Maintenance Manual

On-Line UPS

Tower

10 kVA (1:1)

General

This document describes maintenance requirement for 10 kVA UPS, including safety precautions for maintenance, product description, internal structure description, single board composition, main components of single board, main functions description, troubleshooting, replacement and maintenance of single board and commissioning after maintenance. It is helpful for an engineer to provide technical support and maintenance service for UPSs mentioned in the manual.

Revision History

The revision history provides description on each document upgrade. The latest version of document includes the upgraded content of all previous versions.

Date	Version	Summary of Changes
2019-03-28	V01	Initial version
2023-02-01	V02	Two appendices have beed added

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1 Safety Information

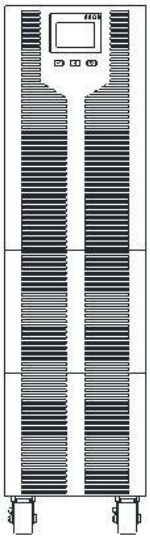
- As the UPS and the battery holder may present a hazardous voltage, only qualified electricians who has skills and knowledge related to the construction, installation, and operation of electrical equipment and has received safety training to recognize and avoid the hazards involved are allowed to perform UPS installation and maintenance.
- The UPS contains internal batteries and may present a shock hazard even when disconnected from the branch circuit (mains). Before installing or servicing the UPS system, ensure that the units are OFF and that mains and batteries are disconnected. Wait (about 10 minutes) until the UPS is completely powered down, then the corresponding operation can be performed.
- The UPS must be properly grounded before use to ensure personal safety and the normal use of the UPS.
- Before performing the maintenance, electricians should wear rubber gloves and boots and use tools with insulated handles.
- Do not operate the equipment when the temperature and humidity exceeds the limit value specified in the user manual.
- Before the maintenance of the UPS, disconnect all inputs (including battery input) and outputs of the UPS.
- All safety instructions in this manual must be read, understood and followed. Failure to follow these instructions will result in death or serious injury.
- Before installing or replacing the batteries, remove jewelry such as wristwatches and rings. High short circuit current through conductive materials could cause severe burns.
- Do not dispose of batteries by burning them. The batteries may explode.
- Do not open or mutilate batteries. Released electrolyte is harmful to the skin and eyes, and may be toxic.
- Be sure that all panels are fixed securely and front door is closed when the equipment is operating.

2 Product Overview

2.1 Product Description

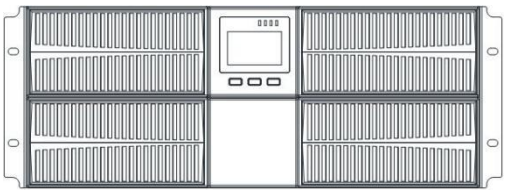
The series of UPS includes rack-mounted UPS and tower type UPS with 10 kVA power levels and output power factor 1.0. Up to 4 UPS units can be connected in parallel to operate, providing stable and reliable power supply for the loads.

10 kVA long backup model UPS (Tower)



10 kVA standard model UPS (Tower)

10 kVA long backup model UPS (Rack-mount)



10 kVA standard model UPS (Rack-mount)

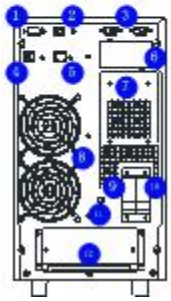
Table 2-1 10 kVA series models

Products	Models	Description	Others
UPS	10kVAS	10 kVA standard model (Tower type)	Charging current: 1 A
UPS	10kVAH	10 kVA long backup model (Tower type)	Max. charging current: 12 A (standard configuration is 5 A; 12 A is optional)
UPS	10kRTS	10 kVA standard model (Rack-mounted)	Charging current: 1 A
UPS	10kRTH	10 kVA long backup model (Rack-mounted)	Max. charging current: 12 A (standard configuration is 5 A; can be expanded to 12 A)
Battery bank	9 Ah battery bank	Built-in 16 × 12 V / 9 Ah batteries. It is a standard configuration for 10kRTS UPS.	Capacity expansion is available by adding additional battery banks connected in parallel. A maximum of 5 battery banks can be connected in parallel.

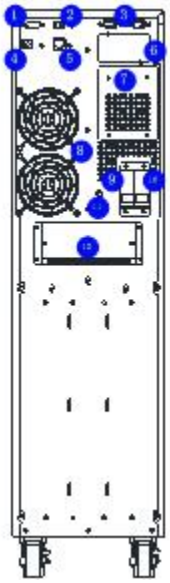
Table 2-2 Accessories of 10 kVA UPS

Item	Descriptions	Standard Configuration	Optional Configuration
RS232	Background monitoring of single UPS.	√	
USB	Realize USB communication function		√
Built-in RS485 protocol convert card	Realize communication protocol between RS485 interface and MODBUS; Can be inserted into the communication card slot of the UPS.		√
Dry contacts card	Realize detection of system monitoring switch signals, including UPS failure, system failure, bypass mode, low battery, UPS status and mains abnormality		√
Built-in SNMP card	SNMP card: Ethernet networking monitoring of multiple UPSs		√
SMS Cat	Needs to be equipped with a SNMP card. When the SNMP card detects an alarm in the UPS, the SNMP card can control the SMS Cat to send the alarm message to the designated user's phone; SIM card is not included, additional purchases are required, and only standard SIM card for China mobile and China Unicom are applicable.		√
SMS alarm	Can be directly connected to the RS232 interface of the UPS. Can automatically send the UPS alarm message to the designated user's phone. SIM card is not included, additional purchases are required, and only standard SIM card for China mobile and China Unicom are applicable.		√
EPO	Emergency Power Off, default: disable	√	
Parallel kit	Realize parallel function among single units		√
Battery temperature compensation components	Realize battery temperature compensation function		√
Maintenance bypass kit	Realize maintenance function in power-on condition		√
RS485	Realize 485 communication function		√
Charger board	12 A charger board		√

2.2 Rear Panel Features

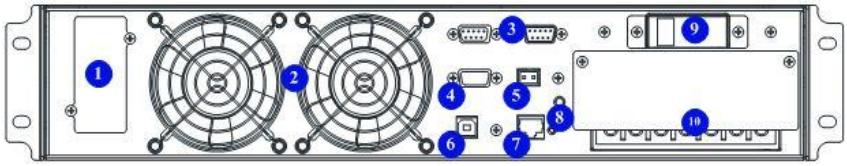


10kVAH

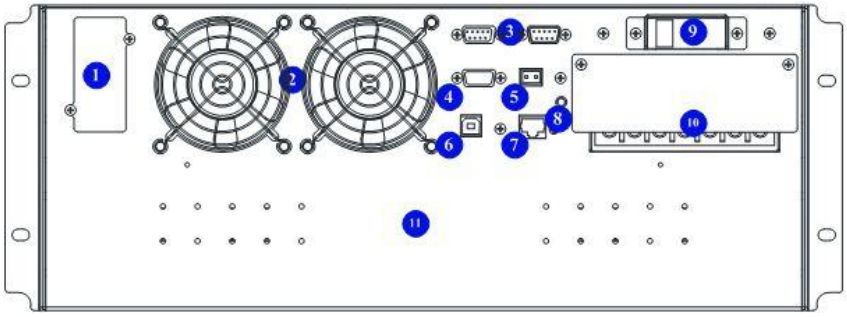


10kVAS

1. RS232
2. EPO
3. Parallel port (optional)
4. USB (optional)
5. Battery temperature (optional)
6. SNMP (optional)
7. Reserved: for manual bypass, battery breaker, socket etc.
8. Fans
9. Bypass breaker
10. Input breaker
11. GND
12. Terminal cover



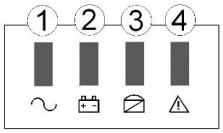
10kRTH



10kRTS

1. SNMP (optional)
2. Fans
3. Parallel port (optional)
4. RS232
5. EPO
6. USB (optional)
7. Battery temperature (optional)
8. GND
9. Bypass breaker
10. Terminal and cover
11. Battery bank

2.3 LED Indicators



No.	Function	Description
①	Inverter indicator (green)	Illuminated: The inverter is working in normal mode. Unilluminated: The UPS is working in non-inverter mode. Flashing: The inverter is starting or waiting (ECO mode)
②	Battery indicator (yellow)	Illuminated: Battery is discharging. Unilluminated: The battery is connected but not charged. Flash: Battery alarm or charger failure.
③	Bypass indicator (yellow)	Illuminated: The UPS is working in bypass mode. Unilluminated: The UPS is working in non-bypass mode. Flashing: Bypass alarm
④	Alarm indicator (red)	Illuminated: Fault occurs on the UPS. Unilluminated: UPS is normal. Flashing: There is abnormality and the UPS emits an alarm.
⑤	Buzzer	Fault: Beep continuously Alarms: Beep every 4 s Battery discharge and battery low voltage: Beep every 1 s

Table 2-3 List of LED indicators corresponding to operating status

No.	Operating Status	Signal of Panel Indicator				Audible Alarm
		Inverter	Battery	Bypass	Fault	
1	Utility inverter mode					
	Utility power in normal	●				None
	Utility power with high/low voltage protection, switch to battery	●	●		★	Beep every 4 s
2	Battery mode					
	battery normal	●	●		★	Beep every 4 s
	Low battery	●	★		★	Beep every 1 s
3	Bypass mode					
	Utility power in normal (in bypass mode)			●	★	Beep every 4 s
	Utility power with high voltage alarm (in bypass mode)			●	★	Beep every 4 s
	Utility power with low voltage alarm (in bypass mode)			●	★	Beep every 4 s
4	Battery disconnected alarm					
	In the state of bypass			●	★	Beep every 4 s
	In the state of inverter	●			★	Beep every 4 s
	Power on or switching on					Beep every 4 s
5	Output overload protection					
	Overload in utility mode, emiting an	●			★	Beep every 4 s

	alarm					
	Overload in utility mode, in protection action			●	●	Beep continuously
	Overload in battery mode, emiting an alarm	●	●		★	Beep every 4 s
	Overload in battery mode, in protection action	●	●		●	Beep continuously
6	Bypass overload alarm			●	★	Beep every 4 s
7	Fan failure (the fan icon flashes)	▲	▲	▲	★	Beep every 4 s
8	Fault mode				●	Beep continuously

● _The indicator is illuminated continuously.

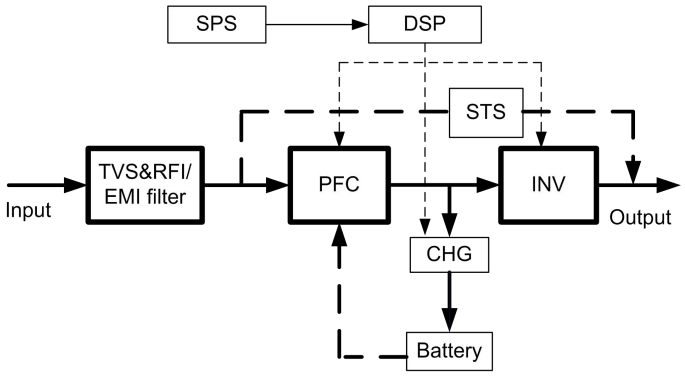
★ _The indicator is flashing.

▲ _ The indicator status depends on other conditions.

3 Internal Structure Description

3.1 Working Principle

3.1.1 Working principle diagram

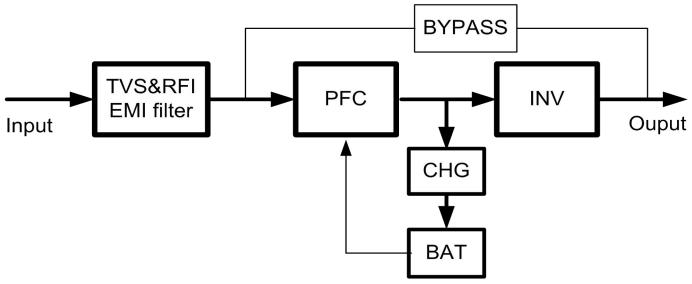


3.1.2 Working modes

Normally the 10 kVA UPS working mode includes normal mode, bypass mode, battery mode, ECO mode, frequency converter mode, and self aging mode.

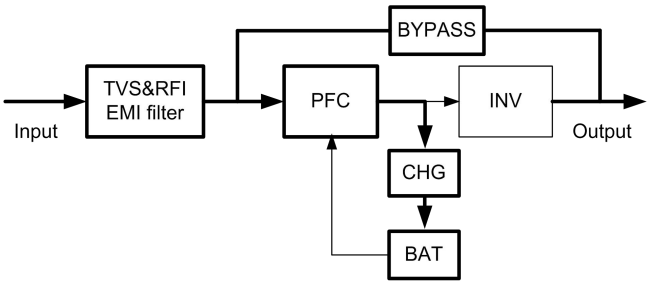
Normal Mode

As below shown, rectifier supply DC supply to inverter, the load is fed by inverter. Charger is charging the battery.



