TMN1APSU

Technical Manual

Issue 1.2

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HUAWEI TECHNOLOGIES CO., LTD.

About This Document

Purpose

This document describes the TMN1APSU power supply unit (PSU), including its features, electrical specifications, applications, and communication.

The figures provided in this document are for reference only.

Intended Audience

This document is intended for:

- Hardware engineers
- Software engineers
- System engineers
- Technical support engineers

Symbol Conventions

The symbols that may be found in this document are defined as follows.

Symbol	Description
DANGER	Indicates a hazard with a high level of risk which, if not avoided, will result in death or serious injury.
WARNING	Indicates a hazard with a medium level of risk which, if not avoided, could result in death or serious injury.
CAUTION	Indicates a hazard with a low level of risk which, if not avoided, could result in minor or moderate injury.
NOTICE	Indicates a potentially hazardous situation which, if not avoided, could result in equipment damage, data loss, performance deterioration, or unanticipated results. NOTICE is used to address practices not related to personal injury.
NOTE	Supplements the important information in the main text. NOTE is used to address information not related to personal injury, equipment damage, and environment deterioration.

Change History

Changes between document issues are cumulative. The latest document issue contains all updates made in previous issues.

Issue 1.2 (2020-11-16)

Updated **1 Product Overview**, **2.4 Efficiency**, **Output Protection**, **8 Mechanical Overview** and **A.3 EMC Requirements**.

Issue 1.1 (2020-07-29)

Updated **About This Document** , **1 Product Overview**, **2 Electrical Specifications**, **5 PSU Output Signal Definition**, **7.3.2 Commands**, **8.3 LED Indicator** and **A Safety**. Added **7.6 Detection Precision** and **7.7 Supplying Power to PSUs**.

Issue 1.0 (2019-11-11)

This issue is the first official release.

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1 Product Overview

The TMN1APSU converts AC power to DC power. The input range is 90–290 V AC or 190–290 V DC. The rated output is 53.5 V DC, and the rated output power is 3000 W.

It also supports I2C communication, current sharing, and 1+1 parallel connection, and it is hot swappable.

Features

- Efficiency: ≥ 95% (V_{in} = 230 V AC/270 V DC, 25°C, without fans and 3.3 V load)
- Depth x Width x Height: 132.0 mm x 91.0 mm x 81.5 mm (5.20 in. x 3.58 in. x 3.20 in.)
- Weight: ≤ 2.0 kg
- Power grid: 220 V AC single-phase, 110 V AC dual–live wire
- Input overvoltage and undervoltage protection, input overcurrent protection, output overvoltage protection, output overcurrent and short-circuit protection, overtemperature protection, input fault alarm, and output fault alarm
- I2C for control, programming and monitoring
- NRTL, TUV, CQC and CB
- Complies with IEC 60950-1, IEC 62368-1, EN 60950-1, EN 62368-1, UL 60950-1, UL 62368-1 and GB 4943.1.
- Complies with RoHS6.

Model Naming Convention

TM	N	1	A	PSU
1	2	3	4	5

1: Product line board code

2: Product family code

3: Board hardware version: power and function upgrade

4: AC

5: Board acronym

Applications

- Routers/Switches
- Servers/Storage equipment
- Telecommunications equipment
- Advanced workstations

2 Electrical Specifications

2.1 Environmental Specifications

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Ambient temperature (T_A)	–5	25	55	°C	–10°C to –5°C: The PSU can be started. –20°C to –10°C: The PSU can be started. No requirements are posed for performance specifications. –40°C to –20°C: The PSU is allowed to shut down.
Storage temperature	–40	25	85	°C	-
Relative humidity	5	-	95	% RH	Non-condensing
Altitude	–60	-	5000	m	1800–5000 m: the highest operating temperature reduces by 1°C for each additional 160 m.
Atmospheric pressure	54	-	106	Kpa	-

2.2 Input

Table 2-1 AC input

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Operating voltage	90	220	290	V	-
Rated voltage	100	220	240	V	-
Input frequency	45	50/60	65	Hz	-

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Power factor	0.95	-	1.00	-	V_{in} = 220/230 V AC (50 Hz), ≥ 20% load; V_{in} = 110 V AC (60 Hz), ≥ 40% load
THDi	-	-	10	%	THDi ≤ 10%; V_{in} = 220/230 V AC (50/60 Hz), 50%–100% load
Input current	-	-	16	A	V_{in} = 220 V AC; rated load
Input inrush current	-	-	50	A	The AC input inrush current is less than 50 A @ 290 V AC, T_A = 25°C. ETSI 300 132-3 compliant
Input system	-	-	-	-	Supports a 110 V AC dual-live wire or 220 V AC single-phase three-wire input.
Power conversion point	180	-	200	V	See the following figure. **Figure 2-1**
Input overcurrent and short circuit protection	-	-	-	-	The PSU is faulty, and the upstream C32 circuit breaker cannot trip.

Table 2-2 240 HVDC input

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Operating voltage	190	240	290	V	The PSU operation should not be affected if the L and N ports of the PSU and the input positive and negative terminals are reversely connected. Not support 336 V DC.
Input current	-	-	16	A	V_{in} = 240 V DC; rated load
Input inrush current	-	-	50	A	The inrush current of 240 HVDC input is less than 40 A@ 290 V DC, T_A = 25°C. ETSI 300 132-3 compliant
Power conversion point	-	-	-	V	See the following figure. **Figure 2-2**

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Input overcurrent and short circuit protection	-	-	-	-	The PSU is faulty, and the upstream C32 circuit breaker cannot trip.

NOTE

- The PSU can withstand an input voltage of 318 V AC for 48 hours (non-working state is acceptable).
- Before delivery, the 240 HVDC test must be performed on the PSU to ensure that it works properly at 240 V DC.

Figure 2-1 AC input power conversion points

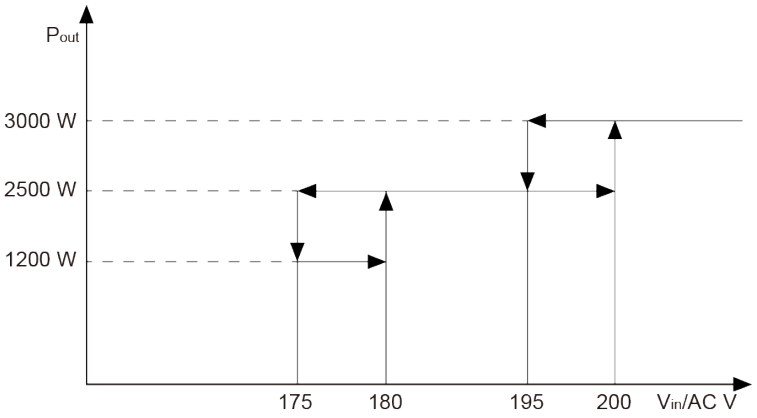
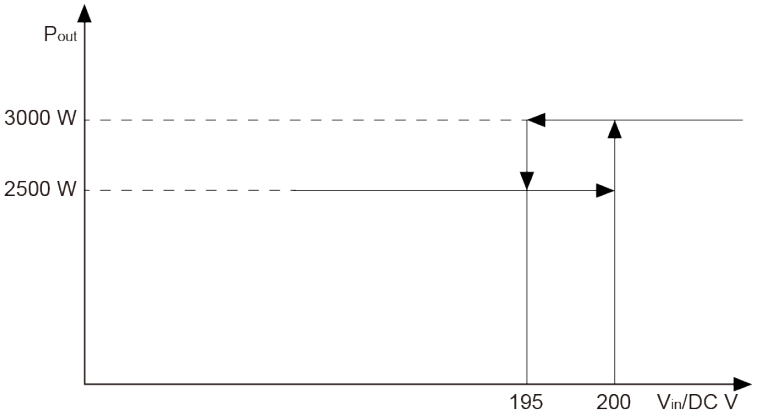


Figure 2-2 DC input power conversion points



2.3 Output

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Number of outputs	-	-	2	-	V_{out} = 53.5 V DC, I_{out} = 56 A V_{out} = 3.3 V DC, I_{out} = 1 A
Output power	-	-	3000	W	V_{in} = 200–290 V AC; V_{in} = 200–290 V DC; input voltage detection deviation: ±5 V
	-	-	2500	W	V_{in} = 180–200 V AC; V_{in} = 190–200 V DC; input voltage detection deviation: ±5 V
	-	-	1200	W	V_{in} = 90–180 V AC; input voltage detection deviation: ±5 V
Rated output voltage	53.2	53.5	53.8	V	T_A = 25°C; V_{in} = 220 V AC; I_{out} = 28 A
	3.0	3.3	3.6	V	T_A = 25°C; V_{in} = 220 V AC; I_{out} = 0–1 A
Output voltage range	51.89	53.50	55.10	V	Within the output current range
Output current	1.5	-	56.0	A	V_{in} = 200–290 V AC; V_{in} = 200–290 V DC; P_{out} < 3000 W
	1.5	-	46.0	A	V_{in} = 180–200 V AC; V_{in} = 190–200 V DC; P_{out} < 2500 W
	1.5	-	22.5	A	V_{in} = 90–180 V AC; P_{out} < 1200 W
53.5 V regulated voltage precision	–3	-	3	%	Full voltage, full load
Line regulation	–1	-	1	%	Rated current output
Load regulation	–2	-	2	%	Rated voltage input
Current share imbalance	–10	-	10	%	28–56 A load

