Communicate wire port is loose or connecter surface is corrosive, or water drop lead to poor contact.
- Communicate wire break or poor contact for reasons (such as rat beat, or bond and connection).

2.2.5 Procedure



2.3 U2: System combination error

2.3.1 Digital display output

2.3.2 Description

- System combination error.
- The system stops running.
- Error code is displayed on the outdoor unit PCB.

2.3.3 Trigger / recover condition

- Trigger condition:

  A. Both DHW Kit and hydraulic module exist in the system.

  B. The number of DHW Kit in the system is not less than 2

  C. The number of hydraulic modules in the system is not less than 2
- Recover condition: The number of DHW Kit Kit or hydraulic module in the system must be less than or equal to 1.
- Reset method: After meeting the conditions resume automatically.

2.3.4 Possible causes

- Combination system error, no connection equipment in accordance with the requirements.

2.3.5 Procedure

Connect system devices as required

2.4 E2: Communication error between indoor and outdoor unit (For all models)

2.4.1 Digital display output

2.4.2 Description

- Communication error between indoor and outdoor unit.
- The system stops running.
- Error code is displayed on the outdoor unit PCB.

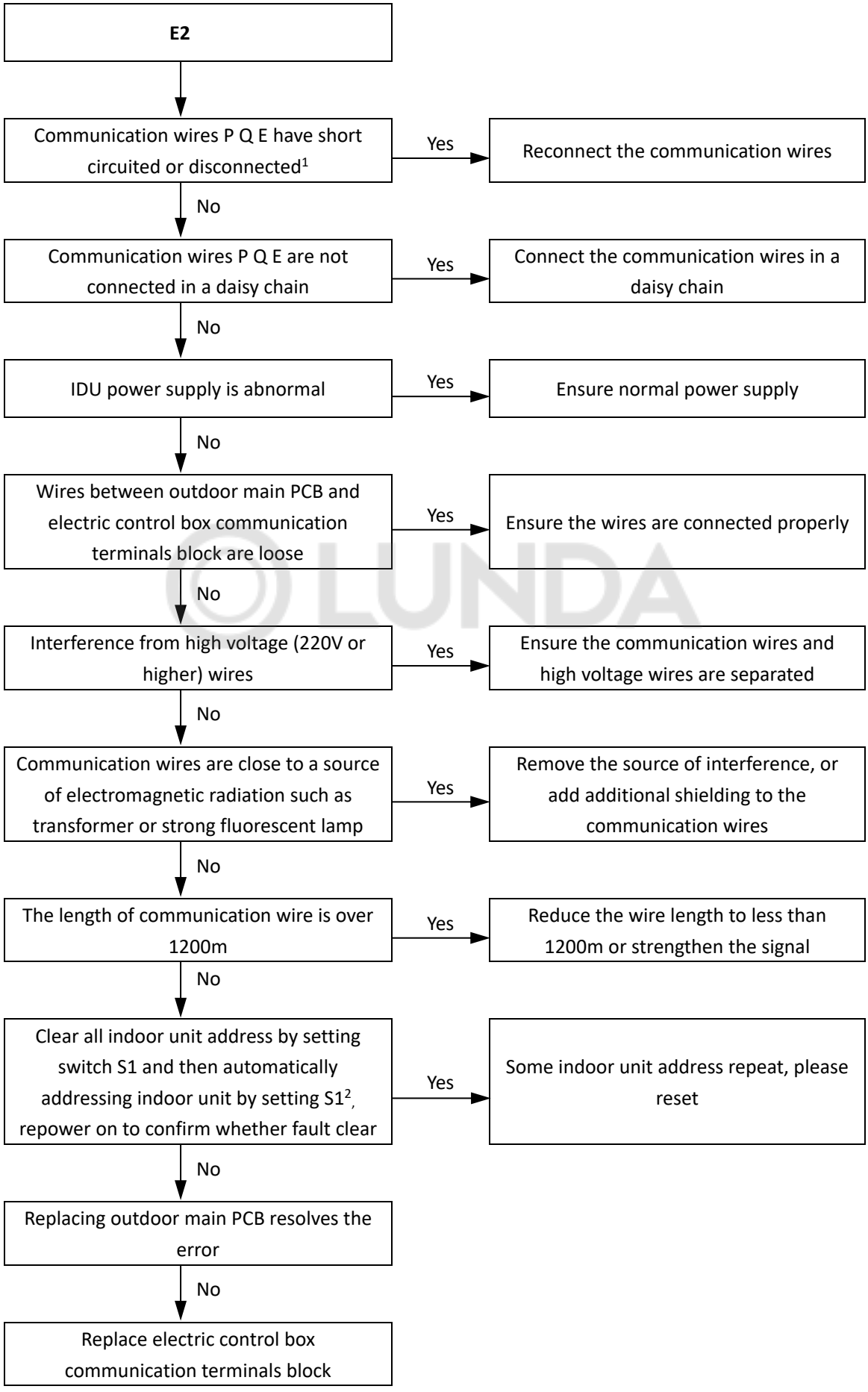
2.4.3 Trigger / recover condition

- Trigger condition: Indoor units and the outdoor unit cannot communicate for 2 minutes after the system is powered on for 20 minutes.
- Recover condition: Communication go back to normal.
- Reset method: Resume automatically.

2.4.4 Possible causes

- Communication wires between indoor and outdoor units not connected properly.
- Indoor unit power supply abnormal.
- Loosened wiring within electric control box.
- Interference from high voltage wires or other sources of electromagnetic radiation.
- Communication wire too long.
- Damaged main PCB or electric control box communication terminals block.
- Communication wire break or poor contact.

2.4.5 Procedure



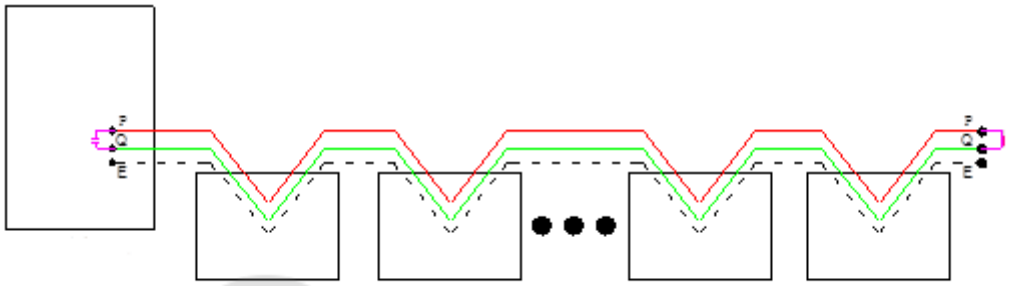
Notes:

1. Measure the resistance among P, Q and E. The normal resistance between P and Q is 120Ω, between P and E is infinite, between Q and E is infinite.
2. S1 switch setting as below table, for every times setting, you need to repower on to make the switch dial function works.

Switch	Switch positions	Description
S1	S1-1 ON 1 2 3	S1-1 is ON, indicating forced implementation of old indoor unit protocol S1-1 is OFF, indicating automatically adapting to indoor unit protocol (OFF by factory default)
	S1-2 ON 1 2 3	S1-2 is ON, indicating clearing of indoor unit address S1-2 is OFF, indicating automatic addressing (OFF by factory default)

- If the signal is weak, connect a 120Ω resistor between P and Q of the farthest indoor unit, or connect a 0.5-1.5uF capacitor between P and Q of outdoor unit. Installation refers to Figure 6-2.1:

Figure 6-2.1: Indoor unit installation



Notes:

1. Communication wires should be shield wire and indoor units should be connected in a daisy chain.

2.5 E4: Temperature sensor (T3/T4) fault (For all models)

1.1.1 Digital display output

2.5.1 Description

- Outdoor heat exchanger temperature sensor (T3) error or outdoor ambient temperature sensor (T4) error.
- The system stops running.
- Error code is displayed on the outdoor unit PCB.

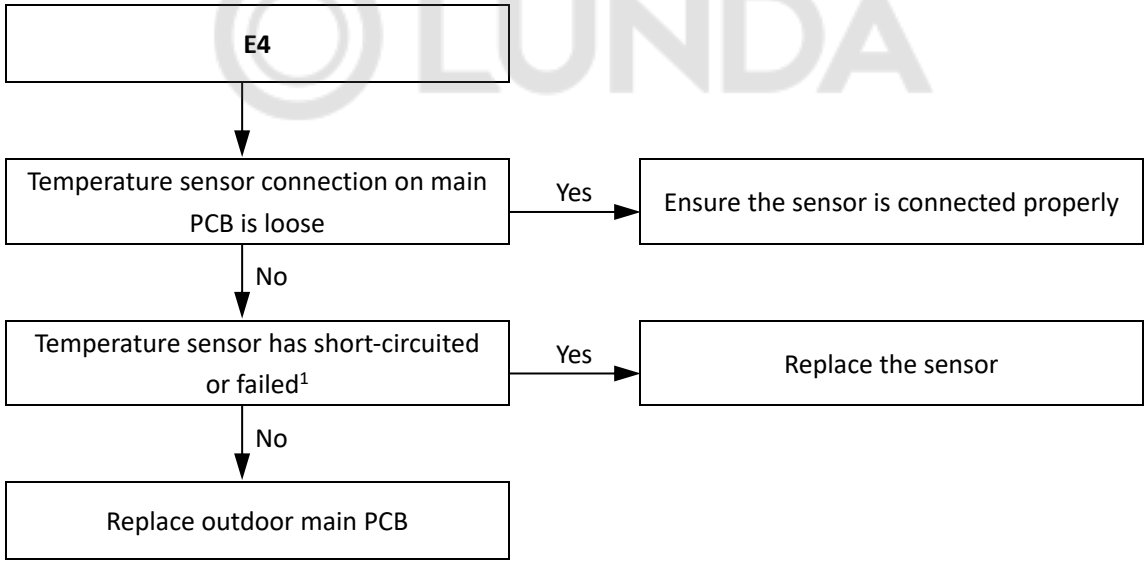
2.5.2 Trigger / recover condition

- Trigger condition: The main control board cannot receive the feedback signal of temperature sensor T3 or T4.
- Recover condition: The main control board can receive the feedback signal of temperature sensor T3 or T4.
- Reset method: Resume automatically.

2.5.3 Possible causes

- Temperature sensor not connected properly or has malfunctioned.
- Temperature sensor port connect to the main board connecter is loose.
- Damaged main PCB.

2.5.4 Procedure



Notes:

1. 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.

2.6 E5: Abnormal power supply voltage (For all models)

1.1.2 Digital display output

2.6.1 Description

- Abnormal power supply voltage.
- The system stops running.
- Error code is displayed on the outdoor unit PCB.

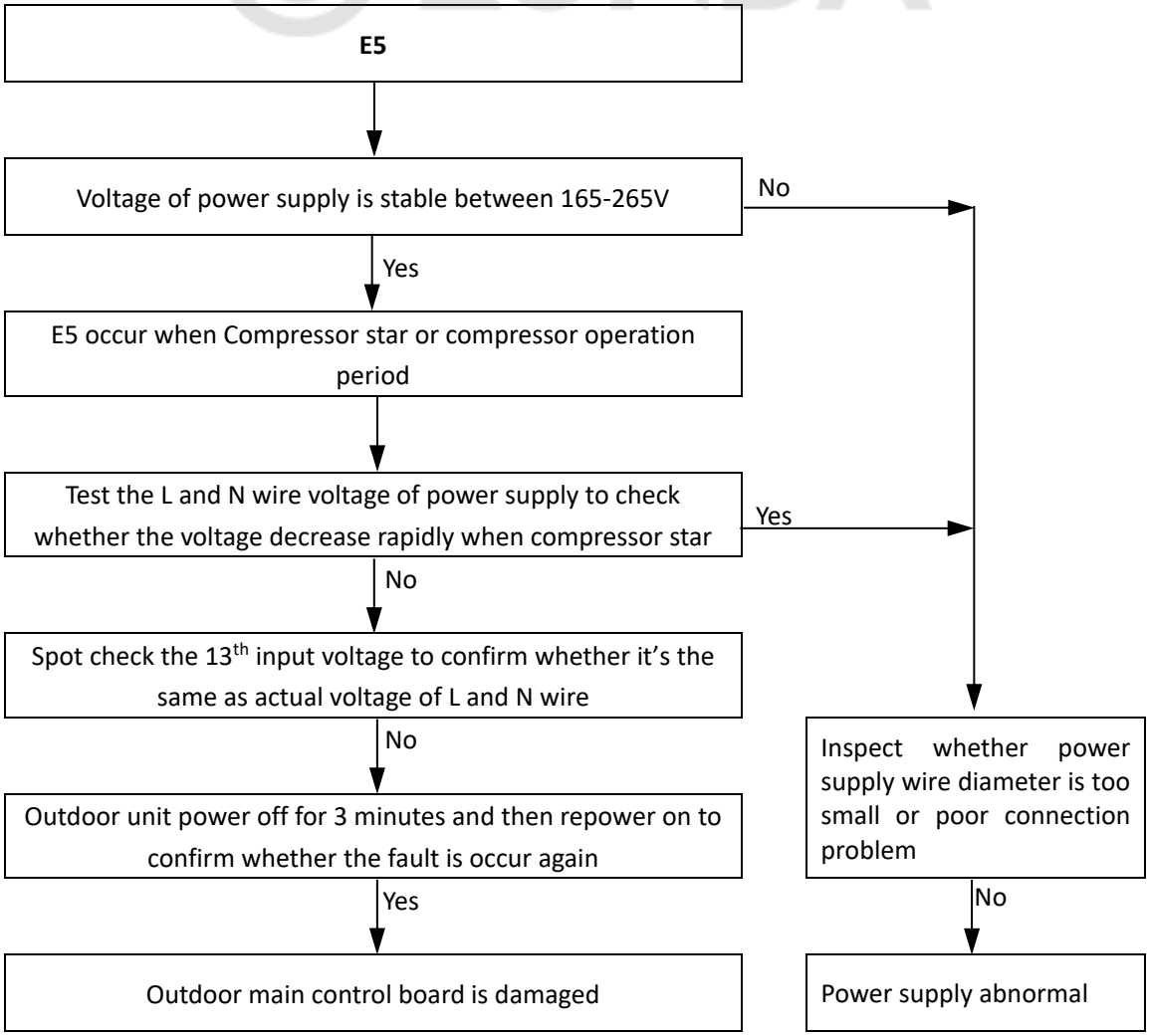
2.6.2 Trigger / recover condition

- Trigger condition: Outdoor unit power supply phase voltage < 165V or > 265V.
- Recover condition: Outdoor unit power supply phase voltage is within 198V ~265V.
- Reset method: Resume automatically.