Bypass Mode

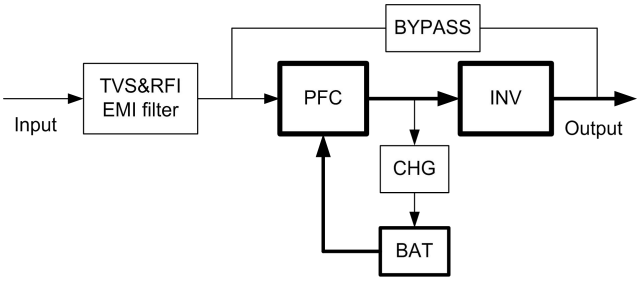
If inverter is failure or overload, UPS will transfer to bypass mode. Or press“ ◄ + ► ”to transfer from normal mode to bypass mode. The load is feed by input power directly, and UPS can not protect load from surge. Shown as below.



Battery Mode

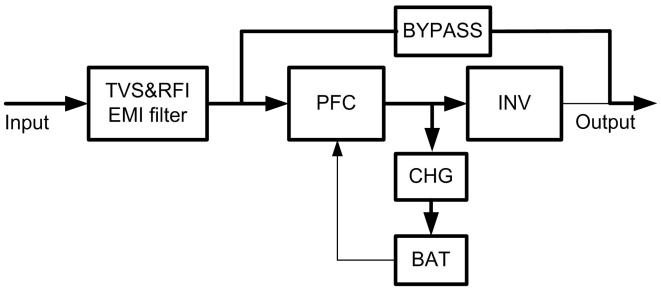
If input power is failure when in normal mode, UPS will transfer to battery mode. In this mode, the battery provide power to inverter. Shown as below.

NOTICE: press“ ◄ + ► ”in battery mode. The UPS will shut down completely.



ECO Mode (only available for single unit)

When UPS works in ECO mode, load is fed by bypass. Inverter is standby, charger is working normally. The efficiency is up to 98%, but UPS can protect the load from surge disturb. If input power is failure, UPS transfer to battery mode. Shown as below.



Frequency Converter Mode

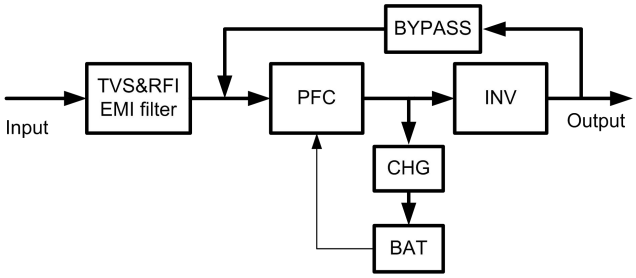
In this mode, input and output nominal frequency is different, and the bypass is forbidden to use.

NOTICE: if overload timeout, UPS will shutdown output.

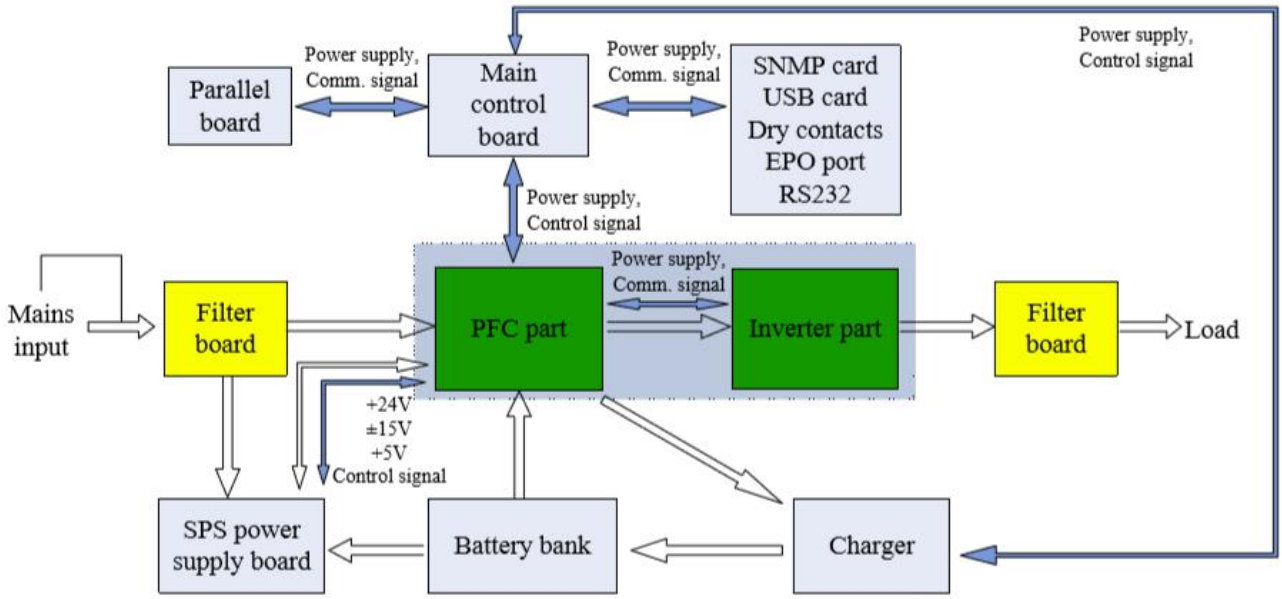
NOTICE: the load should be derated to 50% and below.

Self Aging Mode

If users want to burn in UPS without load, could set the UPS as Self Aging Mode, in this mode, the current flow through rectifier, inverter, and back to input through bypass. It needs only 5% loss to burn in UPS with 100% load. Shown as below.

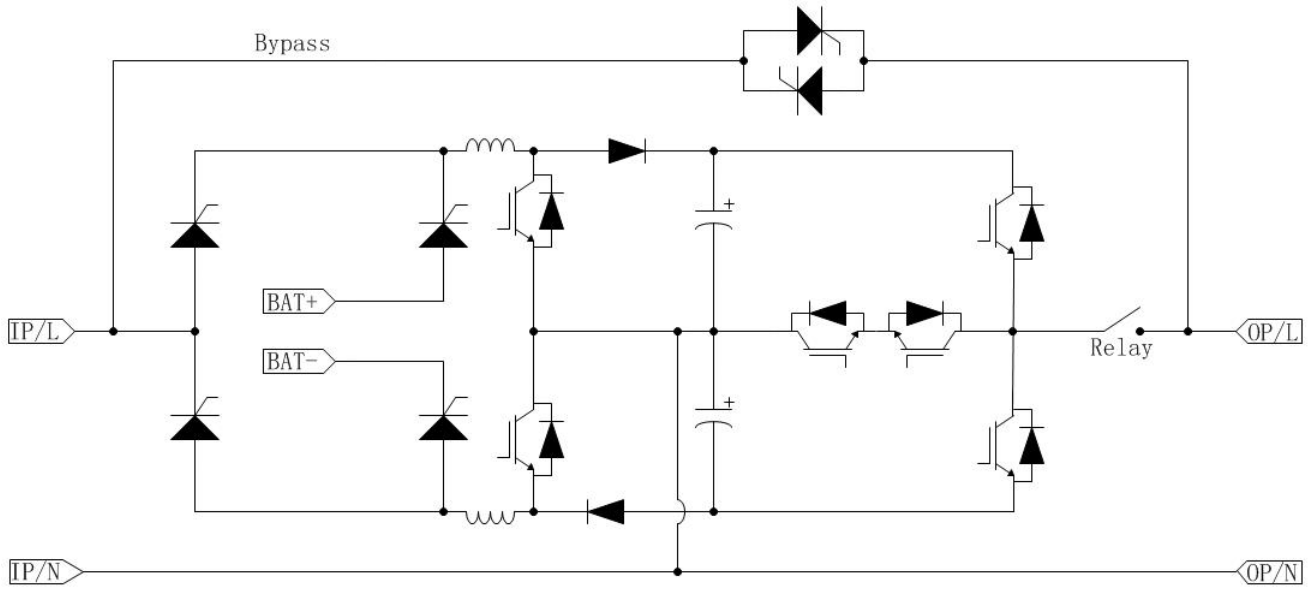


3.2 Principle Block Diagram



3.3 Main Circuit Topology

Main circuit topology is as follows:



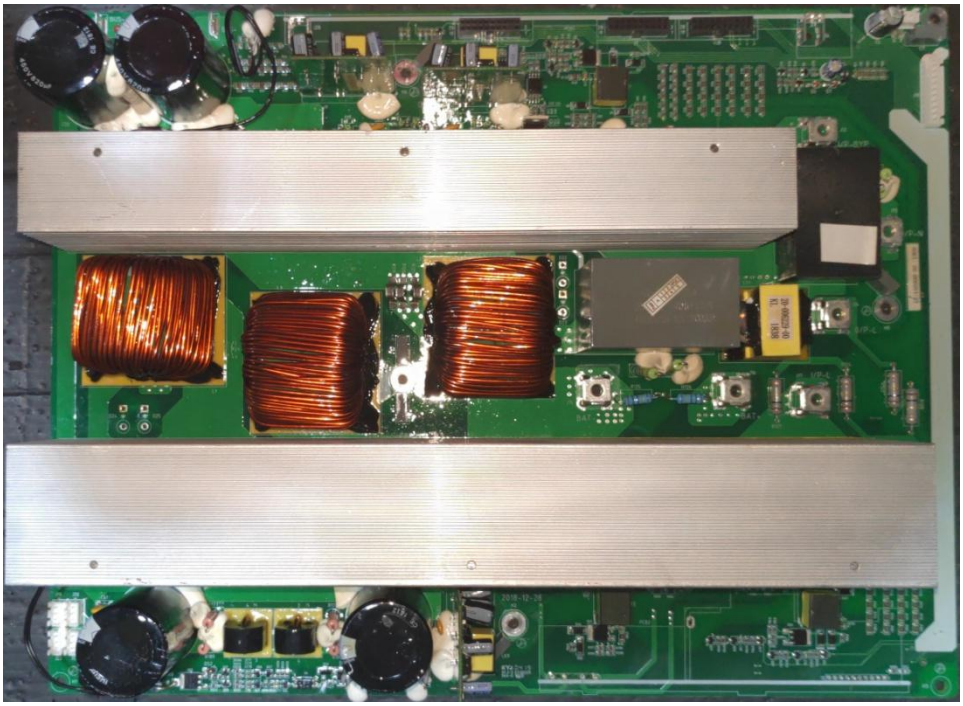
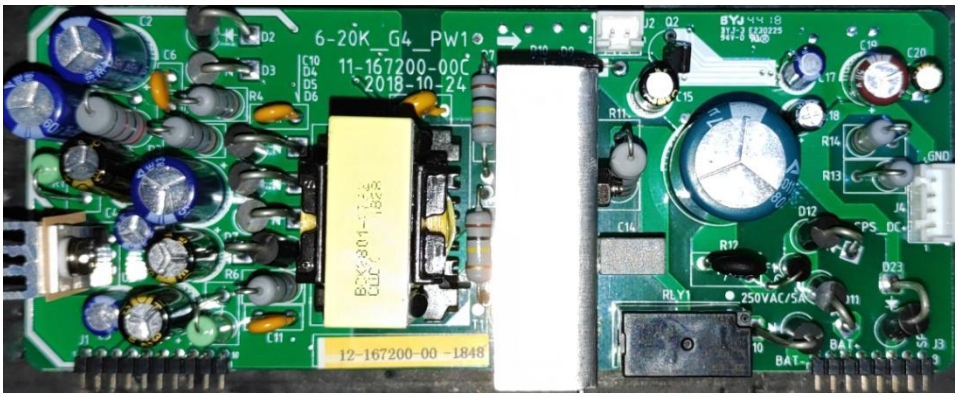
3.4 Internal Single Boards