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Overshoot at turn-on/ turn-off	–10	-	10	%	The system load voltage is 30 V. The maximum allowed voltage dip during startup is 2000 mV. (If the system subrack is used, the maximum power consumption is 800 W and the load voltage is 30 V when the system is started.)
Dynamic response overshoot	–10	-	10	%	• di/dt = 1 A/μs; response cycle: 4 ms; load: 25%–50%–25%; 50%–75%–50%; 75%–100%–75%; The output voltage overshoot does not exceed ±10%. Dynamic restoration time: 200 μs (max.) • di/dt = 0.1 A/μs; response cycle: 4 ms; load: 10%–90%–10%; The output voltage overshoot does not exceed ±10%. • Test with the minimum capacitive load 470 μF.
Temperature coefficient	–0.02	-	0.02	%/°C	Rated input voltage: 230 V AC/ 240 V DC
Capacitive load	470	-	2200	μF	Full voltage, full load, full temperature range
53.5 V output ripple and noise (peak to peak)	-	-	1500	mV	Oscilloscope bandwidth: 20 MHz; a 0.1 μF ceramic capacitor and a 10 μF ceramic capacitor connected to the output end in parallel
Current sharing bus voltage at full load	2.7	2.8	2.9	V	$V_{share} = \frac{3}{60} \times I_{out}$ V_{share}: current sharing bus voltage (unit: V) I_{out}: output current (unit: A) 3/60: coefficient of proportionality

2.4 Efficiency

Parameter	Load	Min.	Typ.	Max.	Unit	Notes & Conditions
Efficiency	50% load (1500 W)	95	-	-	%	V_{in} = 230 V AC/ 270 V DC, T_A = 25°C; without fan and 3.3 V load
Efficiency	50% load (600 W)	90	-	-	%	V_{in} = 115 V AC, T_A = 25°C; without fan and 3.3 V load

2.5 Protection

AC Input Protection

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Input overvoltage protection threshold	295	-	-	V	Self-recovery; hysteresis > 5 V
Input overvoltage recovery threshold	290	-	-	V	
Input undervoltage protection threshold	-	-	85	V	Self-recovery; hysteresis > 5 V
Input undervoltage recovery threshold	-	-	90	V	
Input overcurrent protection	-	-	-	-	Supports input overcurrent protection.
Input short circuit protection	-	-	-	-	Supports input short circuit protection.
PFC overvoltage protection	-	-	-	-	PFC overvoltage does not damage the bus capacitor (excluding damage caused by input overvoltage)

240 HVDC Input Protection

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Input overvoltage protection threshold	305	-	-	V	Self-recovery; hysteresis > 5 V

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Input overvoltage recovery threshold	290	-	-	V	
Input undervoltage protection threshold	-	-	185	V	Self-recovery; hysteresis > 5 V
Input undervoltage recovery threshold	-	-	190	V	
PFC overvoltage protection	-	-	-	-	PFC overvoltage does not damage the bus capacitor (excluding damage caused by input overvoltage)

Output Protection

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Output overvoltage protection threshold	56.5	-	60.0	V	Self-recovery
Output overcurrent protection threshold	107	-	130	%	High voltage range; self-recovery
Overtemperature protection	60	-	-	°C	-
Overtemperature protection fault recovery	-	-	-	-	Output recovers when the temperature of the internal components is lower than the overtemperature protection threshold. Hysteresis > 5°C.
Output undervoltage protection	-	-	44	V	Self-recovery

NOTE

1. After a fault protection action, the MCU and I2C inside the PSU should be able to work properly.
2. During output overload protection, it is not required to ensure output regulated voltage precision.

2.6 Insertion and Removal Requirements

During PSU hot swap, the PSU output voltage cannot exceed the PSU specifications. The minimum bus voltage cannot be lower than 42 V, and the maximum bus voltage cannot be higher than 60 V.

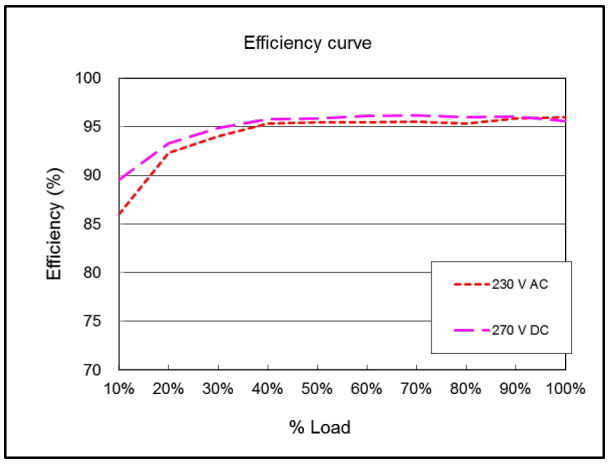
1. Insertion and removal when AC power is applied (The PSU does not work before the removal and insertion.)
   - AC removal: Disconnect the AC power supply from the PSU and remove the PSU from the system.
   - The PSU is working and removed from the system.
   - AC insertion: The PSU is inserted into the system without power applied. Then, power is applied after the insertion.
   - AC insertion: The PSU is inserted into the system with power applied.
2. The preceding four requirements and requirements in AC input and 240 HVDC input scenarios must be met.

2.7 Timing Requirements

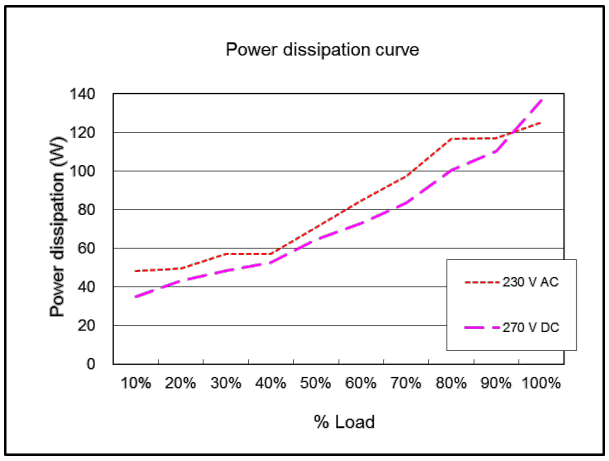
Mark	Description	Min.	Max.	Unit
Output power increasing time	Time for the output voltage to increase from 10% to 90%, full load	-	200	ms
Startup output delay	Full input/full load	-	5	s
Holding time	Time for the output voltage to drop to 42 V after the AC/DC source input powers off and the input voltage drops to 20 V. Test conditions: 220 V AC/240 V DC input and half load output.	5	-	ms

