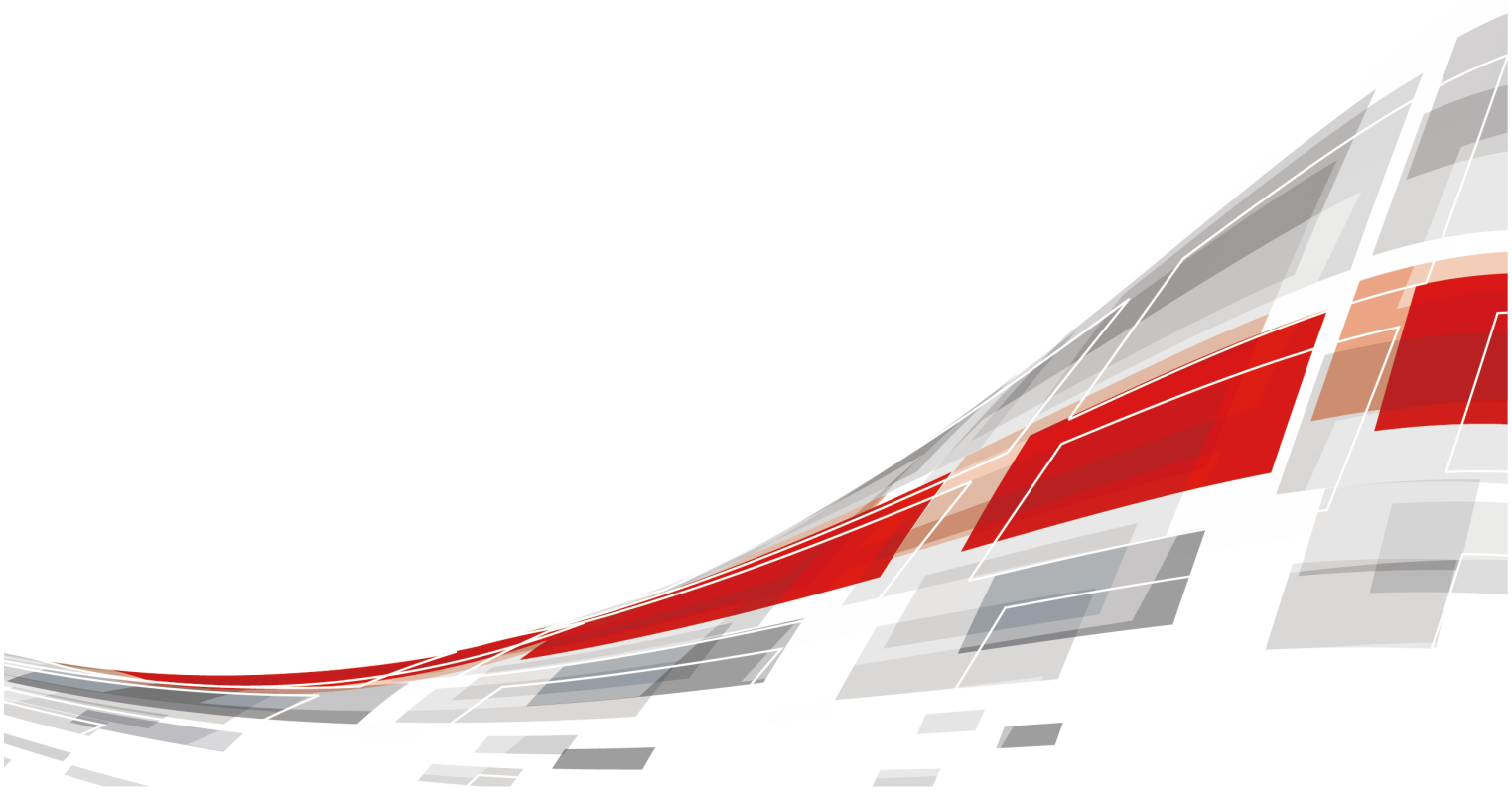
CRPS1K6S12-P AC-DC PSU

Technical Manual

Issue 01

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About This Document

Overview

This document describes the CRPS1K6S12-P AC/DC power supply unit (PSU) in terms of its pin description and application, sequencing requirements, and storage requirements.

The figures in this document are for reference only. For details, see the actual product.

Intended Audience

- Pre-sales engineers
- Technical support engineers
- System engineers
- Software engineers
- Hardware 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.

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Symbol	Description
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.

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1 Safety Precautions

1.1 General Safety

1.2 Personnel Requirements

1.3 Electrical Safety

1.1 General Safety

Statement

Before installing, operating, and maintaining the device, read this document and observe all the safety instructions on the device and in this document.

