**Faith**
Technologies

# Programmable DC Power Supply
# User's Manual

## (FTP9000 Series)

## Introduction

Dear users :

First of all, thank you for choosing shenzhen Faith technology co., LTD. (hereinafter referred to as the Faithtech), FTP9000 series high power wide range programming power system (hereinafter referred to as FTP9000 series). This User manual (hereinafter referred to as the manual) is applicable to the FTP9000 series and includes detailed information on installation, operation and specifications of the equipment.

In order to ensure safe and correct use of the equipment, please read this manual carefully before use, especially the safety precautions.

Please keep this manual for use in the process of inspection.

## Notice

The copyright of this manual belongs to our company. The information contained in the manual is for the user's reference only and is subject to change without notice.

The Company is not responsible for errors that may be contained in this manual or damages caused by the provision, implementation and use of this manual.

## The warranty service

The company guarantees that the specifications and use characteristics of this instrument fully meet the technical indicators claimed in the manual, and the raw materials and manufacturing processes used in this product are strictly checked to ensure that the product is stable and reliable.

Since the acquisition date, one year warranty, the product in normal use and maintenance condition of what's going on fault, the company responsible for free maintenance. For free maintenance products, users need to prepay the one-way freight to the company's maintenance department, and the return freight shall be borne by the company. If the product is returned to the factory from another country for repair, all freight, duties and other taxes shall be borne by the customer.

## Limitation of warranty

This warranty is limited to the equipment host. The Company is not responsible for free repair of damage caused by incorrect use, unmanaged, unauthorized modification, use under abnormal environment and force majeure factors, and will submit the valuation form before the repair.

**No OTHER EXPRESS OR IMPLIED WARRANTIES, INCLUDING THE IMPLIED WARRANTIES OF merchANTABILITY, REASONABILITY AND FITNESS FOR PARTICULAR APPLICATIONS, WHETHER IN CONTRACT, CIVIL NEGLIGENCE, OR OTHERWISE, ARE MADE.** The company shall not be liable for any special, incidental or indirect damages.

## Safety Summary

In the process of operating and using the equipment, please strictly observe the following safety instructions. Failure to comply with the following precautions or specific warnings as indicated in other sections of this manual may impair the protection provided by the device.

**The Company is not responsible for the consequences caused by the user's non-compliance with these precautions.**

# Safety instructions

| | |
|---|---|
| **Please ground it reliably** | Before turning on the equipment, make sure the equipment is reliably grounded to prevent electric shock |
| **3 phase 380VAC Input** | The input wire meets the specified standards; Be sure to install a protective cover to prevent electric shock. |
| **Output terminal cable connection** | The input wire meets the specified standards; Be sure to install a protective cover to prevent electric shock. |
| **Do not open the instrument housing** | The operator shall not open the equipment shell; Non-professional personnel do not perform maintenance or adjustment. |
| **Do not use in dangerous environment** | Do not use the equipment in inflammable and explosive environment. |

# Safety mark

Please refer to the following table for the explanation of international symbols used in the case and user manual of this product.

| Symbol | Meaning | Symbol | Meaning |
|---|---|---|---|
| ⎓ | Direct current | N | Zero or neutral line |
| ∿ | AC current | L | Line of fire |
| ≂ | AC/DC current | I | Power on |
| 3∿ | 3 phase current | ○ | Power off |
| ⏚ | Ground | ⏻ | Backup power supply |
| ⏛ | Protective grounding | | The button switch is pressed |
| | Connect the enclosure or chassis | | Button switch popup |
| ⏄ | Signal ground | ⚡ | Be careful with the shocks |
| WANNING | Sign of danger | | High temperature Warning |
| Caution | be careful | ⚠ | Warning |

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# Version Revision Record

| Date | Vesion | Revised chapter |
|------|--------|-----------------|
| 2019-7 | 1.0 | Complete this manual |
| 2020-9 | 1.01 | Add 750V specifications and models; Add the installation size of 20kW ~ 30kW power grade chassis |
| 2021-1 | 1.02 | Added 1200V specification model; |
| 2021-3 | 1.03 | Update the voltage model |
| 2021-8 | 1.04 | Add external control signal 0-10V gear description |
| 2022-11 | 1.05 | Added PV curve function |

# Table Of Contents

# 1.  General Description

## 1.1 Overview

FTP9000 series high-power programmable DC power supply has the characteristics of high power density, high power factor, high efficiency, and wide range of output. Its wide range voltage / current output and automatic constant power function can greatly increase the application coverage. FTP9000 series DC power supply output power 5kW up to 180kW in a single unit, and expandable up to 1800kW when paralleling 10 identical models. Its voltage output up to 2250V, current up to 6120A.

For bench top applications, this series provides an intuitive user interface with full keypad and rotary knob. System integrators benefit from the standard USB (virtual SERIAL) and LAN interfaces supporting both SCPI commands and ModBus RTU protocol. Free application software, programming manual and a complete set of development DLLs are available to reduce programming time and increase productivity. The application software allows users to control the power supply, execute test sequences, or log measurements.

## 1.2 Main features

■ Output voltages: 80 V up to 2250 V;

■ Output current: 20 A up to 6120 A;

■ Output power: 5 kW up to 180 kW, expandable up to 1800 kW;

■ CV, CC, CP operation modes;

■ Easy Master-Slave parallel;

■ Precision V & I measurement;

■ High speed programming;

■ Programmable sequence;

■ Voltage & current slew rate control;

■ CV / CC priority;

■ Voltage ramp function;

■ Wide operating region for output;

■ Internal resistance simulating;

■ Remote sense compensation;

■ Optional analog programming & monitoring interface;

■ ±OVP, ±OCP, ±OPP, OTP, ±LVP;

■ Voltage / current / power limit;

■ Standard LAN, USB (serial), optional RS485, GPIB or CAN ports;

■ SCPI and ModBus RTU protocol;

## 1.3 Dimension diagram

### 1.3.1 Model of 5kW, 10kW, 15kW
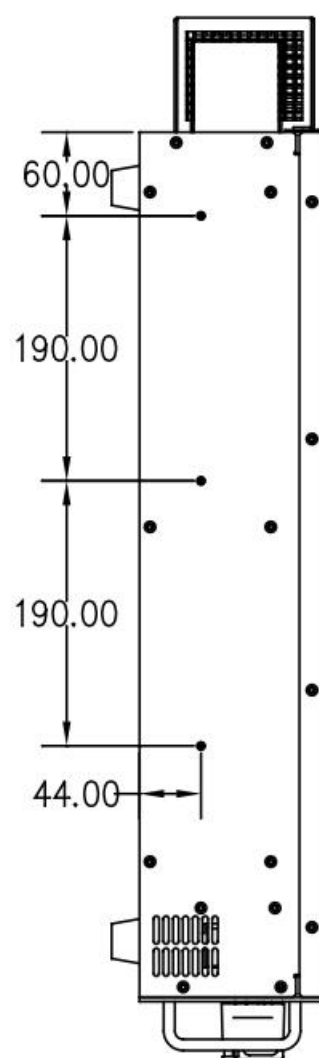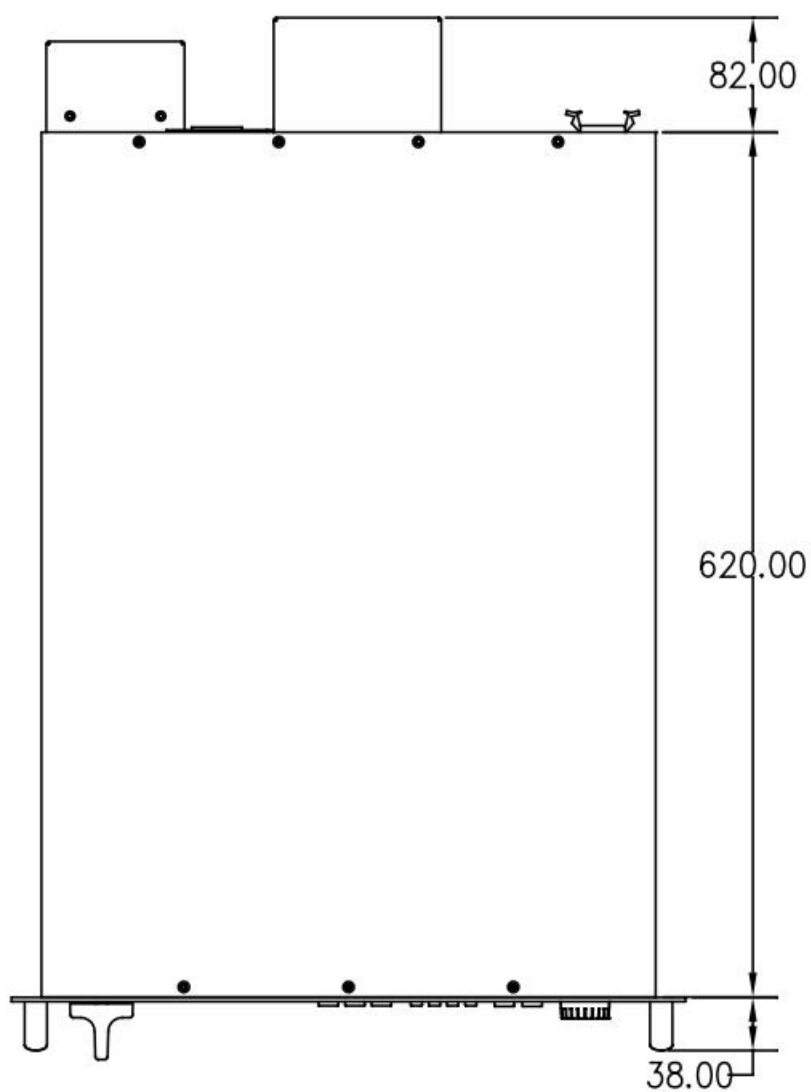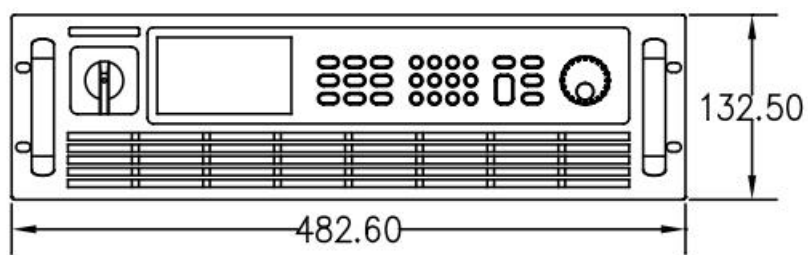
## 1.3.2 Model of 20kW, 25kW, 30kW
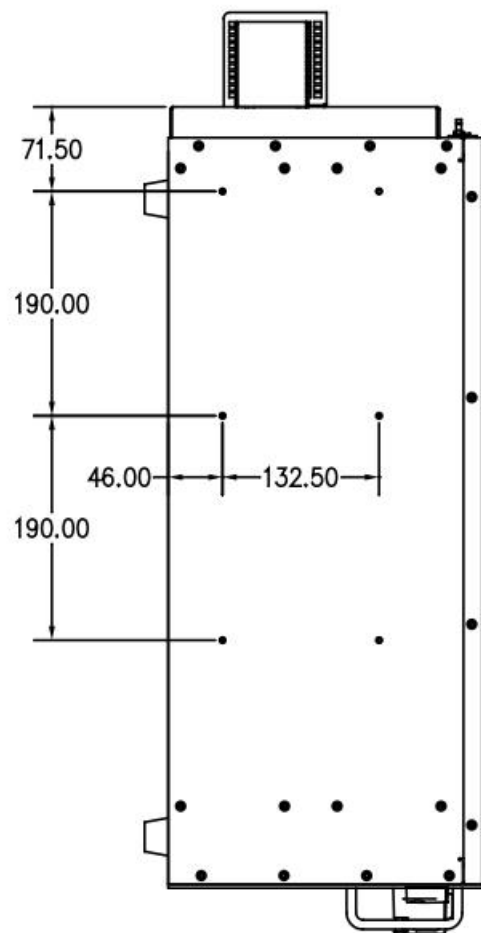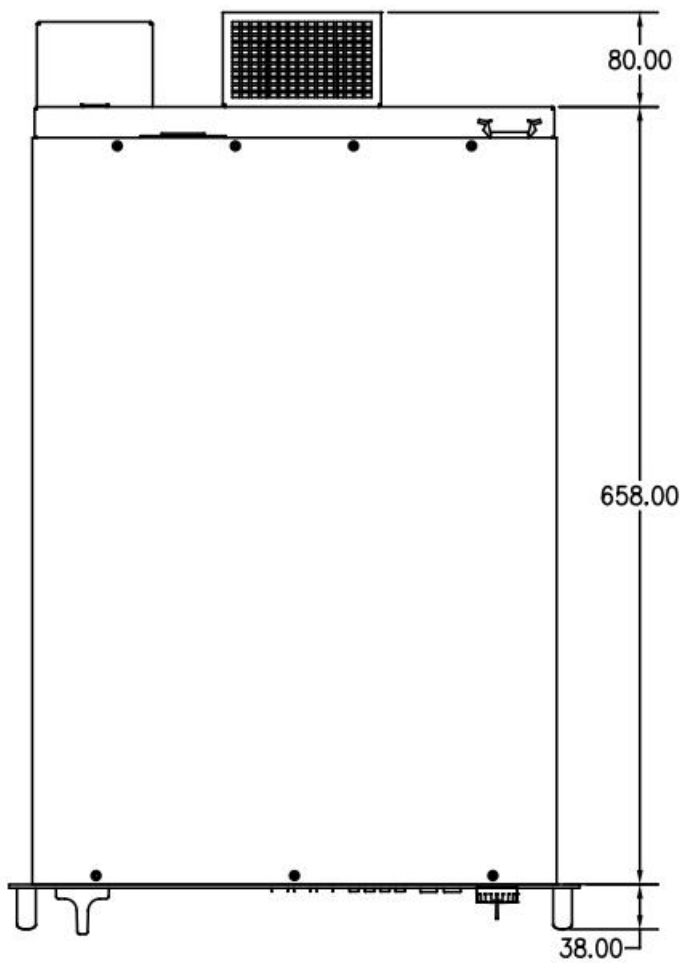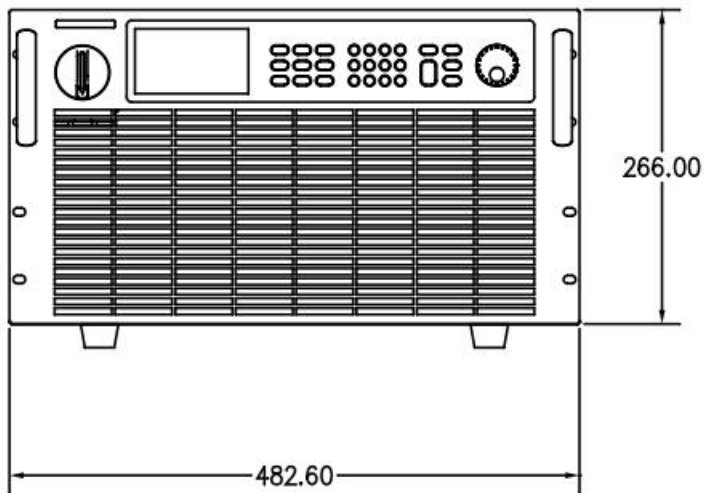
## 1.4 Model Naming
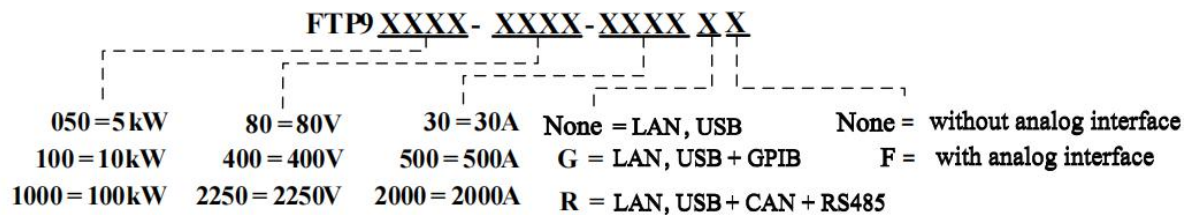