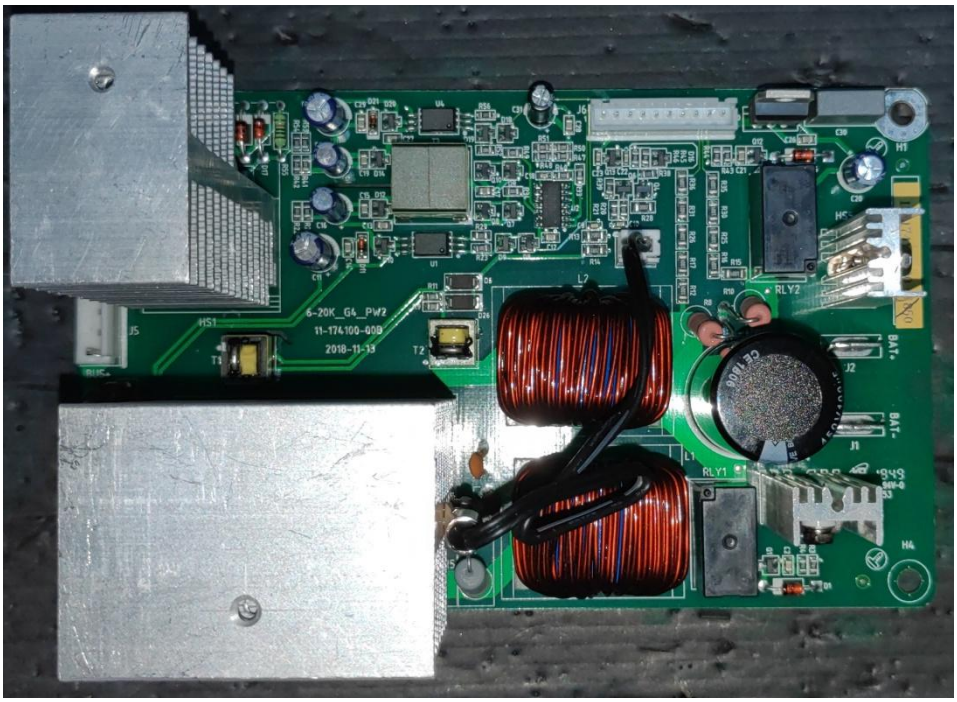
Table 3-1 Function description of internal single boards

No.	Name of Single Board	Description	Function	Qty.	Others
1	DR1	Including PFC power board and INV power board	Invert the power of the utility or the battery input to high quality AC output	1	
2	EM1	Input EMI board	Filter board	1	
3	PW1	SPS power supply board	SPS power supply board provides power for whole UPS system, mainly including + 5 V, +24 V and ±15 V etc.	1	
4	PW2	Charging board	The charging board gets power from the bus and charges the battery	1	Standard configuration for standard model UPS: 1 A (PW3); Standard configuration for long backup model UPS: 5 A (PW2); Optional configuration for long backup model UPS: 12 A (PW4);
5	CT1	Main control board	The main control board is the control core of the UPS, which is responsible for the realization of a variety of signals sampling, control and communication of the UPS	1	
6	CP1	Capacitor board	Reduce bus voltage ripple	1	
7	Parallel board	Used for parallel communication	Provide a communication port for parallel operation: 2*DB9 ports, and achieve communication of multiple UPSs in parallel operation	1	Optional

8	LCD display board	Human-machine interface control	1. Communicate with the main control board, and real-timely monitor UPS status; 2. Provide the human-machine interface to monitor the UPS	1	
9	RS232 communication board	RS232 communication interface board	Provide RS232 communication interface; achieve the monitoring of single UPS	1	RS232 communication board is standard configuration, and USB communication board is optional; select one of two communication boards
10	USB communication board	communication interface board	Provide USB communication interface; achieve the monitoring of single UPS	1	
11	SNMP card	Network communication card	Provide Ethernet networking solution for the users	1	Optional; select one between the three
12	RS485 port	RS485	Provides advanced communication and control functions	1	
13	Dry contact card	Dry contact card	Achieve the detection and control extension of the system monitoring switch. Control signal includes reporting of assoliated alarm dry contact, mainly including UPS normal operation, battery mode, bypass mode, low battery and UPS fault	1	

	Main control board

	Main power board
	CP2 Capacitor board
	PW1 power supply board

	PW2 charging board

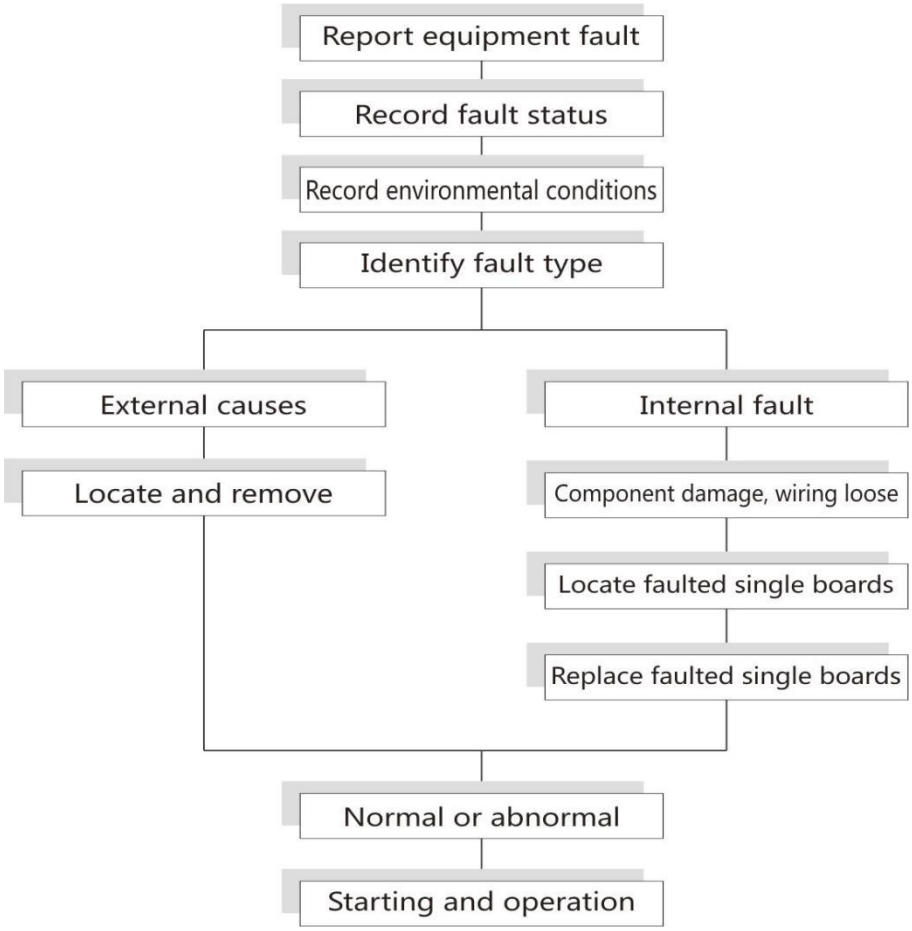
4 Troubleshooting

This section mainly describes all alarm information of the system, alarm meaning, possible causes for alarming and troubleshooting.

4.1 List of Maintenance Tools

Tools	Qty.	Others
Oscilloscope	1	Measure relative waveform
Multimeter	1	Measure voltage, resistance, etc.
High-voltage probe	Some	Measure voltage signal
DC power supply	1	Provide current-limiting DC power supply
AC power supply	1	Provide current-limiting AC power supply
Screw driver, nipper pliers, diagonal pliers, etc.	1 set	Be used for disassembly and installation of device and single boards.
Soldering iron, tin wire, etc.	1 set	For repair welding
Load	1	Be used after the maintenance and commissioning of the UPS

4.2 Troubleshooting Process



On-site fault record: First site fault data are very important. According to these data, fault point and fault cause may be identified approximately, and correct solution can be formulated. Therefore, the first thing an engineer needs to do is to record all the conditions of the power system after arrival, mainly including:

- Status of power supply system (panel and monitoring information): display interface of LCD screen, UPS display status on network management side and history record when faults occure;
- Actual input/output battery parameter of power supply system: the parameters displayed during the fault are not always the actual parameter of the power supply, and the actual parameters of the terminal may be measured by the multimeter and recorded, including input voltage, output voltage, and battery voltage;
- Positions of all power system switches;
- Environment record: Ambient environment is also very important for the operation of the power supply system, and the ambient operating environment should be recorded after the above records are made.
    - Ventilation condition
    - Ambient temperature
    - If the installation distance from other equipment meets requirement
    - If the ambient environment is harmful (e.g. dust or humidity)
    - Are input and output batteries are wired properly, does wire diametermeet requirement, is cable sheath damaged, and is the wiring terminal is loose?
    - Name, type, rated power of the load (consult with the customer)

Fault type identification: After all indications are recorded, refer to the following fault information table, and check the abnormal indication light. In most cases, the fault results from external power supply, and therefore, following the principle of “external to internal, the external fault can be identified and removed according to the fault information table.

Causes for common external faults:

- Overload
- Input/output overvoltage/undervoltage

- Mains breaker is open or mains power is abnormal
- Output short circuit
- Battery voltage is below the low-voltage limit

If the fault results from the internal power supply, a solution can be made after fault location. Each key step of the solution should be recorded for providing reference for re-making the solution when failure to remove the fault.
If the faults still persist, feed back the record information to the technical support engineer for removal advice.

4.3 Alarm Information Collection

4.3.1 LCD panel alarm information collection

After arrival at the spot in right way, the maintainer needs to collect the alarm information as soon as possible to obtain effective basis of fault analysis. The messages displayed on the LCD panel (mainly fault code) should be recorded in detail, and the operating condition of the LED indicator should be recorded. According to the fault category and the operating condition of the LED indicator, the fault point can be located preliminarily.

4.3.2 Network management alarm information collection

If the customer's power supply system is connected to network management software, the electrician can download and export current alarm information and all data via the network management software for analysis. See the corresponding network management software of user manual for details.

4.4 Troubleshooting

Use the table below to solve minor problems.

No.	Problem	Possible Cause	Corrective Action
1	The unit is unresponsive when power up, and the LCD display screen is unilluminated.	1. The UPS input breaker is not closed.	Close the input breaker.
		2. There is very high or very low mains input voltage	Use a multimeter to measure and verify that the input voltage is within specifiifed operating limits.
2	There is an audible beeping sound (every 4 s) when power up.	1. The battery is disconnected.	Be sure the battery is connected to the UPS and close the external breaker of the battery bank.
		2. The battery is damaged.	Use a multimeter to measure the battery voltage. If the voltage is too low, it means that the battery has been damaged. Replace the battery in time.
3	After startup with the battery, it shuts down automatically soon.	Battery voltage is too low or the battery is damaged.	Charge or replace the battery in time.
4	The discharge time of the battery is obviously lower than the standard value.	1. The battery is not fully charged.	Recharge the battery more than 8 h when utility power is normal, and retest discharge time.
		2. The battery is damaged.	Repalce the battery.
5	In battery mode, the battery indicator (yellow) and alarm indicator (red) flash. The buzzer emits a beeping sound every second.	It is battery low voltage alarm. The UPS is about to shut down and the power is cut off on the load.	1. Save the load data immediately and shut down all connected critical loads to avoid losing an unsaved data. 2. Connect the UPS to the standby AC power supply immediately.
6	In utility power mode or battery mode, the	The UPS output is overloaded.	Unplug unnecessary equipment.

	buzzer emits a rapid beeping sound (every 4 s).		
7	When the UPS is turned on, “EPO” is displayed on the LCD screen.	The EPO terminal is plugged in or the remote EPO interface switch is closed.	Unplug the EPO terminal or disconnect the remote EPO interface switch.
8	There is abnormal noise or smell inside the UPS cabinet.	There is a fault inside the UPS.	Shut down the UPS immediately and cut off the input power. Contact the supplier for technical support.

Tabel below lists the alarm message that the UPS might display, a suggested corrective action is listed with each alarm message to help you troubleshoot problems.