The "NOTICE", "CAUTION", "WARNING", and "DANGER" statements in this document do not cover all the safety instructions. They are only supplements to the safety instructions. xFusion will not be liable for any consequence caused by the violation of general safety requirements or design, production, and usage safety standards.

Ensure that the PSU is used in environments that meet its design specifications. Otherwise, the PSU may become faulty, and the resulting malfunction, component damage, personal injuries, or property damage are not covered by the warranty.

Follow local laws and regulations when installing, operating, and maintaining the PSU. The safety instructions in this document are only supplements to local laws and regulations.

xFusion will not be liable for any consequences of the following circumstances:

- Although the device has passed security and compatibility tests, the radio frequency and magnetic fields emitted from the device may have a negative impact on the operation of other electronic devices. The device may affect normal operation of implanted medical appliances or personal medical appliances, such as pacemakers, cochlear implants, and hearing aids. If such appliances are used, consult the appliance manufacturer about the restrictions for using this device.
- Operation beyond the conditions specified in this document.

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- Installation or use in environments which are not specified in relevant international or national standards.
- Unauthorized modifications to the product or software code or removal of the product.
- Failure to follow the operation instructions and safety precautions on the product and in this document.
- Equipment damage due to force majeure, such as earthquakes, fire, and storms.
- Damage caused during transportation by the customer.
- Storage conditions that do not meet the requirements specified in this document.
- Do not drop, squeeze, or pierce the PSU. Protect the PSU from external high pressure to prevent internal short circuits and overheating.
- Do not disassemble, refit, or insert foreign objects into the PSU, or expose the PSU to water or other liquids, so as to avoid short circuits, overheating, fire, or electric shocks.
- Use the PSU at a temperature ranging from 0°C to 55°C (32°F to 131°F) and store the PSU at a temperature ranging from –40°C to +85°C (–40°F to +185°F).
- Do not expose the PSU to heat sources such as direct sunlight, radiators, microwave ovens, or water heaters.
- If the PSU is damaged, cracked, or wet, stop using it. Continuing to use it in such conditions may lead to electric shocks, short circuits, or fire.
- Dispose of the PSU in accordance with local regulations. Do not dispose of it as normal household waste. Follow local regulations on disposal of the PSU and its accessories, and support proper collection and recycling.
- Keep the PSU dry. Do not use the PSU in a dusty or damp place. Otherwise, the PSU may be faulty. Do not splash water on the PSU. Keep the PSU far away from fire sources. Do not ignite the PSU.

WARNING

In a household scenario, operation of this device may cause wireless interference.

Personal Safety

- Do not alter, disassemble, or remove the shell of the PSU.
- If there is a probability of personal injury or PSU damage during operations on the PSU, immediately stop the operations, report the case to the supervisor, and take feasible protective measures.
- Before the installation is completed or confirmed by professionals, do not power on the PSU.

1.2 Personnel Requirements

- Personnel who plan to install, operate or maintain the PSU must receive thorough training, understand all necessary safety precautions, and be able to correctly perform all operations.
- During the installation, operation, and maintenance of the PSU, no collision or drop is allowed.

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- During the secondary assembly of the PSU, do not introduce conductive foreign objects.

1.3 Electrical Safety

Operation Requirements

WARNING

Failure to follow the operating procedures may cause personal injury or even death.

- Only qualified personnel are allowed to perform operations to prevent electric shocks.
- Before installing or removing the PSU, disconnect the upstream power supply to the PSU.
- Before powering on the PSU, ensure that the PSU cables are correctly connected.
- Before making electrical connections, disconnect the upstream power supply to the PSU if people may contact energized components.
- Do not open, alter, or repair the product as the voltage inside the product is high.
- To ensure safety, connect the shell ground and the device ground reliably. When installing the device, install the PGND cable first. When uninstalling the device, remove the PGND cable last.
- Do not operate the PSU with wet hands. Otherwise, electric shocks may occur.
- If any damage or fault occurs during installation or operation, power off the PSU immediately and return it to the manufacturer for inspection or repair.
- In case of emergency, remove the power plug from the power outlet to completely cut off the power supply.
- If the PSU has multiple inputs, disconnect all the inputs to completely power it off before operating the PSU.

ESD

- When installing, operating, and maintaining the PSU, comply with the ESD protection regulations and wear the ESD clothing, gloves, and wrist strap.
- When holding the PSU, hold its edge without touching any components. Do not touch the components with your bare hands.
- Package the removed PSU with ESD packaging materials before storing or transporting it.