3 Characteristic Curves

Conditions: T_A = 25°C unless otherwise specified



Efficiency curve

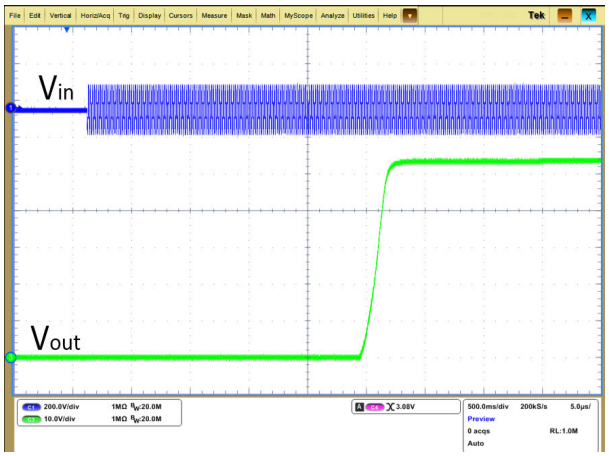


Power dissipation curve

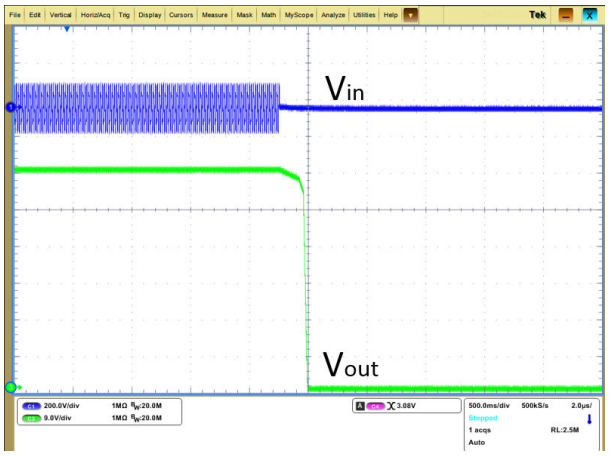
4 Typical Waveforms

4.1 Turn-on/Turn-off

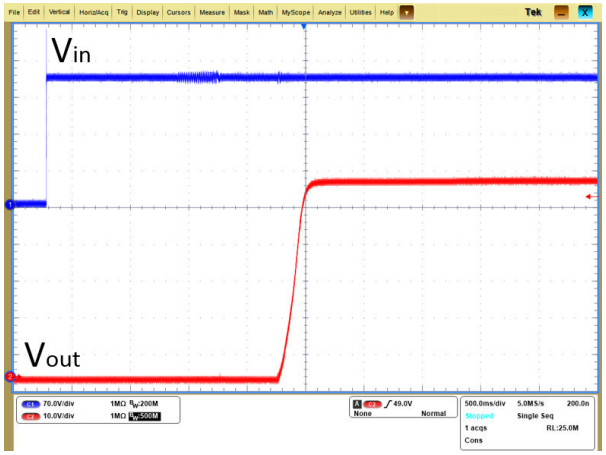
Conditions: T_A = 25°C unless otherwise specified



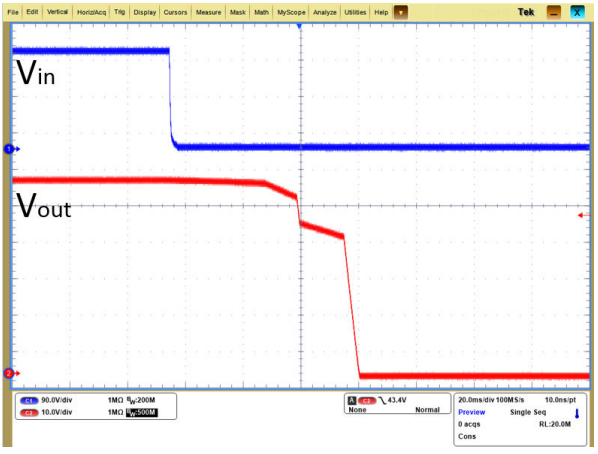
Startup by power-on
(V_{in} = 220 V AC, V_{out} = 53.5 V DC)



Shutdown by power-off
(V_{in} = 220 V AC, V_{out} = 53.5 V DC)



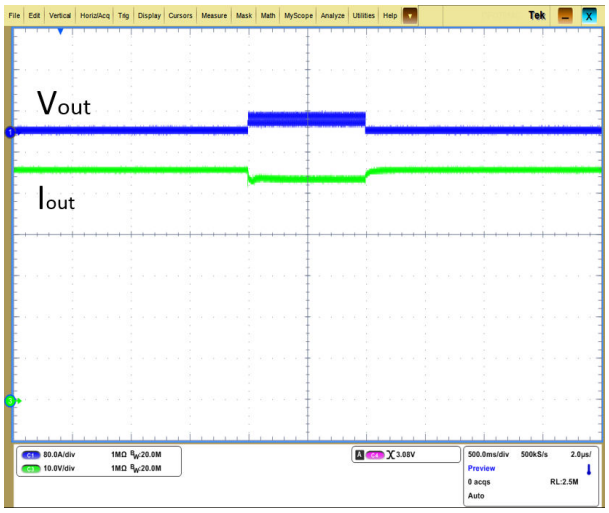
Startup by power-on
(V_{in} = 240 V DC, V_{out} = 53.5 V DC)



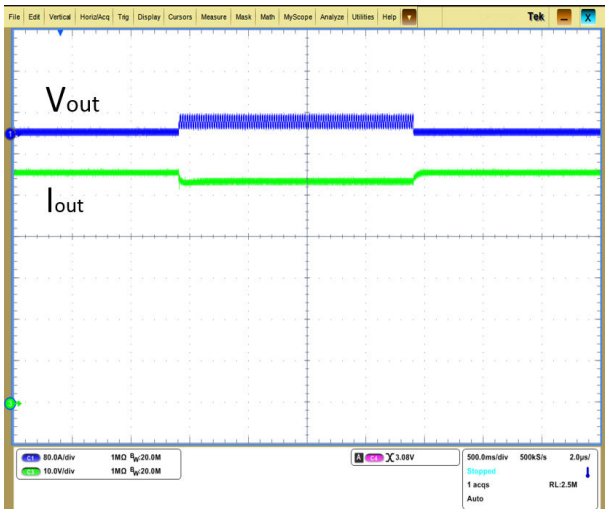
Shutdown by power-off
(V_{in} = 240 V DC, V_{out} = 53.5 V DC)

4.2 Output Voltage Dynamic Response

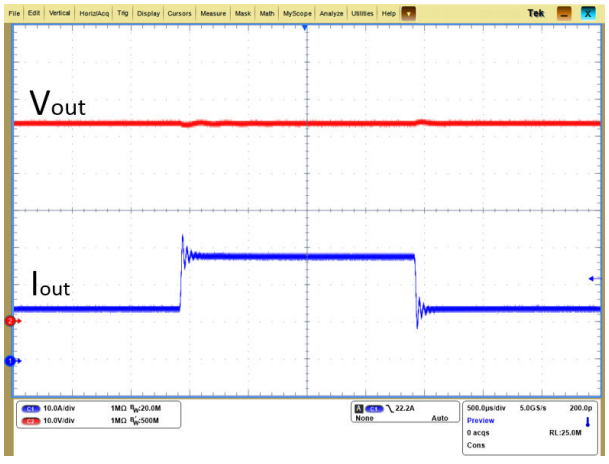
Conditions: T_A = 25°C unless otherwise specified



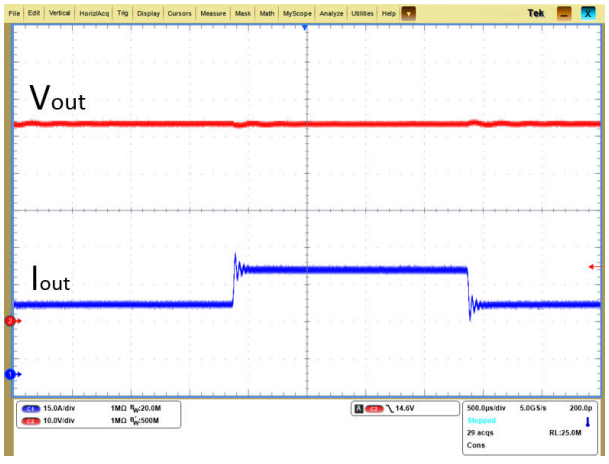
Output voltage dynamic response
(V_{in} = 220 V AC; load: 25%–50%–25%; 1 A/μs; T = 4 ms; V_{out} = 53.5 V DC)



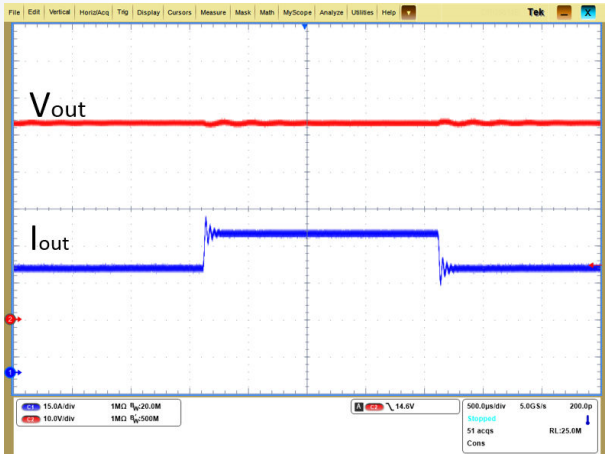
Output voltage dynamic response
(V_{in} = 220 V AC; load: 50%–75%–50%; 1 A/μs; T = 4 ms; V_{out} = 53.5 V DC)



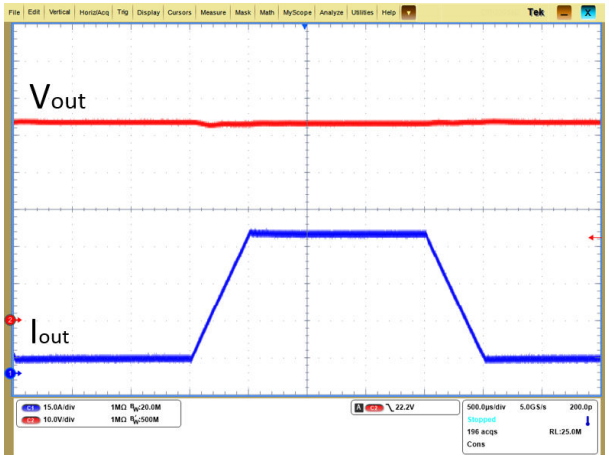
Output voltage dynamic response
(V_{in} = 240 V DC; load: 25%–50%–25%; 1 A/μs; T = 4 ms; V_{out} = 53.5 V DC)