Fault Code					**Explanation**	**Corrective Action**
Bypass mode	**Utility power mode**	**Battery mode**	**Self test mode**	**ECO mode**		
00	01	02	03	04	BUS high voltage	Replace the main control board and retest. If the problem still persists, replace the PFC power board.
05	06	07	08	09	BUS low voltage	
10	11	12	13	14	BUS unbalanced	
15	16	17	18	19	BUS soft start failure	
20	21	22	23	24	Inverter soft start failure	Replace the main control board and retest. If the problem still persists, replace the INV power board.
25	26	27	28	29	Inverter high voltage	
30	31	32	33	34	Inverter low voltage	
35	36	37	38	39	Inverter prohibited	
40	41	42	43	44	Overtemperature	Check the fan at the rear panel of the UPS to see if the fan outlet is blocked by obstacles or the distance between the rear panel and the wall is less than 0.5 m (in single UPS system, after overtemperature fault, the UPS will automatically restart when the internal temperature of the UPS drops to a certain value)
45	46	47	48	49	Output short circuit	The inverter output is short-circuited, replace the INV power board. The load inside is short-circuited, check whether the load equipment is abnormal or not. Verify that the load is normal, then restart the UPS and connect the load to it.
50	51	52	53	54	Overload fault	Disconnect the loads and turn off the UPS, unplug nonessential equipment, restart the UPS and

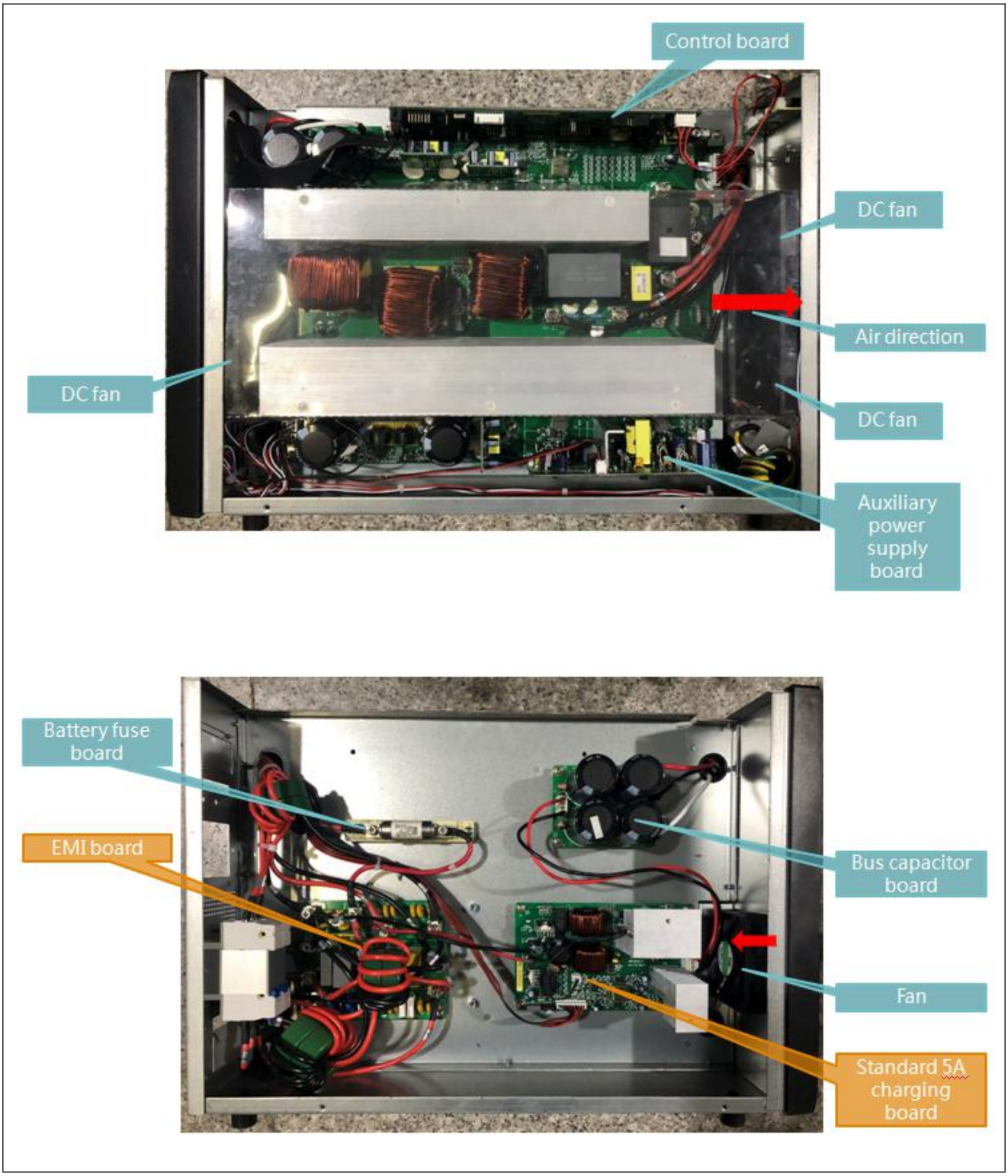
						reconnect the critical load.
55	56	57	58	59	Negative power abnormality	It is caused by the bypass feeding back to the inverter. Check if the inverter output relay on the main power board is adhered. It is caused by the abnormal loads. Check the load condition.
60	61	62	63	64	Shutdown fault	Check whether the first button on the LCD panel can be pressed and rebounded. If the button works normally, replace the cables between the LCD panel and the main control board, and replace the main control board in turn, then retest it.
65	66	67	68	69	Software versions of parallel UPS are inconsistent	These fault codes are not enabled.
70	71	72	73	74	Synchronizing signal abnormality	These fault codes are not enabled.
75	76	77	78	79	Synchronizing pulse abnormality	
80	81	82	83	84	The inverter relay is adhered	Check if the relay contact on the main power board is adhered. If it is, replace it.
85	86	87	88	89	BUS short circuit	
90	91	92	93	94	CAN communication abnormality	Check whether the parallel UPS cables are damaged or not, and whether they are connected properly to the parallel port on the rear panel of the UPS. Restart the UPS after verifying them in good condition. If the problem still persists, replace the parallel board and the main control board, and restart the UPS.
95	96	97	98	99	Physical address conflict	There are 2 or more units with the same IP address in the parallel UPS system, reconfigure the IP of each UPS and verify that each IP is different, then connect them in parallel and restart them. (Please refer to the user manual for the IP address setting method)
100	101	102	103	104	Parallel UPS models incompatible	Check whether the model of each UPS is consistent. Verify that the model of each

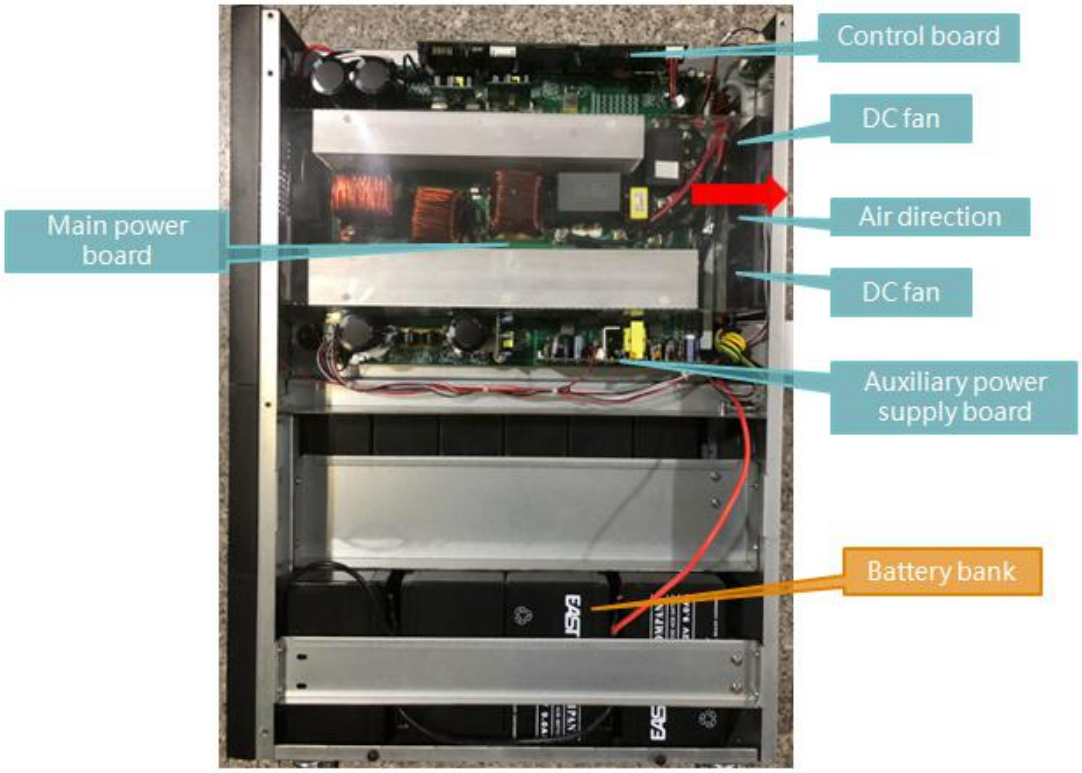
						UPS connected in parallel is consistent, then reconnect them in parallel and restart them.
105	106	107	108	109	Wrong setting on number of batteries	Detect the battery voltage. It is reported when the detected voltage value is inconsistent with the number of batteries.
110	111	112	113	114	Input SCR soft start failure	After mains power soft starting in 13 min, the BUS voltage is still lower than 240 V, mains power soft starting fault is reported.
115	116	117	118	119	Rectifier SCR fault	These fault codes are not enabled.
120	121	122	123	124	Inverter abnormality	Check whether the inverter IGBT is damaged or not, if not, replace the main power board.
125	126	127	128	129	Incorrect bypass wiring in parallel system	Remove cables and reconnect them correctly.(Refer to user manual for specific wiring method)
130	131	132	133	134	Inverter fuse tripped	
135	136	137	138	139	PFC abnormality	Check if the input SCR and rectifier IGBT are damaged. Replace the main power board.
140	141	142	143	144	Inverter capacitor abnormality	
145	146	147	148	149	Fan fault	Replace the fan if it is damaged. Check the fan drive circuit and the fault signal circuit if the fan is not damaged.
150	151	152	153	154	EPO	The fault code is only used to store fault information in the background. The panel does not display the code when the fault occurs, only the EPO is displayed.
155	156	157	158	159	auxiliary power supply abnormality	Test whether the output voltage on the auxiliary power supply is normal or not. If not, replace it with a new auxiliary power supply board.

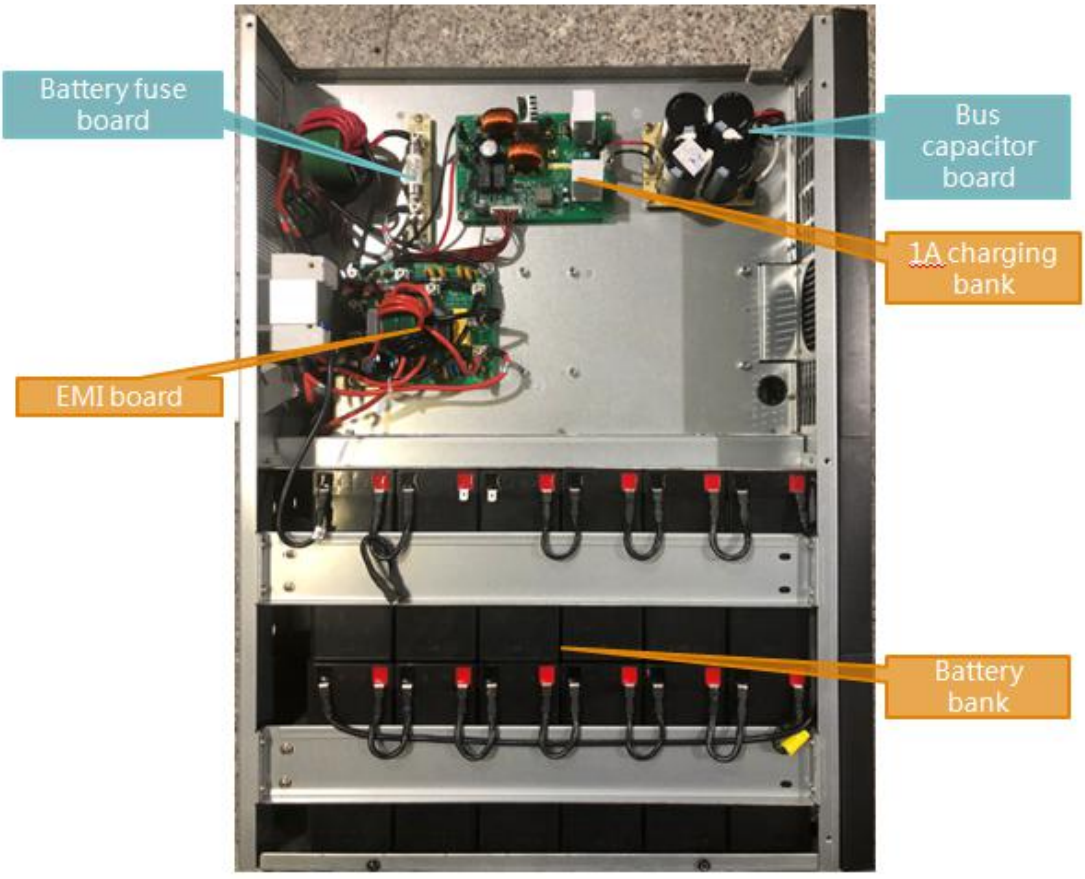
5 Replacement of Single Boards

The follow figures can be referred for the replacement of single boards

EA9010H




Control board
DC fan
Air direction
Main power board
DC fan
Auxiliary power supply board
Battery bank


Battery fuse board
Bus capacitor board
1A charging bank
EMI board
Battery bank

6 Maintenance of Single Boards

The maintainers of UPS need to have basic circuit theory knowledge, relevant power electronic knowledge and the relevant circuit topology knowledge. In addition, the improvement of maintenance skill depends on long-term maintenance experience accumulation, and the maintenance record should be made so that it is available for further reference during the maintenance and can help the maintainer to locate the fault point and remove the fault rapidly for improving the maintenance efficiency.

According to the actual usage, the damageable components of 10 kVA UPS include main power board, SPS power supply board and CHGR charging board. The following provides simple description for the maintenance of these three circuit boards.