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2 Product Overview

The Platinum-certified CRPS1K6S12-P AC/DC PSU provides a single output of 12.2 V. When accepting a voltage input of 180 V AC to 264 V AC or 180 V DC to 300 V DC, the rated output power of the PSU is 1600 W. When accepting a voltage input of 90 V AC to 132 V AC, the rated output power of the PSU is 1000 W The PSU is hot-swappable, equalizes current, and supports N+M (N ≤ 2, M ≤ 2) parallel connection. It can operate at a temperature from 0°C to 55°C (32°F to 131°F). The PSU supports forcible air cooling, with a case and fans used for air extraction and heat dissipation. The PSU is designed according to the safety requirements and complies with the information technology equipment safety standards.

Figure 2-1 CRPS1K6S12-P AC-DC



Model Naming Convention

CRPS	1K6	S	12	–P
1	2	3	4	5

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No.	Description	No.	Description
1	Type of the PSU	2	If the value is a number less than 1000 without the letter K, it directly represents the rated output power without unit. For example, 750 and 900 respectively mean 750 W and 900 W. If the value contains the letter K, it means that the rated power output is equal to or larger than 1000 W (1K means 1000 W). For example, 1K3, 2K0, and 2K4 respectively means 1300 W, 2000 W, and 2400 W.
3	Number of outputs. S indicates single output.	4	Output voltage
5	Energy efficiency certification of the PSU ● P: Platinum-certified PSU ● T: Titanium-certified PSU ● S: Ultra-Titanium-certified PSU	-	-

Features

- Efficiency: ≥ 94% (T_A=25°C or 77°F; V_{in}=230 V AC; 20% or 50% load; without fans)
- Depth x Width x Height: 185.0 mm x 73.5 mm x 40.0 mm (7.28 in. x 2.89 in. x 1.57 in.)
- Weight: < 1.2 kg (2.65 lbs)
- Input overvoltage protection, input undervoltage protection, output overvoltage protection, output overcurrent protection, short-circuit protection, overtemperature protection, input fault alarm, and output fault alarm
- I2C communication for control, online upgrade, and monitoring
- NRTL, TUV, CCC, CE and CB certifications
- 80 PLUS platinum energy efficiency certification
- IEC 62368-1, EN 62368-1, and GB 4943.1 compliant
- RoHS 6 compliant

Application Scenario

Servers

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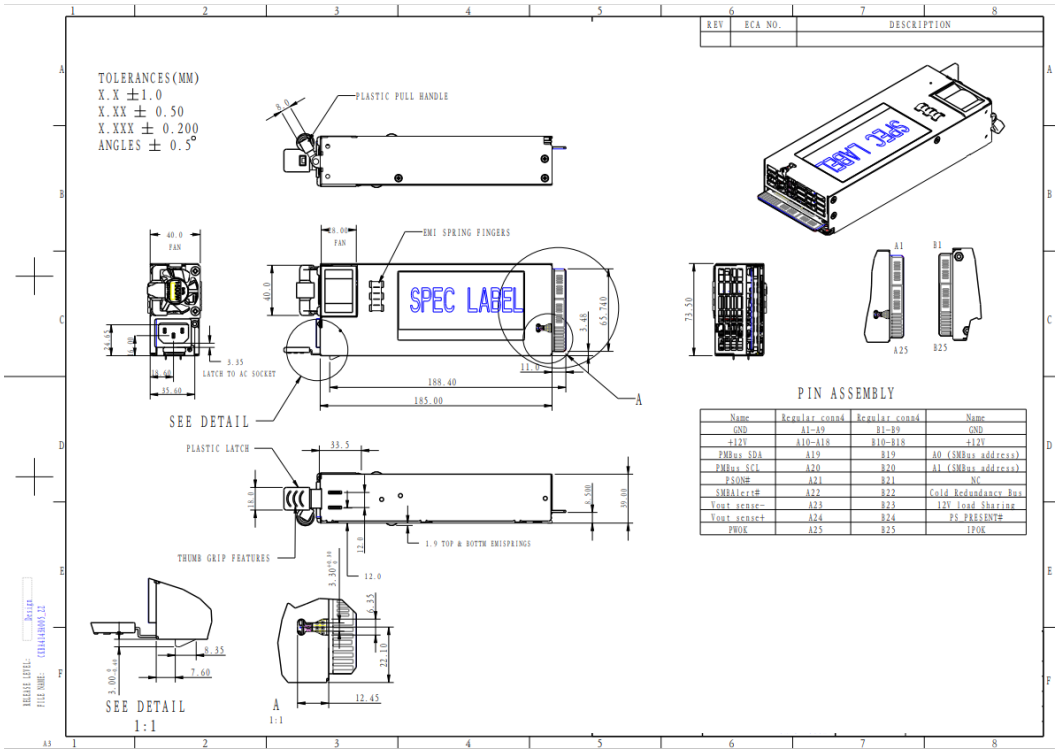
3 Product Structure Overview

3.1 Dimensions

3.2 Terminal Introduction

3.1 Dimensions

Dimensions (D x W x H): 185.0 mm x 73.5 mm x 40.0 mm (7.28 in. x 2.89 in. x 1.57 in.)