2.6.3 Possible causes

- Outdoor unit power supply voltage is abnormal.
- Loosened wiring within electric control box.
- Power wire or air switch selection is too small.
- Main PCB damaged.

2.6.4 Procedure



2.7 E6: DC fan motor error; Eb: E6 protection appears 6 times in one hour (For all models)

2.7.1 Digital display output

2.7.2 Description

- E6:DC fan motor error; Eb: E6 protection appears 6 times in one hour
- The system stops running.
- Error code is displayed on the outdoor unit PCB.

2.7.3 Trigger / recover condition

- Trigger condition:
  For E6 protection: Main control board can't receive the fan speed feedback signal.
  For Eb protection: E6 protection appears 6 times in one hour.
- Recover condition: The fan speed feedback signal is normal.
- Reset method: For E6 protection, Resume automatically; For Eb protection, Manually restart.

2.7.4 Possible causes

- Loosened wiring within electric control box.
- DC fan motor damaged.
- Main PCB damaged.

2.7.5 Procedure

E6, Eb

Red to black: standby 310V startup 375V
White to black: DC 15V
Yellow to black: DC 0-6V(varies with speed)
Blue to black: DC 15-0V(varies with speed)

DC fan motor is forbidden to pluck and insert in power on conditions, operation when the capacitance discharge finished (3 LEDs all off)

No

Check whether DC fan motor is normal → No → DC fan motor is fault

Yes

Pull out the connection wire of DC fan motor, Check the Voltage of DC fan motor 310V port and 15V port to confirm whether their voltage is normal → Yes → Disconnect the DC fan motor wire and test the voltage of pin which corresponding to yellow and black wire, check whether the voltage change

No

Check whether the L and N port (in the left bottom of Inverter module board) has 220V input → Yes → ODU main control board is fault

No

Power off and then exclude fault source.

2.8 E9: EEPROM error (For all models)

2.8.1 Digital display output

2.8.2 Description

- EEPROM error
- The system stops running.
- Error code is displayed on the outdoor unit PCB.

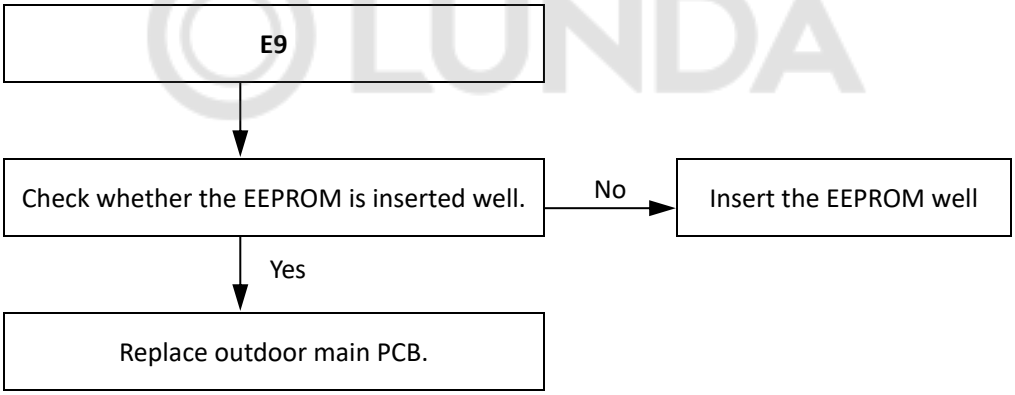
2.8.3 Trigger / recover condition

- Trigger condition: Unable to read the EEPROM when startup.
- Recover condition: EEPROM goes back to normal.
- Reset method: Manually restart.

2.8.4 Possible causes

- The EEPROM is not inserted well
- Damaged main PCB.

2.8.5 Procedure



2.9 E.9.: Compressor parameters mismatch (For all modes)

1.1.3 Digital display output

2.9.1 Description

- Main control chip detect the power setting number mismatch the model, the unit will display E.9. error.
- The system stops running.
- Error code is displayed on the outdoor unit PCB.

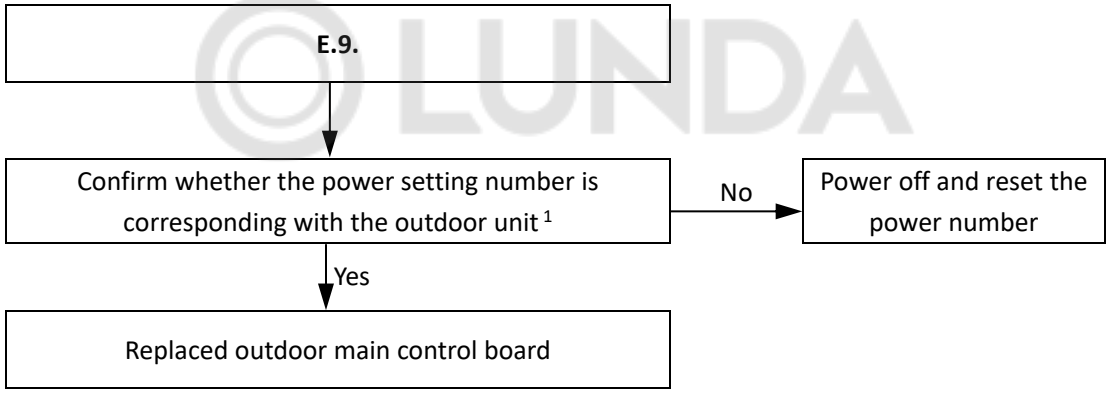
2.9.2 Trigger / recover condition

- Trigger condition: Main control chip detect the power setting number mismatch the model.
- Recover condition: Main control chip detect the power setting number match the model.
- Reset method: Manually restart.

2.9.3 Possible causes

- Power number setting mistake.
- Damaged main PCB.

2.9.4 Procedure



Notes:

1. Power setting switch is only for 100-160 model, 80 model don't need to setting
   Power setting switch for 100/120 mode is S3, S3=100 is corresponding to 100 model and S3=010 is corresponding to 120 model.
   Power setting switch for 140/160 mode is ENC2, ENC2=3 is corresponding to 140 model and ENCE=3 is corresponding to 160 model.

2.10 EF: PFC fault (Only for 100~160 model)

2.10.1 Digital display output

2.10.2 Description

- PFC fault protection.
- The system stops running.
- Error code is displayed on the outdoor unit PCB.

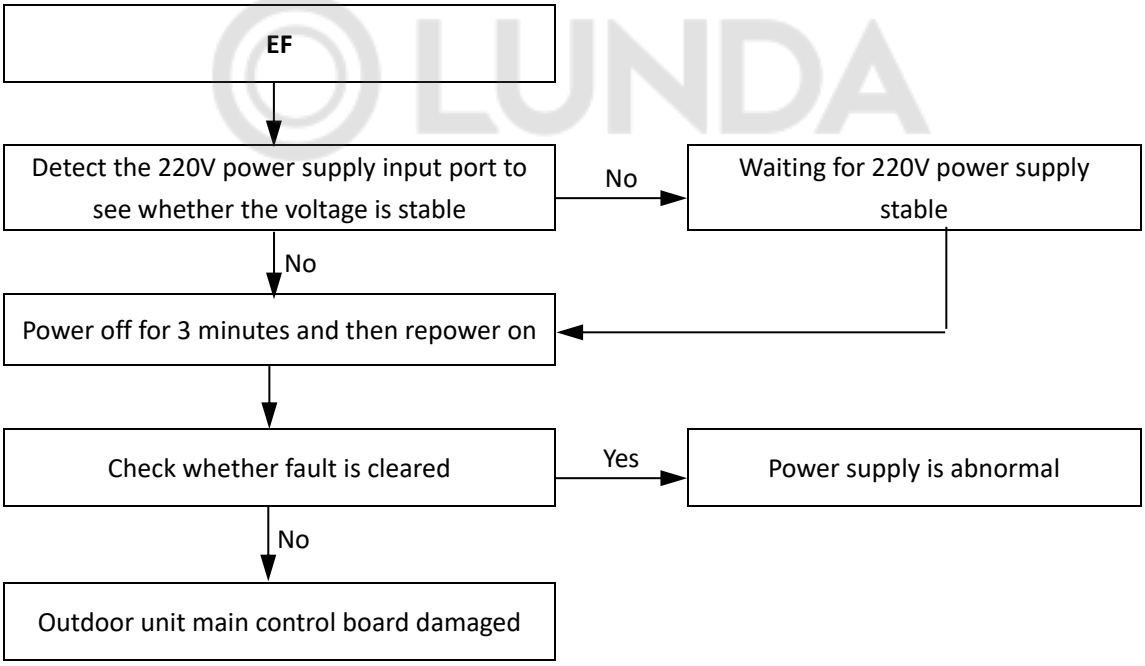
2.10.3 Trigger / recover condition

- Trigger condition: if DC generatrix voltage is over 450V for continue 3 S or over 500V in the first 5 s in PFC star period.
- Recover condition: DC generatrix voltage is normal in the first 5 s in PFC star period.
- Reset method: Manually restart.

2.10.4 Possible causes

- DC fan motor damaged.
- Main PCB damaged.

2.10.5 Procedure



2.11 EH: Refrigerant radiator temperature sensor error (For all models)

2.11.1 Digital display output

2.11.2 Description

- Refrigerant radiator temperature TL sensor error.
- The system stops running.
- Error code is displayed on outdoor unit PCB.

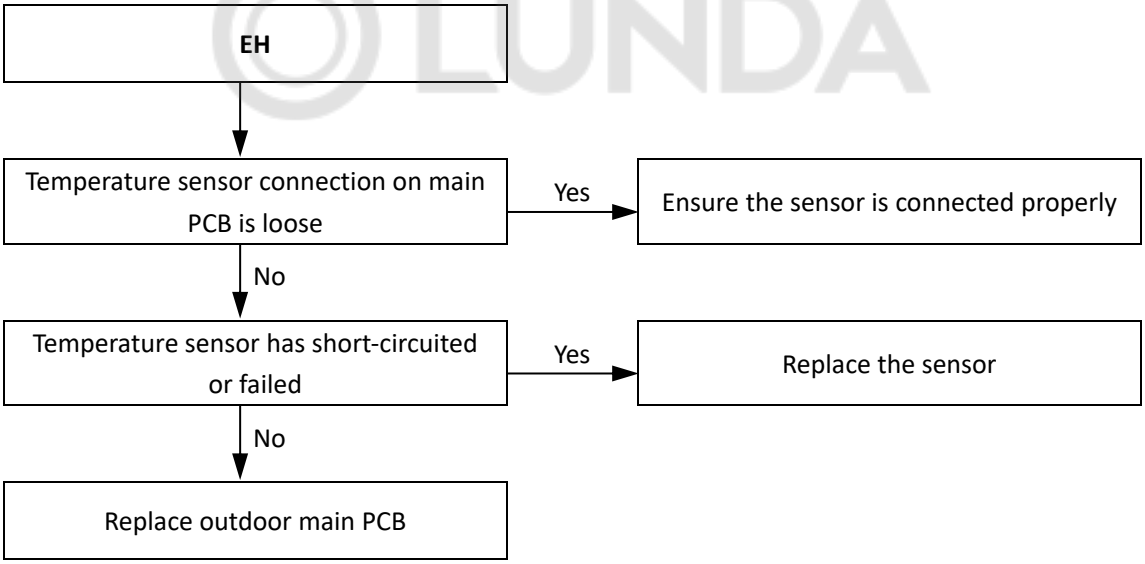
2.11.3 Trigger / recover condition

- Trigger condition: TL temperature sensor is open circuited (or connecter loose) or short circuited.
- Recover condition: The main control board can receive a normal feedback signal of TL sensor.
- Reset method: Resume automatically.