6.1 Maintenance of Main Power Board

The main power board has two parts: rectifier PFC part and inverter part. The two parts are introduced respectively as follows.

1. The damageable components of the PFC part are listed below (sort by the damageable condition):

    - IGBT Q15/Q16/Q17/Q18 and corresponding driving regulator diodes D30, D37 (Q15)/D31, D38Q (16)/D34, D39 (Q17)/D36, D40 (Q18)
    - Power diode D28/D29
    - Mains rectification SCR Q21/Q24
    - Battery SCR Q19/Q20/Q22/Q23
    - PFC_IGBT tube RCD and absorption circuit diodes D32/D35/D33/D41
    - IGBT drive module PCB03
    - Thyristor SCR drive circuit
    - Other components

Table 6-1 List of damageable components of the PFC part

Components	**Position Number**	**Others (the value is standard value and there is deviation actually)**
BOOST circuit IGBT IKW50N65ES5	Q15/Q16/Q17/Q18	50 A/650 V
IGBT tube driving regulator diode 1N4746A	D30, D37(Q15)	14 mA/18 V/1 W
	D31, D38(Q16)	
	D34, D39(Q17)	
	D36, D40(Q18)	
BOOST circuit power diode APT75DQ60BG	D28/D29	75 A/600 V
Mains rectifier SCR CLA50E1200HB	Q21/Q24	50 A/1200 V
Battery SCR CLA50E1200HB	Q19/Q20/Q22/Q23	50 A/1200 V
IGBT tube RCD and absorption circuit diode MUR460	D32/D33	4 A/600 V
IGBT tube RCD and absorption circuit diode 1N4937	D35/D41	1 A/600 V
IGBT drive module	PCB3	——
Thyristor SCR drive circuit	Diode, MOSFET, transformer	——
Other components	——	——

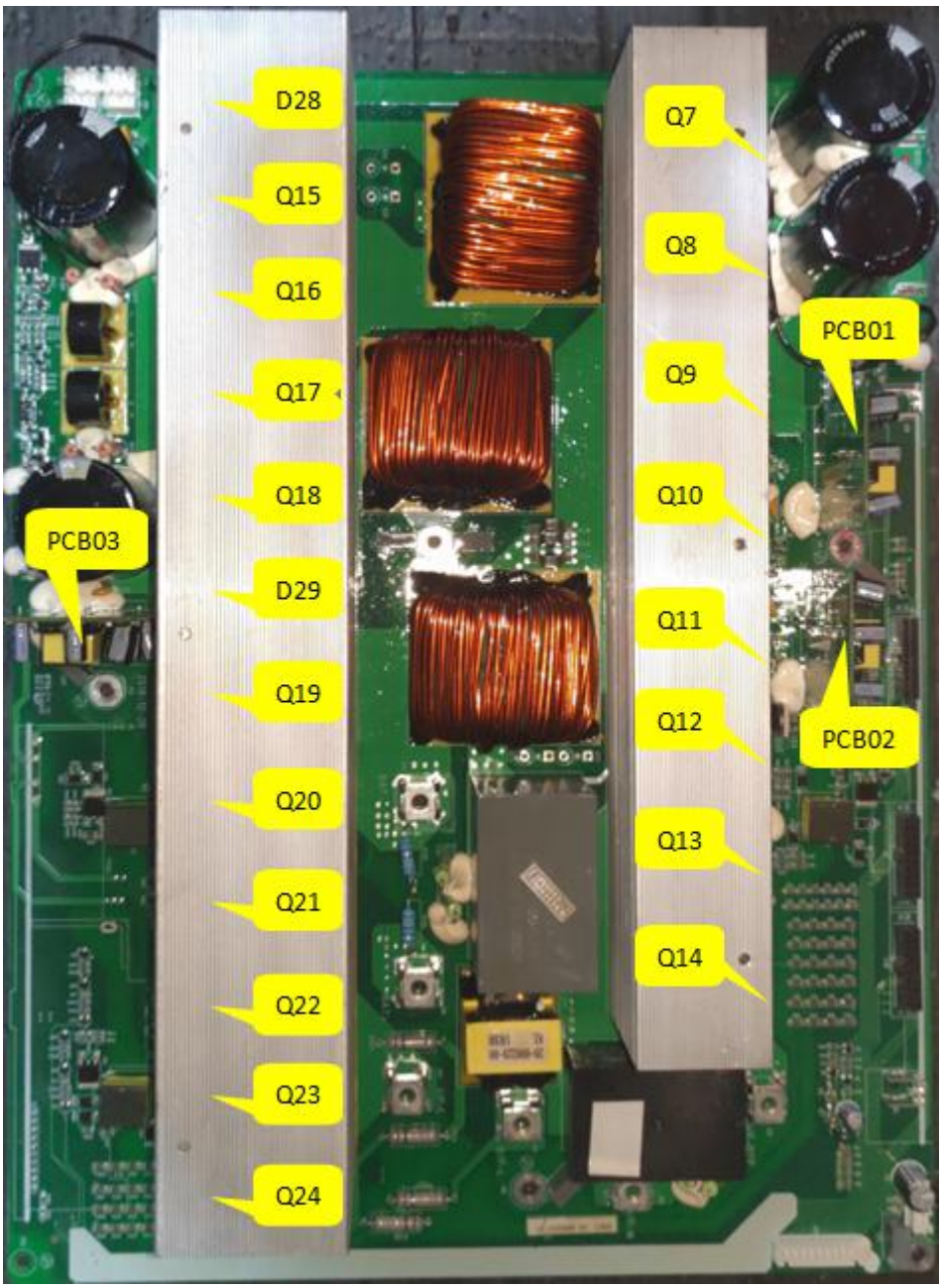


Fig. 6-1 Key components of PFC power board

Maintenance procedures:

Step 1: Check if there is copper foil corrosion on the power board, which can be checked using a multimeter. If the copper foil is corroded, properly re-weld it.

Step 2: Visually inspect that if there is obvious components burnout or burst on the whole power board. If yes, replace them.

Step 3: Use a multimeter to test the two ends of GE and two ends of EC on the IGBT tube Q15/Q16/Q17/Q18. If the measured diode voltage drop is too low (less than 0.1 V), the corresponding IGBT tube needs to be replaced.

Note: When replacing the IGBT tube, heat dissipation paste should be painted on the back of the IGBT tube. If its corresponding insulation spacer is charred, burned out, burned through, melted or has other abnormal conditions, it should also be replaced.

Step 4: Use a multimeter to test the driving regulator diode D30, D37(Q15)/D31, D38(Q16)/D34, D39(Q17)/D36, D40(Q18) of the IGBT tube Q15/Q16/Q17/Q18. If the measured diode voltage drop is too low (less than 0.1 V), the corresponding voltage regulator diode needs to be replaced.

Tips: In Step 3, if the IGBT tube is damaged, the corresponding driving regulator diode would also be damaged.

Step 5: Use a multimeter to test the power diode D28/D29 and absorber diodes D32/D35/D33/D41. If the forward voltage drop is too low (less than 0.1 V) or there is a reverse voltage drop, the diode might be damaged and needs to be replaced.

Step 6: Use a multimeter to test the resistance value at two ends of GK on the mains power SCR Q21/Q24 and the battery SCR Q19/Q20/Q22/Q23. Normal resistance value should be about 20Ω. If not, replace them.

Step 7: After completing the maintenance items specified in Step 3 to Step 6, repeat the tests specified in Step 3 to Step 6. If the measured values are normal, perform the maintenance procedure of the inverter part. If they are abnormal, proceed to the next step.

Step 8: Replace the corresponding IBGT drive module PCB3 or inspect the corresponding SCR drive circuit. The components in the SCR drive circuit prone to problems are diodes, MOSFET and transistors. The components corresponding to the mains SCR Q21/Q24 are diode D43, D45, D48 and D49, MOSFET Q26 and transistor Q29 and Q30. The components corresponding to the battery SCR Q19/Q20/Q22/Q23 are diode D42, D44, D46 and D50, MOSFET Q25 and transistor Q27 and Q28. Damage conditions are: the diode forward voltage drop is too low (less than 0.1 V), the diode voltage drop at two ends of SD on the MOSFET is too low (less than 0.1 V), the diode voltage drop at two ends of BE on the transistor is too low (less than 0.1 V), the corresponding components should be replaced at this moment, and then repeat the tests specified in Step 3 to Step 6. If the measured value is normal, perform the maintenance procedure of the inverter part, if it is abnormal, repeat Step 8.

2. The damageable components of the inverter part are listed below (sort by the damageable condition):

    - IGBT Q7/Q8/Q9/Q10/Q11/Q12 and corresponding driving regulator diodes D10, D19(Q7)/D14, D18(Q8)/D15, D20(Q9)/D11, D21(Q10)/D12, D16(Q11)/D13 and D17(Q12)
    - Bypass thyristor SCR Q13/Q14
    - Inverter output relay RLY1
    - IGBT drive module PCB1 (Q7/Q8/Q11) and PCB2 (Q9/Q10/Q12)
    - Other components

Table 6-2 List of damageable components of the inverter part

Components	**Position Number**	**Others (the value is standard value and there is deviation actually)**
Three-level inverter IGBT NGTB40N120FL3WG	Q7/Q8/Q9/Q10	40 A /1200 V
Three-level inverter IGBT IKW75N65ES5	Q11/Q12	75 A /650 V
IGBT tube driving regulator diode 1N4746A	D10, D19(Q7)	14 mA/18 V/1 W
	D14, D18(Q8)	
	D15, D20(Q9)	
	D11, D21(Q10)	
	D12, D16(Q11)	
	D13, D17(Q12)	
Bypass thyristor SCR CLA50E1200HB	Q13/Q14	50 A/1200 V
Inverter output relay T92S7D12-24	RLY1	24 VDC
IGBT drive module	PCB1/PCB2	——
Other components	——	——

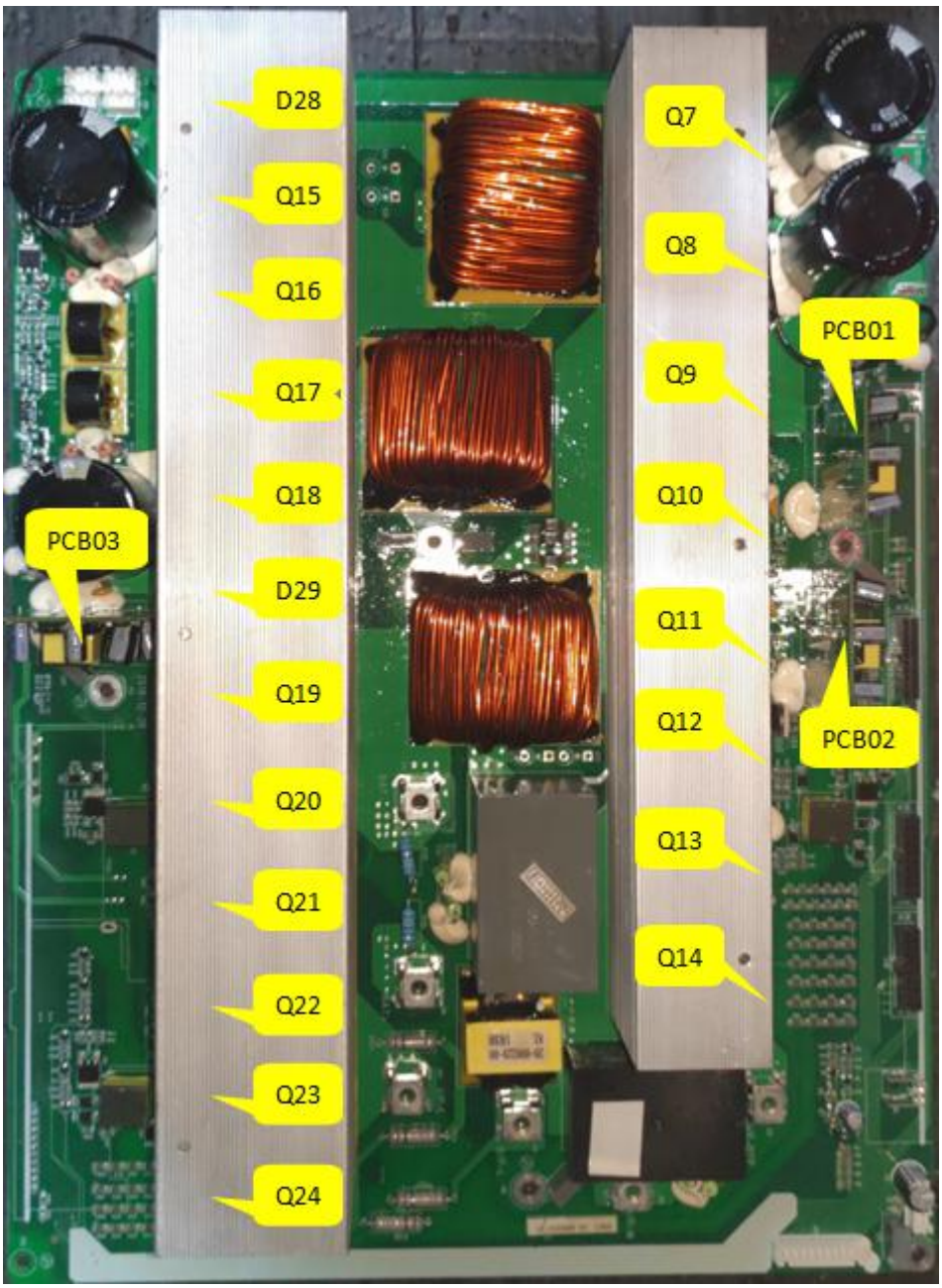


Fig. 6-2 Key components of INV power board

Maintenance procedures:

Step 1: Check if there is copper foil corrosion on the power board, which can be checked using a multimeter. If the copper foil is corroded, properly re-weld it.