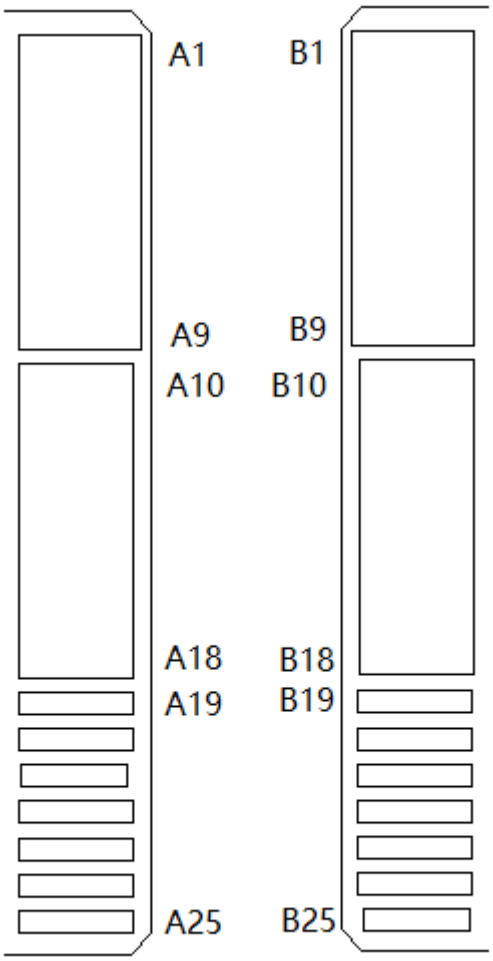


Name	Regular conn4	Regular conn4	Name
GND	A1~A9	B1~B9	GND
+12V	A10~A18	B10~B18	+12V
PMBus SDA	A19	B19	A0 (SMBus address)
PMBus SCL	A20	B20	A1 (SMBus address)
PSON#	A21	B21	NC
SMBAlert#	A22	B22	Cold Redundancy Bus
Vout sense-	A23	B23	12V load Sharing
Vout sense+	A24	B24	PS_PRESENT#
PWOK	A25	B25	IPOK

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3.2 Terminal Introduction

Figure 3-1 Terminal



Pin Number	Pin Name	Pin Number	Pin Name
A1 to A9	GND	B1 to B9	GND
A10 to A18	+12 V DC	B10 to B18	+12 V DC
A19	PMBus SDA	B19	A0 (SMBus address)
A20	PMBus SCL	B20	A1 (SMBus address)
A21	PSON12V#	B21	+12Vsb
A22	SMBAlert#	B22	Cold Redundancy Bus

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Pin Number	Pin Name	Pin Number	Pin Name
A23	Vout sense-	B23	I-MON
A24	Vout sense+	B24	PRESENT#
A25	PWOK	B25	IPOK

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4 Electrical Specifications

4.1 Environmental Characteristics
4.2 Input Characteristics
4.3 Output Characteristics
4.4 Efficiency Characteristics
4.5 Protection Characteristics

4.1 Environmental Characteristics

Parameter	Min.	Typ.	Max.	Unit	Remarks
Operating temperature (T_A)	0	25	55	℃	• The PSU is able to start at a temperature of -15°C (5℉) but there are no requirements on the PSU performance. • No protection for long-term operation at half load at 65°C (149°F).
Storage temperature	–40	25	85	℃	-
Relative humidity	5	-	95	%RH	Non-condensing when not in operation.
	5	-	90	%RH	Non-condensing. The PSU can work properly.

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Parameter	Min.	Typ.	Max.	Unit	Remarks
Altitude	–60	-	5000	m	The PSU can work at altitudes ranging from –60 m to 5000 m (–197 ft to 16,404.2 ft). The PSU can be stored at altitudes ranging from –60 m to 15,200 m (–197 ft to 49,868.77 ft).
Atmospheric pressure	61	-	106	kPa	● Passed the low atmospheric pressure test at an altitude of 4000 m (13,123.36 ft) and with rated input of 230 V AC. ● When the altitude ranges from 1800 m to 4000 m (5905.51 ft to 13,123.36 ft), the highest operating temperature decreases by 1°C (1.8℉) for every increase of 220 m (721.78 ft).