2.11.4 Possible causes

- TL temperature sensor damaged.
- TL temperature sensor connect to the main control board is loose.
- Main PCB damaged.

2.11.5 Procedure



2.12 EP: Outdoor ambient temperature is lower than -15℃ in cooling operation (For all models)

2.12.1 Digital display output

2.12.2 Description

- Outdoor ambient temperature is lower than -15℃ in cooling operation.
- The system stops running.
- Error code is displayed on outdoor unit PCB.

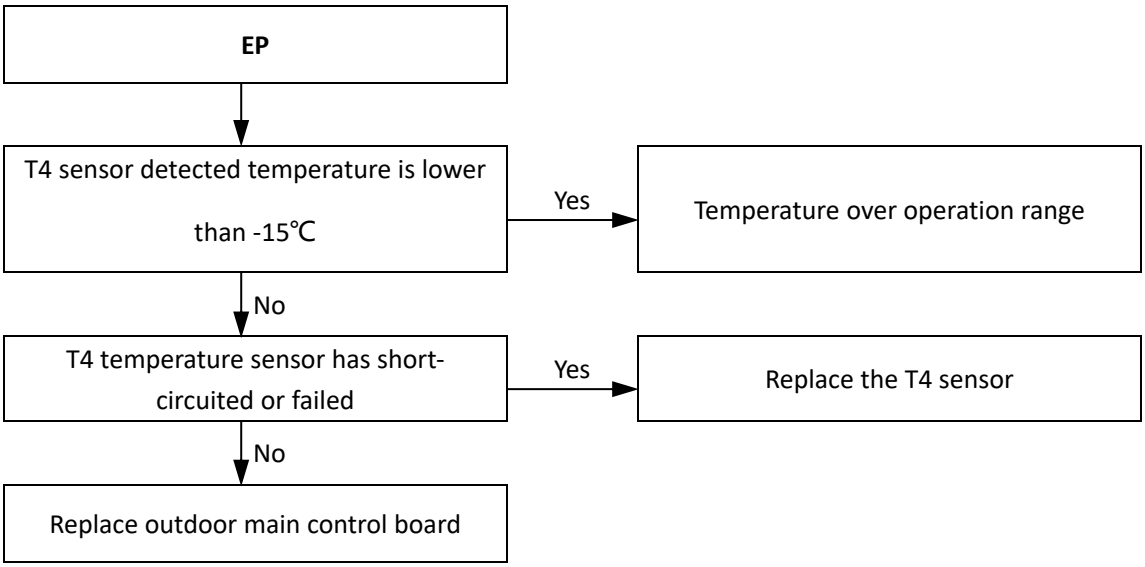
2.12.3 Trigger / recover condition

- Trigger condition: Outdoor ambient temperature is lower than -15℃ in cooling operation.
- Recover condition: Outdoor ambient temperature is over -15℃.
- Reset method: Resume automatically.

2.12.4 Possible causes

- TL temperature sensor damaged.
- TL temperature sensor connect to the main control board is loose.
- Main PCB damaged.

2.12.5 Procedure



2.13 F1: DC bus voltage protection (Only for 100~160 model)

2.13.1 Digital display output

2.13.2 Description

- F1 indicates DC bus voltage protection.
- The system stops running.
- Error code is displayed on the outdoor unit PCB.

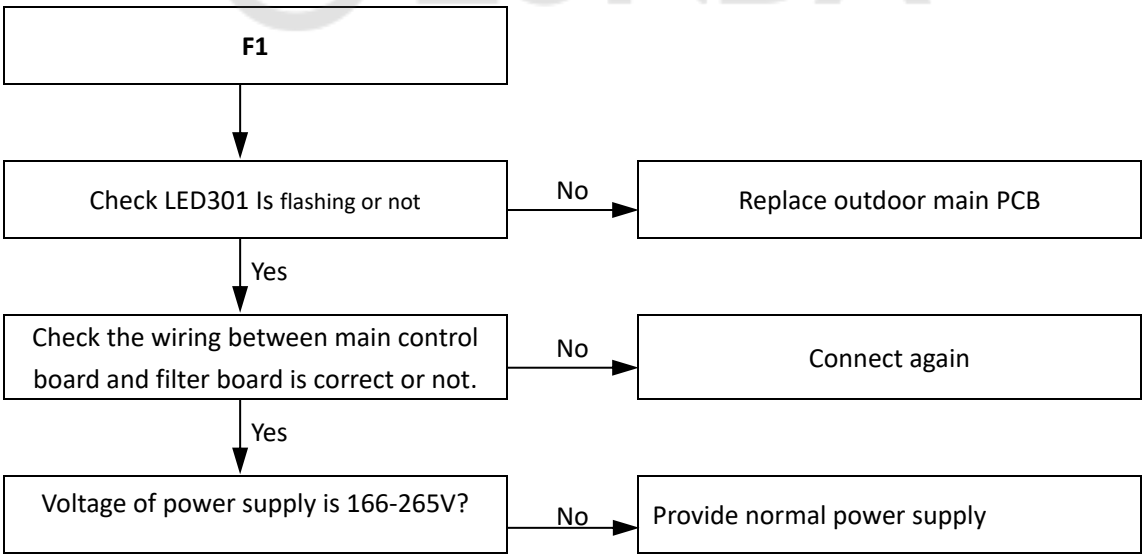
2.13.3 Trigger / recover condition

- Trigger condition: If IC55 main chip couldn't receive the DC generatrix voltage detection signal or the voltage less than 200VDC in the first 5 seconds period when power on, it would report F1 and the big relay is forbid to close.
- Recover condition: IC55 main chip can receive the DC generatrix voltage detection signal and the voltage over 200VDC .
- Reset method: Resume automatically.

2.13.4 Possible causes

- DC fan motor damaged.
- Main control board damaged.
- Filter board damaged (100/120 model can ignore this reason for they don't have a filter board).

2.13.5 Procedure



2.14 H7: Number of indoor unit detected is increase or decrease (For all models)

2.14.1 Digital display output

2.14.2 Description

- Number of indoor unit detected is increase or decrease protection.
- The system stops running.
- Error code is displayed on the unit with the error.

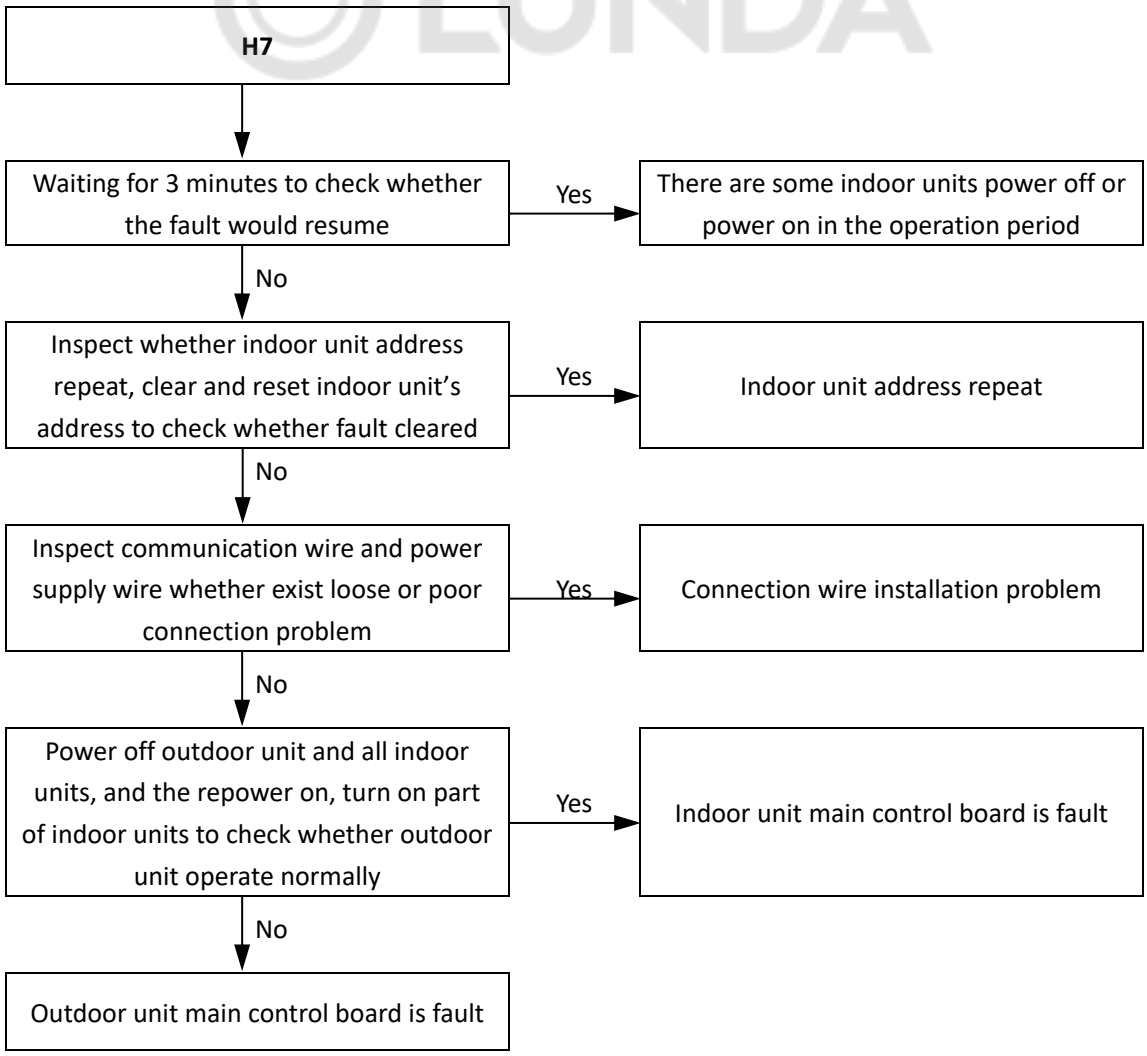
2.14.3 Trigger / recover condition

- Trigger condition: Number of indoor unit detected is increase or decrease.
- Recover condition: Number of indoor unit detected is the same as first power on.
- Reset method: Resume automatically.

2.14.4 Possible causes

- Communication wire or power supply wire connection problem.
- Indoor unit main control board damaged.
- Outdoor unit main control board damaged.

2.14.5 Procedure



2.15 P1: Discharge pipe high pressure protection (for 100~160 model)

2.15.1 Digital display output

2.15.2 Description

- Discharge pipe high pressure protection.
- The system stops running.
- Error code is displayed on the outdoor unit PCB.

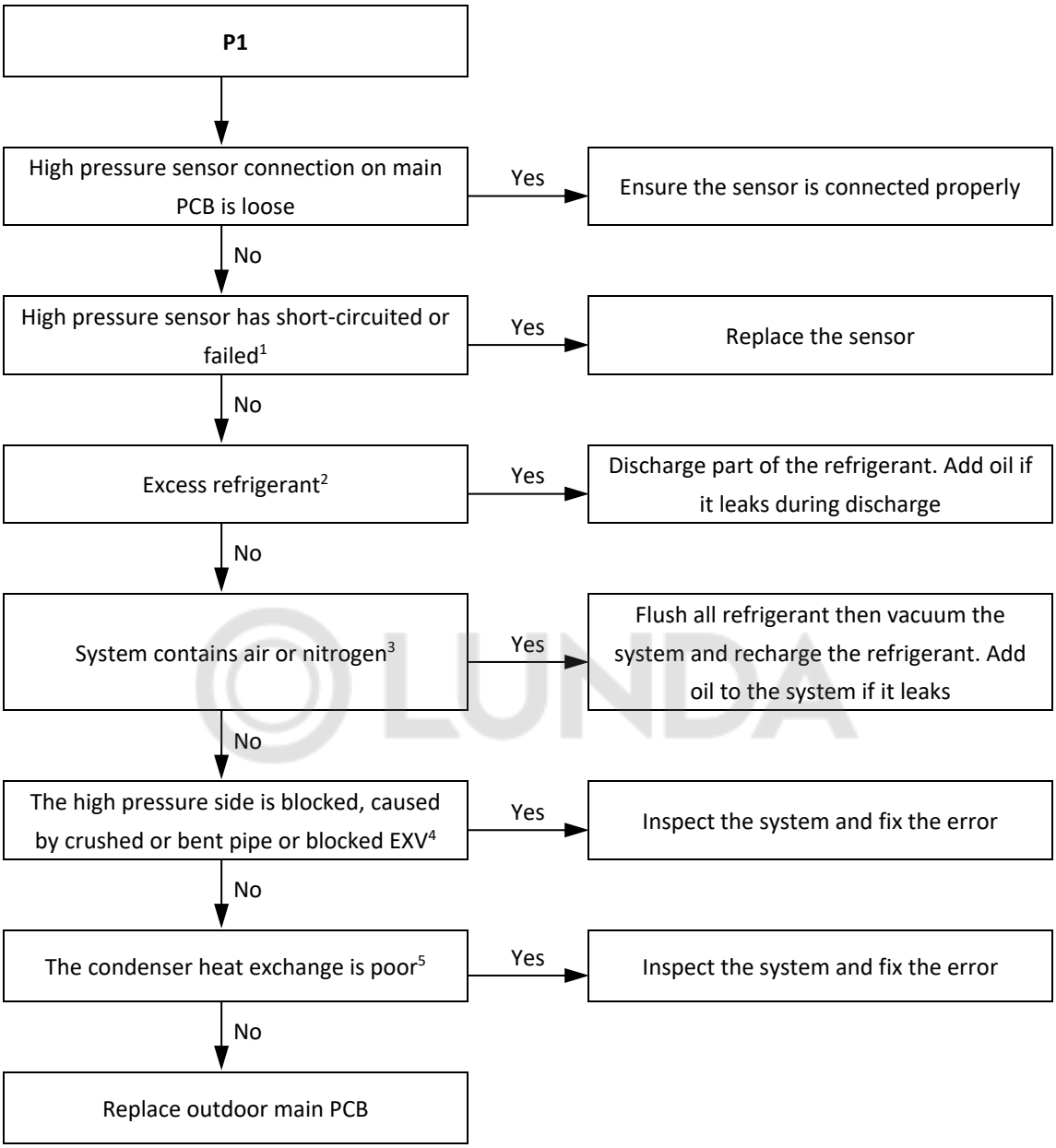
2.15.3 Trigger / recover condition

- Trigger condition: Discharge pressure ≥ 4.3MPa.
- Recover condition: Discharge pressure ≤ 3.2MPa.
- Reset method: Resume automatically.