## 1.5 Specification sheet

| General specification | |
|---|---|
| Voltage rise slew rate | |
| Maximum slew rate | 6000V/s |
| Voltage fall time | |
| No load | ＜2s |
| Full load | ≤30ms |
| Transient response | Typical 2ms |
| Parallel | Parallel up to 10 identical units through master-slave mode for max 1800W output |
| Protection | OVP, OCP, OPP, OTP, LVP etc.. |
| Interface | Standard LAN、USB(serial) (optional GPIB、CAN、RS485) |
| Protocol | SCPI、MODBUS、CAN-Open protocols |
| Input characteristics | |
| Input voltage | 340VAC～460VAC, 47Hz～63Hz |
| Power factor | 0.99 (Typical) |
| Efficiency | ＞93% (Typical) |
| Operation environment | |
| Working temp | 0℃～40℃ |
| Storage temp | -20℃～70℃ |
| Altitude | ＜2000m |
| Cooling | Air cooling |

**Specification table 1**

| Model | FTP9050-80-170 | FTP9050-200-70 | FTP9050-400-40 | FTP9050-500-30 | FTP9050-800-25 |
|---|---|---|---|---|---|
| Voltage | 0～80V | 0～200V | 0～400V | 0～500V | 0～800V |
| Current | 0～170A | 0～70A | 0～40A | 0～30A | 0～25A |
| Power | 0～5kW | | | | |
| Model | FTP9100-80-340 | FTP9100-200-140 | FTP9100-400-80 | FTP9100-500-60 | FTP9100-800-50 |
| Voltage | 0～80V | 0～200V | 0～400V | 0～500V | 0～800V |
| Current | 0～340A | 0～140A | 0～80A | 0～60A | 0～50A |
| Power | 0～10kW | | | | |

| Model | FTP9150-80-510 | FTP9150-200-210 | FTP9150-400-120 | FTP9150-500-90 | FTP9150-800-75 |
|---|---|---|---|---|---|
| Voltage | 0～80V | 0～200V | 0～400V | 0～500V | 0～800V |
| Current | 0～510A | 0～210A | 0～120A | 0～90A | 0～75A |
| Power | 0～15kW | | | | |
| Model | FTP9300-80-1020 | FTP9300-200-420 | FTP9300-400-240 | FTP9300-500-180 | FTP9300-800-150 |
| Voltage | 0～80V | 0～200V | 0～400V | 0～500V | 0～800V |
| Current | 0～1020A | 0～420A | 0～240A | 0～180A | 0～150A |
| Power | 0～30kW | | | | |
| Model | FTP9600-80-2040 | FTP9600-200-840 | FTP9600-400-480 | FTP9600-500-360 | FTP9600-800-300 |
| Voltage | 0～80V | 0～200V | 0～400V | 0～500V | 0～800V |
| Current | 0～2040 A | 0～840A | 0～480A | 0～360A | 0～300A |
| Power | 0～60kW | | | | |
| Model | FTP9900-80-3060 | FTP9900-200-1260 | FTP9900-400-720 | FTP9900-500-540 | FTP9900-800-450 |
| Voltage | 0～80V | 0～200V | 0～400V | 0～500V | 0～800V |
| Current | 0～3060 A | 0～1260A | 0～720A | 0～540A | 0～450A |
| Power | 0～90kW | | | | |
| Model | ～ | FTP91200-200-1680 | FTP91200-400-960 | FTP91200-500-720 | FTP91200-800-600 |
| Voltage | ～ | 0～200V | 0～400V | 0～500V | 0～800V |
| Current | ～ | 0～1680A | 0～960A | 0～720A | 0～600A |
| Power | 0～120kW | | | | |
| Voltage programming① | | | | | |
| Resolution | 16bits | | | | |
| Accuracy | 0.05%+0.1%F.S. | | | | |
| Current programming① | | | | | |
| Resolution | 16bits | | | | |
| Accuracy | 0.1%+0.2% F.S. | | | | |
| Power programming① | | | | | |
| Accuracy | 1%F.S. | | | | |
| External analog programming① | | | | | |
| Control voltage | 0～5V corresponds to 0～100%F.S. | | | | |
| Voltage accuracy | 0.5%F.S. | | | | |
| Current accuracy | 0.5%F.S. | | | | |
| Line regulation② | | | | | |
| Voltage | 0.02%F.S. | | | | |
| Current | 0.05%F.S. | | | | |
| Power | 0.05%F.S. | | | | |
| Load regulation③ | | | | | |
| Voltage | 0.05%F.S. | | | | |
| Current | 0.15%F.S. | | | | |
| Power | 0.75%F.S. | | | | |
| Voltage measurement① | | | | | |
| Resolution | 16bits | | | | |
| Accuracy | 0.05%+0.1%F.S. | | | | |
| Current measurement① | | | | | |
| Resolution | 16Bits | | | | |

| Accuracy | | 0.1%+0.2% F.S. | | | | |
|---|---|---|---|---|---|---|
| Power measurement① | | | | | | |
| Accuracy | | 1%F.S. | | | | |
| Ripple noise④ | | | | | | |
| Ripple Vpp | 5kW | 160mV | 300mV | 550mV | 450mV | 800mV |
| | 10kW | 320mV | 300mV | 550mV | 450mV | 800mV |
| | 15kW | 320mV | 300mV | 550mV | 450mV | 800mV |
| Ripple Vrms | 5kW | 16mV | 40mV | 65mV | 70mV | 200mV |
| | 10kW | 25mV | 40mV | 65mV | 70mV | 200mV |
| | 15kW | 25mV | 40mV | 65mV | 70mV | 200mV |
| Size（W x H x D） | | 5kW～15kW: 482.6mm x 132.5mm x 702.0mm, includes output protection cover | | | | |
| | | 20kW～30kW: 482.6mm x 266mm x 738.0mm, includes protection cover, excludes casters | | | | |
| Weight | | 5kW≈17kg, 10kW≈24kg, 15kW≈30kg, 30kW≈65kg | | | | |

## Specification table 2

| Model | FTP9100-1000-30 | - | FTP9100-1500-25 | - |
|---|---|---|---|---|
| Voltage | 0～1000V | - | 0～1500V | - |
| Current | 0～30A | - | 0～25A | - |
| Power | 0～10kW | | | |
| Model | FTP9150-1000-40 | FTP9150-1200-40 | FTP9150-1500-30 | FTP9150-2250-25 |
| Voltage | 0～1000V | 0～1200V | 0～1500V | 0～2250V |
| Current | 0～40A | 0～40A | 0～30A | 0～25A |
| Power | 0～15kW | | | |
| Model | FTP9200-1000-60 | - | FTP9200-1500-50 | |
| Voltage | 0～1000V | - | 0～1500V | |
| Current | 0～60A | - | 0～50A | |
| Power | 0～20kW | | | |
| Model | FTP9300-1000-80 | FTP9300-1200-80 | FTP9300-1500-60 | FTP9300-2250-50 |
| Voltage | 0～1000V | 0～1200V | 0～1500V | 0～2250V |
| Current | 0～80A | 0～80A | 0～60A | 0～50A |
| Power | 0～30kW | | | |
| Model | FTP9400-1000-120 | - | FTP9400-1500-100 | - |
| Voltage | 0～1000V | - | 0～1500V | - |
| Current | 0～120A | - | 0～100A | - |
| Power | 0～40kW | | | |
| Model | FTP9600-1000-180 | FTP9600-1200-160 | FTP9600-1500-120 | FTP9600-2250-100 |
| Voltage | 0～1000V | 0～1200V | 0～1500V | 0～2250V |
| Current | 0～180A | 0～160A | 0～120A | 0～100A |
| Power | 0～60kW | | | |
| Model | FTP9800-1000-240 | FTP9900-1200-240 | FTP9900-1500-180 | FTP9900-2250-150 |
| Voltage | 0～1000V | 0～1200V | 0～1500V | 0～2250V |
| Current | 0～240A | 0～240A | 0～180A | 0～150A |
| Power | 0～80kW | | 0～90kW | |
| Model | FTP91000-1000-300 | FTP91200-1200-320 | FTP91200-1500-240 | FTP91200-2250-200 |
| Voltage | 0～1000V | 0～1200V | 0～1500V | 0～2250V |

| Current | 0～300A | 0～320A | 0～240A | 0～200A |
|---|---|---|---|---|
| Power | 0～100kW | | 0～120kW | |
| Voltage programming① | | | | |
| Resolution | 16bits | | | |
| Accuracy | 0.05%+0.1%F.S. | | | |
| Power programming① | | | | |
| Resolution | 16bits | | | |
| Accuracy | 0.1%+0.2% F.S. | | | |
| Power programming① | | | | |
| Accuracy | 1%F.S. | | | |
| External analog programming① | | | | |
| Control voltage | 0～10V corresponds to 0～100%F.S. | | | |
| Voltage accuracy | 0.5%F.S. | | | |
| Current accuracy | 0.5%F.S. | | | |
| Line regulation② | | | | |
| Voltage | 0.02%F.S. | | | |
| Current | 0.05%F.S. | | | |
| Power | 0.05%F.S. | | | |
| Load regulation③ | | | | |
| Voltage | 0.05%F.S. | | | |
| Current | 0.15%F.S. | | | |
| Power | 0.75%F.S. | | | |
| Voltage measurement① | | | | |
| Resolution | 16bits | | | |
| Accuracy | 0.05%+0.05%F.S. | | | |
| Current measurement① | | | | |
| Resolution | 16Bits | | | |
| Accuracy | 0.1%+0.2% F.S. | | | |
| Power measurement① | | | | |
| Accuracy | 1%F.S. | | | |
| Ripple noise④ | | | | |
| Ripple Vpp | 10kW | 1600mV | | - | - |
| | 15kW | 2000mV | 2000mV | 2400mV | 3600mV |
| Ripple Vrms | 10kW | 350mV | | - | - |
| | 15kW | 350mV | 350mV | 400mV | 400mV |
| Size（W x H x D） | 5kW～15kW: 482.6mm x 132.5mm x 702.0mm, includes output protection cover | | | | |
| | 20kW～30kW: 482.6mm x 266mm x 738.0mm, includes protection cover, excludes casters | | | | |
| Weight | 5kW≈17kg, 10kW≈24kg, 15kW≈30kg, 30kW≈65kg | | | | |

# 2. Quick Guide

## 2.1 Checking Goods

Upon reception of the power supply, please examine the equipment according to procedures stipulated as below.

**(1) Check if there is damage during transportation.**

Contact authorized dealer or Faithtech after-sale service immediately if the packing or protective cushion is severely damaged.

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**Notice**    **Do not return the instrument without obtaining prior approval from Faithtech.**

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**(2) Check for the accessories.**

Make sure you have received the following accessories along with the power supply:

Table 2-1 Accessories Explanation

| Accessory | QTY | Explanation |
|---|---|---|
| Protective cover | 1 Set | Input and output protection |
| 2PIN 5.08mm terminal | 1 PCS | Voltage remote sense connection terminal |
| 2PIN 2.54mm terminal | 1 PCS | Master-Slave parallel connection terminal |
| USB communication cable | 1 PCS | For connecting PC and USB port |
| LAN communication cable | 1 PCS | For connection PC and LAN port |
| User Manual | 1 PCS | Installing and operation info |
| CD Disk | 1 PCS | Software and tech info |
| Warranty & QC PASS Card | 1 PCS | Warranty and after-sale info |

Contact authorized dealer or Faithtech after-sale service immediately if there is damage or miss.

**(3) Check for the power supply unit.**

Contact authorized dealer or Faithtech after-sale service immediately if the power supply case is damaged or working abnormally.

**(4) Cleaning.**

If you need to clean the casing of the machine, please wipe it gently with a dry cloth or a slightly damp cloth. Do not wipe the inside of the machine.

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**WARNING**    **Turn off the power supply before cleaning.**

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## 2.2 Front Panel
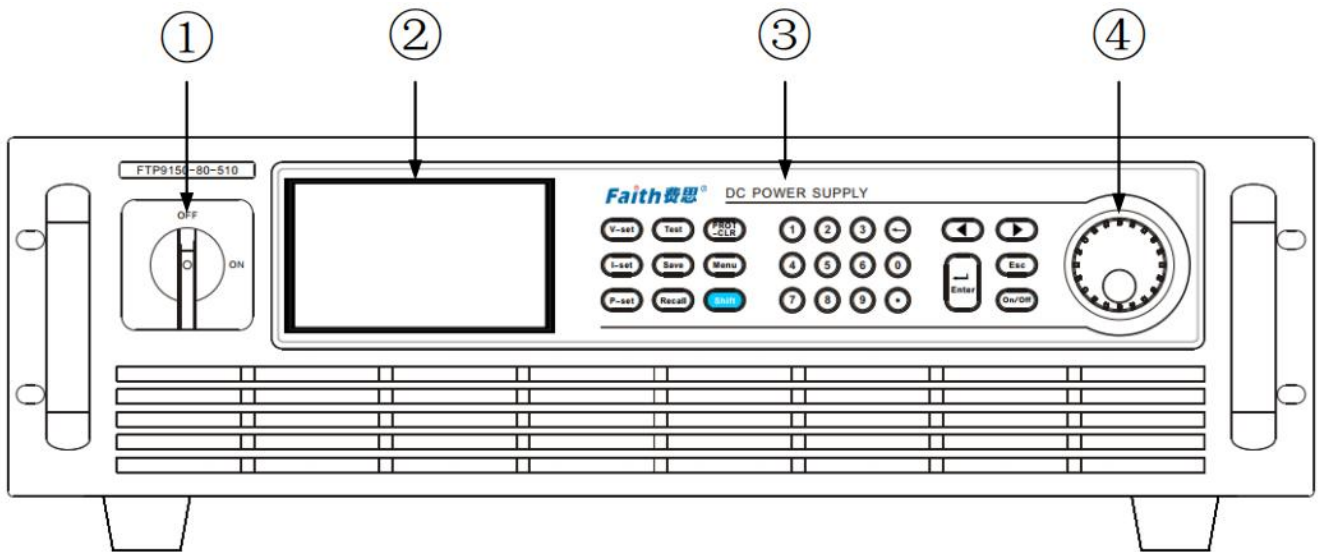