Output voltage dynamic response
(V_{in} = 240 V DC; load: 50%–75%–50%; 1 A/μs; T = 4 ms; V_{out} = 53.5 V DC)



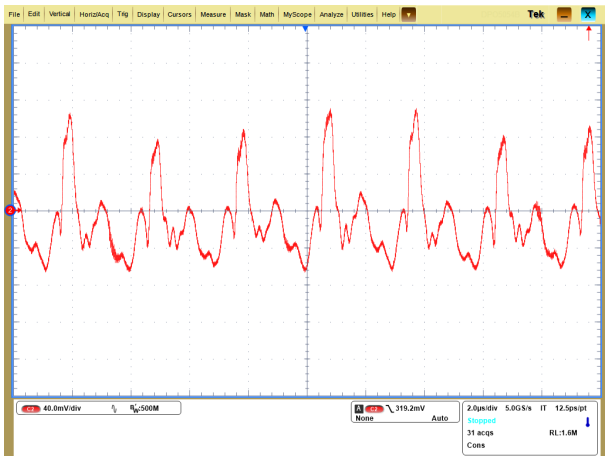
Output voltage dynamic response
(V_{in} = 240 V DC; load: 75%–100%–75%; 1 A/μs; T = 4 ms; V_{out} = 53.5 V DC)



Output voltage dynamic response
(V_{in} = 240 V DC; load: 10%–90%–10%; 0.1 A/μs; T = 4 ms; V_{out} = 53.5 V DC)

4.3 Output Voltage Ripple

Conditions: T_A = 25°C unless otherwise specified



Output voltage ripple
(V_{in} = 240 V DC, V_{out} = 53.5 V DC)

5 PSU Output Signal Definition

Current Share

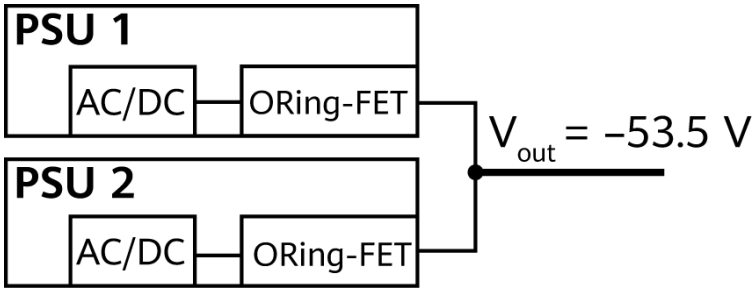
- Supports 1+1 standby mode.
- The total load at startup in parallel operation scenarios is less than the rated load of a single PSU.
- The current share signals of two PSUs are directly connected, which does not affect the normal working and current share of the PSUs.

5.1 RTN and –53.5 V

Table 5-1 RTN and –53.5 V signals

PSU Side	System Side
Add an ORing-FET failure isolation circuit inside PSU output. In actual application, adopt 1+1 standby mode. If an internal fault occurs in one of the PSUs, the PSU should automatically exit to avoid bus abnormality. The following figure is for reference. **Figure 5-1**	Capacitive load < 2200 μF

Figure 5-1 ORing-FET circuit

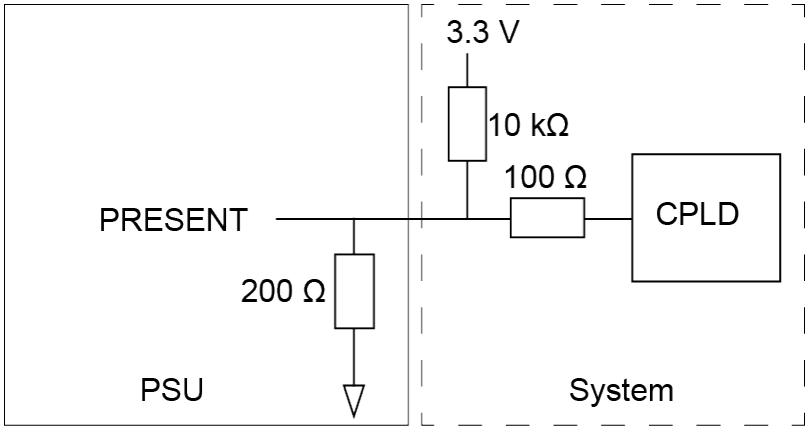


5.2 PRESENT (GND)

The PRESENT signal is used to detect whether a PSU is present. The pins are required to be shorter than other pins on the PSU. The PSU is grounded internally. (Connected to the system ground) The signal processing mode is as follows.

PSU Side	System Side
Grounded internally	The pull-up voltage is 3.3 V. The reference value for the pull-up resistor is 4.7–10 kilohms. Then the signal is sent to CPLD over series resistors.

Figure 5-2 PRESENT circuit



5.3 PG (GND)

The PG signal indicates whether the main output is normal. The high level indicates that the main output is normal, and the low level indicates that the main output is abnormal.

PSU Side	System Side
The signal is output over the drive circuit and pulled up to the auxiliary power supply 3.3 V inside the PSU. The reference value for the pull-up resistor is 1000 ohms.	The signal is pulled down to GND by a 100-kilohm (reference value) resistor and connected to the system CPLD over a 100-ohm (reference value) resistor.

Figure 5-3 PG circuit

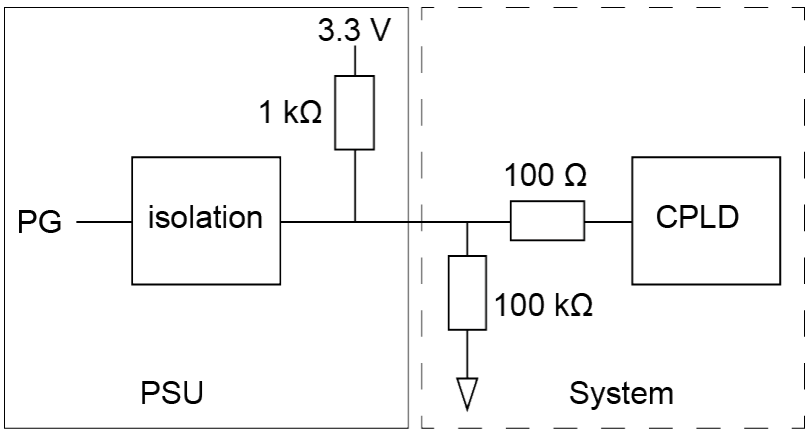


Table 5-2 PG signal characteristics

PG Signal Characteristics	
PG = High	Output is normal.
PG = Low	The output is abnormal and the output voltage is not lower than 39 V. Output short circuit and output undervoltage faults are excluded.

Table 5-3 PG output

PG Output	Min.	Max.
Low level voltage	0 V	0.5 V
High level voltage	2.5 V	3.6 V
Sink current, PG = Low	0.1 mA	-
Source current, PG = High	2 mA	-

5.4 Share+（–53.5 V）

The Share+ signal is a current sharing signal. The signals are connected together on the system backplane.

- Supports 1+1 standby modes.
- The current sharing imbalance is ±10% (28–56 A).
- Supports the average current sharing method; 3 V/60 A; The signals are connected together on the system backplane.

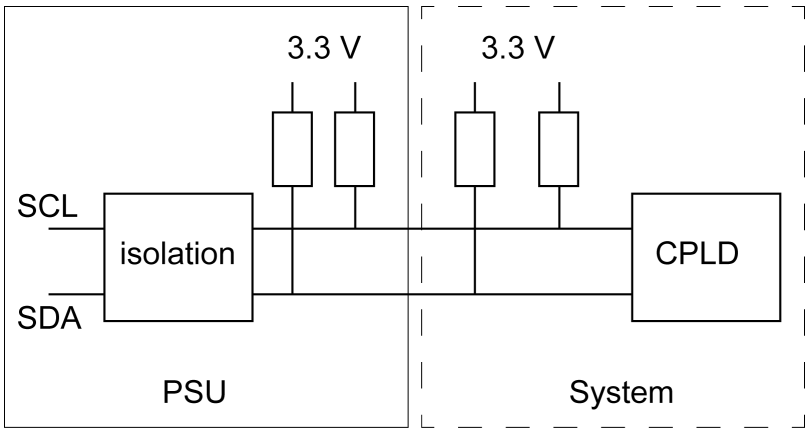
PSU Side	System Side
Internal current sharing bus	The Share+ signals of all PSUs are connected together on the backplane.