2.15.4 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.
- Main PCB damaged.

2.15.5 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.
2. Excess refrigerant causes discharge temperature to be lower than normal, discharge pressure to be higher than normal and suction pressure to be higher than normal.
3. Air or nitrogen in the system causes discharge temperature to be higher than normal, discharge pressure to be higher than normal, compressor current to be higher than normal, abnormal compressor noise and an unsteady pressure meter reading.
4. 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.
5. In cooling mode check outdoor heat exchangers, fans and air outlets for dirt/blockages. In heating mode check indoor heat exchangers, fans and air outlets for dirt/blockages.

2.16 P2: Suction pipe low pressure protection (For all models)

2.16.1 Digital display output

2.16.2 Description

- Suction pipe low pressure protection.
- The system stops running.
- Error code is displayed on outdoor unit PCB.

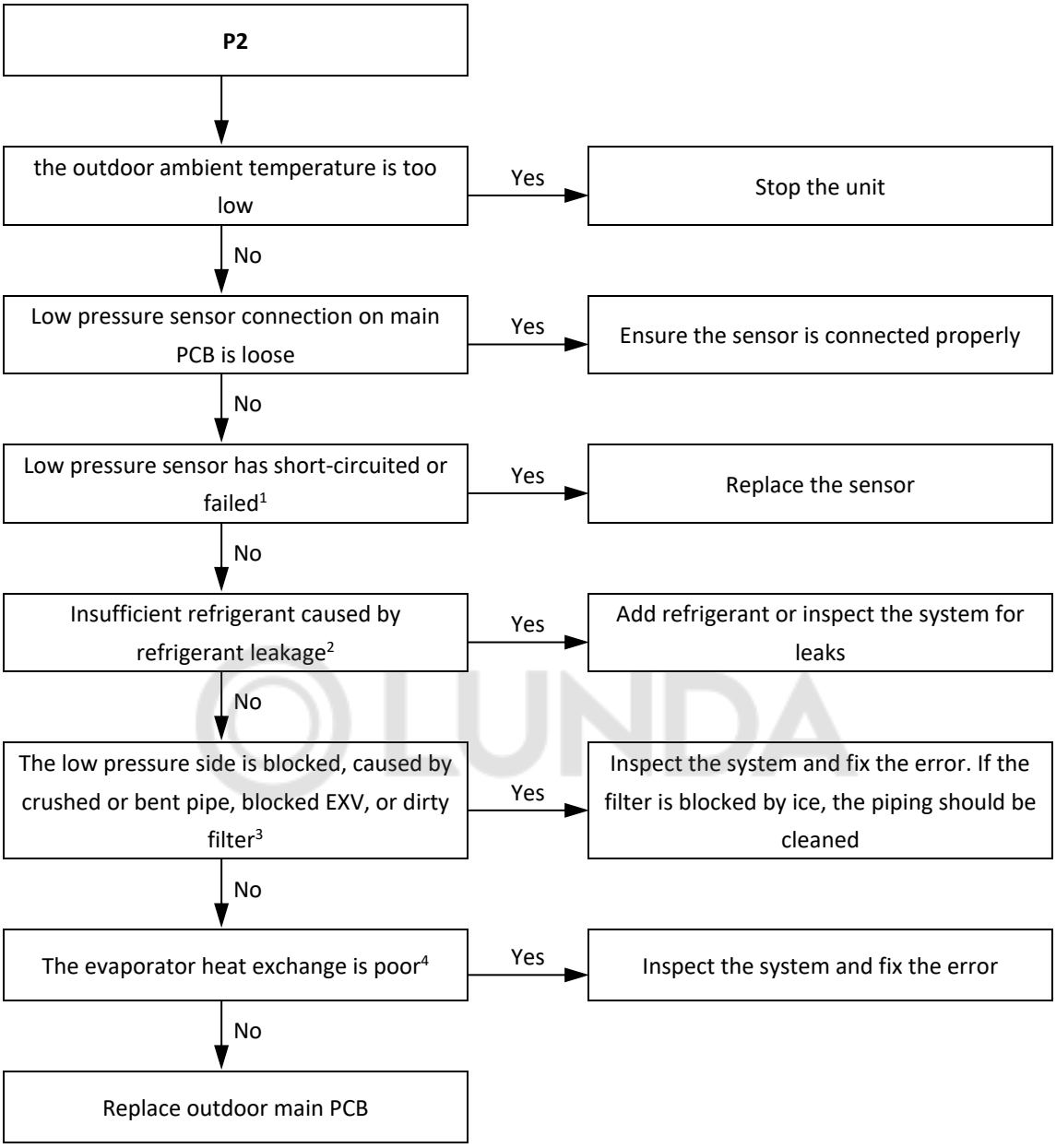
2.16.3 Trigger / recover condition

- Trigger condition: Suction pressure ≤ 0.05MPa.
- Recover condition: Suction pressure ≥ 0.15MPa.
- Reset method: Resume automatically.

2.16.4 Possible causes

- Insufficient refrigerant.
- Low pressure side blockage.
- Poor evaporator heat exchange.
- Main PCB damaged.

2.16.5 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.
2. 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.
3. 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.
4. In cooling mode check indoor heat exchangers, fans and air outlets for dirt/blockages. In heating mode check outdoor heat exchangers, fans and air outlets for dirt/blockages.

2.17 P3: Compressor current protection (For all models)

2.17.1 Digital display output

2.17.2 Description

- P3 indicates current protection on compressor.
- The system stops running.
- Error code is displayed on the outdoor unit PCB.

2.17.3 Trigger / recover condition

- Trigger condition: Current of compressor ≥ C[1].
- Recover condition: Current of compressor < C[1].
- Reset method: Resume automatically.

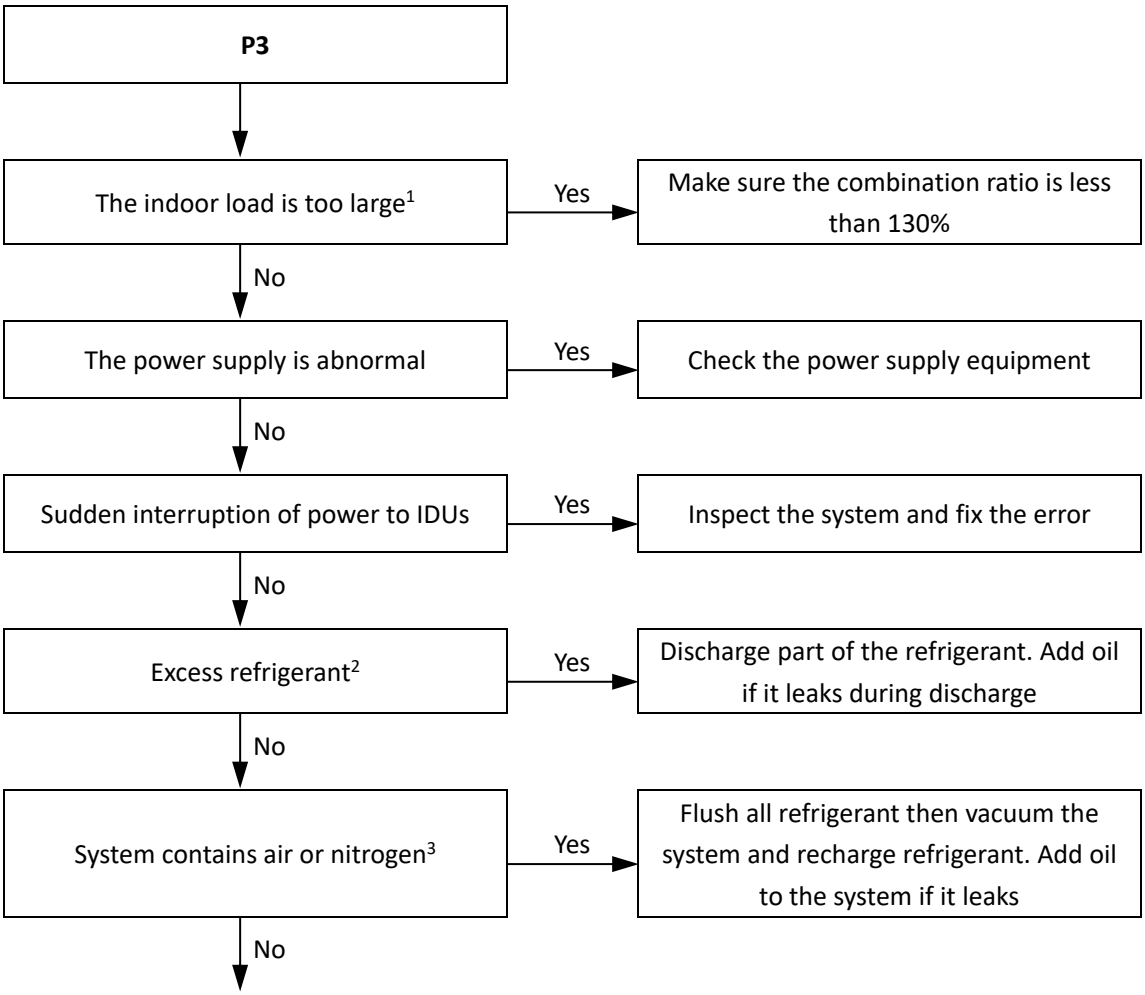
Notes:

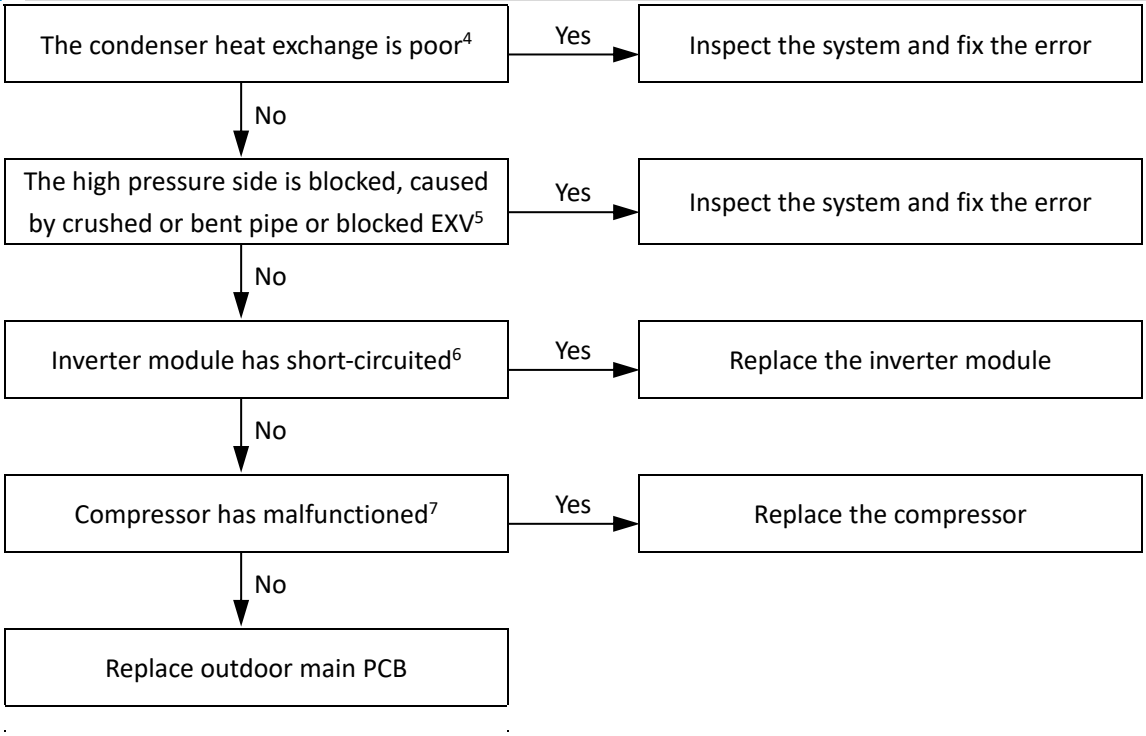
1. 80 model in cooling mode C=19A, 80 model in heating mode C=20A; 100 model C=24A; 120 model C=29A; 140-160 model C=33A)

2.17.4 Possible causes

- Indoor load too large.
- Power supply abnormal.
- Sudden interruption of power to IDUs.
- Excess refrigerant.
- System contains air or nitrogen.
- Poor condenser heat exchange.
- High pressure side blockage.
- Inverter module damaged.
- Compressor damaged.
- Main PCB damaged.