① Power switch

② TFT color screen

③ Keyboard

④ Rotary knob

## 2.3 Keyboard
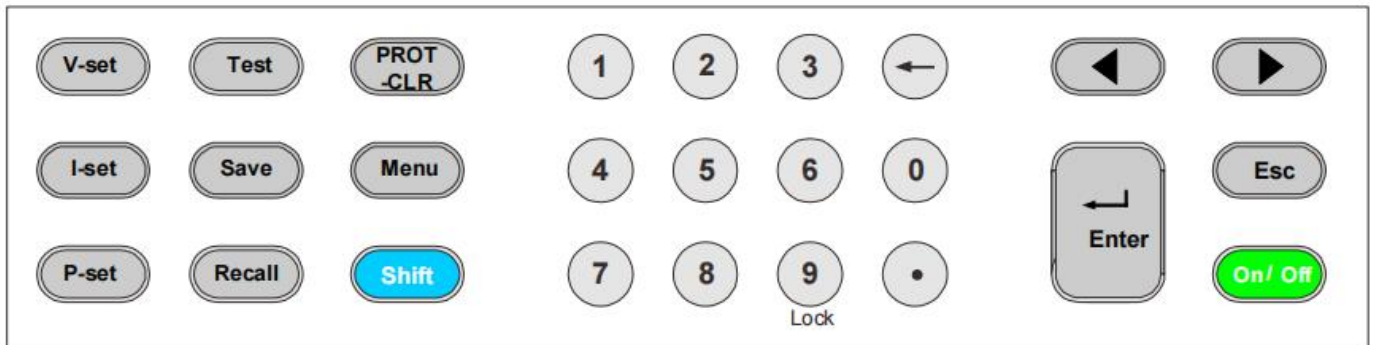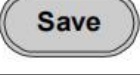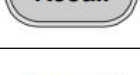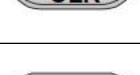


Figure 2-2 FTP9000 keyboard

Table 2-2 Key Function Descriptions

| Button | Key Name | Description |
|--------|----------|-------------|
| V-set | Voltage Setting Key | Switch to output setting mode from other functions, and Voltage is now settable; |
| I-set | Current Setting Key | Switch to output setting mode from other functions, and Current is now settable; |

| | | |
|---|---|---|
| P-set | Power Setting Key | Switch to output setting mode from other functions, and Power is now settable; |
| Test | Advanced Test Key | For performing Sequence Test, Voltage RAMP, RESI internal resistance simulation, etc. |
| Save | SAVE Key | Save the settings of the static output to internal memory. |
| Recall | Recall Key | Recall the saved settings from internal memory. |
| PROT -CLR | Protection Clear Key | Clear the occurred protection and warning messages. |
| Menu | Main Menu Key | Enter the main menu. |
| Shift | Compound Function Key | Work with other key together |
| Shift + 9 Lock | Lock or unlock the keyboard | In locked state, only On/Off and Shift + 9 Lock are valid. |
| 0 to 9 and • | Numeric and Decimal Point | Enter digital data. |
| ← | Clear Key | Each press clears one digit of your numeric input. |
| ◄ ► | Cursor Movement Keys | Control the cursor to move between digits when setting parameters. In menu navigation, used for selecting the specified item. |
| Enter | ENTER Key | Enter set item, or confirm input and exit set item. |
| Esc | EXIT Key | Exit set item or current menu. |
| On/Off | Output On/Off Key | Turn on/off power supply output. |

## 2.4 Screen Display
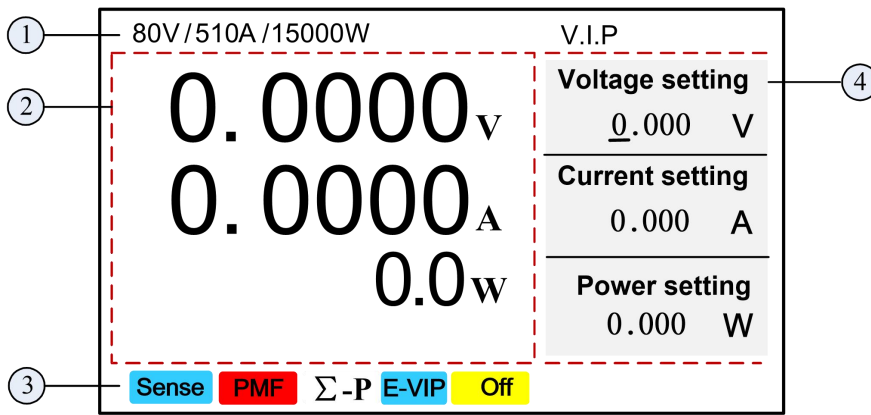


Figure 2-3 MAIN PAGE Display

① Specification info of the power supply;

② Readback voltage, current, etc. parameters display area;

③ Status prompt area;

④ Parameters setting area;

**About specification info:**

Displays the rated voltage, rated current, rated power of the power supply;

**About V, I parameters display area:**

Displays readback voltage, current, power, measurement result etc.. However, the actual displayed information varies, for example, in V.I.P static output mode, the area displays output voltage, current and power; in sequence test mode, the area displays output voltage, current, sequence current steps and sequence cycle times.

**About Status prompt area**:

**Sense** **V-Sense**: Blank (local sensing), Sense (remote sensing);

**PMF** **Protection occurred**: Blank (no protection occurred), PMF, OVP, OCP, OPP, OTP1, OTP2, LVP, OP, OC, OV, RVP, CMF etc.. protections occurred;

$\Sigma$-P **Parallel operation;**

**E-VIP** **External programming**: Blank (Analog programming is off), E-VIP;

**Off** **Output mode indicator**: CV, CC, CP, Off;

## 2.5 Rear Panel
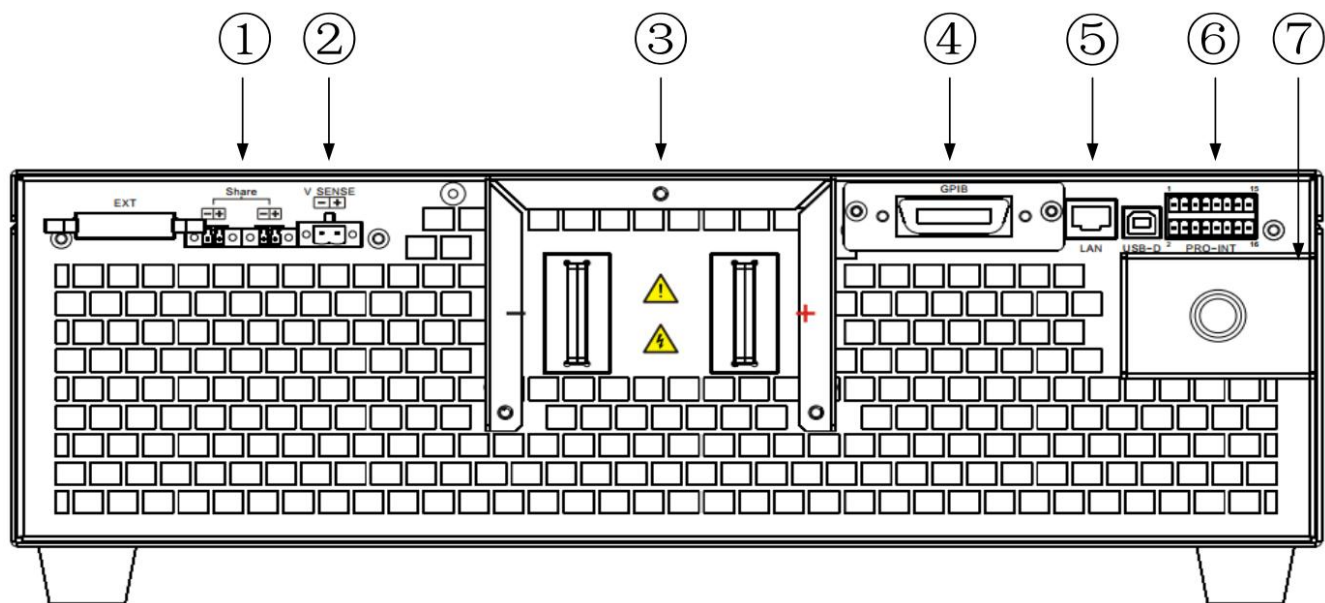


Figure 2-4 FTP9000 Rear Panel

| Item | Name | Description |
|------|------|-------------|
| 1 | Share | Master-Slave parallel ports |
| 2 | V SENSE | This connector compensates for any voltage drop generated by the cable resistance. Be sure to connect the remote sense connector "+" to the positive output terminal and the "−" connector to the negative output terminal. **Do not reverse the connections.** |
| 3 | "+", "-" Output | The output terminals of the DC Power Supply. |
| 4 | GPIB (or CAN + RS485) | The remote controller uses the GPIB connector to connect to a PC for remote operation. |
| 5 | LAN, USB | The remote controller uses the USB/LAN connector to connect to a PC for remote operation. |
| 6 | PRO-INT | This interface has the functions of analog programming input, voltage/current monitoring output, external control, power supply status and work mode indication. Refer to "2.7.5 PRO-INT Analog Interface" for details. |
| 7 | AC INPUT | L1、L2、L3、PE three phase AC INPUT |

## 2.6 Installing

## 2.6.1 Preparation For Use

(1) Insure the Power Supply is connected to the AC line input that meets the specification.

(2) The instrument must be installed in an area with good air circulation to avoid the internal temperature getting too high.

(3) For indoor use only, ambient temperature 0°C to 40°C.

## 2.6.2 Requirements of Input Power

Please pay attention to the following items for FTP9000 series power supply input connection:

① Three-phase input: 340VAC~460VAC, 47~63Hz;

② Ensure reliable grounding;

③ 5kW model power supply is connected to L1, L2 and grounding terminal, other types of power supply need to be connected to L1, L2, L3 and grounding terminal;

④ Please refer to "Table 6-1 Recommended Wire Diameters for Cables" for the selection of input wire diameters to avoid potential safety hazards due to thinner wire diameters.

-------------------------------------------------------------------------------------------------------------

**⚠WARNING**

1. To protect the operator, the wire connected to the GND terminal must be connected to the earth. Under no circumstances shall this DC Power Supply be operated without an adequate ground connection.

2. Installation of the power cord must be done by a professional and compliant with local electrical codes.

-------------------------------------------------------------------------------------------------------------

## 2.6.3 Power ON Self Check

When powered on, the power supply will conduct self check, the check process and results will be displayed on the screen, such as below:

```
(c)All rights reserved.

Test PRI Fault.    OK

Loading calibration data.    OK

Test sample.    OK

Loading parameters.    OK


```

Figure 2-5 FTP9000 Power ON Self Check

The power supply will enter MAIN PAGE if all checking results are OK, otherwise it will wait for 5 seconds before entering the MAIN PAGE.

-------------------------------------------------------------------------------------------------------------

⚡ **CAUTION**   For fault meaning please refer to "Table 5-2 Power On Fault Check".

-----------------------------------------------------------------------------------------------------------------

## 2.7 Connection

## 2.7.1 Input Connection

The user connects the three-phase wire and the ground wire to the power supply input terminal as shown in Figure 2-6. For the size of the wire diameter, please refer to "Table 6-1 Recommended Wire Diameter for Cables".
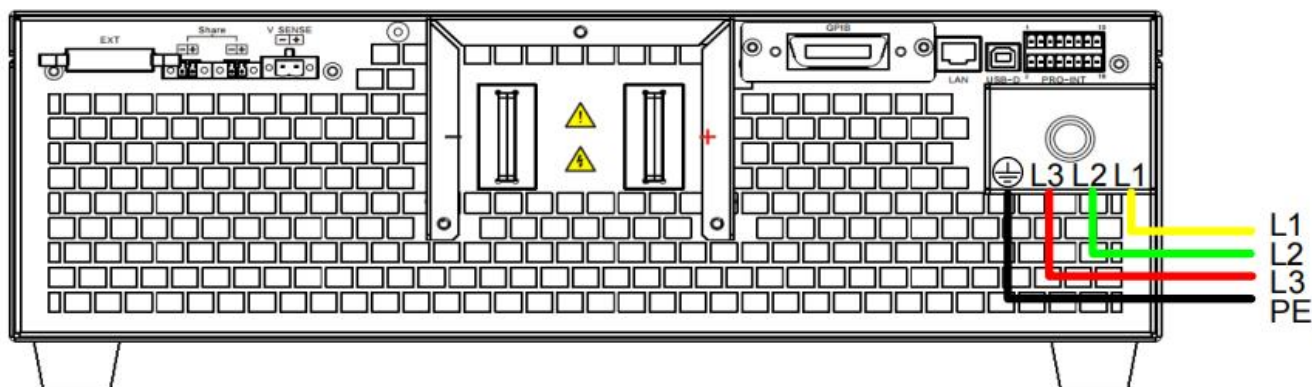


Figure 2-6 Power supply Input Connection

-----------------------------------------------------------------------------------------------------------------

⚠**WARNING**
1. To protect the operator, the wire connected to the GND terminal must be connected to the earth. Under no circumstances shall this DC Power Supply be operated without an adequate ground connection.
2. Installation of the power cord must be done by a professional and compliant with local electrical codes.

-----------------------------------------------------------------------------------------------------------------

## 2.7.2 Input Connection for Multiple Power Supplies

If multiple 5kW or 10kW models are connected to the grid, it is recommended to distribute the access points in a balanced manner as shown in the figure below. When the 15kW model is connected to the three-phase power grid, there is no need to consider the imbalance of the power grid.
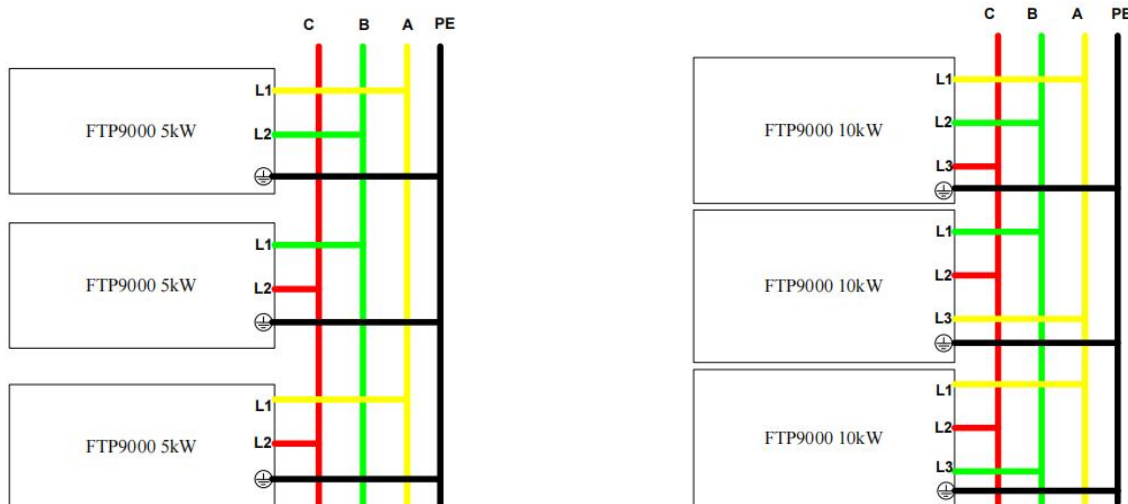
## 2.7.3 Output Connection

The device under test is connected to the "+" and "-" output terminals on the rear panel of the power supply. When connecting, pay attention to the wire diameter, length and polarity of the output cable. To prevent the wire diameter from being too small to affect the test accuracy and generate large heat to cause safety accidents, please refer to "Table 6-1 Recommended Wire Diameters for Cables" for wire diameter selection.
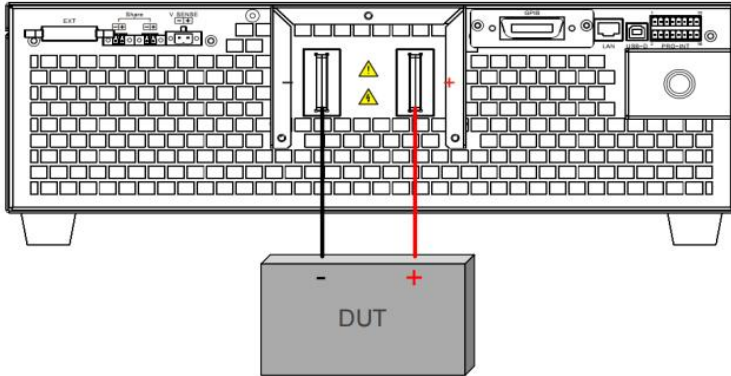


Figure 2-9 Power Supply Output Connection

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⚡ **CAUTION**   The diameter of the wire connected to the load must be adequate so as to carry the maximum applied current.