5.5 SCL and SDA (GND)

The I2C serial clock signal (SCL) and serial data signal (SDA) occupy two signal pins of the output connector. Related protocols meet the requirements in chapter 7.

PSU Side	System Side
• PSU internal connection: The SCL and SDA must be pulled up to 3.3 V by a 3-kilohm to 10-kilohm (reference value) resistor. • The capacitance of the SCL and SDA in the PSU cannot exceed 66 pF.	Pulled up to 3.3 V. Equivalent pull-up resistor: 3–10 kilohms

Figure 5-4 SCL and SDA circuit



5.6 PSKILL (–53.5 V)

The PSKILL signal indicates whether the PSU is powered on. The low level indicates that the PSU is powered on, and the high level indicates PSU is powered off. The pins are required to be shorter than other pins on the PSU. The signal is pulled up internally in the PSU and is connected to –53.5 V at the system side.

PSU Side	System Side
PSU internal connection: The PSKILL must be pulled up to 3.3 V by a 3-kilohm to 10-kilohm (reference value) resistor.	This signal is connected to –53.5 V through a 300-ohm resistor (reference value).

Figure 5-5 PSKILL circuit

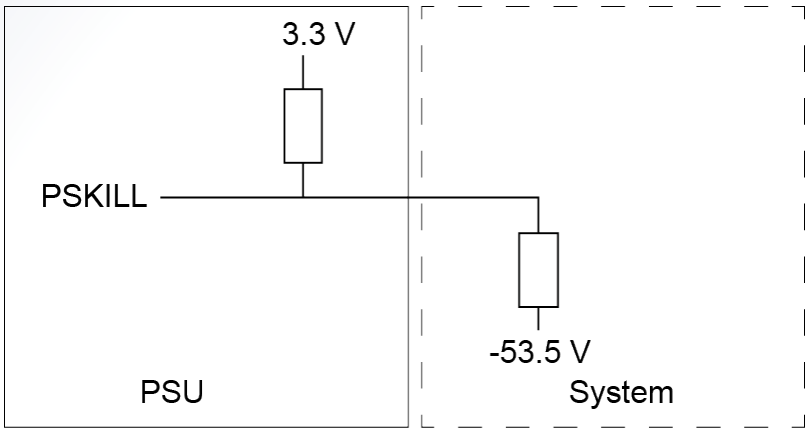


Table 5-4 PSKILL signal type

PSKILL Signal Type	PSU Status
PSKILL = low impedance	On
PSKILL = open	Off (not connected to the system)

Table 5-5 PSKILL output time

PSKILL Output Time	Min.	Max.
Signal rise and fall time	-	300 µs

5.7 3.3 V

This signal is used by the fan board. 3.3 V/1 A (3.0–3.6 V) (on the same side as system ground): The main control board uses I2C to control 3.3 V power system to cut off. After 3.3 V power system is cut off, the automatic restart time of it is no less than 1s. After the 3.3 V power system is cut off, the communication between the PSU and the main control board is abnormal. The PSU must be able to detect whether the 3.3 V power system is faulty. If the communication between the PSU and the I2C is abnormal, faults of the 3.3 V power system are not reported. The PSU supplies power by default after the first power-on and carries loads after the output is normal.

The control board and service board of the PSU support fast overcurrent protection. When a short circuit occurs, the PSU will trigger protection.

Figure 5-6 3.3 V circuit

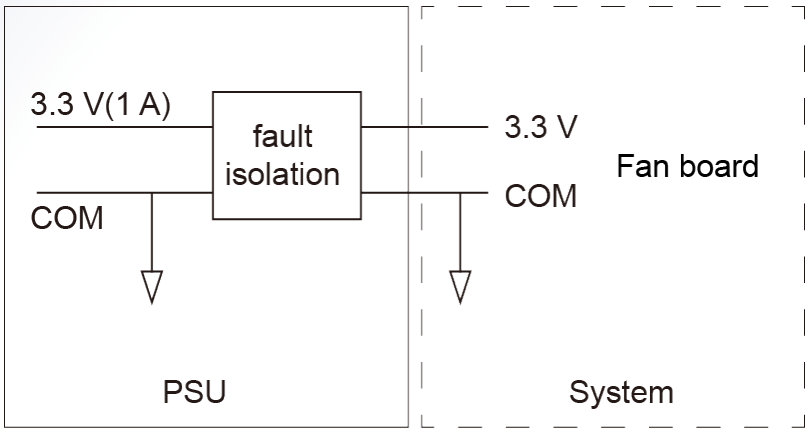


Table 5-6 3.3 V output

3.3 V Output	Min.	Max.
3.3 V voltage range	3.0 V	3.6 V
Load current	-	1000 mA

6 Heat Dissipation Requirements and Fan Control

The PSU is installed with fans for forced air cooling. Air flows in from the rear and exhausts from the front. (The output connector is at the rear, and the input connector is at the front.) The fan in the PSU is 40 mm wide and 40 mm high.

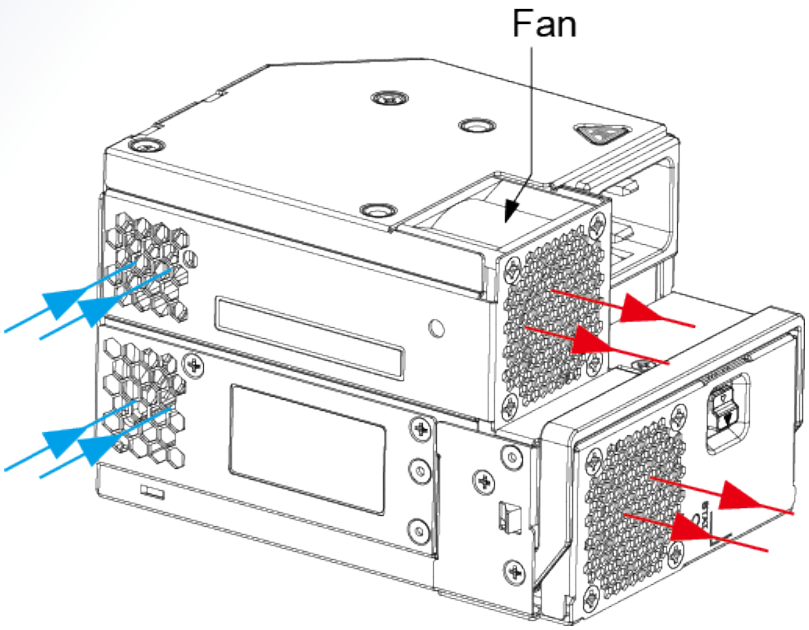
PSU Noise Requirements

Inlet Temperature	Maximum Noise	Description
55°C	68 dBA	Rated input voltage: 230 V AC/240 V DC, 1200 W; complies with ISO 7779.

Fan Protection Features

- If PSUs are connected in parallel and one of the fans or the power supply circuit is short-circuited or open-circuited, the system busbar voltage cannot exceed the normal dynamic change voltage restriction specifications. The normal running of the system cannot be affected.
- The fan fault detection circuit can report a fault only when it detects a fan or fan circuit fault and the fault lasts for over 30s. (Note: Long-time fan operation ages the internal bearing, which prolongs fan startup time. The fan is considered to be faulty only when it does not reach the specified rotational speed after more than 30s.) The fan fault can be rectified.
- The fan speed adjustment curve is designed based on the hardware requirements. When the power supply is reversed, the fan stops working. (The PSU has an independent air channel, and the fan does not dissipate heat for the system.) Before overtemperature protection is triggered, fans must run at full speed.

Figure 6-1 Air channel



7 Communications Protocol

7.1 Data Link Layer Protocol

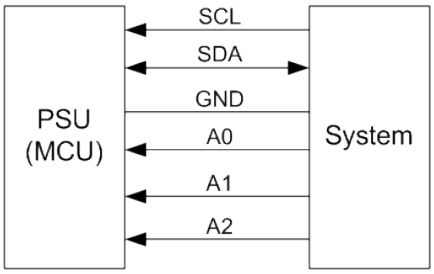
The link layer uses the PMBus V1.2 protocol and complies with *PMBus_Specification_Part_I_Rev_1-2_20100906* and *PMBus_Specification_Part_II_Rev_1-2_20100906*.

7.1.1 I2C Signal

The PSU includes a main control unit (MCU) used for monitoring, and a 256-byte internal EEPROM used for storing fault records. The PSU can use the internal EEPROM in the MCU to store fault records. The system sends commands to the MCU over the I2C bus to read fault records from the PSU.

Figure 7-1 shows the I2C interface communication diagram.

Figure 7-1 I2C interface



7.1.2 I2C Address

Addresses A2, A1, and A0 are allocated to a PSU. The I2C address of the PSU from high to low is A2, A1, and A0. See Table 7-1 for details.