Step 2: Visually inspect that if there is obvious components burnout or burst on the whole power board. If yes, replace them.

Step 3: Use a multimeter to test the two ends of GE and two ends of EC on the IGBT tube Q7/Q8/Q9/Q10/Q11/Q12. If the measured diode voltage drop is too low (less than 0.1 V), the corresponding IGBT tube needs to be replaced.

Note: When replacing the IGBT tube, heat dissipation paste should be painted on the back of the IGBT tube. If its insulation spacer is charred, burned out, burned through, melted or has other abnormal conditions, it should also be replaced.

Step 4: Use a multimeter to test the driving regulator diode D10, D19(Q7)/D14, D18(Q8)/D15, D20(Q9)/D11, D21(Q10)/D12, D16(Q11)/D13 and D17(Q12) of the IGBT tube Q7/Q8/Q9/Q10/Q11/Q12. If the measured diode voltage drop is too low (less than 0.1 V), the corresponding voltage regulator diode needs to be replaced.

Step 5: Use a multimeter to test the resistance value at two ends of GK on the bypass SCR Q13/Q14. Normal resistance value should be between 20Ω~50Ω. If not, replace them.

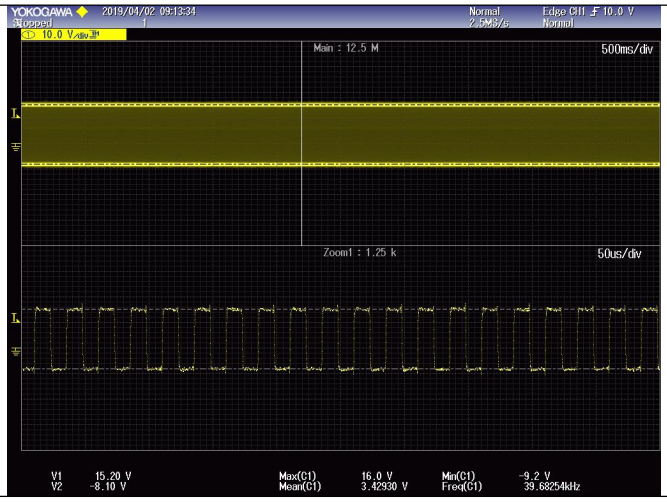
Step 6: Connect a 24V DC voltage to the both ends of the relay RLY1 coil. Use a multimeter at resistance gear to measure whether the relay terminals are acting on and off with the coil voltage, if no acting, it needs to be replaced.

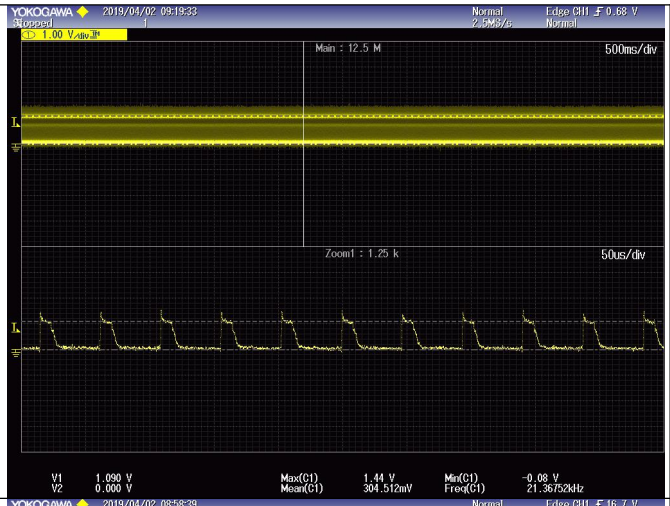
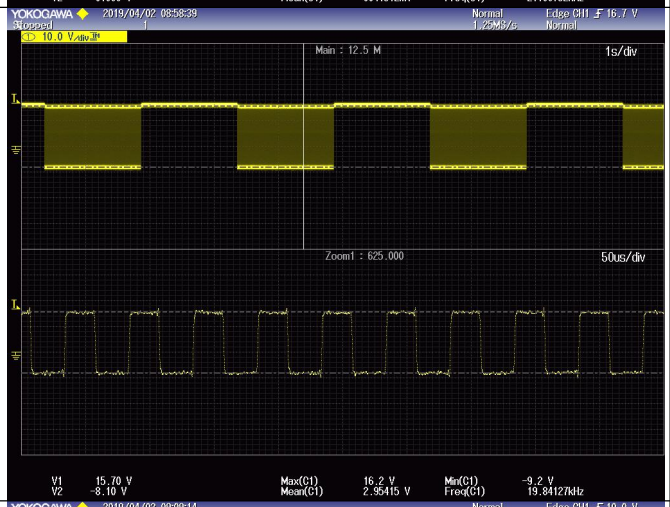
Step 7: After completing the maintenance items specified in Step 3 to Step 6, repeat the tests specified in Step 3 to Step 7. If everything is normal, it means that the inverter part has been maintained. If there is any abnormality, proceed to the next step.

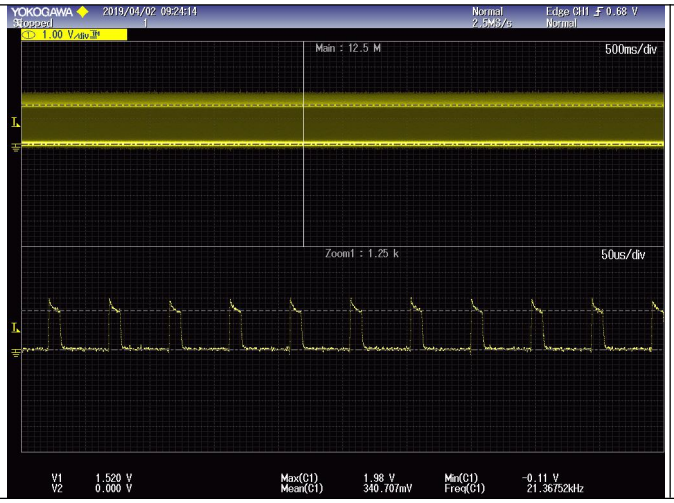
Step 8: Replace the corresponding IBGT drive module or inspect the corresponding SCR drive circuit. The drive module corresponding to IGBT Q7/Q8/Q11 is PCB1 and the drive module corresponding to IGBT Q9/Q10/Q12 is PCB2. The components in the SCR drive circuit prone to problems are diodes, MOSFET and transistors. The components corresponding to the bypass SCR Q13/Q14 are diode D8, D9, D2 and D3, MOSFET Q3 and transistor Q2 and Q4. Damage conditions are: the diode forward voltage drop is too low (less than 0.1 V), the diode voltage drop at two ends of SD on the MOSFET is too low (less than 0.1 V), the diode voltage drop at two ends of BE on the transistor is too low (less than 0.1 V), the corresponding components should be replaced at this moment, and then repeat the tests specified in Step 3 to Step 6. If the measured value is normal, the maintenance of the main power board is finished, if it is abnormal, repeat Step 8.

The completion of the above steps indicates that the maintenance of the main power board is completed preliminarily. Moreover, drive testing is required. First, plug the control board with short-circuited TEST terminal into the main power board, then pass through any DC voltage between 100 VDC ~ 350 VDC to the J4 terminal of the auxiliary power board. Before electrifying, carefully check whether the DC positive and negative are reversely connected, wait 5 s, there will be a sound from the relay cycling, at this time, use an oscilloscope to measure the drive waveform of the IGBT and the SCR tube. Measure pin 1 (positive) and pin 3 (negative) on the IGBT, measure pin 3 (positive) and pin 1 (negative) on the SCR. The normal waveform and its data are as follows:

Table 6-3 List of driving waveform of power tubes on the main power board

No. of Power Tube	Waveform	Description
PFC part IGBT Q15/Q16/Q17/Q18		High-level +15V±1V; Low-level -8V±1V; Frequency 40 KHz; Constant driving

PFC part SCR Mains power Q21/Q24 Battery Q19/Q20/Q22/Q23		Platform voltage about 1V; Low-level 0V; Frequency 21KHz; Constant driving
Inverer part IGBT Q11/Q12		High-level +15V±1V; Low-level -8V±1V; Driving frequency 20 KHz; Drive groups appear alternately with high levels, each lasting 1.5 s
Inverer part IGBT Q7/Q8/Q9/Q10		High-level +15V±1V; Low-level -8V±1V; Driving frequency 20 KHz; Drive groups appear alternately with low levels, each lasting 1.5 s

Bypass SCR Q13/Q14		Platform voltage about 1.5V; Low-level 0V; Frequency 21 KHz; Constant driving

After passing the test, it can be normally powered on and tested with load. If there is any problem during the test, follow the above steps to perform the maintenance again.

6.2 Maintenance of SPS Power Supply Board

Table 6-4 List of damageable components on the SPS power supply board

Components	**Position Number**	**Others (the value is standard value and there is deviation actually)**
Mains/bus input diode	D12	4 A/600 V
Battery input diode	D10, D11	3 A/1000 V
Battery input relay	RLY1	5 VDC
Input fuse	F1	5 A/250 V
Input thermistor	R12	Under normal temperature, the resistance is about 5 Ω
Power chip A7805	U1	Input end and output end shall not be short-circuited to ground
Switching diode UF1010	D8	1 A/1000 V
Switching diode MUR460	D2, D3, D4, D5, D7,	600 V, 4 A
Switching diode SB3100	D6	100 V, 3 A
Switching diode UF3010	D23	1000 V, 3 A
MOSFET K3878	Q1	9 A/900 V
MOSFET Q1 driving resistor	R10	20 Ω/1/4 W, ±1%,
MOSFET Q1 IDS current sampling resistor	R11	0.2 Ω, 3 W, ±5%
SMD power chip 3845	U3	Generate MOSFET Q1 driving signal
SMD power chip 431	U7	
Optocoupler LTV816S	U6	
Input electrolytic capacitor	C16	47 uF/450 V
Other components	——	——