2.17.5 Procedure





Notes:

1. An indoor load that is too large causes suction and discharge temperatures to be higher than normal.
2. Excess refrigerant causes discharge temperature to be lower than normal, discharge pressure to be higher than normal and suction pressure to be higher than normal.
3. Air or nitrogen in the system causes discharge temperature to be higher than normal, discharge pressure to be higher than normal, compressor current to be higher than normal, abnormal compressor noise and an unsteady pressure meter reading.
4. In cooling mode check outdoor heat exchangers, fans and air outlets for dirt/blockages. In heating mode check indoor heat exchangers, fans and air outlets for dirt/blockages.
5. 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.
6. Set a multi-meter to buzzer mode and test any two terminals of P N U V W of the inverter module. If the buzzer sounds, the inverter module has short-circuited.
7. The normal resistances of the inverter compressor are 0.5-1.5Ω 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.

2.18 P4: Discharge temperature protection (For all models)

2.18.1 Digital display output

2.18.2 2.18.2 Description

- Discharge temperature protection.
- The system stops running.
- Error code is displayed on the unit with the error.

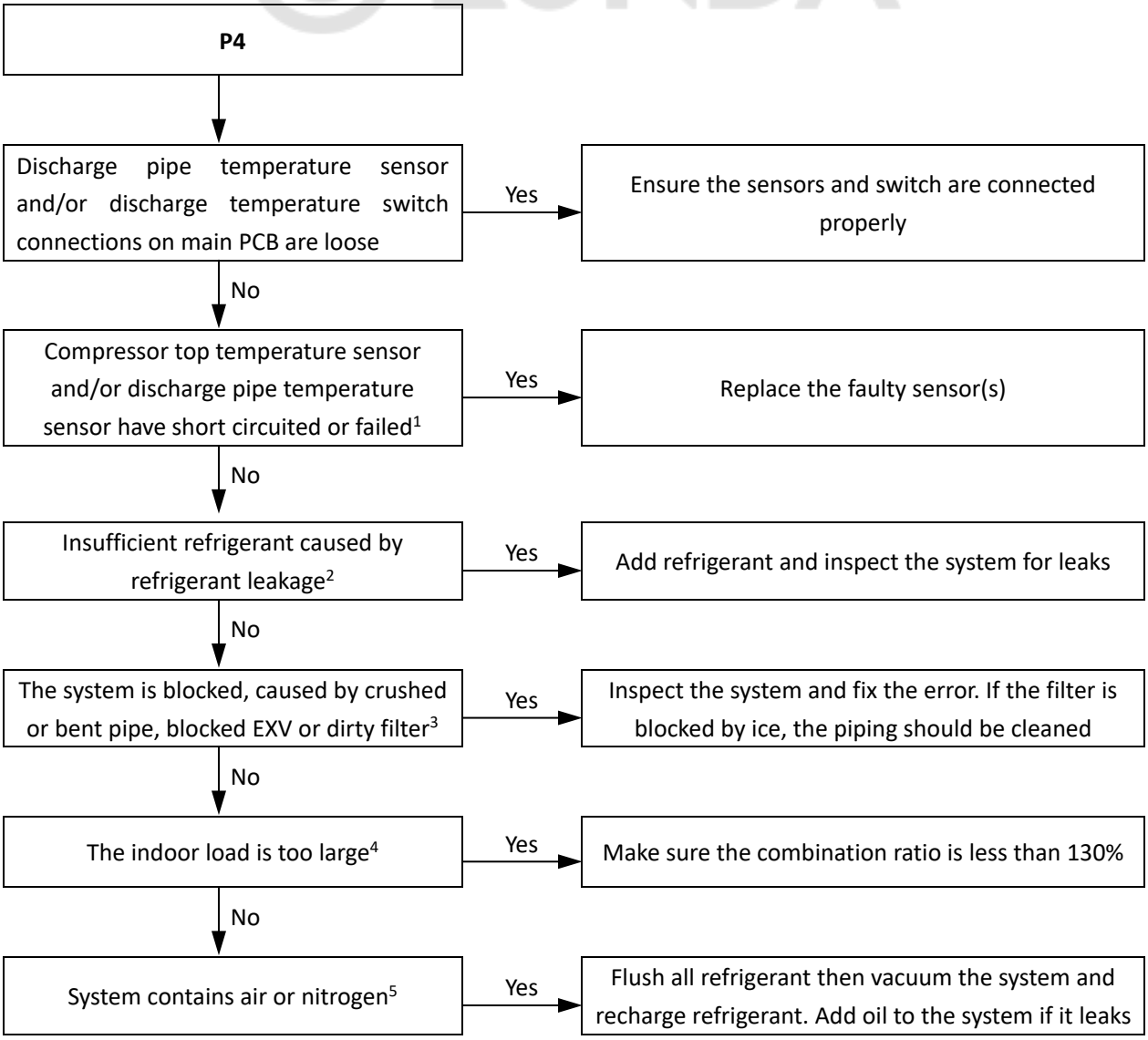
2.18.3 Trigger / recover condition

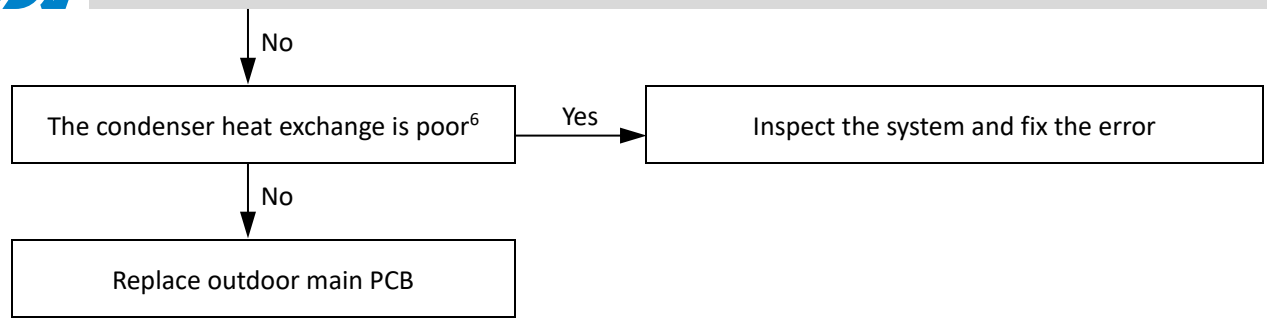
- Trigger condition: Discharge temperature (T5) > 115°C.
- Recover condition: Discharge temperature (T5) < 90°C.
- Reset method: Resume automatically.

2.18.4 Possible causes

- Temperature sensor/switch not connected properly or has malfunctioned.
- Insufficient refrigerant.
- System blockage.
- Indoor load too large.
- System contains air or nitrogen.
- Poor condenser heat exchange.
- Main PCB damaged.

2.18.5 Procedure





Notes:

1. 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.
2. 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..
3. 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.
4. An indoor load that is too large causes suction and discharge temperatures to be higher than normal.
5. Air or nitrogen in the system causes discharge temperature to be higher than normal, discharge pressure to be higher than normal, compressor current to be higher than normal, abnormal compressor noise and an unsteady pressure meter reading.
6. In cooling mode check outdoor heat exchangers, fans and air outlets for dirt/blockages. In heating mode check indoor heat exchangers, fans and air outlets for dirt/blockages.

2.19 P5: Outdoor heat exchanger temperature protection (For all models)

2.19.1 Digital display output

2.19.2 Description

- Outdoor heat exchanger temperature protection.
- The system stops running.
- Error code is displayed on the unit with the error.

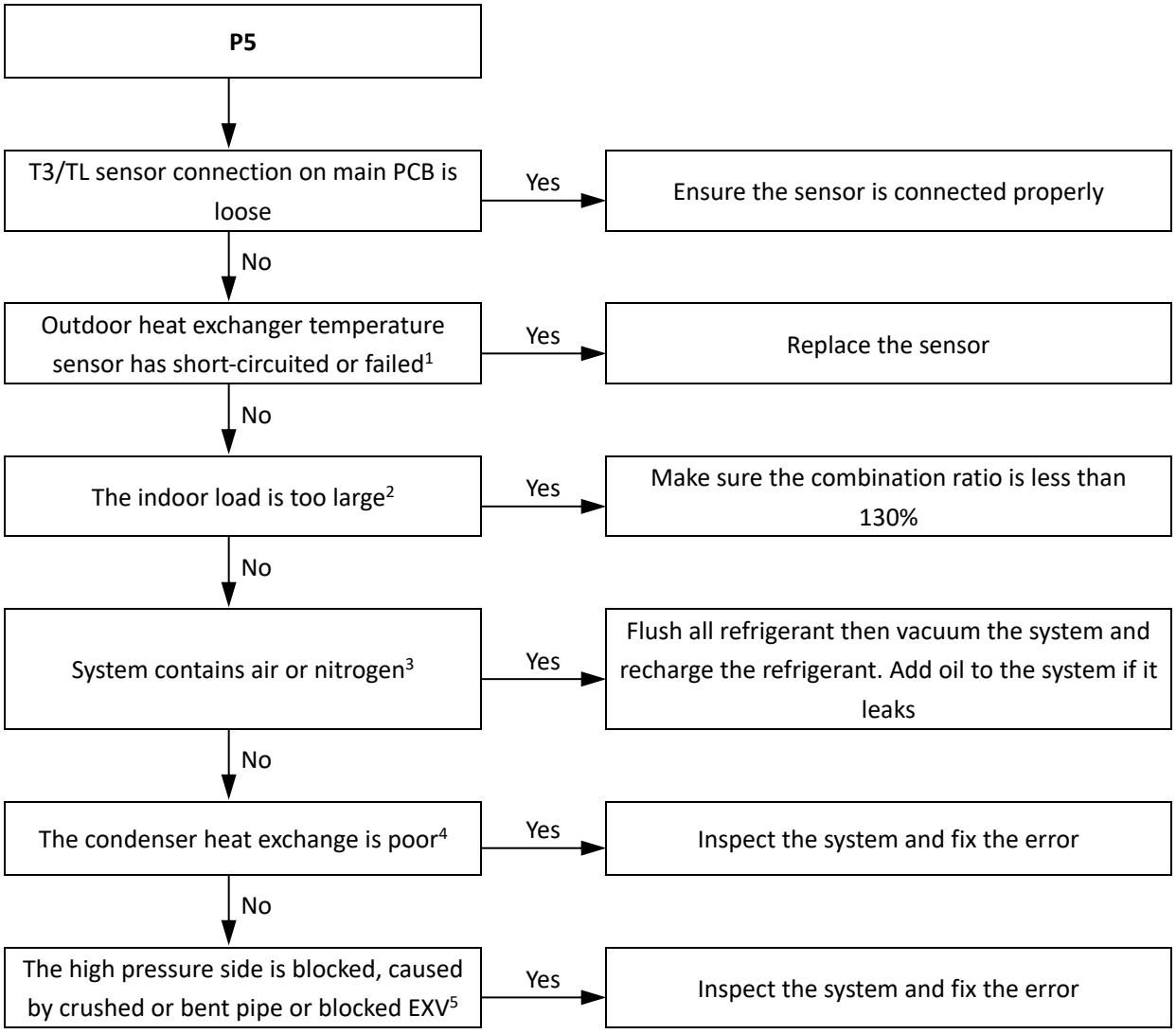
2.19.3 Trigger / recover condition

- Trigger condition: Outdoor heat exchanger temperature (T3) or Refrigerant radiator temperature(TL)≥ 63°C.
- Recover condition: Outdoor heat exchanger temperature (T3) or Refrigerant radiator temperature(TL)< 56°C.
- Reset method: Resume automatically.

2.19.4 Possible causes

- T3、TL Temperature sensor not connected properly or has malfunctioned.
- Indoor load too large.
- System contains air or nitrogen.
- Poor condenser heat exchange.
- High pressure side blockage.
- Main PCB damaged.

2.19.5 Procedure



No

Replace outdoor main PCB

Notes:

1. 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.
2. An indoor load that is too large causes suction and discharge temperatures to be higher than normal.
3. Air or nitrogen in the system causes discharge temperature to be higher than normal, discharge pressure to be higher than normal, compressor current to be higher than normal, abnormal compressor noise and an unsteady pressure meter reading.
4. In cooling mode check outdoor heat exchangers, fans and air outlets for dirt/blockages. In heating mode check indoor heat exchangers, fans and air outlets for dirt/blockages.
5. 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.