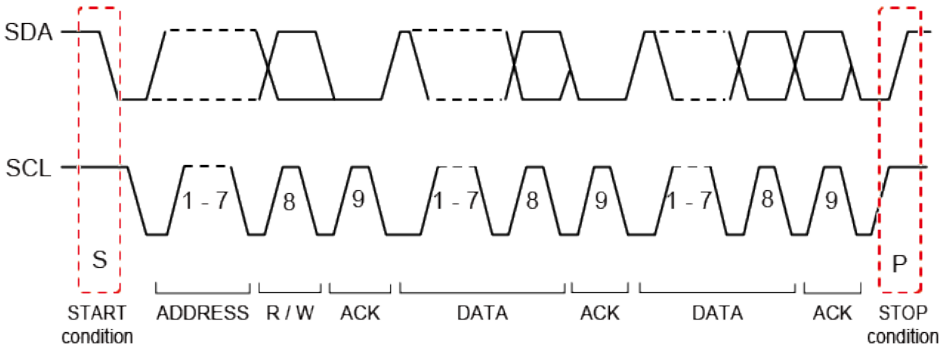
Table 7-1 I2C address

PSU A2/A1/A0	0/0/0	0/0/1	0/1/0	0/1/1	1/0/0	1/0/1	1/1/0	1/1/1
MCU	0xB0	0xB2	0xB4	0xB6	0xB8	0xBA	0xBC	0xBE

7.1.3 Data Transmission Mode

The I2C transmission standard is used. The default clock frequency allowed by the I2C is 100 kHz. The timing definition of lower-layer signals, such as START, STOP, R/W, ADDRESS, ACK/NACK, bus arbitration, clock synchronization, and clock extension (except bus timeout) complies with PSMI. Figure 7-2 shows the I2C data transmission mode.

Figure 7-2 I2C data transmission mode



7.1.4 I2C Bus Timeout

The I2C program of the PSU is reset to 0 if the PSU detects that the SCL or SDA data line is held low for more than 300 ms.

7.2 Network Layer Protocol

7.2.1 Slave Addressing Method

The PSU serves as the slave device, and the PSU address is identified by the hardware and assigned in static mode. The master device accesses slave devices independently based on the slave device addresses determined by the hardware.

7.2.2 Checksum

To ensure data integrity and accuracy during communication, the PSU uses the 8-bit CRC checksum mechanism.

The last byte sent for each communication is the CRC checksum for the communication data. For example, the last byte of the data returned by the PSU is the checksum.

The CRC checksum is generated using the multinomial: CRC8.

7.2.3 Data Transmission

The PSU complies with standard PMBus communication data formats. The data in each PMBus communication data format carries the CRC checksum.

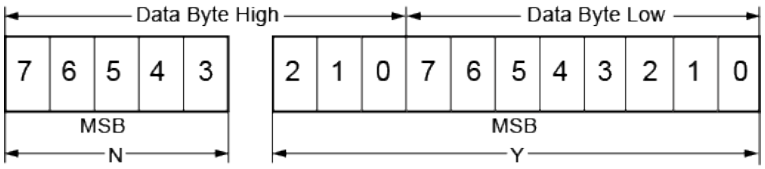
7.3 Application Layer Protocol

7.3.1 Data Format

Linear 11 Data Format

The linear data format consists of two parts, with an 11-bit binary signed mantissa (two's complement) and a 5-bit binary signed exponent (two's complement), as shown in the following figure.

Figure 7-3 Linear 11 data format



The relationship between N, Y, and actual value X is given by the following equation:

$$X = Y \times 2^{N}$$

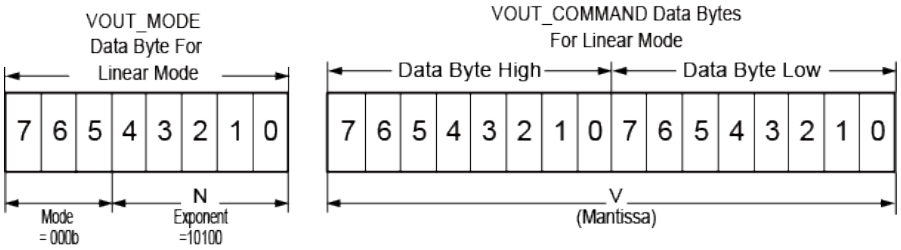
Where:

- Y is the 11-bit, binary signed mantissa (two's complement).
- N is the 5-bit, binary signed exponent (two's complement).

Linear 16 Data Format

The linear data format consists of two parts, with an 16-bit binary unsigned mantissa and a 5-bit binary signed exponent (two's complement), as shown in the following figure.

Figure 7-4 Linear 16 data format



The output voltage is calculated as follows:

$$Voltage = V \times 2^{N}$$

Where:

- Voltage is the output voltage value.
- V is the 16-bit unsigned integer.
- N is the 5-bit signed integer (two's complement).

7.3.2 Commands

Table 7-2 PMBus commands

Hex Code	Command Name	Data Type	Data Format
0x20	PMBUS_CMD_VOUT_MODE	Read Byte	HEX
0x31	PMBUS_CMD_RATED_POUT	Read Word	Linear 11
0x79	PMBUS_CMD_STATUS_WORD	Read Word	HEX
0x7A	PMBUS_CMD_STATUS_VOUT	Read Byte	HEX
0x7B	PMBUS_CMD_STATUS_IOUT	Read Byte	HEX
0x7C	PMBUS_CMD_STATUS_INPUT	Read Byte	HEX
0x7D	PMBUS_CMD_STATUS_TEMP	Read Byte	HEX
0x7F	PMBUS_CMD_STATUS_OTHER	Read Byte	HEX
0x81	PMBUS_CMD_STATUS_FANS	Read Byte	HEX
0x83	PMBUS_CMD_SET_SYS_3V3_RESTART	Read/Write Byte	HEX
0x88	PMBUS_CMD_READ_VIN	Read Word	Linear 11
0x8B	PMBUS_CMD_READ_VOUT	Read Word	Linear 16
0x8C	PMBUS_CMD_READ_IOUT	Read Word	Linear 11
0x8D	PMBUS_CMD_READ_TEMPERATURE_1	Read Word	Linear 11
0x96	PMBUS_CMD_READ_POUT	Read Word	Linear 11
0x97	PMBUS_CMD_READ_PIN	Read Word	Linear 11
0x98	PMBUS_CMD_READ_PMBUS_VER	Read Byte	HEX
0x9B	PMBUS_CMD_HARD_VERSION	Read Byte	HEX
0xCA	PMBUS_CMD_SET_SYS_3V3_EN	Read/Write Byte	HEX
0xD6	PMBUS_CMD_LED_CTRL	Read/Write Byte	HEX
0xDF	PMBUS_CMD_READ_INPUT_TYPE	Read Byte	HEX
0xEA	PMBUS_CMD_WRITE_EVENT_INDEX	Read/Write Word	HEX

Hex Code	Command Name	Data Type	Data Format
0xEB	PMBUS_CMD_READ_EVENT_LOG	Read Block	HEX
0xEC	PMBUS_CMD_UPDATE_TIME	Read/Write Block	HEX
0xEE	PMBUS_CMD_READ_BBOXLEN	Read Word	HEX
0xEF	PMBUS_CMD_READ_BBOX_FRAME_NUM	Read Word	HEX
0xF1	PMBUS_CMD_SET_MODULE_ID	Read/Write Word	HEX
0xF2	PMBUS_CMD_READ_MODULE_ID_VER	Read Word	HEX
0xF3	PMBUS_CMD_DCDC_SOFT_VER	Read Word	HEX
0xF7	PMBUS_CMD_PFC_SOFT_VER	Read Word	HEX
0xFB	PMBUS_CMD_LOAD_PARAM	Read Block	HEX
0xFC	PMBUS_CMD_LOAD_START	Read/Write Word	HEX
0xFD	PMBUS_CMD_LOAD_DATA	Write Block	HEX

7.3.3 Command Descriptions

STATUS_WORD (0x79)

Status word

Bit No.	Protocol	Description
Bit 15	VOUT	Output voltage fault; 0: normal, 1: faulty
Bit 14	IOUT/POUT	Output current or power fault; 0: normal, 1: faulty
Bit 13	INPUT	Input fault; 0: normal, 1: faulty
Bit 12	Reserved, default value: 0	Reserved
Bit 11	POWER_GOOD	Output fault; 0: normal, 1: faulty This fault is reported when the PSU has no output.
Bit 10	FANS	Fan fault; 0: normal, 1: faulty
Bit 9	SYSOUT_3.3V	3.3 V output fault; 0: normal, 1: faulty