----------------------------------------------------------------------------------------------------------------

## 2.7.4 Remote Sensing Connection

FTP9000 series power supplies are able to compensate for the voltage drop caused by output connecting cables. Use two wires to connect the positive/negative connectors of the load to the corresponding positive/negative remote sensing connector on the rear panel, symbol "Sense" will be prompted in the status prompt area of the screen if the power supply output is turned on.



----------------------------------------------------------------------------------------------------------------
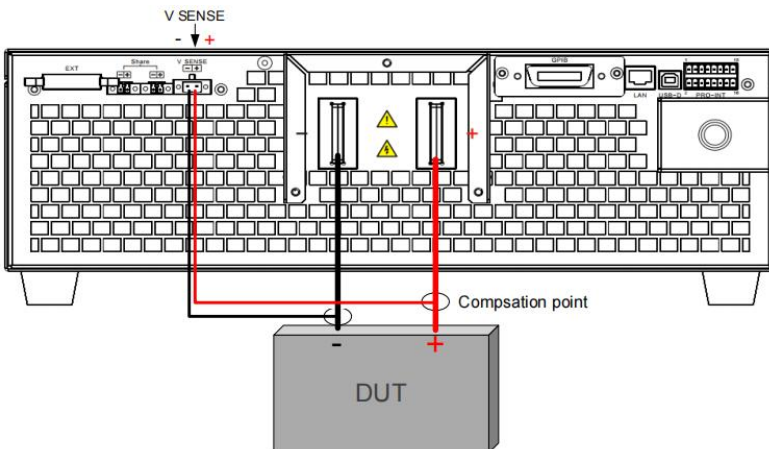
⚡ **CAUTION**   1. It is OK to choose red and black wires with a cross-sectional area of 0.5mm² to 1mm² for voltage compensation wire, try double strand the wire as much as possible.

2. The 80V type of FTP9000 series power supply has a compensation voltage drop of less

than 1.5V, and other voltage models have a compensation voltage drop of less than 5V. For special requirements, please consult the dealer or the Faithtech Technology Department.

-----------------------------------------------------------------------------------------------------------

# 2.7.5 PRO-INT Analog Interface

FTP9000 series power supply provides optional PRO-INT analog Interface at its rear panel. This interface has the functions of analog programming input, voltage/current monitoring output, external control, power supply status and work mode indication.
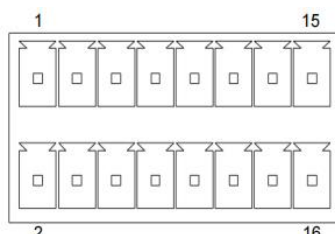


Figure 2-11 PRO-INT Analog Interface

Table 2-4 Analog Interface Function Description

| PIN No. | PIN Name | I/O | Description |
|---|---|---|---|
| 1 | Ready | Output | Power supply status indicating, 5V TTL, H: fault, L: normal |
| 2 | MODE | Output | Power supply output mode indicating, 5V TTL, H: CC or CP, L: CV |
| 3 | INHIBIT | Input | External control port, 5V TTL, low level or falling edge effective, can be set to Trigger, Toggle, Hold three behaviors. Refer to "3.7.2 External Control" |
| 4 | DGND | - | Digital ground |
| 5 | DGND | - | Digital ground |
| 6 | AGND | - | Analog ground |
| 7 | VMON | Output | Output Voltage monitoring port, monitoring output range 0~5VDC corresponds to 0~100%F.S. rated voltage of the power supply output |
| 8 | IMON | Output | Output current monitoring port, monitoring output range 0~5VDC corresponds to 0~100%F.S. rated current of the power supply output |
| 9 | I-SET | Input | Analog programming current input port, input range 0~5VDC or optional 0~20mA corresponds to 0~100%F.S. rated current of the power supply output |
| 10 | AGND | - | Analog ground |
| 11 | V-SET | Input | Analog programming voltage input port, input range 0~5VDC or optional 0~20mA corresponds to 0~100%F.S. rated voltage of the power supply output |
| 12 | P-SET | Input | Analog programming power input port, input range 0~5VDC or optional 0~20mA corresponds to 0~100%F.S. rated power of the power supply output |
| 13, 14 | RS485-A | - | Communication port for master-slave parallel operation |

_____

| 15, 16 | RS485-B | - | Communication port for master-slave parallel operation |
|---|---|---|---|

# 3. Function Introduction

This chapter describes the main functions and characteristics of the power supply. Reading this chapter, you will have a deeper understanding of FTP9000 series power supplies.

## 3.1 Local & remote operation mode

The power supply provides two operation modes: local operation and remote operation. In the local operation mode, the user mainly operates through the keyboard and knob on the front panel, and checks the power status through the LCD display; in the remote operation mode, the user mainly performs settings and operations via the communication interface and programming commands.

**Local operation mode**

When the power supply is turned on, it operates in local operation mode by default. In this mode, the user operates the power supply through the front panel keyboard. The LCD screen provides users with display functions such as parameter viewing, measurement display and status indication.

Some parameters can only be set in local mode, including:

 * System language
 * Serial port baud rate and parity method
 * Key sound
 * IP address and subnet mask
 * Communication protocol selection

**Remote operation mode**

To enter the remote operation mode, please use the proper communication cable to connect the PC with the power supply. The communication configuration parameters must be consistent with the control device settings. Upon receiving the programming command, the power supply automatically switches to the remote operation mode from local control mode.

In remote control mode, the power supply can only be controlled by programming commands. Press "Enter" to return to local operation mode.

## 3.2 Menu Layout

## 3.2.1 Set Menu

Press **Menu** to enter main menu, then select "Set" and press **Enter** to pop up sub menu as below:

Table 3-1 Set Menu Layout

| | | |
|---|---|---|
| | Samp Rate | Data transmission speed, choices: 1000Hz/500Hz/200Hz/100Hz/10Hz, default value 10Hz |
| | Prio SLT | Choice for CV or CC priority. Default value: Volt (CV Priority) |
| App Set | $V_{slew-UP}$ | Voltage rise slew rate, range: 0.0006V/s~ 6000V/s, default value: 50% of max value |
| | $V_{slew-DN}$ | Voltage fall slew rate, range: 0.0006V/s~ 6000V/s, default value: 50% of max value |
| | $I_{slew-UP}$ | Current rise slew rate, range: 0.0006A/s~ 2000A/s, default value: max value |
| | $I_{slew-DN}$ | Current fall slew rate, range: 0.0006A/s~ 2000A/s, default value: max value |
| | OVP | Set overvoltage protection point, set 0 to turn off this protection. |
| | OCP | Set overcurrent protection point, set 0 to turn off this protection. |
| | OPP | Set overpower protection point, set 0 to turn off this protection. |
| Protect | LVP | Set low voltage protection point, set 0 to turn off this protection. |
| | Over time | Set communication error time out, range:   0.0~ 60.0s, set 0 to turn off this protection; |
| | Detect RV | Turn on/off reverse voltage protection, default value: Closed |
| | V_MAX | Upper limit of static output voltage set , default max output voltage |
| | V_MIN | Lower limit of static output voltage set, default 0 means no limit |
| | I_MAX | Upper limit of static output current set, default max output current |
| Limit | I_MIN | Lower limit of static output current set, default 0 means no limit |
| | P_MAX | Upper limit of static output power set, default max output power |
| | P_MIN | Lower limit of static output power set, default 0 means no limit |
| | APG_V | Turn on/off external voltage programming, default: OFF. |
| | APG_I | Turn on/off external current programming, default: OFF. |
| | APG_P | Turn on/off external power programming, default: OFF. |
| Ext Prog | EXT-S | Set external input signal behavior, choices: Trigger/Toggle/Hold; default value: Trigger (Refer to 3.7.2 External Control) |
| | Vref | reference voltage for external programming or monitoring, choose 5V or 10V |
| | M_or_S | Set the power supply as master or slave, default value: master |
| Parallel | S.NUM | Set number of slaves in master, range: 1~9 |
| | MS_CTRL | Turn on/off parallel function, default value: OFF |

## 3.2.2 System Menu

Press [Menu] to enter main menu, then select "System" and press [Enter] to pop up sub menu as below:

Table 3-2 System Menu Layout

| | | |
|---|---|---|
| Communication | IP | Default 192.168.1.123 |
| | S-Mask | Default 255.255.255.0 |
| | Baud | Serial port baud rate, 4800/9600/19200/38400/115200, default: 9600. |
| | Parity | no parity/odd parity/even parity, default: no parity. |
| | DEVI-ADDR | Device address in MODBUS protocol, range 0~254, default: 160 |
| | GPIB | set GPIB address, range: 0~30, default: 5. |
| | Protocol | SCPI/MODBUS, default: MODBUS |
| Factory | | Reset to factory setting. Reboot the machine to take effect. |
| Others | Language | Simplified Chinese/Traditional Chinese/English. Default: English. |
| | Sound | Keyboard sound ON/OFF. Default: ON |
| | Power Save | Power down save function ON/OFF. Default: ON |
| | Shortcut | Fast recall function ON/OFF. Default: OFF |

## 3.2.3 Edit Menu

Press [Menu] to enter main menu, then select "Edit" and press [Enter] to pop up sub menu as below:

Table 3-3 Edit Menu Layout

| | | |
|---|---|---|
| Edit | Sequence | Select sequence file number, range 1~10 |
| | Back | Exit |

## 3.2.4 About Menu

Press [Menu] to enter main menu, then select "About" and press [Enter] to pop up sub menu such as HMI, MAIN, COMM program version information etc..

# 3.3 Static Output Function

FTP9000 series power supply provides auto ranging wide range output within its rated power. The output range is 0 ~ 102% rated output of voltage, current and power.

Press (V-set), (I-set) or (P-set), the power supply enters static output function, the screen displays information as below:
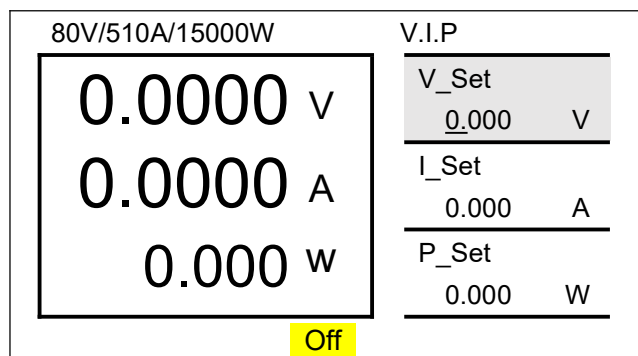
```
80V/510A/15000W          V.I.P
 ┌──────────────────┐     ────────────────
 │                  │     V_Set
 │   0.0000 V       │       0.000    V
 │                  │     ────────────────
 │   0.0000 A       │     I_Set
 │                  │       0.000    A
 │    0.000 W       │     ────────────────
 │                  │     P_Set
 └──────────────────┘       0.000    W
         Off
```

Figure 3-1 Static Output View

**Setting output voltage:**

1. Press (V-set), power supply enters static output mode, the cursor for voltage set blinks, also you can rotate the knob to highlight the voltage setting and press [Enter] to edit voltage,

2. Use (0) 至 (9) 与 (•) to set the value and press [Enter] to confirm the voltage setting or rotate the knob to set the value.

When using the "Rotary" knob for setting, use (◀) 与 (▶) to move the cursor to the individual digit, and then rotate the rotary knob to increase or decrease the value.

When power supply is reset to factory setting, the default voltage set is 0V.

**Setting output current or output power:**

Press (I-set) or (P-set) and follow the similar steps.

When power supply is reset to factory setting, the default set current is maximum output current, default set power is maximum output power.

## 3.3.1 Power supply output modes

FTP9000 series power supply has three output modes: CV (constant voltage mode), CC (constant current mode), CP (constant power mode).
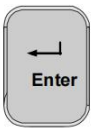
The power supply generally outputs voltage according to the set value, in such situation, "CV" is displayed in status prompt area. When the output current exceeds the set current value, the power supply will automatically switch to CC mode, the output current can be changed by setting the output current value, in this situation "CC" is displayed in status prompt area. When the output power exceeds the set power value, the power supply automatically switch to CP mode, in which the output power can be changed by setting the output power value, in this situation, "CP" is displayed in status prompt area.

## 3.3.2 Limit Voltage/Current/Power Set

FTP9000 series power supply allows for setting upper and lower limits on voltage, current and power. When the upper and lower limit is set to non-zero, the setting range of static output voltage, current, and power parameters is limited between the upper and lower limit. If the input exceeds the limit, it will be invalid. This function is useful for preventing misoperation from damaging the user's equipment.

The limit function will be canceled if upper and lower limit both are set to 0.

**Operation:**

1. Press $\boxed{\text{Menu}}$ ;

2. Select "Set" >> "Limit", press $\boxed{\text{Enter}}$ to enter the limit setting page shown as below:

| Set | System | Edit | About |
|------|--------|------|-------|
| V_MAX | 0.000 | V | |
| V_MIN | 0.000 | V | |
| I_MAX | 0.000 | A | |
| I_MIN | 0.000 | A | |
| P_MAX | 0.000 | W | |
| P_MIN | 0.000 | W | |

Figure 3-2 Voltage, Current, Power Limit Set

3. Select the desired item and set the corresponding parameter.

# 3.4 Voltage Slew Rate And Current Slew Rate

FTP9000 series power supply supports adjustable voltage and current slew rate, which effectively avoids the inrush damage or surge damage to the units under test.