2.20 P9: Poor reversing of four-way valve

2.20.1 Digital display output

2.20.2 Description

- Poor reversing of four-way valve
- The system stops running.
- Error code is displayed on the outdoor unit PCB.

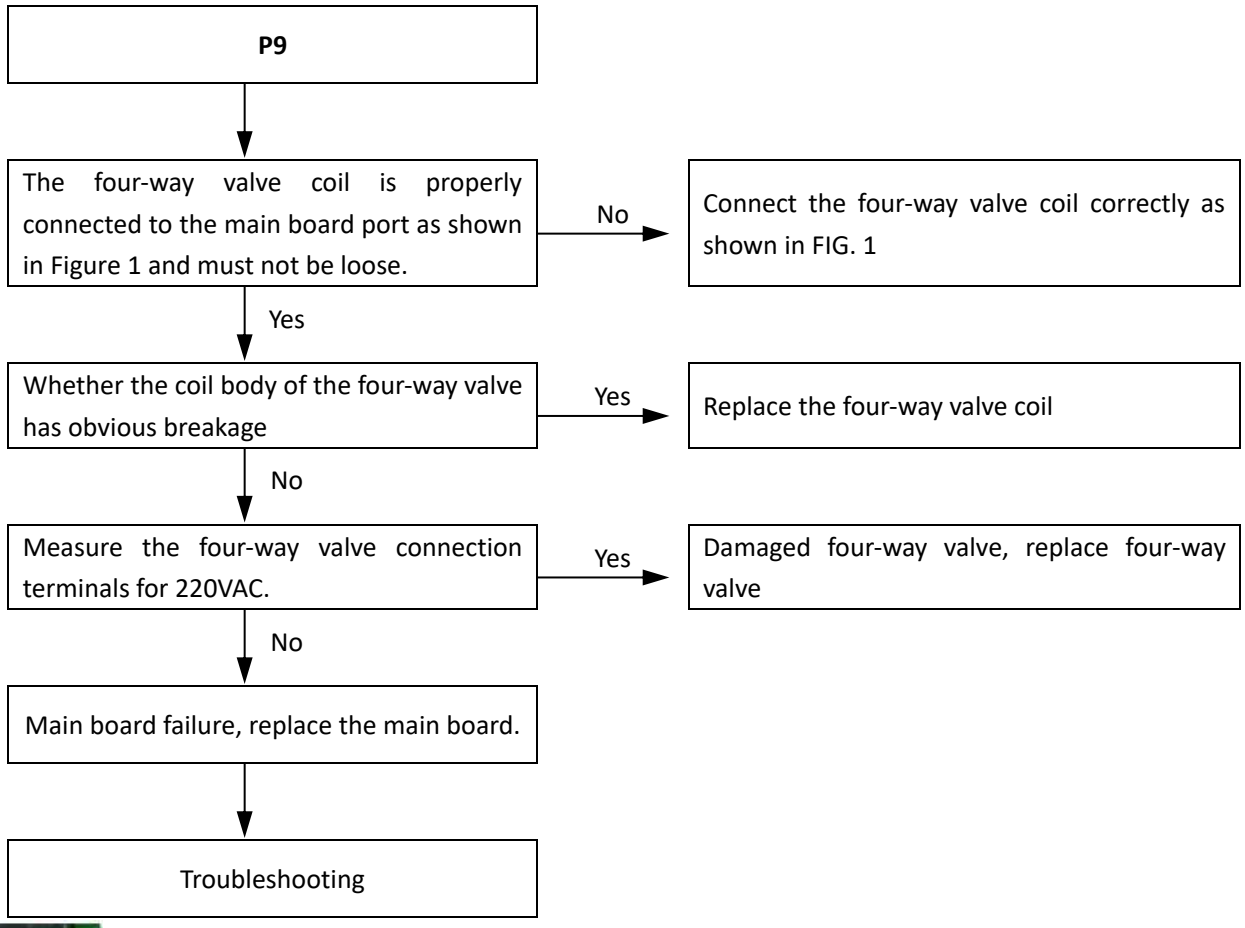
2.20.3 Trigger / recover condition

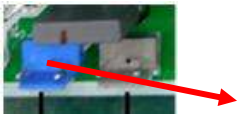
- Trigger condition:
  1). Heat model;
  2). T2＜-2℃ for 5 min;
- Recover condition: If three consecutive P9 faults are detected within two hours, a permanent fault is reported, and power failure is required.
- Reset method: Manually restart.

2.20.4 Possible causes

- Main PCB damaged.
- Four-way valve damaged.
- Loosened wiring within electric control box.

2.20.5 Procedure





The four-way valve coil terminal on the PCB is blue

2.21 PE: Evaporator high temperature protection (For all models)

2.21.1 Digital display output

2.21.2 Description

- Evaporator high temperature protection
- The system stops running.
- Error code is displayed on the outdoor unit PCB.

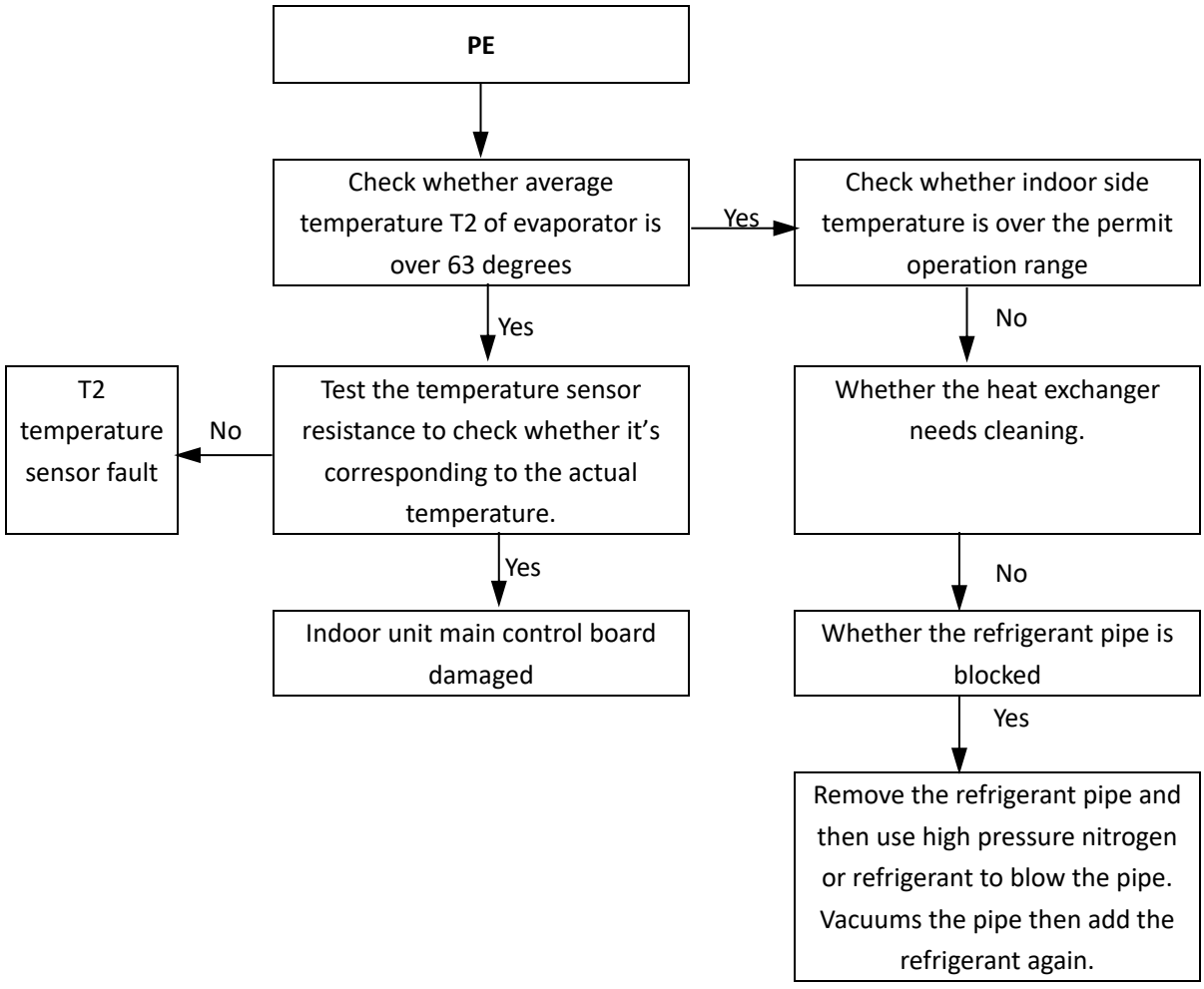
2.21.3 Trigger / recover condition

- Trigger condition:
  The middle average temperature of the evaporator is higher than 63°C for 20 seconds
- Recover condition: Pipe temperature < 50°C.
- Reset method: Resume automatically.

2.21.4 Possible causes

- Indoor temperature is too high.
- Temperature sensor not connected properly or has malfunctioned.
- System blockage.
- Poor condenser heat exchange.
- Indoor unit Main PCB damaged

2.21.5 Procedure



2.22 PL: Radiator surface high temperature protection (For all models)

2.22.1 Digital display output

2.22.2 Description

- Radiator surface high temperature protection.
- The system stops running.
- Error code is displayed on outdoor unit PCB.

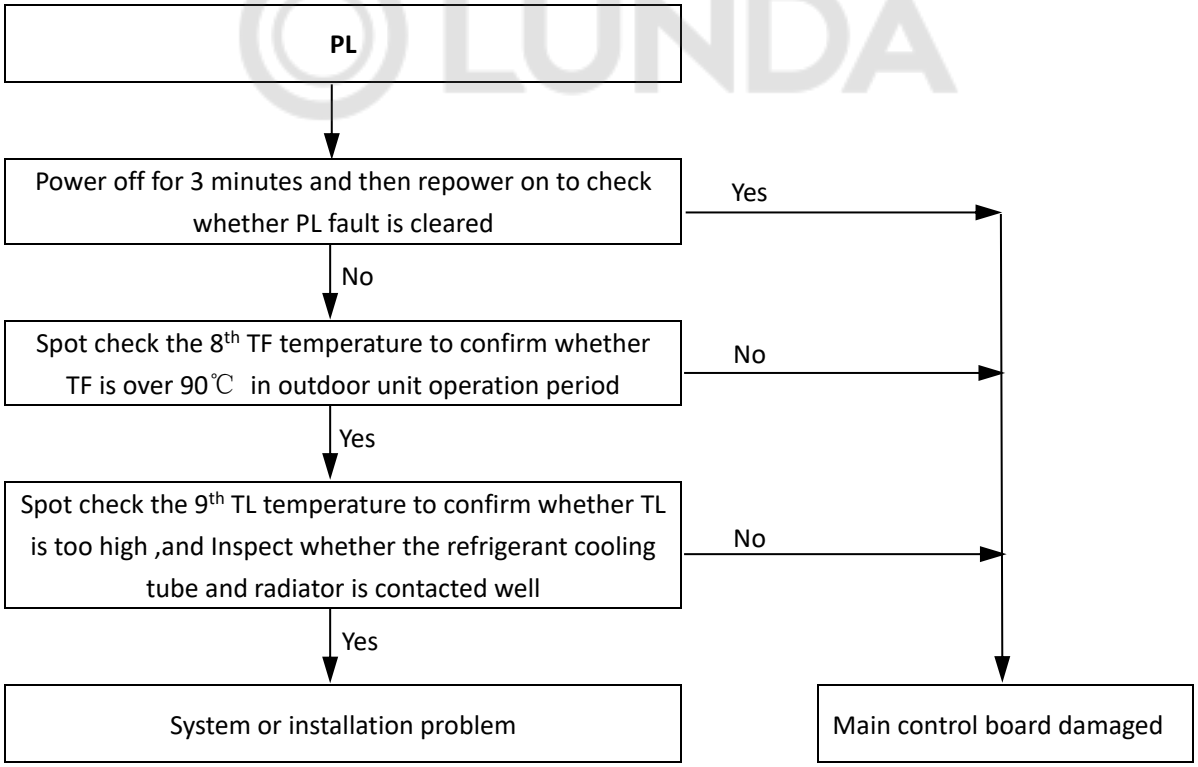
2.22.3 Trigger / recover condition

- Trigger condition: Radiator surface temperature TF≥90℃.
- Recover condition: Radiator surface temperature TF≤84℃.
- Reset method: Resume automatically.

2.22.4 Possible causes

- Refrigerant leakage/ Poor condenser heat exchange/ System blockage.
- The connection between refrigerant cooling tube and radiator is loose.
- Main PCB damaged.

2.22.5 Procedure



2.23 Ph, Pd: Anti-condensation protection

2.23.1 Digital display output

2.23.2 Description

- Abnormal condensation protection
- The system stops running.
- Error code is displayed on the outdoor unit PCB.