Bit No.	Protocol	Description
Bit 6–Bit 8	Reserved, default value: 0	Reserved
Bit 5	VOUT_OV	Output overvoltage; 0: normal, 1: faulty
Bit 4	IOUT_OC	Output overcurrent; 0: normal, 1: faulty
Bit 3	VIN_UV	Input undervoltage; 0: normal, 1: faulty
Bit 2	TEMPERATURE	Temperature fault; 0: normal; 1: faulty
Bit 0–Bit 1	Reserved, default value: 0	Reserved

STATUS_VOUT (0x7A)

Output voltage status

Bit No.	Protocol	Description
Bit 7	OV_FAULT	Output overvoltage protection; 0: normal, 1: faulty
Bit 5–Bit 6	Reserved, default value: 0	Reserved
Bit 4	UV_FAULT	Output undervoltage
Bit 0–Bit 3	Reserved, default value: 0	Reserved

STATUS_IOUT (0x7B)

Output current status

Bit No.	Protocol	Description
Bit 7	OC_FAULT	Output overcurrent; 0: normal, 1: faulty
Bit 2–Bit 6	Reserved, default value: 0	Reserved
Bit 0–Bit 1	Reserved, default value: 0	-

STATUS_INPUT (0x7C)

Input status

Bit No.	Protocol	Description
Bit 7	OV_FAULT	Output overvoltage; 0: normal, 1: faulty
Bit 5–Bit 6	Reserved, default value: 0	-
Bit 4	UV_FAULT	Input undervoltage; 0: normal, 1: faulty
Bit 3	Unit Off For Low Input Voltage	Input power failure; 0: normal, 1: faulty
Bit 0–Bit 2	Reserved, default value: 0	Reserved

STATUS_TEMPERATURE (0x7D)

Temperature status

Bit No.	Protocol	Description
Bit 7	OV_FAULT	Overtemperature fault; 0: normal, 1: faulty
Bit 0–Bit 6	Reserved, default value: 0	Reserved

STATUS_OTHER (0x7F)

Other status

Bit No.	Protocol	Description
Bit 1–Bit 7	NA	Reserved
Bit 0	SYSOUT_3.3V_FAULT	3.3 V output fault; 0: normal, 1: faulty

STATUS_FANS_1_2 (0x81)

Fan status

Bit No.	Protocol	Description
Bit 7	Fan Fault	Fan fault; 0: normal, 1: faulty
Bit 0–Bit 6	Reserved, default value: 0	Reserved

PMBUS_CMD_VOUT_MODE (0x20)

Format for reporting output voltage

- Reserved function: The data related to the output voltage is in the Linear16 or exp=–9 format.
- The report format is the same as that of 8B.

PMBUS_CMD_SET_SYS_3V3_EN (0xCA)

Enable or disable the 3.3 V output.

- 0x55: enable the 3.3 V output. 0xAA: disable the 3.3 V output
- This command is used with the restart command (0x83) of the 3.3 V output

PMBUS_CMD_SET_SYS_3V3_RESTART (0x83)

- 0x5A: restart the 3.3 V output.
- This command is valid only when the 3.3 V output restart command is enabled.
- After the setting takes effect, wait at least 1s for the PSU to automatically clear the enable and restart commands.
- The system delivers this command in special cases to disable the 3.3 V output and power off the EE on the main control board to deal with the EE suspension.
- During the restart, the I2C is disconnected for a short period of time. During this period, the system cannot be accessed.

PMBUS_CMD_READ_MODULE_ID_VER (0xF2)

Read the version number of the software ID.

- 0x0100 indicates version 1.00.
- When the software is being loaded, the corresponding version number is reported as 0xFFFF.
- If the software does not exist, the corresponding version number is reported as 0.
- When there is no input, 0 is reported for non-80 software.
- When the 80 software is being loaded, 0 is reported for other software.

7.4 Online Upgrade

Both the primary and secondary sides of the PSU support online upgrade.

7.5 Black Box Function

The PSU has 80-byte space for storing fault logs. The PSU provides a read channel for external systems by the Read Event Log command.

7.5.1 Runtime Counter

The PSU needs to calculate the total runtime. The total runtime is the sum of the time when the PSU works properly (PG# is normal), is presented in the unit of seconds, and occupies four bytes.

7.5.2 Event Log

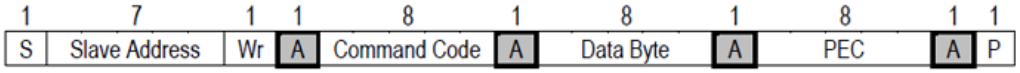
The PSU maintains a circular event log of the last ten records. Before saving the event log, the PSU shall set the event update flag in the event log to 1. Each event shall start with an event number followed by a 4-byte runtime (measured in minutes). The total runtime must be updated before the log is saved.

The black box only records fault alarms, which include input power failure, input undervoltage, and input overvoltage. Fan alarm, shutdown/reset by command, failure to communicate with the upstream device, communication fault of the original secondary side, ambient overtemperature, PFC shutdown, primary side overtemperature, secondary synchronous MOSs overtemperature, combination circuit overtemperature, output overvoltage, output undervoltage, output overcurrent or short circuit, EE fault, and output fault. If a new fault is the same as the latest record in the event log, this fault will not be stored. That is, two consecutive same faults cannot exist in the fault record.

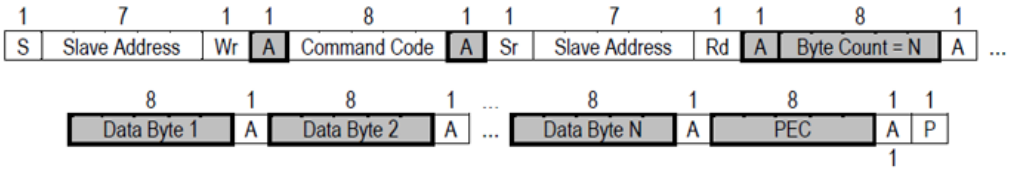
A generated event is saved only when it is different from the last event record. The runtime counter shall be updated every time an event occurs regardless of whether the event is written into the event log. When there are more than 10 events, the 11 event shall overwrite the 1st event, the 12 event shall overwrite the 2nd event, and so on.

7.5.3 Format of Reading Logs

- Write Byte Index (0–10)



- Read Block (N = 40)



7.6 Detection Precision

Table 7-3 I2C detection precision

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Input power detection and reporting	–5	-	5	% W	Load: 1500 W or above; tested under normal temperature with rated input load. When a fault occurs, the input power is reported as 0.
	–10	-	10	% W	Load: 301–1500 W; tested under normal temperature with rated input load. When a fault occurs, the input power is reported as 0.

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
	-	-	-	% W	This detection item is not required for load that is lower than 300 W. Tested under normal temperature with rated input load. When a fault occurs, the input power is reported as 0.
Output power detection and reporting	–5	-	5	% W	Load: 1500 W or above; This detection requirement must be met.
	–10	-	10	% W	Load: 301–1500 W; This detection requirement must be met in various input and output voltages within the specifications.
	-	-	-	% W	This detection item is not required for load that is lower than 300 W. This detection requirement must be met in various input and output voltages within the specifications.
PSU output voltage detection and reporting	–1	-	1	V	-
Output current detection	–1	-	1	A	Load: 50% or higher; If the output current is less than 0.2 A, 0.2 A is reported.
	–2	-	2	A	Load: 10%–50%; If the output current is less than 0.2 A, 0.2 A is reported.
	-	-	-	A	This detection item is not required when the load is less than 10%. The test is performed in various input and output voltages within the specifications. If the output current is less than 0.2 A, 0.2 A is reported.
AC input voltage detection	–5	-	5	V	V_{in}=85–300 V AC
DC input voltage detection	–5	-	5	V	V_{in}=190–290 V DC
Temperature monitoring	–5	-	5	°C	-