**Operation:**

1. Press [Menu] ;

2. Select "Set" >> "App Set", press [Enter] to enter the application setting page shown as below:

| Set | System | Edit | About |
|---|---|---|---|
| Samp Rate | 10Hz | | |
| Prio SLT | Volt | | |
| $V_{slew-UP}$ | 5000.0 | V/s | |
| $V_{slew-DN}$ | 5000.0 | V/s | |
| $I_{slew-UP}$ | 2000.0 | V/s | |
| $I_{slew-DN}$ | 2000.0 | V/s | |

Figure 3-3 Voltage, Current Slew Rate Set

3. Select parameters to set corresponding value.

# 3.5 CV/CC Priority Start function

FTP9000 series power supply provides CC priority and CV priority start function, which forces the power supply to operate in CC or CV mode at the moment the output is turned on, effectively avoids the current or voltage overshoot resulted from capacitive or inductive load.
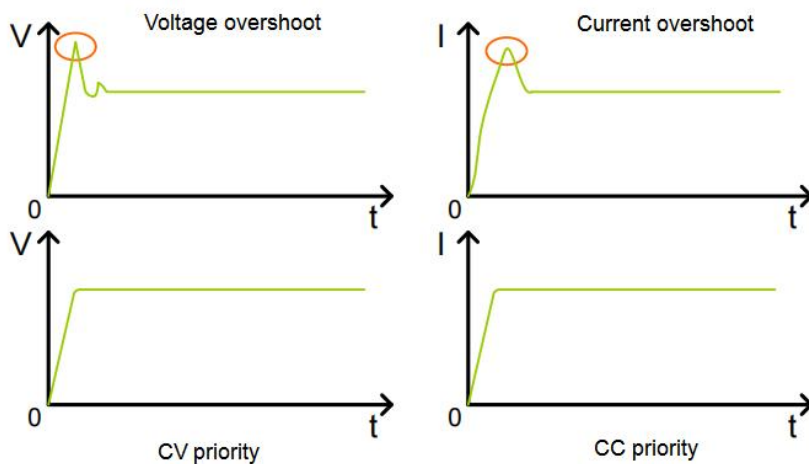


Figure 3-4 CV, CC Priority V / I Waveform

**Operation:**

1.  Press (Menu) ;

2.  Select "Set" >> "App Set", press "Enter" to enter the application setting page shown as below:

| Set | System | Edit | About |
|-----|--------|------|-------|
| Samp Rate | 10Hz | | |
| Prio SLT | Volt | | |
| $V_{slew-UP}$ | 5000.0 V/s | | |
| $V_{slew-DN}$ | 5000.0 V/s | | |
| $I_{slew-UP}$ | 2000.0 V/s | | |
| $I_{slew-DN}$ | 2000.0 V/s | | |

Figure 3-5 CV, CC Priority Set

3.  Select "Prio SLT" item to set, "Volt" stands for voltage priority while "Curr" stands for current priority.

## 3.6 Output Control

The power supply's output is turned off when it is switched on. Users control its output via front panel (On/ Off) key.

● (On/ Off)    key is lighted, suggests the output is turned on, the screen displays voltage, current, power, operation mode in real time;

● (On/ Off)    key is light off, suggests the output is turned off, "OFF" is displayed in the status prompt area.

## 3.7 Analog interface (optional PRO-INT interface)

## 3.7.1 Analog Programming

Users are able to control the power supply's output voltage, output current and output power through external 0...5VDC or 0...10VDC voltage, connections as follows:
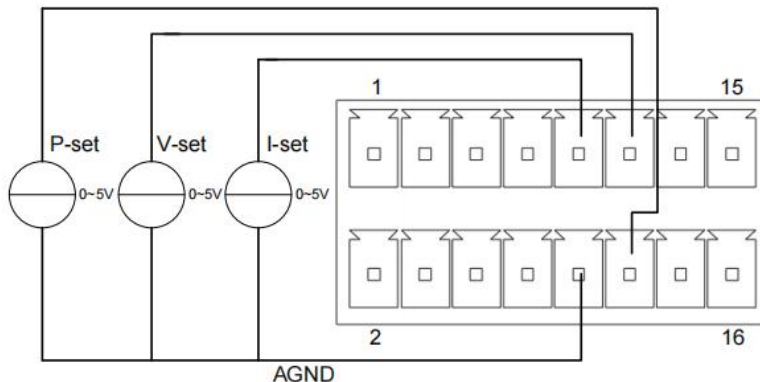


Figure 3-6 Analog Interface Programming Connection

Analog programming control speed is 1000 points per second, external 0...5VDC or 0...10VDC voltage corresponds to 0 ~ 100%F.S. output voltage, current, power.
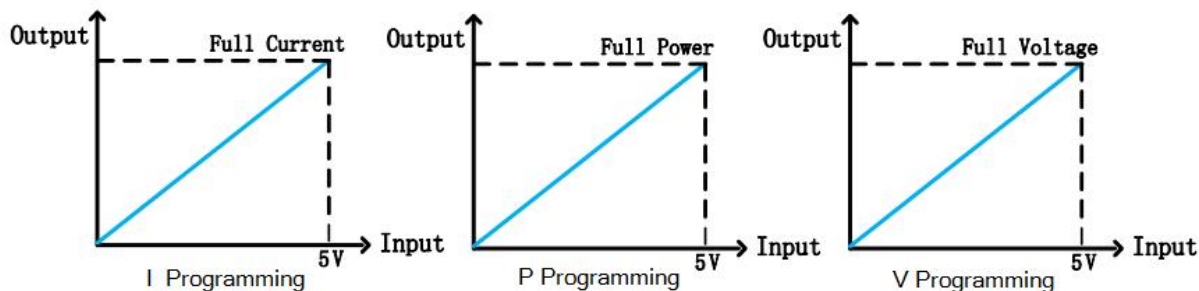


Figure 3-7 Input Programming Signal And Output Relation

**Operation:**

1. Press [Menu] to enter the main menu.

2. Select "Set" >> "EXT Prog" and press [Enter] to enter external programming page as shown below:

| Set | System | Edit | About |
|-----|--------|------|-------|
| APG_V | OFF | | |
| APG_I | OFF | | |
| APG_P | OFF | | |
| EXT-S | Trigger | | |
| Vref | 0-5V | | |

Figure 3-8 External Programming Set

3. Select APG_V, APG_I, APG_P for performing voltage programming, current programming or power programming turn on/off operations respectively, the status prompt area will prompt "E-VIP" symbol if any of these three programming selections is turned on.

4. Press [On/ Off] to turn on output.

---------------------------------------------------------------------------------------------------------------------

1. Altering of "External Programming Set" is allowed only when the output is turned off.

[Notice] 2. The external signal controls the output voltage/current/power on the condition that corresponds voltage/current/power programming is turned on, otherwise the power supply output can still be controlled by the front panel or remote communication.

---------------------------------------------------------------------------------------------------------------------

## 3.7.2 External Control

FTP9000 series power supply analog interface provides an input "INHIBIT" for trigger signal, as shown below:
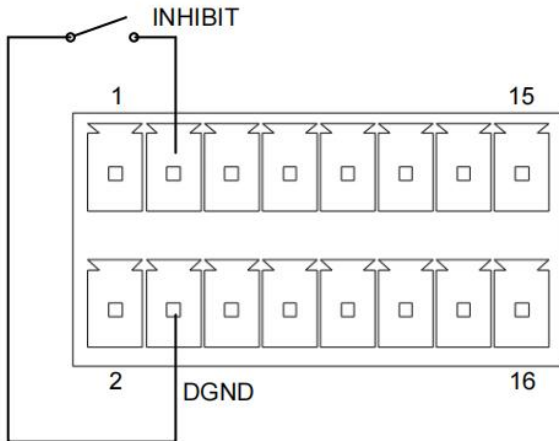


Figure 3-9 Trigger Signal Connection

This "INHIBIT" port receives 5V TTL level signal, low level is effective. You can use a physical switch such as "Figure 3-9 Trigger Signal Connection" or a 0~5VDC signal source for triggering. Closed or 0V is low level, open or 5V is high level. The port response time is about 20 milliseconds, and can be set to Trigger, Toggle, Hold three behaviors.

**Trigger**: Default setting. Used as trigger signal. The port detects a valid low-level pulse, that is, a trigger signal is received.

**Toggle**: Used as power supply output ON/OFF control signal. The output ON/OFF is switched once when the port detects a valid low-level pulse. Same effect as you press [On/ Off] once on the front panel.

**Hold**: Used as power supply output ON/OFF control signal. Output is turned ON when the port detects a valid low-level signal; turned off when the port detects a valid high-level signal.

----------------------------------------------------------------------------------------------------------------------

📌 **Notice**   Keyboard control, external control and System Bus control take effect at the same time and work together.

----------------------------------------------------------------------------------------------------------------------

**Operation:**

1. Press [Menu] to enter the main menu.

2. Select "SET" >> "Ext Prog" and press [Enter] to enter external programming page as shown in Figure 3-8.

3. Select "EXT-S", you can configure among "Trigger", "Toggle", or "Hold". Default setting is "Trigger".

## 3.7.3 Voltage, Current Monitoring Output

FTP9000 series power supply provides analog monitoring output function for its output voltage and current, with a speed up to 1000 points per second. Power supply 0 ~ 100%F.S. output voltage/current corresponds to 0...5VDC or 0...10VDC monitoring output, this function is valid once the power supply is powered on.
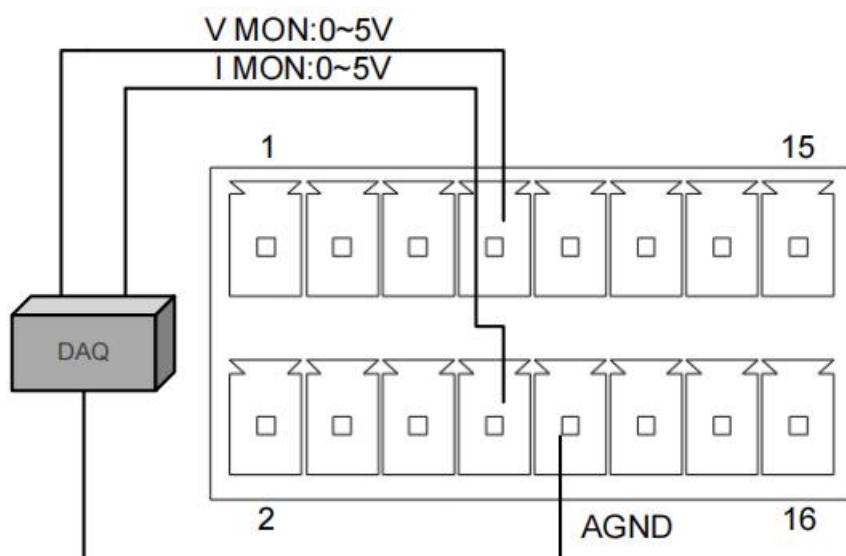


Figure 3-10 Voltage, Current Analog Monitoring Connection
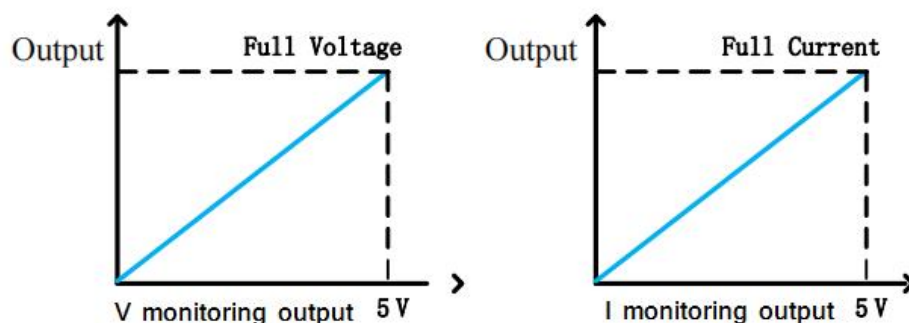


Figure 3-11 Output Voltage, Current And Monitoring Output

## 3.7.4 Output Mode & Status Monitoring

The FTP9000 series power supply has an output mode signal port and a fault indication signal port. The port outputs a 5V TTL level signal, and its functions are as follows:

**Output mode signal port**, low level indicates that the power supply is working in CV mode, and high level indicates that the power supply is working in CC or CP mode;

**Fault indication signal port**, low level indicates that the power supply is working normally, high level indicates that the power supply is abnormal, or protection has occurred but not cleared.

For specific please refer "Table 2-4 Analog Interface Function Explanation".

# 3.8 Protection

FTP9000 series power supply provides protections against overvoltage, overcurrent, overpower, low voltage, output reverse voltage, communication timed out, overtemperature.

When a protection occurs, the power supply will turn off output, sounds an alarm, and prompt corresponding protection information on display.

1.  Press  **Menu**  to enter the main menu.

2.  Select "Set"  >> "Protect" and press  **Enter**  to enter protection setting page as shown below:

| Set | System | Edit | About |
|-----|--------|------|-------|
| OVP | 0.000 V | | |
| OCP | 0.000 A | | |
| OPP | 0.000 W | | |
| LVP | 0.000 V | | |
| Over time | 0.0 s | | |
| Detect RV | OFF | | |

Figure 3-12 Protection Set

3.  Select the corresponding item to set the desired value.

4.  When a protection occurred, press  **PROT -CLR**  to clear the protection state and warning message.

**Overvoltage protection (OV/OVP)**

It has two kinds of overvoltage protection: hardware overvoltage (OV) and software overvoltage (OVP).

Hardware overvoltage protection (OV): It is triggered once the output voltage exceeds 105% rated output voltage, and "OV" is prompt on display.

Software overvoltage protection (OVP): It is programmable as shown in "Figure 3-12 Protection Set". Users are able to set the OVP threshold, set to 0 means to turn off OVP. OVP is triggered once the output voltage exceeds OVP set, and "OVP" is prompt on display.

**Overcurrent protection (OC/OCP)**

It has two kinds of overcurrent protection: hardware overcurrent (OC) and software overcurrent (OCP).

Hardware overcurrent protection (OC): It is triggered once the output current exceeds 105% rated output current, and "OC" is prompt on display.

Software overcurrent protection (OCP): It is programmable as shown in "Figure 3-12 Protection Set". Users are able to set the OCP threshold, set to 0 means to turn off OCP. OCP is triggered once the output current exceeds OCP set, and "OCP" is prompt on display.

**Overpower protection (OP/OPP)**

It has two kinds of overpower protection: hardware overpower (OP) and software overpower (OPP).

Hardware overpower protection (OP): It is triggered once the output power exceeds 110% rated output power, and "OP" is prompt on display.

Software overpower protection (OPP): It is programmable as shown in "Figure 3-12 Protection Set". Users are able to set the OPP threshold, set to 0 means to turn off OPP. OPP is triggered once the output power exceeds OPP set, and "OPP" is prompt on display.

**Low voltage protection (LVP)**

It is programmable as shown in "Figure 3-12 Protection Set". Users are able to set the low voltage protection threshold, set to 0 means to turn off this protection. Low voltage protection is triggered once the output voltage is below the set value, and "LVP" is prompt on display.

**Reverse voltage warning (RVP)**

It is triggered once the output polarities are reverse connected, and "RVP" is prompt on display.

**Communication timed out protection (CMF)**

When power supply is controlled remotely, you can turn on this protection. It is triggered if the host computer did not send communication command to the power supply for a certain period, the power supply output will be turned off and "CMF" is prompt on display. The triggering time can be set as in "Figure 3-12 Protection Set", range 0.0 ~ 60.0 seconds.