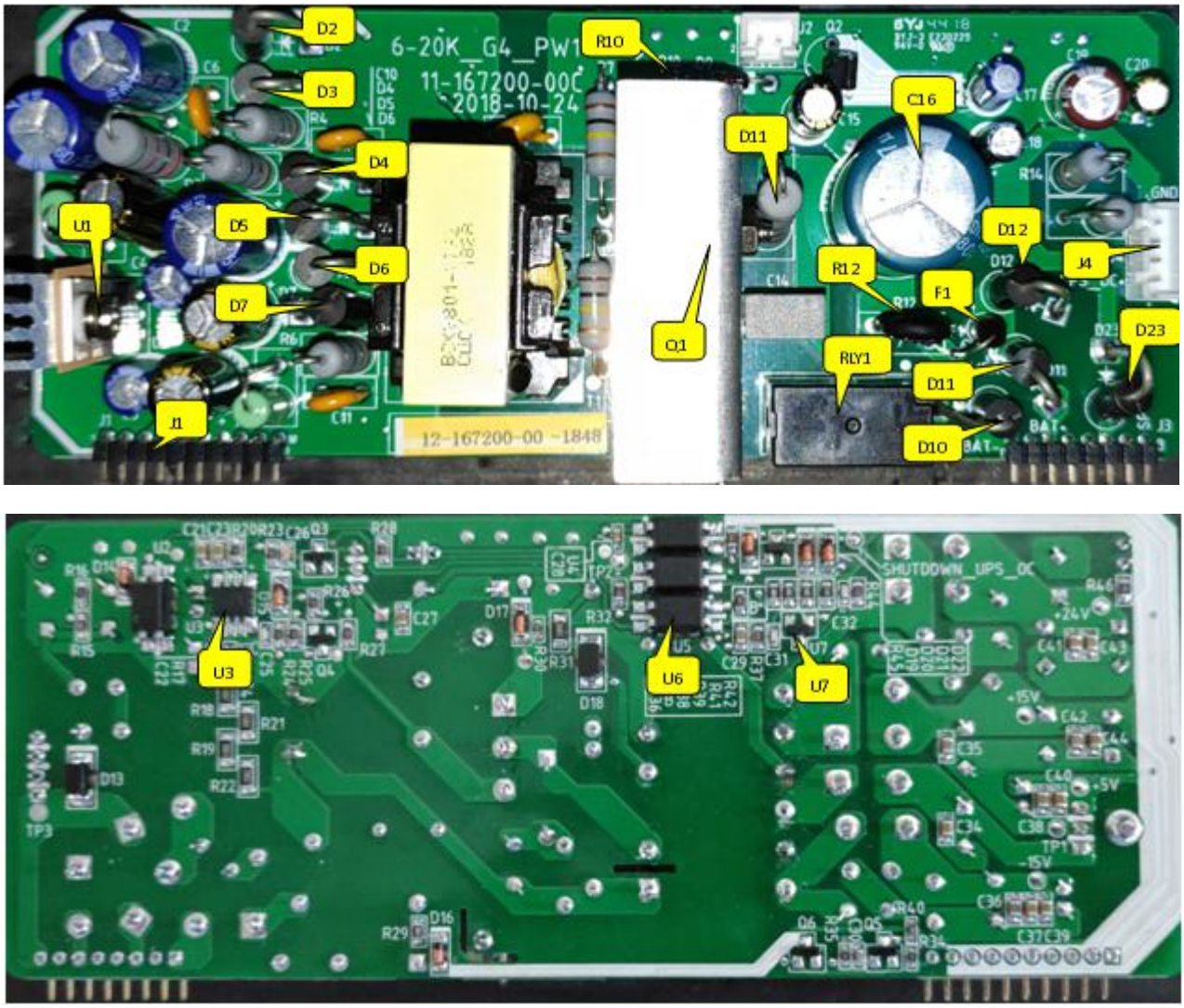


Fig. 6-3 Key components of SPS power supply board

Maintenance procedures:

Step 1: Check if there is copper foil corrosion on the SPS power supply board, which can be checked using a multimeter. If the copper foil is corroded, properly re-weld it.

Step 2: Visually inspect that if there is obvious components burnout or burst on the SPS power supply board. If yes, replace them.

Step 3: Test all components shown in Table 6-4 using a multimeter, identify the damaged component according to the data shown in the table, and replace the damaged components with the components of same specification and model.

Step 4: Connect the J4 terminal of the SPS power supply board after maintenance to any DC voltage between 100 Vdc-350 Vdc and use a multimeter to measure whether the output voltage of the J1 terminal pins are normal or not. The pin 1 to pin 5 of the J1 terminal are respectively: +24 V, +15 V, —15 V, GND and + 5 V. Re-repair if these voltages are abnormal. If they are normal, it indicates that the SPS power supply board has been preliminarily maintained, then proceed to the next step.

Step 5: Install the SPS power supply board on a good main power board, and measure the driving of each power tube on the main power board, if the driving is abnormal, re-repair the SPS power supply board, if the driving is normal, install it into the UPS, and test to check if the UPS works correctly, if the UPS does not work properly, it needs to re-repair the SPS power supply board, if the UPS works properly, it means that the SPS power supply board is completely repaired.

6.3 Maintenance of Charging Board PW2 (5 A)

Table 6-5 List of damageable components on the charging board PW2

Components	Position Number	Others (the value is standard value and there is deviation actually)
Input fuse	F1/F2	5 A/250 V
IGBT tube IKW15N120T2	Q2/Q11	15 A /1200 V
Switching diode RHRG30120	D4	30 A /1200 V
Fast recovery diode DSEI12-06A	D5/D7	14 A/600 V
DC relay 892H-1CH-C	RLY1/RLY2	DC 12 V
Voltage regulator diode 1N4746A	D1/D2/D3/D15/D17/D22	14 mA/18 V/1 W
Power supply IC L7812CV	U3	Input end and output end shall not be short-circuited to ground
SMD transistor MMBT4401LT1G	Q1/Q12/Q7/Q9/Q6/Q13	NPN tube
SMD transistor PMBT4403	Q8/Q10	PNP tube
SMD transistor MMBT4403LT1G	Q4	PNP tube
SMD voltage regulator diode MMBZ5231BLT1G	D16	20 mA /5.1 V/225 mW
SMD diode STPS2H100A	D6/D26	2 A/100 V
Optocoupler ACPL-W340-500E	U1/U4	
SMD voltage regulator tube GLZ9.1B	D11/D21	20 mA/9.1 V/500 W
SMD switching diode MMBD7000LT1G	D10/D12/D14/D20	200 mA /100 V, each package contains two diodes
Other components	——	——

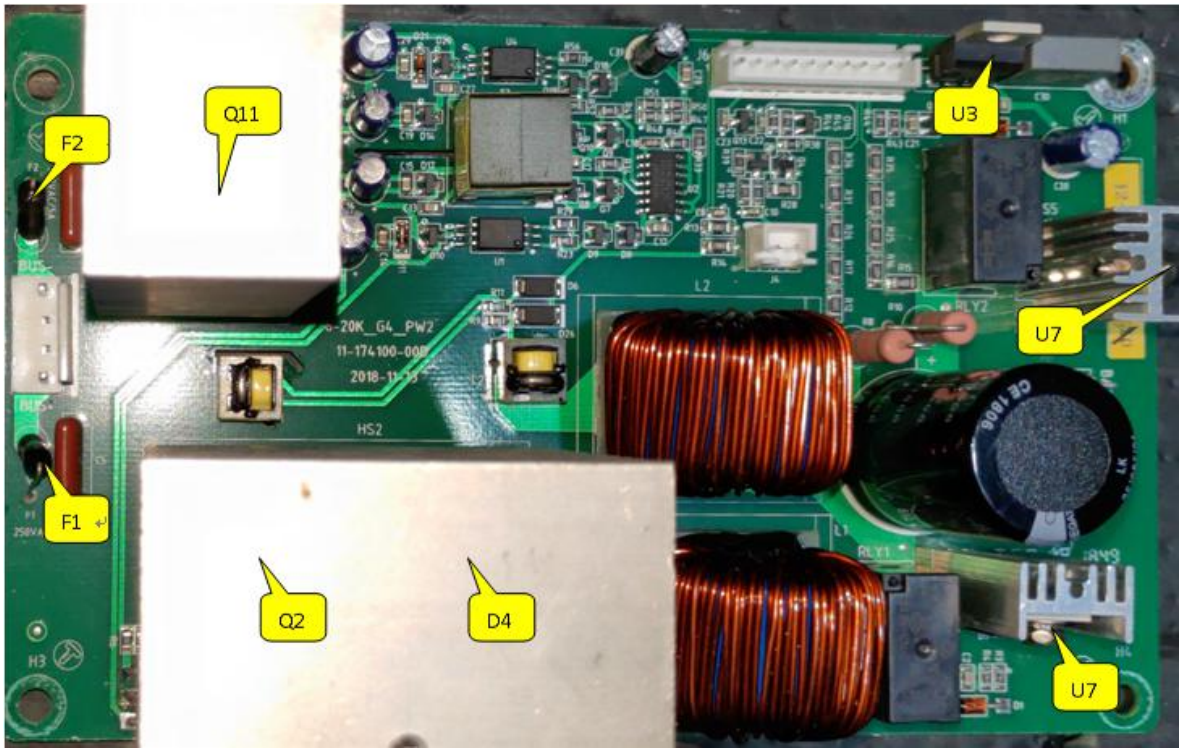


Fig. 6-4 Key components of charging board PW2

Maintenance procedures:

Step 1: Check if there is copper foil corrosion on the charging board PW2, which can be checked using a multimeter. If the copper foil is corroded, properly re-weld it.

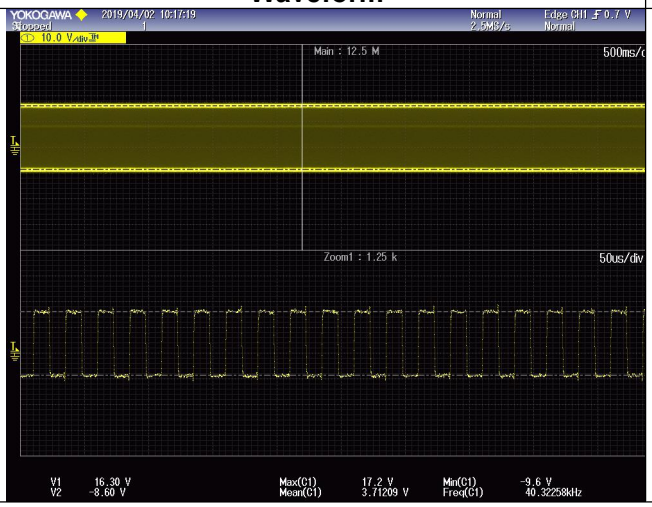
Step 2: Visually inspect that if there is obvious components burnout or burst on the whole charging board PW2. If yes, replace them.

Step 3: Test all components shown in Table 6-5 using the multimeter, identify the damaged component according to the data shown in the table, and replace the damaged components with the components of same specification and model.

Step 4: Test driving of the IGBT tube on the repaired charging board PW2. Connect the J6 terminal of the charging board PW2 to the J11 terminal of the main power board, and make the power board into test mode. At this time, measure the driving of IGBT tube Q2 and Q11, if the driving is abnormal, it needs to be repaired again, if it is normal, proceed to the next step.

The normal driving waveform is as follows:

Table 6-6 List of driving waveform of power tubes on the charging board PW2

No. of Power Tube	Waveform	Description
Charging board IGBT Q2/Q11		High-level about +16V; Low-level about -8V; Frequency 40 KHz； Constant driving

Step 5: Install the charging board PW2 which drives normally on the UPS. Connect the cable properly (J5, J6, J1, J2; Do not connect the positive and negative terminals of the battery in reverse). Take a DC power supply as batteries, power on the UPS, wait until the battery current stabilizes at the target values, switch off the DC power supply, and use a multimeter to test whether the charging voltage of the output ends between BAT + and BAT- on the charging board is normal or not. If not, re-maintain the charging board. If normal, it indicates that the charging board PW2 has been preliminarily maintained, then proceed to the next step.

Step 6: Power off the UPS, replace the DC power supply with the battery bank, and close the switch of the battery bank, then power on. Wait until the battery current stabilizes at the target values, then use a DC ammeter to test if the actual charging current is normal. If not, re-maintain the charging board. If normal, it indicates that the charging board PW2 has been maintained properly.

6.4 Maintenance of Charging Board PW3 (1 A)

Table 6-7 List of damageable components on the charging board PW3

Components	**Position Number**	**Others (the value is standard value and there is deviation actually)**
Input fuse	F1/F2	5 A/250 V
MOSFET FQA9N90C_F109	Q1/Q8	9 A /900 V
Switching diode RHRP15120	D1	15 A /1200 V
Switching diode MUR460	D2/D3	4 A/600 V
DC relay 892H-1CH-C	RLY1/RLY2	DC 12 V
Power supply IC L7812CV	U3	Input end and output end shall not be short-circuited to ground

SMD diode STPS2H100A	D4/D24	2 A/100 V
Voltage regulator diode 1N4746A	D9/D10	14 mA/18 V
SMD diode BAW56LT1G	D5/D8/D11/D12	200 mA /70 V
SMD switching diode MMBD7000LT1G	D6/D14	200 mA /100 V
SMD transistor MMBT4401LT1G	Q2/Q4/Q5/Q6	NPN tube
SMD transistor PMBT4403	Q3/Q7	PNP tube
Optocoupler ACPL-W340-500E	U1/U4	
Other components	——	——

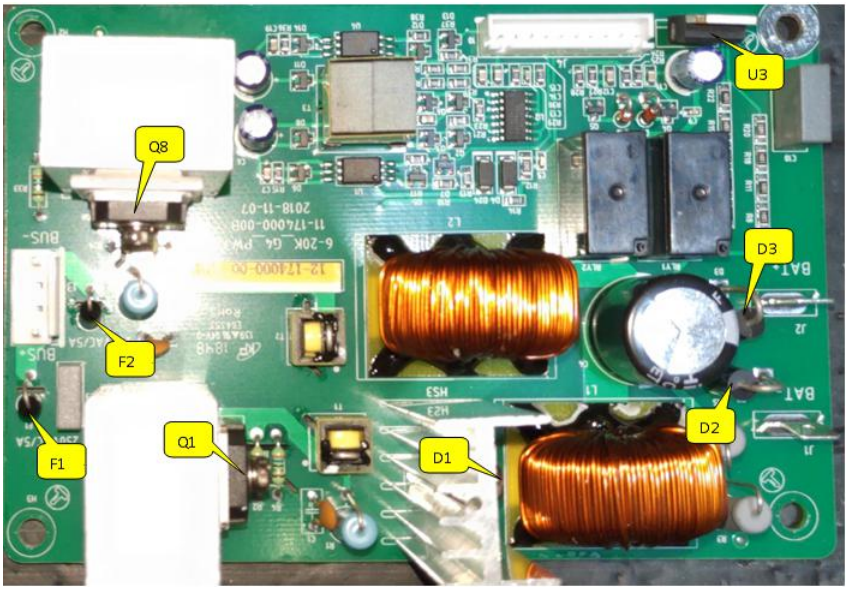


Fig. 6-5 Key components of charging board PW3

Maintenance procedures:

Step 1: Check if there is copper foil corrosion on the charging board PW3, which can be checked using a multimeter. If the copper foil is corroded, properly re-weld it.