7.7 Supplying Power to PSUs

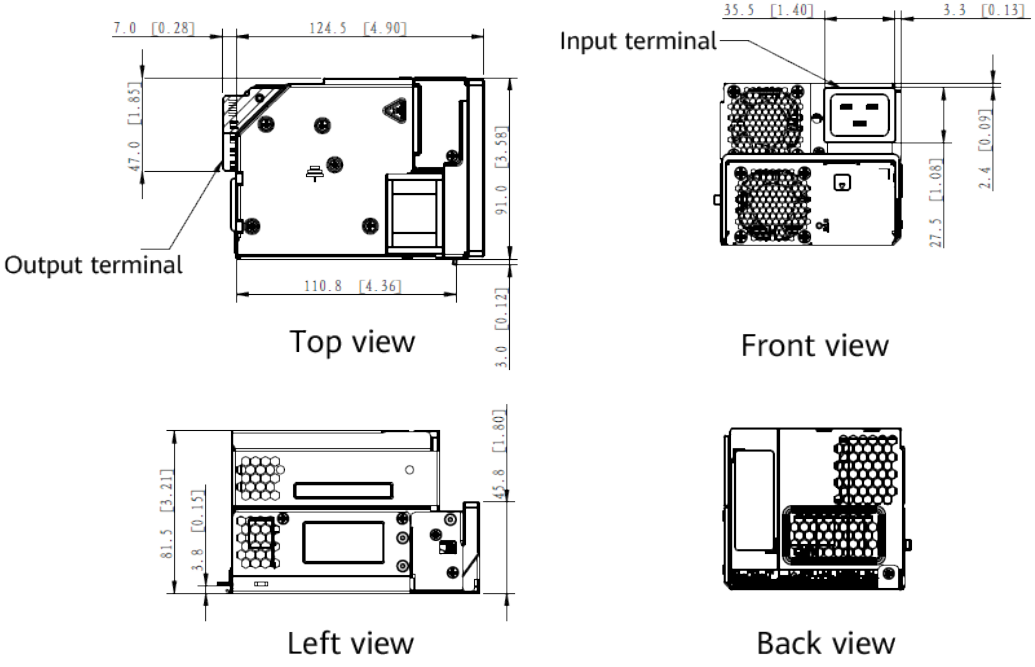
When PSUs are connected in parallel, if one of the PSUs has no input, the system is able to communicate with it properly. Supplying power to PSUs is supported.

8 Mechanical Overview

8.1 Dimensions

Unit of measurement: mm (in.)

Dimensions (D x W x H): 132.0 mm x 91.0 mm x 81.5 mm (5.20 in. x 3.58 in. x 3.20 in.)



8.2 Output Connector

Figure 8-1 Output connector (bottom view)

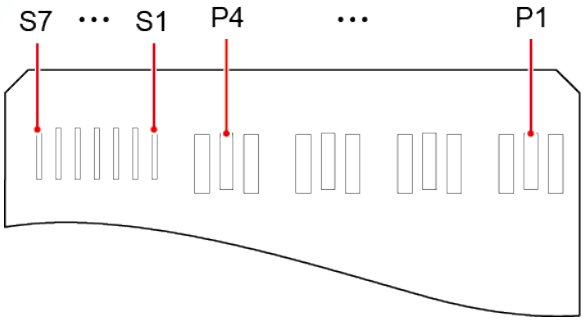


Figure 8-2 Output connector (top view)

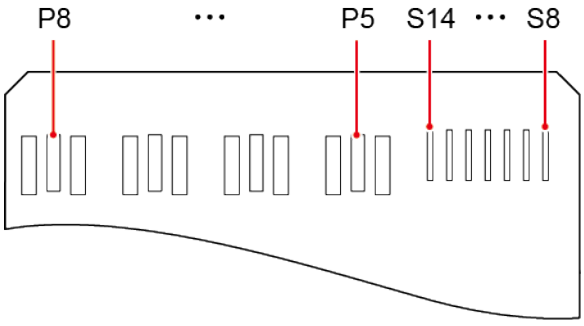


Table 8-1 Output connector pin definitions

Pin	Name	Description
P1–P2, P7–P8	RTN	Power+
P3–P6	–48 V	Power–
S14	PSKILL	AC Turn On/Off Signal
S13	Share+	Current sharing signal between PSUs
S12	NA	NA
S11	NA	NA
S10	GND	System ground
S9	SCL	I2C Clock
S8, S7	3.3 V	Power supply of the system fan monitoring device

Pin	Name	Description
S6	SDA	I2C Data
S5	GND	System ground
S4	PRESENT	PSU presence signal
S3	PG	This signal indicates whether the main output is normal. The high level indicates that the main output is normal, and the low level indicates that the main output is abnormal.
S2	NA	NA
S1	NA	NA

8.3 LED Indicator

Table 8-2 LED Indicator

Indicator	Color	Status	Description
Power status indicator	Green	Steady on	Both the input power supply and the active and output are normal.
		Blinking green at 4 Hz	Online upgrade is in progress.
		Blinking green at 1 Hz	There is input but no output. No other alarms are generated. The PSKILL is not grounded.
	Red	Steady on	There is no output due to input undervoltage/ overvoltage, overtemperature protection, output overcurrent/short circuit, output overvoltage, short circuit protection, and component failures (excluding the failures of all components). The external 3.3 V system is faulty. The indicator is steady on during short circuit, overcurrent, and fan fault.
	-	Off	There is no AC/DC input.
			There is input but no output. No other alarms are generated.

Indicator	Color	Status	Description
	Orange	Blinking	Maintenance indicator. After receiving a control command from the system control board, the PSU forcibly enables all external indicators to blink orange (on for 500 ms and off for 500 ms). The priority of this indicator is higher than other indicator-blinking rules. The indicators become normal after the command from the system control board is canceled.

NOTE

1. For normal startup, the green indicator should be on and should not blink. For normal power-off, the power indicator should be off and should not be steady red or blinking red.
2. The position of the LED indicator should meet the ESD requirements.
3. The indicator uses the Φ3 mm bi-color indicator.

A Safety

A.1 Reliability Requirements

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Mean time between failures (MTBF)	-	250,000	-	Hours	Telcordia SR332; rated input (10 V AC/220 V AC/ 240 V DC), 80% load; T_A = 25°C

A.2 Safety Requirements

Dielectric Strength Testing

Test Item	Safety Requirements
Insulation resistance	≥ 10 megohms; V_{in} = 500 V DC; relative humidity < 90%, non-condensing, normal atmospheric pressure
Leakage current (single PSU)	≤ 3.5 mA (V_{in} = 264 V AC/60 Hz)
PE input and enclosure	< 0.1 ohm; measured current = 64 A; voltage drop < 12 V
Input and PE	V_{in} = 2121 V DC; 1 minute; leakage current ≤ 10 mA; no breakdown or arcing
	V_{in} = 1500 V AC; 1 minute; leakage current ≤ 10 mA; no breakdown or arcing
Input and output	V_{in} = 4242 V DC; 1 minute; leakage current ≤ 10 mA; no breakdown or arcing
Output and PE	V_{in} = 1000 V DC; 1 minute; leakage current ≤ 10 mA; no breakdown or arcing

A.3 EMC Requirements

Parameter	Conditions	Criterion
Conducted emission (CE)	3.3 dB margin when used with the system	EN 55032
Radiated emission (RE)	4 dB margin when used with the system	EN 55032
Surge	Differential mode: L-N ±2 kV (1.2/50 µs, 2 ohms) Common mode: L-PE; N-PE; L\N-PE ±4 kV (1.2/50 µs, 12 ohms)	IEC 61000-4-5, criterion B
Electrical fast transient	±2 kV, 5 kHz	IEC 61000-4-4, criterion B
Dip (AC 230 V) (Works in the 1+1 standby mode)	Dip to 0% UT, hold-up time: 10 ms	IEC 61000-4-11, criterion A
	Dip to 0% UT, hold-up time: 20 ms	IEC 61000-4-11, criterion A
	Dip to 70% UT, hold-up time: 500 ms	IEC 61000-4-11, criterion A
	Dip to 0% UT, hold-up time: 5000 ms	IEC 61000-4-11, criterion A
Dip (HVDC) (Works in the 1+1 standby mode)	Dip to 40%, hold-up time: 1, 3, 10, 30, 100, 300, and 1000 ms	IEC 61000-4-11, criterion A
	Dip to 70%, hold-up time: 1, 3, 10, 30, 100, 300, and 1000 ms	IEC 61000-4-11, criterion A
	Dip to 0%, hold-up time: 1, 3, 10, 30, 100, 300, and 1000 ms	IEC 61000-4-11, criterion A
	Dip to 80%, hold-up time: 100, 300, 1000, 3000, and 10000 ms	IEC 61000-4-11, criterion A
	Dip to 120%, hold-up time: 100, 300, 1000, 3000, and 10000 ms	IEC 61000-4-11, criterion A
Electrostatic discharge (ESD)	Contact: ±6 kV, air: ±8 kV	IEC 61000-4-2, criterion B
	Contact: ±8 kV, air: ±15 kV	IEC 61000-4-2, criterion R
Conducted susceptibility (CS)	150 kHz–80 MHz, 10 V	IEC 61000-4-6, criterion A
Radiated susceptibility (RS)	80 MHz–6 GHz, 10 V/m	IEC 61000-4-3, criterion A
Voltage fluctuation and flicker	Class A	IEC 61000-3-3

Parameter	Conditions	Criterion
Current harmonics emission	Class A	IEC 61000-3-2
Power magnetic susceptibility (PMS)	30 A/m	IEC 61000-4-8, criterion A

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Huawei Technologies Co., Ltd.

Huawei Industrial Base
Bantian, Longgang
Shenzhen 518129
People's Republic of China

www.huawei.com