**Overtemperature protection**

It is triggered once the temperature of inner power components exceeds allowed temperature range, "OTP1" or "OTP2" is prompt on display.

# 3.9 Save And Recall

The power supply provides 20 groups of storage locations for users to save static output parameters, such as voltage setting, current setting, power setting, voltage slope, and current slope to a designated internal memory location, so that the user can easily and quickly recall and use. If the shortcut function is turned on, you only need to press a number key to recall the saved parameters. This function can significantly reduce user's operations and improve test efficiency.

**Operation**:

When users need to use the save and recall functions, they should first configure the parameters of the static output. The following examples illustrate:

1. Switch to the static output (by pressing the V-Set, I-Set or P-Set button), set the voltage to 12V, the current to 10A, the power to 1000W, the maximum voltage slope, and the maximum current slope;

2. Press **Save** to enter save state;

3. Input number "1" and press **Enter** to validate the setting, so the setting parameters now stored to position "1";

4. Change the static output parameters, set the voltage to 24V, the current to 20A, the power to 2000W, the maximum voltage slope, and the maximum current slope;

5. Press **Save** to enter save state;

6. Input number "2" and press [Enter] to validate the setting, the setting parameters now stored to position "2";

7. Press [Recall] to enter recall interface;

8. Input number "1" and press [Enter] to activated it, the power supply will switch to static output with the recalled parameters of position "1": voltage 12V, current 10A, power 1000W, maximum voltage and current slew rate;

9. Press [Recall] to enter recall interface;

10. Input number "2" and press [Enter] to activated it, the power supply will switch to static output with the recalled parameters of position "2": voltage 24V, current 20A, power 2000W, maximum voltage and current slew rate;

**Shortcut Function**

1. Press [Menu];

2. Select "Set" >> "System" and press [Enter], then select "Others" and press [Enter] again;
3. Set "Shortcut" as ON, so as to activate it;

4. Press [Esc] to return to MAIN PAGE;
5. In MAIN PAGE, when it is not in parameter editing state, press number key to quick recall parameters in position 1~10. [1] ~ [9] corresponds to storage location 1 ~ 9, [0] corresponds to position 10.

# 3.10 Power-down Save

FTP9000 series provides power-down save function. The power supply will resume last time working parameters at its power on moment when power-down save function is activated, otherwise the power supply will initialize using default parameters when it is turned on.

1. Press [Menu];

2. Select "Set" >> "System" and press [Enter], then select "Others" and press [Enter] again;
3. Set "Power Save" item as ON, so as to activate it;

## 3.11 Keyboard Lock And Unlock

Press **Shift** + **9** Lock to lock the keyboard.

When keyboard locked, only ON/OFF button and "Shift+9" operations are valid, the other key operations are invalid. At the same time, the parameter setting area in MAIN PAGE will shown in gray color to differentiate with normal unlocked state.

To unlock the keyboard, press **Shift** + **9** Lock again.

## 3.12 Sequence (SEQ) Function

For sequence test function, the corresponding menu option is "Sequence". Тhe sequence feature allows users to program a list of steps to the power supply's internal memory and execute them. A total of 100 steps can be allocated to each internal memory location, up to a maximum of 10 locations (sequences files). Voltage, current and delay can be set in each step. Sequence file supports "cycle" and "link" attributes. "cycle" controls the sequence file to run cyclically for a specified times, set to 0 means infinite loop. "Link" can add other sequence file into test, set to 0 means no linked sequence file.

When the sequence test is turned on, the highest voltage and current slew rate are used by default.

Table 3-4 Sequence Parameter Explanation

| Parameter | Explanation |
|---|---|
| Length | SEQ file running steps, range 1 ~ 100 |
| Cycle | Set SEQ file running cycles, range 0 ~ 60000, value 0 means infinite cycle. Default value is 1. |
| Link | Range 0 ~ 10, call specified SEQ file to run at this step, value 0 means no linked file |
| SEQ Step | Choose the specified step to edit. Range 0 ~ 100 |
| V_Set | Output voltage for current step, Range 0 ~ max. Output voltage |
| I_Set | Output current for current step, Range 0 ~ max. Output current |
| Step-Time | Delay for current step, range 0.001 ~ 86400s. The delay time is counting from the moment that the current step V/I reaches the setting value. |

**Program Sequence (SEQ):**

1. Press **Menu** ;

2. Select "Edit" >> "Sequence" press **Enter** to enter sequence file choosing page;

3. Rotate the rotary knob or input numbers to choose a file for editing, press [Enter] to enter SEQ editing page:

| Set | System | Edit | About | | |
|-----|--------|------|-------|---|---|
| SEQ Step | 1 | | File Length | 100 | |
| V_Set | 0.000 V | | Cycle | 1 | |
| I_Set | 0.000 A | | Link | 0 | |
| Step-Time | 86400.0 s | | | | |

Figure 3-13 Sequence File Edit

4. Set "Length", press [Enter] to validate it, the editing cursor will move to "Cycle" automatically;

5. Set "Cycle", press [Enter] to validate it, the editing cursor will move to "Link" automatically;

6. Set "Link", press [Enter] to validate it, the editing cursor will move to "SEQ Step" automatically;

7. Set "SEQ Step", press [Enter] to validate it, the editing cursor will move to "V_Set" automatically;

8. Set "V_Set", press [Enter] to validate it, the editing cursor will move to "I_Set" automatically;

9. Set "I_Set", press [Enter] to validate it, the editing cursor will move to "Step-Time" automatically;

10. Set "Step-Time", press [Enter] to validate it, the editing cursor will move to "SEQ step" automatically;

11. Repeat procedures of 7 ~ 11, till all sequence steps have been programmed.

12. Press [Save] to save the programmed sequence file.

13. Press [Esc] to quit sequence editing.

--------------------------------------------------------------------------------------------------------------

[Notice]    **When output is ON, sequence editing is not allowed.**

--------------------------------------------------------------------------------------------------------

**Running sequence file**

1. Press **Test** to enter test function selecting page;

2. Rotate the rotary knob to select "Sequence", press **Enter** to activate sequence test, the screen will displays:

```
┌─────────────────────────────────────────┐
│  80V/510A/15000W        SEQ              │
│  ┌──────────────────┐  ┌──────────────┐ │
│  │                  │  │ Run file     │ │
│  │  0.0000 V        │  │            1 │ │
│  │                  │  └──────────────┘ │
│  │  0.0000 A        │                   │
│  │   Step:    0     │                   │
│  │   Cycle:   0     │                   │
│  └──────────────────┘                   │
│              Off                         │
└─────────────────────────────────────────┘
```
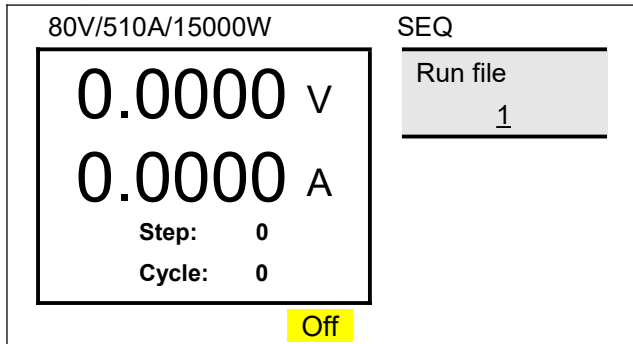
Figure 3-14 Sequence Test Display

3. Set "Run File", press **Enter** to validate it;

4. Press **On / Off** to start sequence test.

About the display information: "Step:" shows the current sequence step, "Cycle:" shows how many cycles the sequence have run.

# 3.13 Internal Resistance Simulation (RESI)

Since a battery has internal resistance, its output voltage will decrease along with the increasing output current. FTP9000 series power supply provides internal resistance simulation feature to imitate the output characteristics of batteries. With this function, the power supply output voltage satisfy below formula:

$$V_O = V_S - I_O \times R_{Inner}$$

$V_o$ : Actual output voltage;

$V_s$ : Theoretical output voltage;

$I_o$ : Output current;

$R_{Inner}$: simulated Inner resistance.

**Operation:**

1. Press **Test** to enter test modes selection interface;

2. Use "Rotary" knob to select "RESI", press [Enter], the screen displays as below:

| 80V/510A/15000W | RESI 1/2 |
|---|---|
| **0.0000** V | Max Volt |
| **0.0000** A | 0.000 V |
| 0.000 Ω | Max Curr |
| Off | 0.000 A |
| | Max Pow |
| | 0.000 W |

| 80V/510A/15000W | RESI 2/2 |
|---|---|
| **0.0000** V | IR-Set |
| **0.0000** A | 1.280 Ω |
| 0.000 Ω | |
| Off | |
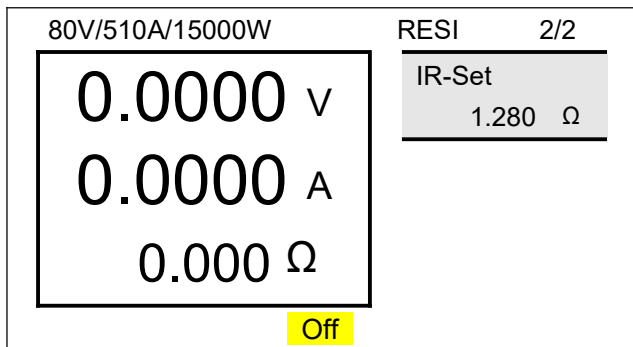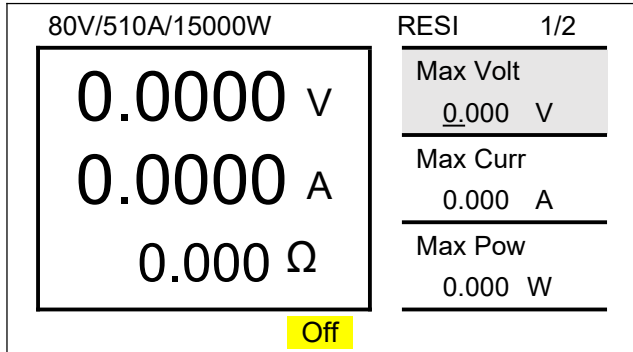
Figure 3-16 Output Test For Battery Simulating

3. Set the corresponding test parameters;

4. Press [On/Off] to turn on battery simulating output.

Table 3-5 RESI Test Parameter Explanation

| Parameter | Notes |
|---|---|
| Max Volt | RESI simulating output max voltage |
| Max Curr | RESI simulating output max current |
| Max Pow | RESI simulating output max power |
| IR-Set | RESI simulating battery inner resistance |

## 3.14 Voltage ramp-up, ramp-down (RAMP)

FTP9000 series power supply allows for output voltage ramp-up and ramp-down according to the set slew rate.

**Operation:**

1. Press [Test] to enter test modes selection interface;

2. Use "Rotary" knob to select "RAMP", press [Enter], the screen displays as below:

```
 80V/510A/15000W       RAMP        1/3
┌──────────────────┐  ┌──────────────────┐
│   0.0000 V       │  │ Ua               │
│                  │  │    0.000   V     │
│   0.0000 A       │  ├──────────────────┤
│                  │  │ Ub               │
│     0.000 W      │  │    0.000   V     │
│                  │  ├──────────────────┤
│                  │  │ Uc               │
│              Off │  │    0.000   V     │
└──────────────────┘  └──────────────────┘
```

```
 80V/510A/15000W       RAMP        2/3
┌──────────────────┐  ┌──────────────────┐
│   0.0000 V       │  │ Slew AB          │
│                  │  │    0.000   V/s   │
│   0.0000 A       │  ├──────────────────┤
│                  │  │ Slew BC          │
│     0.000 W      │  │    0.000   V/s   │
│                  │  ├──────────────────┤
│                  │  │ I_Set            │
│              Off │  │    0.000   A     │
└──────────────────┘  └──────────────────┘
```

```
 80V/510A/15000W       RAMP        3/3
┌──────────────────┐  ┌──────────────────┐
│   0.0000 V       │  │ P_Set            │
│                  │  │    0.000   W     │
│   0.0000 A       │  └──────────────────┘
│                  │
│     0.000 W      │
│                  │
│                  │
│              Off │
└──────────────────┘
```
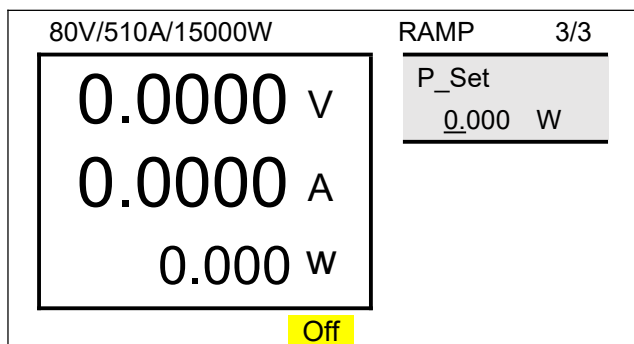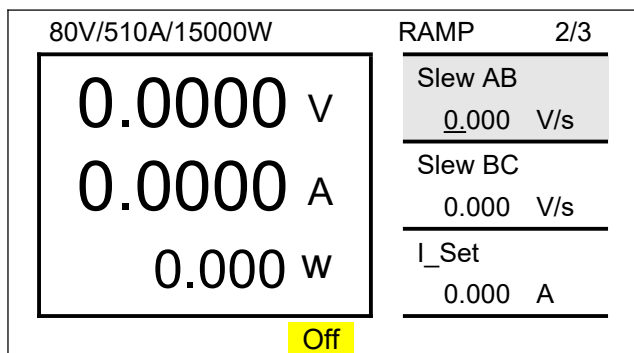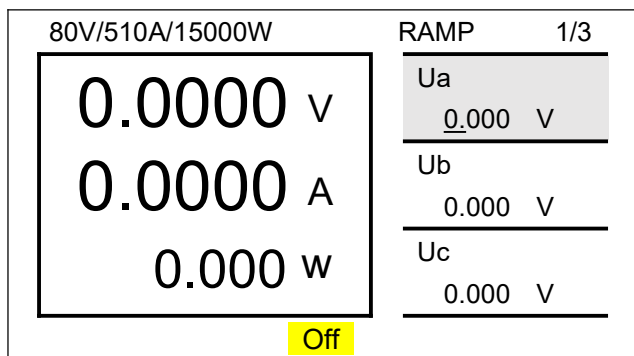
Figure 3-17 RAMP Function Parameter Set