Step 2: Visually inspect that if there is obvious components burnout or burst on the whole charging board PW3. If yes, replace them.

Step 3: Test all components shown in Table 6-7 using the multimeter, identify the damaged component according to the data shown in the table, and replace the damaged components with the components of same specification and model.

Step 4: Test driving of the IGBT tube on the repaired charging board PW3. Connect the J4 terminal of the charging board PW3 to the J11 terminal of the main power board, and make the power board into test mode. At this time, measure the driving of IGBT tube Q1 and Q8, if the driving is abnormal, it needs to be repaired again, if it is normal, proceed to the next step.

Step 5: Install the charging board PW3 which drives normally on the UPS. Connect the cable properly (J3, J4, J1, J2; Do not connect the positive and negative terminals of the battery in reverse). Take a DC power supply as batteries, power on the UPS, wait until the battery current stabilizes at the target values, switch off the DC power supply, and use a multimeter to test whether the charging voltage of the output ends between BAT + and BAT- on the charging board is normal or not. If not, re-maintain the charging board. If normal, it indicates that the charging board PW3 has been preliminarily maintained, then proceed to the next step.

Step 6: Power off the UPS, replace the DC power supply with the battery bank, and close the switch of the battery bank, then power on. Wait until the battery current stabilizes at the target values, then use a DC ammeter to test if the actual charging current is normal. If not, re-maintain the charging board. If normal, it indicates that the charging board PW3 has been maintained properly.

6.5 Maintenance of Charging Board PW4 (12 A single-phase)

Table 6-8 List of damageable components on the charging board PW4

Components	Position Number	Others (the value is standard value and there is deviation actually)
Input fuse	F1/F2	10 A/250 V
IGBT tube IKW40N120H3	Q2/Q1	40 A /1200 V
Switching diode RHRG75120	D1	75 A /1200 V
Fast recovery diode RHRP30120	D4/D7	30 A/1200 V
DC relay RA1-112LM	RLY1/RLY2	12 VDC
Voltage regulator diode 1N4746A	D2/D3/D5/D6/D8 /D9	14 mA /18 V/1 W
Power supply IC L7812CV	U1	Input end and output end shall not be short-circuited to ground
SMD transistor MMBT4401LT1G	Q3/Q4/Q6/Q8/Q16/Q13	NPN tube
SMD transistor PMBT4403	Q5/Q7	PNP tube
SMD transistor MMBT4403LT1G	Q40	PNP tube
SMD voltage regulator diode MMBZ5231BLT1G	D25	20 mA/5.1 V/225 mW
SMD diode STPS2H100A	D10/D11	2 A/100 V
Optocoupler ACPL-W340-500E	U2/U5	
SMD voltage regulator tube GLZ9.1B	D12/D23	20 mA/9.1 V/500 W
SMD switching diode MMBD7000LT1G	D13/D16/D19/D20	200 mA /100 V, each package contains two diodes
Other components	——	——

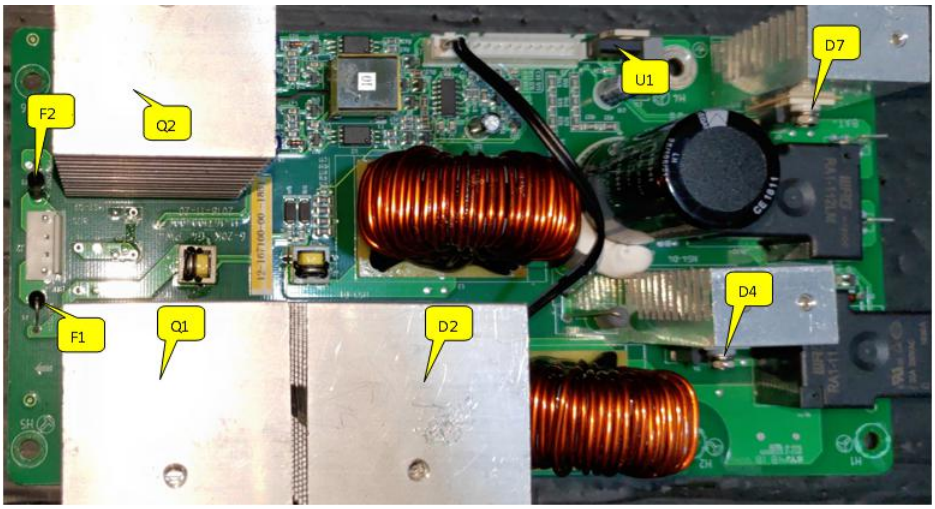


Fig. 6-6 Key components of charging board PW4

Maintenance procedures:

Step 1: Check if there is copper foil corrosion on the charging board PW4, which can be checked using a multimeter. If the copper foil is corroded, properly re-weld it.

Step 2: Visually inspect that if there is obvious components burnout or burst on the whole charging board PW4. If yes, replace them.

Step 3: Test all components shown in Table 6-8 using the multimeter, identify the damaged component according to the data shown in the table, and replace the damaged components with the components of same specification and model.

Step 4: Test driving of the IGBT tube on the repaired charging board PW4. Connect the J6 terminal of the charging board PW4 to the J11 terminal of the main power board, and make the power board into

test mode. At this time, measure the driving of IGBT tube Q1 and Q2, if the driving is abnormal, it needs to be repaired again, if it is normal, proceed to the next step.

Step 5: Install the charging board PW4 which drives normally on the UPS. Connect the cable properly (J2, J6, J1, J4; Do not connect the positive and negative terminals of the battery in reverse). Take a DC power supply as batteries, power on the UPS, wait until the battery current stabilizes at the target values, switch off the DC power supply, and use a multimeter to test whether the charging voltage of the output ends between BAT + and BAT- on the charging board is normal or not. If not, re-maintain the charging board. If normal, it indicates that the charging board PW4 has been preliminarily maintained, then proceed to the next step.

Step 6: Power off the UPS, replace the DC power supply with the battery bank, and close the switch of the battery bank, then power on. Wait until the battery current stabilizes at the target values, then use a DC ammeter to test if the actual charging current is normal. If not, re-maintain the charging board. If normal, it indicates that the charging board PW4 has been maintained properly.

Notes: The bill of alternative component and single board alternative relation are shown in Appendix 1 and Appendix 2

7 Commissioning after Maintenance

This section mainly describes the commissioning after the UPS (single boards) maintenance.

7.1 Installation of Single Boards

After the single boards (mainly including the PFC power board, the INV power board, the SPS power supply board, the charging board and the main control board) have been maintained, install them on the UPS and performing commissioning to confirm that if the single boards have been maintained properly.

According to the contents of section 5, install the maintained single boards on the UPS, and ensure that the installation position and wiring are correct.

7.2 Preparation before Powering On

- Check and confirm that the internal single boards are installed properly.
- Check and confirm that the internal cables are connected properly.
- Check if the cables are connected securely.
- Check if the polarity and sequence of DC power supply input cables are correct.
- Check if the wiring is neatly, loose, and if cable binding meets the process specification.
- Check if grounding is reliable.
- The operator must wear insulated shoes.

7.3 Powering On & Commissioning

Step 1: Set the output of the AC source to the rated input of the UPS (220 V/50 Hz 或 60Hz), and limit the output current to 5 A.

Step 2: Adjust the output voltage of the DC source to the rated DC input voltage of the UPS (DC 192 V), and limit the output current to 3 A-5 A.

Step 3: Open the output switch of the DC source, press “ ↵ + ◀ ” on the LCD panel to turn on the UPS. At this time, the LED indicator lights on the panel are illuminated circularly, and the UPS starts up. After waiting for a while, the UPS is turned on and runs in the battery inverter mode.

Step 4: Close the UPS input breaker, wait for a moment, the UPS will be switched to operation in the mains power inverter mode.

Step 5: Press “ + ” on the LCD panel to perform battery self-test operation.

If the UPS can work normally in battery mode, mains power mode, battery self-test mode, it is indicated that the UPS has been maintained and can be taken to the next step. If the UPS does not work properly after perfoming the above operation, further troubleshooting is required, and make repairs.

Step 6: Turn off the UPS, replace the AC source and DC sources with mains power and batteries respectively, and repeat the operations of step 3 to step 5.

Step 7: Carry out the testing with loads in battery mode and battery self-test mode respectively. If the UPS can work normally, it indicates that the UPS has been repaired. If the UPS does not work properly, further troubleshooting is required, and make repairs.

Tips: If the condition allows, during the above operation, try to use an oscilloscope and high-voltage probe to test the waveform of + BUS, -BUS, INV voltage and output current, that is more helpful to determine whether the UPS has been repaired or not.

Appendix 1 -- The BOM of altarnative semiconductor component

Board Number	Application	Position Number	Component	Alternative Component 1	Alternative Component 2	Remarks
Power Board——DR1	Boost IGBT	Q15/Q16/Q17/Q18	IKW50N65ES5 20-005921-00	MM75G5U65BX 20-009181-00	FGA60N65SMD 20-009181-00 NCE80NCE80TD65BT 20-009427-00	When the alternative components are used, the Q15/Q16 must be the same type and the Q17/Q18 must be the same type
	Boost Diode	Q28/Q29	APT75DQ60BG 20-000899-00	BYC75-600PT2 20-008344-00	MM75FU60B 20-008053-00	
	Rectifier SCR	Q21/Q24	VS-50TPS12L-M3 20-006490-00	CLA50E1200HB 20-000757-00	BT155W-1200T 20-005827-00	
	BAT SCR	Q19/Q20/Q22/Q23	VS-50TPS12L-M3 20-006490-00	CLA50E1200HB 20-000757-00	BT155W-1200T 20-005827-00	When the alternative components are used, the Q19/Q20 must be the same type and the Q22/Q23 must be the same type
	Bypass SCR	Q13/Q14	VS-50TPS12L-M3 20-006490-00	CLA50E1200HB 20-000757-00	BT155W-1200T 20-005827-00	
	Inverter IGBT1	Q7/Q8/Q9/Q10	IKW40N120CS6 20-006474-00	MM40G3U120BX 20-006979-00		When the alternative components are used, the Q7/Q8 must be the same type and the Q9/Q10 must be the same type
	Inverter IGBT2	Q11/Q12	IKW75N65ES5 20-005922-00 IKW75N65EL5 20-006922-00	SGTP75V65SDS1P7 20-009390-00	JT075N065WED 20-008348-00	When the alternative components are used, the Q11/Q12 must be the same type
Charger——PW1	Buck IGBT	Q2/Q11	IKW15N120T2 20-003691-00	SVF3878P7 20-006953-00		When the alternative components are used, the Q2/Q11 must be the same type
	Buck Diode	D4	RHRG30120	MUR30120P		

			20-000910-00	20-008723-00		
	Output Diode	D5/D7	DSEI12-06 20-000932-00	MM15FU60K 20-006395-00		
Charger——PW2	Buck IGBT	Q1/Q8	2SK3878 20-000696-00	JCS9N90WT 20-008614-00	SVF3878P7 20-006953-00	When the alternative components are used, the Q1/Q8 must be the same type
	Buck Diode	D1	RHRG15120 20-000912-00	MM15FU120K 20-006173-00		
	Output Diode	D2/D3	MUR460 20-000906-00			
Charger——PW3	Buck IGBT	Q1/Q2	IKW40N120H3 20-000679-00	IKW40N120CS6 20-006474-00		When the alternative components are used, the Q1/Q2 must be the same type
	Buck Diode	D1	RHRG75120 20-000911-00			
	Output Diode	D4/D7	RHRP30120 20-00914-00			

Appendix 2 -- The alternative relation of single board

Board name	Board code 1	Board code 2	Board code 3	Remarks
Power Board——DR1 For standard model	12-166900-01	12-166903-03		These boards are interchangeable
Power Board——DR1 For Long time model	12-166901-01 12-166901-02	12-166904-03		These boards are interchangeable
Charger——PW1	12-174100-00	12-174100-01	12-174102-01	These boards are interchangeable
Charger——PW3	12-167100-00	12-167100-01		These boards are interchangeable