2.23.3 Trigger / recover condition

- Trigger condition:

  Ph：TL temperature is lower than the anti-condensation setting temperature for more than 10 minutes;

  Pd：Ph protection at least twice within 1 hour
- Recover condition: TL reaches the anti-condensation setting temperature above.
- Reset method:

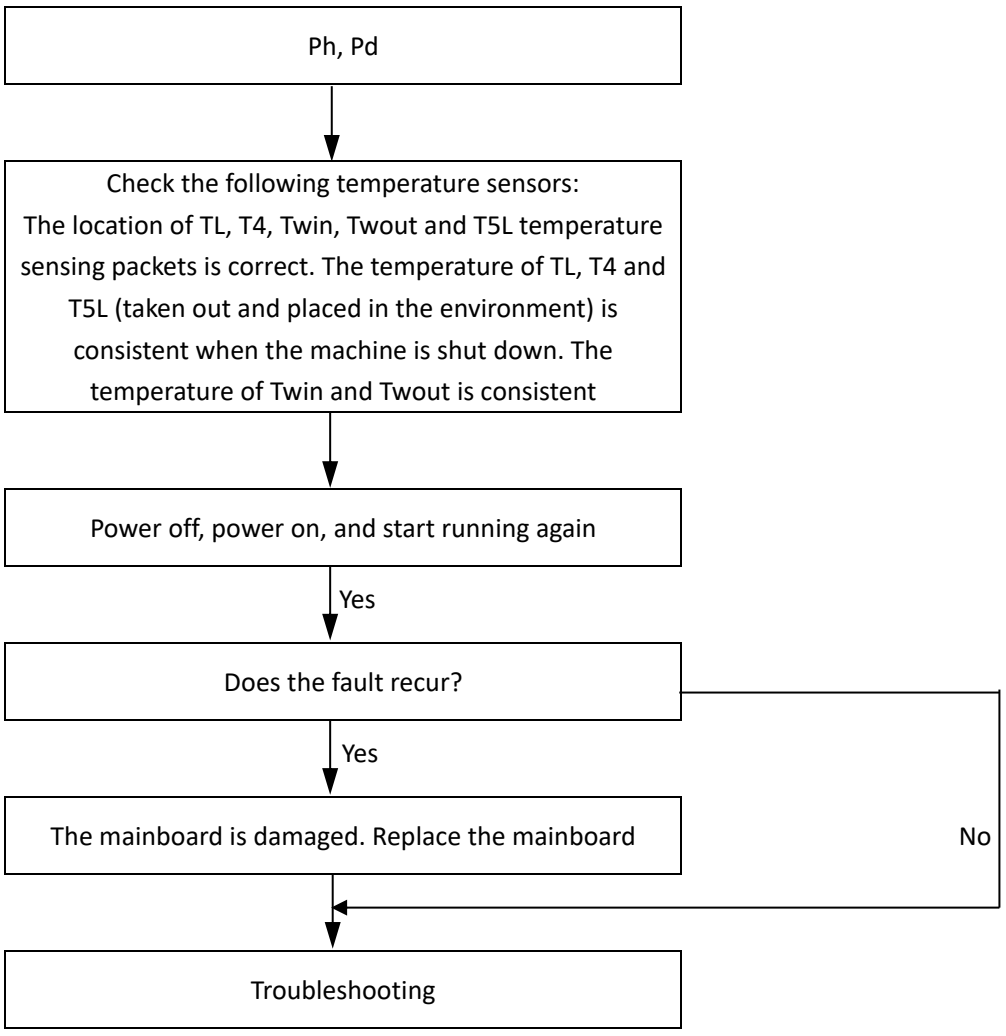
  Ph Resume automatically;

  Pd Manually restart

2.23.4 Possible causes

- TL、T4、Twin、Twout、T5L damage.
- Main PCB damaged

2.23.5 Procedure



2.24 L3: Other driving errors

2.24.1 Digital display output

2.24.2 Description

- Other driving errors.
- The system stops running.
- Error code is displayed on the outdoor unit PCB.

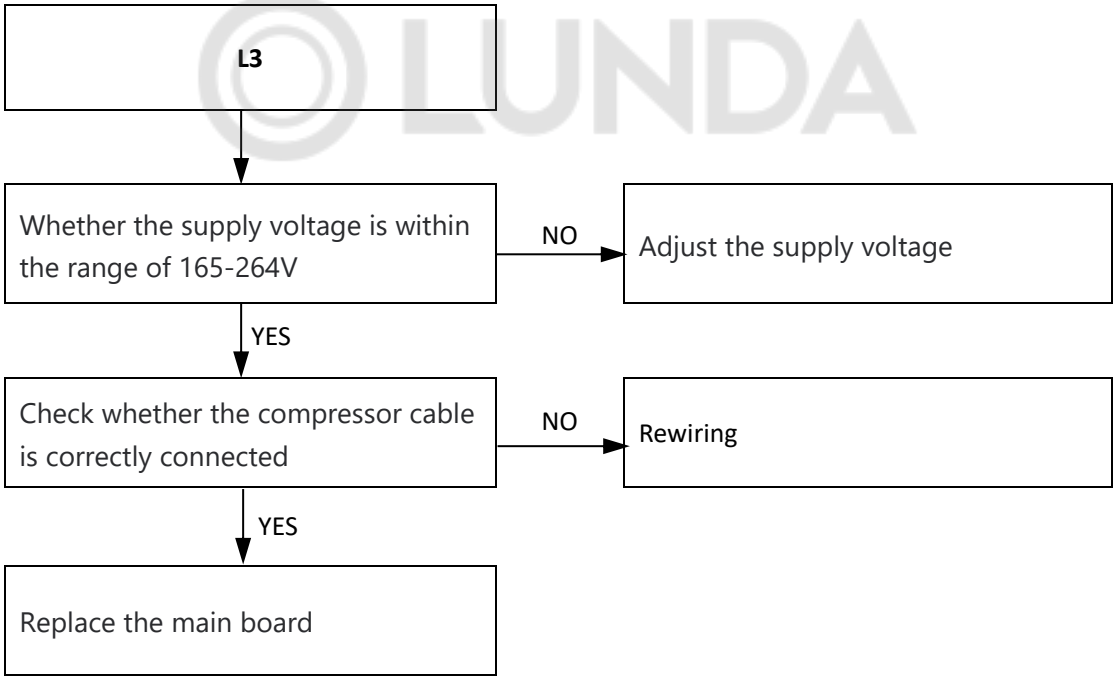
2.24.3 Trigger / recover condition

- Trigger condition: PFCOvercurrent protection, IPM overtemperature
- Reset method: Manually restart.

2.24.4 Possible causes

- Compressor is abnormal.
- Power supply is abnormal.
- Outdoor unit main control board damaged.

2.24.5 Procedure



2.25 L7: Compressor phase sequence error

2.25.1 Digital display output

2.25.2 Description

- Compressor phase sequence error.
- Compressor stop running after failure, in a minute if the fault disappear, the compressor to start again.
- Error code is displayed on the outdoor unit PCB.

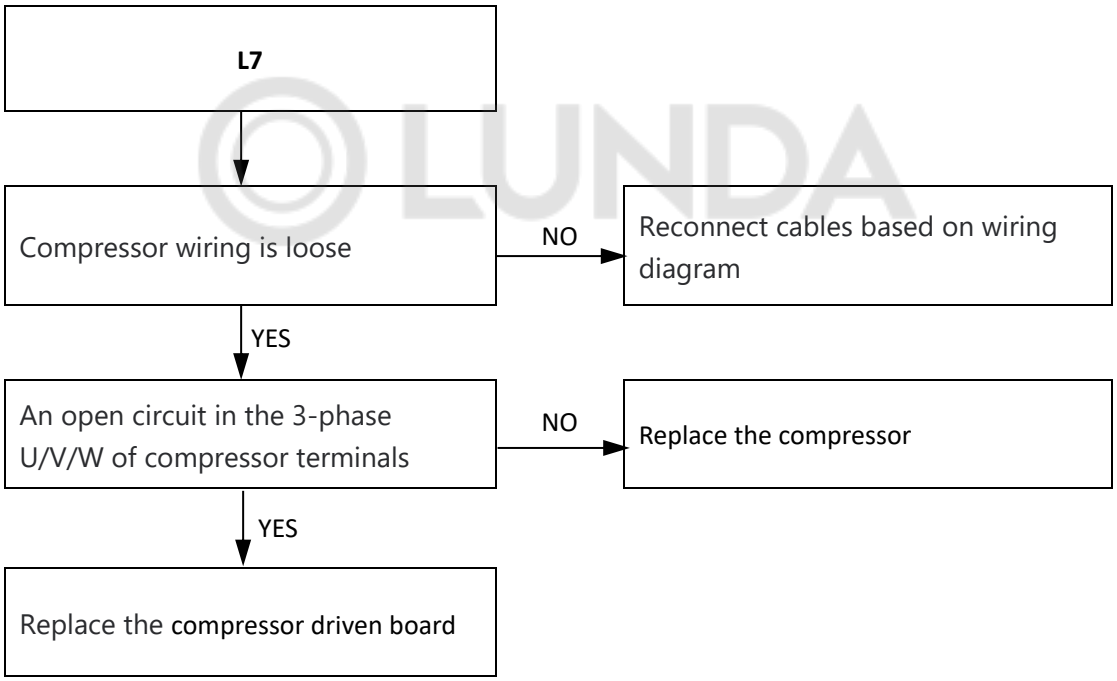
2.25.3 Trigger / recover condition

- Trigger condition: The compressor cable is not connected or is in poor contact

2.25.4 Possible causes

- Poor compressor wiring contact or loose terminal screws.
- Compressor driven board.

2.25.5 Procedure



2.26 L0/L4/L5/L8/L9: L category of inverter module protection (L0 for all models, L4/L5/L8/L9 for 100-160 model)

2.26.1 Digital display output

2.26.2 Description

- Compressor inverter module protection.
- The system stops running.
- Error code is displayed on the outdoor unit PCB.

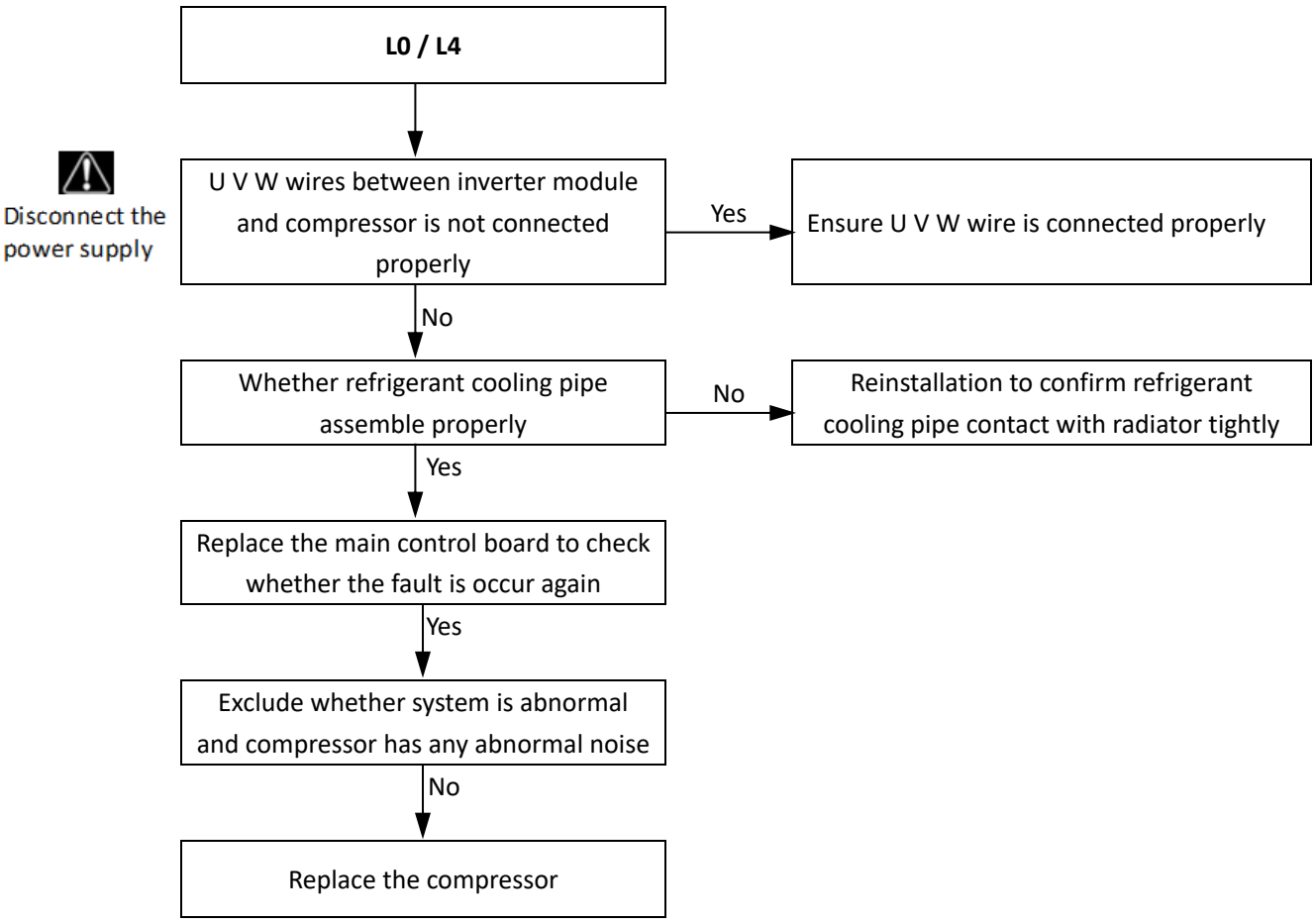
2.26.3 Trigger / recover condition

- Trigger condition: Inverter module or compressor is abnormal.
- Recover condition: Inverter module and compressor goes back to normal.
- Reset method: Manually restart.