3. Set the corresponding parameters, you can refer to "Table 3-6 RAMP Function Parameter Explanation" ;

4. Press [On/Off] to turn on voltage ramp output.

Table 3-6 RAMP Function Parameter Explanation

| Parameter | Explanation |
|-----------|-------------|
| Ua | Set voltage for A, range: 0 - Max output voltage |
| Ub | Set voltage for B, range: 0 - Max output voltage |
| Uc | Set voltage for C, range: 0 - Max output voltage |
| Slew AB | Set voltage slew rate from A to B, range: 0.0006V/s to 6000V/s, default value 50% max slew rate |
| Slew BC | Set voltage slew rate from B to C, range: 0.0006V/s to 6000V/s, default value 50% max slew rate |
| I_Set | Set output current, range: 0 - Max output current |
| P_Set | Set output power, range: 0 - Max output power |
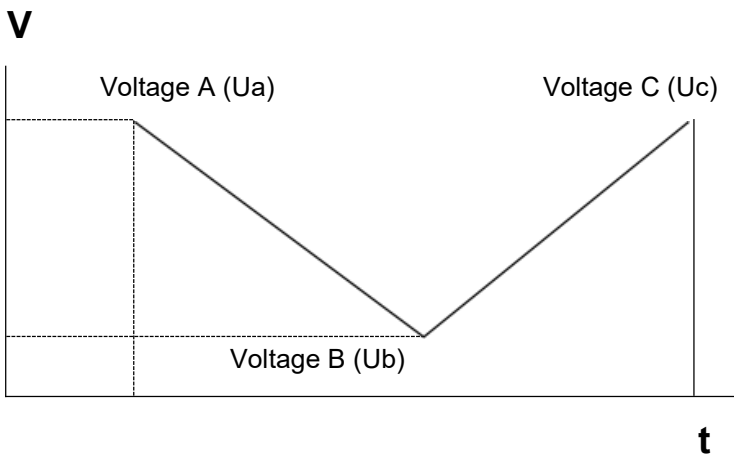


Figure 3-18 RAMP Function Parameter Set

## 3.15 Master-slave Parallel

## 3.15.1 Master-slave parallel connection

FTP9000 series power supplies provide a master-slave parallel mode, so that users can achieve greater output power by paralleling same models. The user uses proper wires to connect the "Share" interface in the rear panel, the "RS485" parallel communication interface in the "PRO-INT" port, and the output positive and negative poles according to "Figure 3-19 Master-Slave Parallel Connection", and then make corresponding configuration for the power supplies to realize the master-slave parallel function, operating the whole group is as simple as operating a stand-alone power supply.
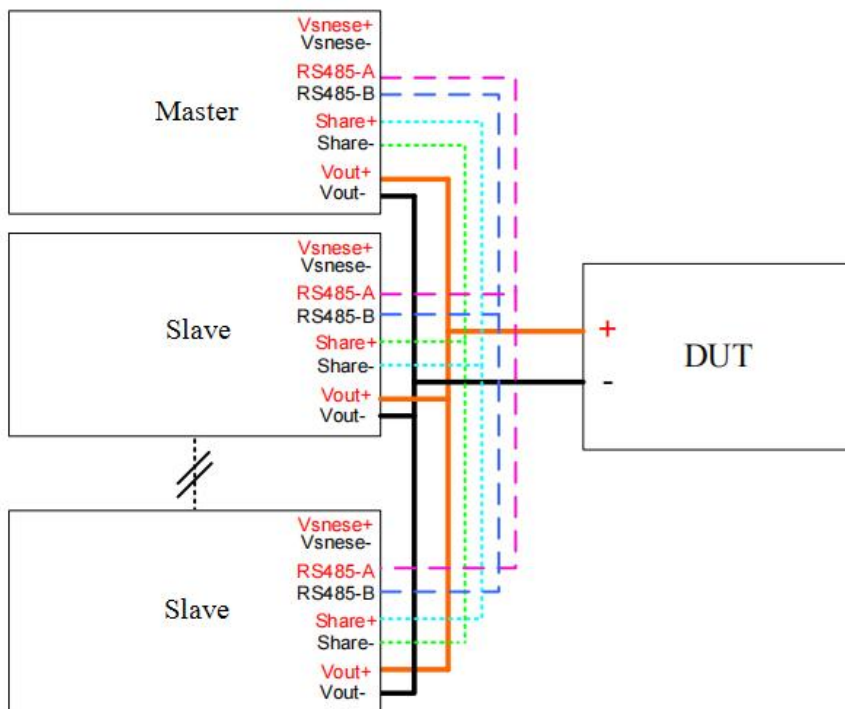
Figure 3-19 Master-Slave Parallel Connection

**Master-slave parallel cable requirements**

It is OK to use cross-sectional area 0.5 mm² ~ 1 mm² double strand wire for RS485 and "Share" ports.

---------------------------------------------------------------------------------------------

⚡ **CAUTION**

1. Master-slave parallel support identical power supplies only;
2. Max 10 units;
3. Use the V SENSE terminal of the master unit if you want to compensate voltage line loss;
4. Does not support master-slave series operation

---------------------------------------------------------------------------------------------

# 3.15.2 Master-slave parallel setting

**Slave setting**

1. Press [Menu] to enter main menu interface;

2. Select "Set" >> "Parallel", then press [Enter] to display master-salve parallel setting page;

3. "M_or_S" item set as "Slave1", "Slave2"... etc., one number corresponds to one slave power supply, number starts from 1 and must be consecutive, repeat numbers are forbidden because it leads to communication error.

4. Unwanted configuration items are hidden when a slave power supply returns to main display page.

**Master setting**

```
┌─────────────────────────────────────────────────┐
│  Set    System   Edit    About                   │
│ ────────────────────────────────────────────────│
│  M_or_S        Master                            │
│  S.NUM           1                               │
│  MS_CTRL       OFF                               │
│                                                  │
│                                                  │
│                                                  │
│                                                  │
│ ────────────────────────────────────────────────│
│                                                  │
└─────────────────────────────────────────────────┘
```

Figure 3-20 Master-Slave Parallel Set

1. Press [Menu] to enter main menu interface;

2. Select "Set" >> "Parallel", then press [Enter] to display master-salve parallel set page;

3. "M_or_S" item set as "Master";

4. "S.NUM" item set as the actual number of slave power supplies;

5. "MS_CTRL" item as as "ON".

Press [Esc] to return to main page after completing the parallel parameter setting. The master power supply specifications will be updated.

## 3.15.3 Master-slave parallel function operations

Simply operate the master unit to control the whole group if you have configured the master-slave parallel correctly. The relative protections are still in effect once parallel function is turned on. The system will automatically turn off all power outputs if one unit in the group is protected. The corresponding slave unit displays the specific fault information, and the master unit displays the master fault information and the fault slave code, as shown in the figure below:

```
┌─────────────────────────────────────────────────┐
│  80V/1020A/30000W          V.I.P                 │
│                         ┌──────────────┐         │
│    0.0000 V             │ V_SET        │         │
│                         │   0.000  V   │         │
│    0.0000 A             │ I_SET        │         │
│                         │   0.000  A   │         │
│      0.000 W            │ P_SET        │         │
│                         │   0.000  W   │         │
│                         └──────────────┘         │
│    [SP01]  ∑-P      [Off]                         │
└─────────────────────────────────────────────────┘
```
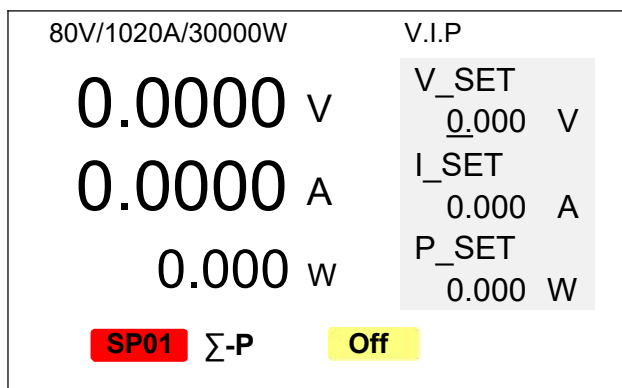
Figure 3-21 Master display

```
┌─────────────────────────────────────────┐
│  80V/510A/15000W          V.I.P          │
│                                          │
│     0.0000 V      ┌──────────────┐       │
│                   │              │       │
│     0.0000 A      │    Slave1    │       │
│                   │              │       │
│        0.0 W      └──────────────┘       │
│                                          │
│   ██OVP██        ██Off██                 │
└─────────────────────────────────────────┘
```
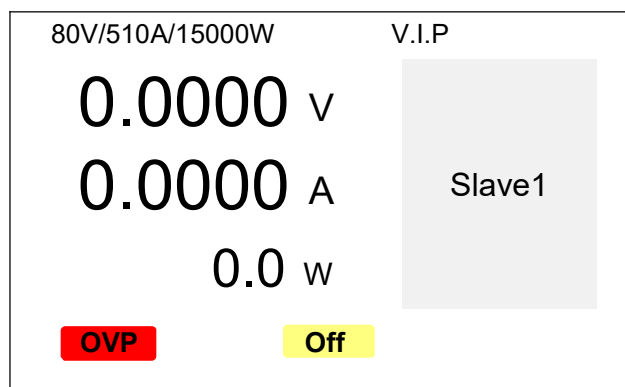
Figure 3-22 Slave display

When a protection occurred in the slave unit, please press [PROT-CLR] to clear fault in corresponding slave unit and in master unit. When protection occurred in master unit only, just press [PROT-CLR] on master unit to clear fault. Possible protections and fault in parallel operations are listed as follows:

Table 3-7 Master-slave parallel protection

| Protection Display | Explanation |
|---|---|
| Σ-P | Parallel communication normal, symbol is white background and not blinking |
| ██Σ-P██ | Parallel communication error, symbol is red background and blinking |
| ██SP01██ ~ ██SP09██ | Indicates the fault slave unit code, requires user to press [PROT-CLR] to clear the fault protection |

----------------------------------------------------------------------------------

⚡ CAUTION

1. Set slave unit first, so as to avoid master unit communication error;

2. Multiple power supplies have been set as master unit leads to parallel operation failure;

3. If cable in "Share" port is not connected or fall off, then although the specifications are updated in accordance with number of slave units when the master unit turns on master-slave parallel control, the actual output will be inconsistent with the master unit configuration due to "Share" port fault.

4. The external programming of the master unit is effective to the whole group.

5. When a power supply is configured as slave unit, the previous set protection value in "Protection" are canceled. To resume you have to reset its values.

6. It is prohibited for paralleling different power supply models, because this will damage the power supplies.

----------------------------------------------------------------------------------

# 3.16 Photovoltaic Simulation Function (PV-SIM) (Optional)

FTP9000 series products have the function of photovoltaic analog power supply to establish maximum power point tracking (MPPT), and can set curve mode and user-defined mode according to the application scene, mainly used for photovoltaic array/module/battery MPPT test.Photovoltaic array/module/cell is mainly a device to convert light energy into electric energy, mainly with a simple semiconductor PN interface. The main output characteristics of the PN interface are: under certain lighting conditions, there is only one maximum power point (MPP), and the use of this function can track the MPP to harvest the maximum power generated by the photovoltaic group.

Table 3-8 Parameters of the PV curve

| Parameter name | Parameter description |
|---|---|
| File number | File serial number for PV operation, ranging from 1 to 20. |
| PMP | Maximum power of the PV curve, ranging from 0 to maximum source power. |
| VMP | The voltage value of the maximum power of the PV curve, ranging from 0 to maximum voltage. |
| Laws and regulations | Supports SANDIA and EN50530. |
| material | SANDIA material options for TF, SCMC, HEC; EN50530 material options for TF, CSI. |

**Edit PV file**

1. Press [ Menu ] button，Enter the menu setting interface；

2. Select "Edit" -> "PV File"，press [ Enter ] key to Enter the PV file selection screen；

3. Turn the knob or enter a number to select the file number you want to edit，press [ Enter ] key to Enter the edit file screen；

| Setting | system | Edit | About | | |
|---|---|---|---|---|---|
| | PMP | 0 W | VMP | 60000 V | |
| | Regulation | SANDIA | | | |
| | Material | TF | | | |

Figure 3-23 photovoltaic file editing screen

4. set"PMP"，press [Enter] key to confirm，Edit focus moves to the next item"VMP"；

5. set"VMP"，press [Enter] key to confirm，Edit focus moves to the next item"Regulation"；

6. Set"Regulation"，press [Enter] key to confirm，Edit focus automatically moves to the next item"material"；

7. press [Save] key，Save the photovoltaic curve file you just edited；

8. Press [Esc] key，Exit the photovoltaic file editing screen。

---

**Note: It is not allowed to edit PV files when the device is on.**

---

## Run PV simulation mode

Menu PV simulation Mode Settings Operation Settings:

The user's photovoltaic operation type selection operation is as follows:

1. press [Menu] key，Enter the Menu menu Settings interface, and select Application Settings in the Settings options；

2. Application Settings -> PV Mode，press [Enter] Scroll the knob to select the desired configuration option Curve or Define.

**Steps of operation**

1.press [Test] key，Enter the Test function selection screen；

2.Roll knob，select"PV-SIM"，press [Enter] key to Enter the "PV-SIM" user-defined function parameter setting screen as follows：

```
┌────────────────────────────────────────────────┐
│  500V / 90A /15000W          PV-SIM       1/2    │
│  ┌───────────────────────┬────────────────────┐ │
│  │                       │        VOC         │ │
│  │     0.0000ᵥ           │   510.00      V    │ │
│  │                       ├────────────────────┤ │
│  │     0.0000ₐ           │        IMP         │ │
│  │                       │   1.000       A    │ │
│  │         0.0   w       ├────────────────────┤ │
│  │                       │        VMP         │ │
│  │                       │   500.00      V    │ │
│  └───────────────────────┴────────────────────┘ │
│                              Off                 │
└────────────────────────────────────────────────┘
```

```
┌────────────────────────────────────────────────┐
│  500V / 90A /15000W          PV-SIM       2/2    │
│  ┌───────────────────────┬────────────────────┐ │
│  │                       │ Short-circuit current│
│  │     0.0000ᵥ           │   1.000       A    │ │
│  │                       ├────────────────────┤ │
│  │     0.0000ₐ           │  Maximum voltage   │ │
│  │                       │   300.00      V    │ │
│  │         0.0   w       ├────────────────────┤ │
│  │                       │                    │ │
│  └───────────────────────┴────────────────────┘ │
│                              Off                 │
└────────────────────────────────────────────────┘
```
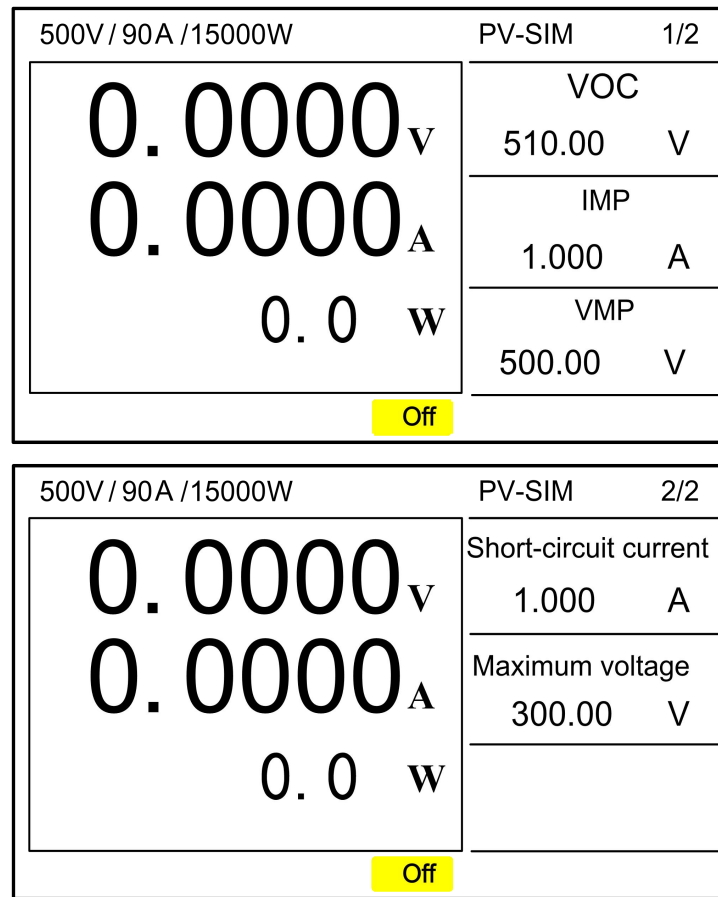
Figure 3-24 Photovoltaic file custom editing screen

3.Set"PV-SIM"Functional parameter，Parameter description such as error! Reference source not found.；

4.Press On/ Off key to Turn on charging，press again On/Off key, Will stop discharging，Zero the power and time at the same time.