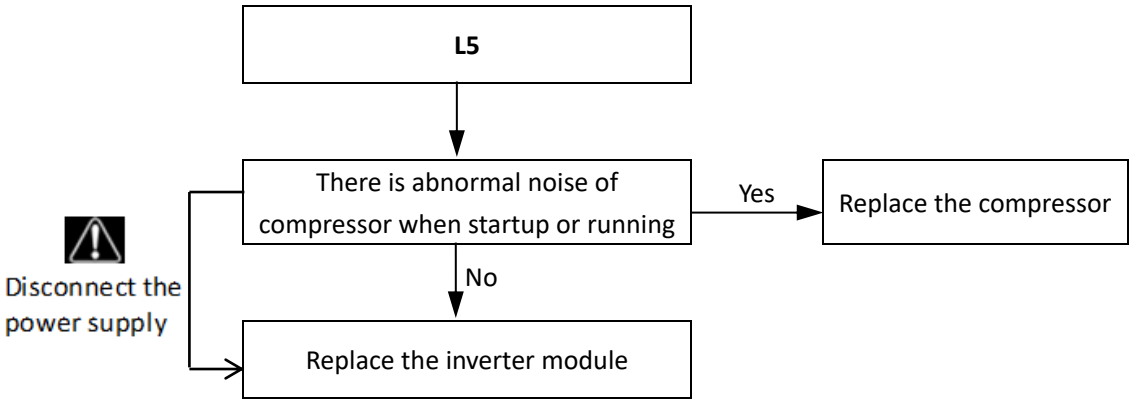
2.26.4 Possible causes

- Power supply is abnormal.
- Refrigerant cooling module is abnormal.
- Compressor is abnormal.
- Outdoor unit main control board damaged.

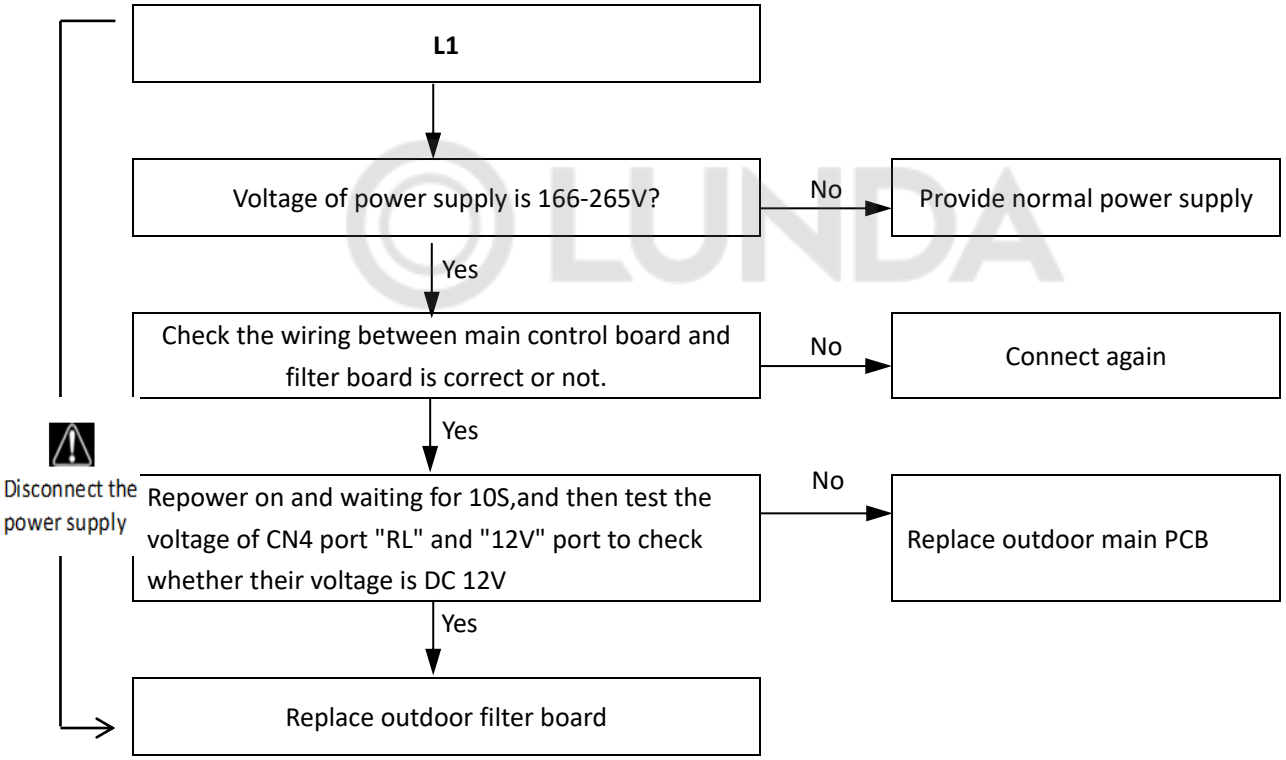
2.26.5 L0/L4: Procedure



2.26.6 L5: Zero speed protection



2.26.7 L1: Procedure



2.26.8 L2 : Procedure

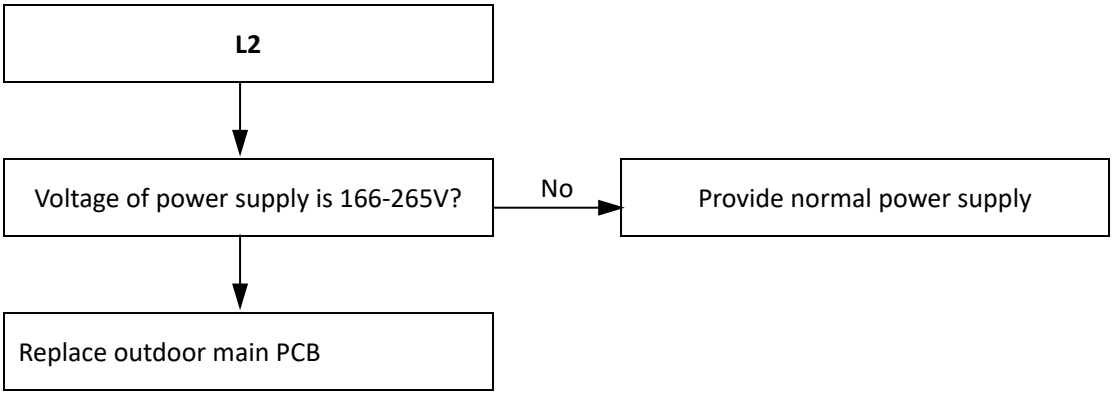


Figure 6-2.5: Draining oil from a compressor

2.26.9 Compressor replacement procedure

Step 1: Remove faulty compressor and remove oil

- Remove the faulty compressor from the outdoor unit.
- Before removing the oil, shake the compressor so as to not allow impurities to remain settled at the bottom.
- Drain the oil out of the compressor and retain it for inspection. Normally the oil can be drained out from the compressor discharge pipe.

Step 2: Inspect oil from faulty compressor

- The oil should be clear and transparent. Slightly yellow oil is not an indication of any problems. However, if the oil is dark, black or contains impurities, the system has problems and the oil needs to be changed. Refer to Figure 6-2.7 for further details regarding inspecting compressor oil. (If the compressor oil has been spoiled, the compressor will not be being lubricated effectively. The scroll plate, crankshaft and bearings will wear. Abrasion will lead to a larger load and higher current. More electric energy will get dissipated as heat and the temperature of the motor will become increasingly high. Finally, compressor damage or burnout will result.)

Step 3: Check oil in other compressors in the system

- If the oil drained from the faulty compressor is clean, go to Step 6.
- If the oil drained from the faulty compressor is spoiled (lightly or heavily), go to Step 4.

Step 4: Replace oil separator and accumulator

- If the oil from a compressor is spoiled (lightly or heavily), drain the oil from the oil separator and accumulator in that unit and then replace them.

Step 5: Check filters(s)

- If the oil from a compressor is spoiled (lightly or heavily), check the filter between the gas stop valve and the 4-way valve in that unit. If it is blocked, clean with nitrogen or replace.

Step 6: Replace the faulty compressor and re-fit the other compressors

- Replace the faulty compressor.
- If the oil had been spoiled and was drained from the non-faulty compressor in Step 3, use clean oil to clean them before re-fitting it into the unit. To clean, add oil into the compressor through the discharge pipe using a funnel, shake the compressor, and then drain the oil. Repeat several times and then re-fit the compressors into the units. (The discharge pipe is connected to the oil pool of the compressor by the inner oil balance pipe.)

Figure 6-2.6: Compressor piping

Step 7: Add compressor oil

- Add oil to each of the compressors from which oil was drained in Step 3.
- Only use RB75EA oil. Different compressors require different types of oil. Using the wrong type of oil leads to various problems.
- Add oil to the accumulator from which oil was drained in Step 4.

Step 8: Vacuum drying and refrigerant charging

- Once all the compressors and other components have been fully connected, vacuum dry the system and recharge refrigerant.

3 Appendix

3.1 Resistance characteristics of temperature sensor

Table 5-6.1: Outdoor ambient temperature sensor, pipe temperature sensor resistance characteristics

Temperature (°C)	Resistance (kΩ)	Temperature (°C)	Resistance (kΩ)	Temperature (°C)	Resistance (kΩ)	Temperature (°C)	Resistance (kΩ)
-20	115.266	20	12.6431	60	2.35774	100	0.62973
-19	108.146	21	12.0561	61	2.27249	101	0.61148
-18	101.517	22	11.5	62	2.19073	102	0.59386
-17	96.3423	23	10.9731	63	2.11241	103	0.57683
-16	89.5865	24	10.4736	64	2.03732	104	0.56038
-15	84.219	25	10	65	1.96532	105	0.54448
-14	79.311	26	9.55074	66	1.89627	106	0.52912
-13	74.536	27	9.12445	67	1.83003	107	0.51426
-12	70.1698	28	8.71983	68	1.76647	108	0.49989
-11	66.0898	29	8.33566	69	1.70547	109	0.486
-10	62.2756	30	7.97078	70	1.64691	110	0.47256
-9	58.7079	31	7.62411	71	1.59068	111	0.45957
-8	56.3694	32	7.29464	72	1.53668	112	0.44699
-7	52.2438	33	6.98142	73	1.48481	113	0.43482
-6	49.3161	34	6.68355	74	1.43498	114	0.42304
-5	46.5725	35	6.40021	75	1.38703	115	0.41164
-4	44	36	6.13059	76	1.34105	116	0.4006
-3	41.5878	37	5.87359	77	1.29078	117	0.38991
-2	39.8239	38	5.62961	78	1.25423	118	0.37956
-1	37.1988	39	5.39689	79	1.2133	119	0.36954
0	35.2024	40	5.17519	80	1.17393	120	0.35982
1	33.3269	41	4.96392	81	1.13604	121	0.35042
2	31.5635	42	4.76253	82	1.09958	122	0.3413
3	29.9058	43	4.5705	83	1.06448	123	0.33246
4	28.3459	44	4.38736	84	1.03069	124	0.3239
5	26.8778	45	4.21263	85	0.99815	125	0.31559
6	25.4954	46	4.04589	86	0.96681	126	0.30754
7	24.1932	47	3.88673	87	0.93662	127	0.29974
8	22.5662	48	3.73476	88	0.90753	128	0.29216
9	21.8094	49	3.58962	89	0.8795	129	0.28482
10	20.7184	50	3.45097	90	0.85248	130	0.2777
11	19.6891	51	3.31847	91	0.82643	131	0.27078
12	18.7177	52	3.19183	92	0.80132	132	0.26408
13	17.8005	53	3.07075	93	0.77709	133	0.25757
14	16.9341	54	2.95896	94	0.75373	134	0.25125
15	16.1156	55	2.84421	95	0.73119	135	0.24512
16	15.3418	56	2.73823	96	0.70944	136	0.23916
17	14.6181	57	2.63682	97	0.68844	137	0.23338
18	13.918	58	2.53973	98	0.66818	138	0.22776
19	13.2631	59	2.44677	99	0.64862	139	0.22231

Table 5-6.2: 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	**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**	2.86
-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**	8.94	**112**	2.63
-7	261.4	**33**	38.89	**73**	8.643	**113**	2.559
-6	247.8	**34**	37.3	**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**	7.82	**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	**81**	6.641	**121**	2.061
2	163.3	**42**	26.9	**82**	6.43	**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**	22.1	**87**	5.488	**127**	1.762
8	121	**48**	21.26	**88**	5.32	**128**	1.717
9	115.2	**49**	20.46	**89**	5.157	**129**	1.674
10	109.8	**50**	19.69	**90**	5	**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		

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