Table 3-9 User-defined parameters of the PV function

| Parameter name | Parameter description |
|---|---|
| VOC | Open circuit voltage set value, range: 0 ~ maximum voltage value |
| IMP | Maximum power current set value, range: 0 ~ maximum current value |
| VMP | Maximum power voltage set value, range: 0 ~ maximum voltage value |
| Short-circuit current | Range: 0 to maximum current value |
| Maximum voltage | Range: 0 ~ maximum voltage value |

Table 3-10 Parameters of the PV function curve mode

| Parameter name | Parameter description |
|---|---|
|  |  |

| File number | Run file number, range: 1 to 20 |
|:-:|:--|
| VLMT | Range: 0 to the maximum voltage |
| Filtering speed | Range: Slow,MIDD,Fast |

# 4. Communication Introduction

FTP9000 series power supply provides users with 5 types of communication interfaces: standard USB (serial), LAN (Ethernet), optional GPIB or CAN or RS485 interfaces. FTP9000 supports standard Modbus, SCPI protocol, default protocol is ModBus. Users are able to configure communication ports and protocols base on requirements.

## 4.1 Communication Setup

1. Press ⬭**Menu** to enter main menu page;

2. Select "System">>"Communication ", press ⎉**Enter** to pop up system parameter setting page as below:

| Set | System | Edit | About |
|---|---|---|---|
| IP | 192.168.1.123 | | |
| S_Mask | 255.255.255.0 | | |
| Baud | 9600 | | |
| Parity | None | Protocol | Modbus |
| DEVI-ADDR | 160 | | |
| GPIB | 5 | | |

Figure 4-1 Communication Parameter Setting Interface

3. For LAN communication: first please set "IP" as 192.168.1.123, subnet mask as 255.255.255.0, then set the IP address of the connecting PC to be in the same segment with the power supply IP. Different IP segments will result in communication failure. For example, computer network IP "192.168.1.100" is OK while "198.168.1.100" is not OK.

4. For USB communication: First please set "Baud", default value 9600, configurable among 4800, 9600, 19200, 38400, 115200. Then set "Parity" as "None".

5. For RS485 communication: First please set "Baud", default value 9600, configurable among 4800, 9600, 19200, 38400, 115200. Then set "Parity" as "None", "DEVI-ADDR" default value 160, range 0 ~ 254.

6. For CAN communication: set "DEVI-ADDR", default value 160, range 0 ~ 254 (Device address).

7. For GPIB communication: set "GPIB", default value 5, range 0 ~ 30 (GPIP address).

8. Set communication protocol, select ModBus or SCPI.

After modifying the communication configuration, you need to restart the power supply to take effect.

-------------------------------------------------------------------------------------------------------------

⚡ **CAUTION**　　After modifying the communication configuration, you need to restart the power supply to take effect.

-------------------------------------------------------------------------------------------------------------

## 4.2 Voltage, current acquisition speed

After the above communication configuration is completed, if the user needs to increase the voltage, current acquisition speed, the configuration can be as follows:

1. Press **Menu** to enter main menu page;

2. Select "Set" >> "App Set", press **Enter** to show as below:

| Set | System | Edit | About |
|---|---|---|---|
| Samp Rate | 10Hz | | |
| Prio SLT | Volt | | |
| $V_{slew-UP}$ | 5000.0 | V/s | |
| $V_{slew-DN}$ | 5000.0 | V/s | |
| $I_{slew-UP}$ | 2000.0 | V/s | |
| $I_{slew-DN}$ | 2000.0 | V/s | |

Figure 4-2 Application Setting

3. Select required speed in "Samp Rate" , there are 5 choices select-able, Default is 10Hz.

## 4.3 Communication Interfaces

## 4.3.1 USB (Serial)

FTP9000 provides a USB virtual serial port, compatible with Windows XP/7/8/10. For specific driver software and installation, please refer to the "CD and Software User Manual".

The USB port uses a baud rate of 9600bps by default, parity type is None, and does not support flow control.

Also, it adopts USB-B type terminal, users can use the accessory USB communication cable to easily connect to the USB port on the PC. Its pin signals are described in the following table:

Table 4-3 USB Interface Signals

| Pin NO. | Description |
|---|---|
| 1 | 5V DC |
| 2 | Data- |
| 3 | Data+ |
| 4 | GND |

## 4.3.2 LAN

The FTP9000 series power supply has an Ethernet communication interface and adopts UDP communication mode. The default IP address is 192.168.1.123, the default subnet mask is 255.255.255.0, and the default port number is 7000.

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⚡ **CAUTION** Before starting communication, make sure that the address of the PC and the power supply are in the same network segment, and that there is no duplicate IP address with the power supply in this network segment, otherwise it will not be able to connect correctly.

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## 4.3.3 CAN

The CAN interface uses a fixed communication speed of 500kbps, and the communication address can be set from 0 to 255.



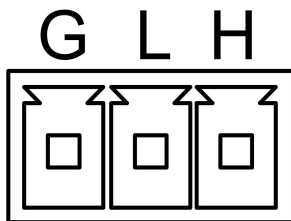Figure 4-3 CAN communication connections

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📌 **Notice** CAN interface uses CANopen protocol.

---

## 4.3.4 RS485

The RS485 communication interface configuration is the same as that of the USB serial port. The baud rate and parity method can be configured through "Figure 4-1 Communication Parameter Setting Interface". The connection method is as follows:
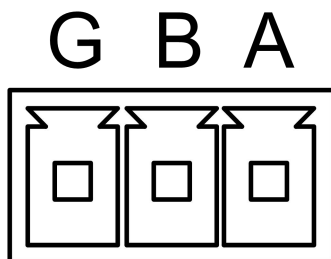


Figure 4-4 RS485 communication connections
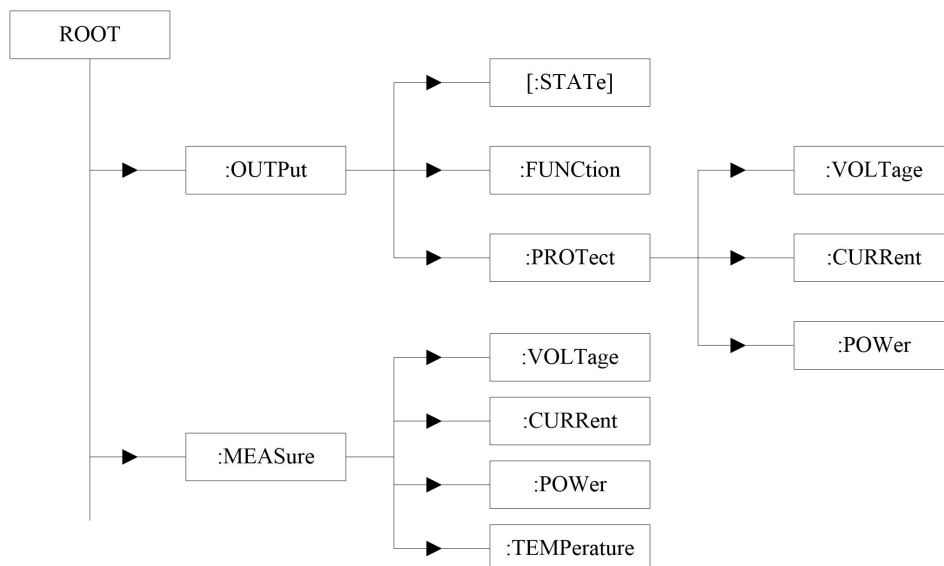
## 4.4 Communication Protocol

FTP9000 series power supplies support SCPI, Modbus and CANopen communication protocols. For LAN, USB serial port, RS485 interface, users can choose SCPI or Modbus; for GPIB interface, only SCPI protocol is supported, and CAN interface only supports CANopen protocol.

## 4.4.1 SCPI protocol

Standard Commands for Programmable Instruments Standard Commands for programmable Instruments SCPI is a standardized instrument programming language based on the existing standards IEEE488.1 and IEEE 488.2, and follows the floating-point arithmetic rules of IEEE754 standard, ISO646 information exchange 7-bit coded symbol (equivalent to ASCII programming) and other standards. It adopts a tree-like hierarchical command set, proposes a universal instrument model, and uses signal oriented measurement. Its mnemonic generation rules are simple, clear, and easy to remember.

Power commands are classified into two types: IEEE488.2 public commands and device-related SCPI commands.

IEEE 488.2 Common Commands define a number of control and query commands common to instrumentation. You can use public commands to perform basic operations on the power supply, such as reset and status query. All IEEE 488.2 public commands consist of "*" and three-letter mnemonics, such as: *RST, *IDN? , *ESE? Etc. SCPI commands are used to test, set, calibrate, and measure the power supply. This type of command is organized as a command tree. Each command can contain multiple mnemonics. Nodes of the command tree are separated by the character: (:), as shown in the following figure. The ROOT at the top of the command tree is called the root. The full path from root to leaf is a complete programming command.



For details of SCPI protocol, please refer to 《FTP9000 Programming Manual SCPI Edition》.

## 4.4.2 Modbus protocol

Modbus is a serial communication protocol published by Modicon (now Schneider Electric) in 1979 for communication using Programmable logic controllers (PLCS). Modbus has become the De facto standard for industrial communication protocols and is a common connection between industrial electronic devices. Modbus is a master/slave protocol. One node is a master node, and the other nodes that participate in communication using Modbus protocol are slave nodes. Each slave device has a unique address. Only the node designated as the master node can start a command.

A Modbus command contains the Modbus address of the device to be executed. All devices receive the command, but only the device at the specified address executes and responds to the instruction. (The exception is address 255, where the instruction at address 255 is a broadcast instruction, and all devices receiving the instruction run but do not respond to the instruction.) All Modbus commands contain a check code to determine that the arriving command is not broken. Basic Modbus commands can direct a device to change its register values, control or read an I/O port, and direct the device to send back data in one or more registers.

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**Notice**　　Regarding to ModBus protocol, FTP9000 series support RTU communication mode only.

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For details about the Modbus protocol, refer to 《FTP9000 Programming Manual Modbus Edition》.

## 4.4.3 CANopen protocol

CANopen is a kind of high-level communication protocol on Controller Area Network (CAN), including communication sub-protocol and equipment sub-protocol, and is a field bus commonly used in industrial control. CANopen implements protocols above the network layer (including the network layer) in the OSI model. The CANopen standard includes an addressing scheme, several small communication subprotocols, and an application layer defined by the device subprotocols. CANopen supports network management, device monitoring, and internode communication, including a simple transport layer that handles segmented transfer and combination of data. Generally speaking, the data link layer and physical layer will be implemented using CAN.

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**Notice**　　CANopen protocol is an optional protocol.

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
For details of CANopen protocol, please refer to 《FTP9000 Programming Manual CANopen Edition》.

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# 5. Troubleshooting

Follow the actions described in this chapter to inspect the instrument and troubleshoot the problem if the FTP9000 series DC Power Supply does not operate normally. Contact Faithtech authorized agent or Faithtech after-sales if the information provided in this manual does not resolve the problem.

**Table 5-1 Fault Check**

| Problem | Possible Cause | Solution |
|---|---|---|
| Measurement accuracy is not within SPEC. | Measurement swings due to aged components. | Do calibration. |
| Output accuracy is not within SPEC. | Output swings due to aged components. | Do calibration |
| PMF Fault | 1. The grid power supply is below the instrument requirement;<br>2. 2. PMF triggered by power failure | 1. Check whether the grid power supply is normal<br>2. 2. Neglectable if PMF triggered by power failure<br>3. Press [PROT -CLR] to clear protection state. |
| Overtemperature Protection (OTP1、OTP2) | 1. The ambient temperature is too high.<br>3. Bad ventilation.<br>4. Fan damaged. | 1. Operate the instrument within an ambient temperature of 0 - 40°C.<br>2. Ensure the instrument is well ventilated.<br>3. Contact Faithtech authorized agent or Faithtech after-sales.<br>4. Press [PROT -CLR] to clear protection state. |
| Overpower Protection (OPP, OP) | The output power exceeds the spec. or OPP settings. | 1. Decrease load or increase OPP setting.<br>2. Press [PROT -CLR] to clear protection state. |
| Overcurrent Protection (OCP, OC) | The output current exceeds the spec. or OCP settings. | 1. Decrease load or increase OCP setting.<br>2. Press [PROT -CLR] to clear protection state. |
| Overvoltage Protection (OVP, OV) | The output voltage exceeds the spec. or OVP settings. | 1. Decrease output voltage or increase OVP setting.<br>2. Press [PROT -CLR] to clear protection state. |

**Table 5-2 Power on Self-test Fault Check**

| Problem | Possible Cause | Solution |
|---|---|---|
| The PRI Fault... Error! | Internal communication error<br>Power module error | Contact Faithtech after-sale service |
| Test sample. Error! | Sampling data error | |
| Loading calibration data. Error! | Loading calibration data failure | |
| Loading parameters. Error! | Loading system para failure | |

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# 6. Appendix

**Table 6-1 Recommended Wire Diameters for Cables**

| Type | Cross-sectional area | Different temperature conditions | | | |
|---|---|---|---|---|---|
| | | 60℃ | 75℃ | 85℃ | 90℃ |
| AWG | mm² | Wire type: RUW, T, UF | Wire type: RHW, RH | Wire type: V, MI | Wire type: TA, TBS, SA, AV |
| | | Rated Current (A) | | | |
| 14 | 2.08 | 20 | 20 | 20 | 20 |
| 12 | 3.31 | 25 | 25 | 30 | 30 |
| 10 | 5.26 | 30 | 35 | 40 | 40 |
| 8 | 8.36 | 40 | 50 | 55 | 55 |
| 6 | 13.3 | 55 | 65 | 70 | 75 |
| 4 | 21.1 | 70 | 85 | 95 | 95 |
| 3 | 26.7 | 85 | 100 | 110 | 110 |
| 2 | 33.6 | 95 | 115 | 125 | 130 |
| 1 | 42.4 | 110 | 130 | 145 | 150 |
| 0 | 53.5 | 125 | 150 | 165 | 170 |
| 00 | 67.4 | 145 | 175 | 190 | 195 |
| 000 | 85 | 165 | 200 | 215 | 225 |
| 0000 | 107 | 195 | 230 | 250 | 260 |