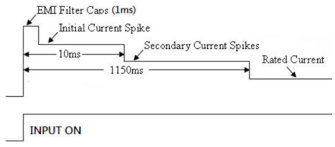
4.2 Input Characteristics

Parameter	Min.	Typ.	Max.	Unit	Remarks
Rated AC input voltage (110 V AC)	90	100 to 120	132	V AC	-
Rated AC input voltage (220 V AC)	180	200 to 240	264	V AC	-
AC input voltage (V AC)	90	220	264	V	-
AC input voltage frequency	47	50/60	63	Hz	-
Power factor	0.90	-	1	-	● Input voltage: 200 V AC to 240 V AC (50 Hz/60 Hz) ● 10% load
	0.96	-	1	-	● Input voltage: 200 V AC to 240 V AC (50 Hz/60 Hz) ● 20% load

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Parameter	Min.	Typ.	Max.	Unit	Remarks
	0.98	-	1	-	● Input voltage: 200 V AC to 240 V AC (50 Hz/60 Hz) ● 50% load
	0.99	-	1	-	● Input voltage: 200 V AC to 240 V AC (50 Hz/60 Hz) ● 100% load
iTHD	-	-	20	%	● Input voltage: 200 V AC to 240 V AC (50 Hz/60 Hz) ● 5% load
	-	-	15	%	● Input voltage: 200 V AC to 240 V AC (50 Hz/60 Hz) ● 10% load
	-	-	10	%	● Input voltage: 200 V AC to 240 V AC (50 Hz/60 Hz) ● 20% load
	-	-	8	%	● Input voltage: 200 V AC to 240 V AC (50 Hz/60 Hz) ● 40% load
	-	-	5	%	● Input voltage: 200 V AC to 240 V AC (50 Hz/60 Hz) ● 50% load
THDv	-	-	10	%	THDv ≤ 10%: The PSU can work properly.
DC input bias	-	-	50	mA	Test requirements: full-range input, light load burst mode.
Maximum AC input current (RMS)	-	-	10	A	V_{in} = 200 V AC, rated load output.
HVDC input current	-	-	8	A	V_{in}=240 V DC, rated load output
AC input DC bias	-	-	50	mA	Rated input, full-range output

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Parameter	Min.	Typ.	Max.	Unit	Remarks
Input inrush current	-	-	35/55	A	At the rated voltage and an ambient temperature of 25°C (77°F), the cold startup inrush current should be less than 35 A within 1 ms to 1150 ms. Within the operating temperature range, for any permissible combination of normal operating input voltages and frequencies, the PSU must meet the requirements for cold startup inrush current.  During a single period AC drop or AC on/off cycling, the warm startup inrush current must be less than 55 A at 25°C (77°F) and 240 V. Note: ● The surge current is negligible within 0 ms to 1 ms after the AC power is connected and the line filter is charged. ● At any allowable operating temperature, the inrush current does not cause the fuse to blow, the circuit breaker to trip, or the PSU to fail. ● During a switchover between the active and standby PSUs of a server, with the total load rate between 50% and 90% of the single PSU load rate, the RMS value of the AC input current is: 20 ms at 150% x Imax; 100 ms at 130% x Imax. (The input voltage of the active server is 220 V/50 Hz and that of the standby server is 230 V/50 Hz).

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Parameter	Min.	Typ.	Max.	Unit	Remarks
AC input mode	-	-	-	-	220 V AC/110 V AC single-phase input and 110 V AC dual-live wire input are supported.
AC input connector	-	-	-	-	The AC input connector should comply with the IEC 320 C-14 power input standard. The rated standard is 10 A/250 V AC.
HVDC input voltage	180	240	320	V DC	The PSU can still work normally even in the case of reverse polarity wiring.

NOTE

- The PSU is capable of starting at full load and rated power under all AC input and operating temperature conditions specified in this specification.
- When the input voltage remains within the range of 265 V AC to 300 V AC for a long time, the PSU cannot fail.
- For any combination of input voltages and frequencies within the AC input range, the PSU must meet all DC output specifications.
- The PSU can output power properly when the input voltage varies continuously from 90 V AC to 264 V AC or from 264 V AC to 90 V AC.
- When the input voltage is below 90 V AC at full load, the PSU must not be damaged. When the input voltage increases from below 90 V AC to 90 V AC, the PSU must work properly.
- When measuring the input inrush current, all capacitors within the PSU must be discharged. At any phase angle of the input voltage, the input inrush current should meet the specifications.
- The input inrush current does not cause the PSU or any safety components to fail.
- To be compatible with HVDC power supply, the PSU must work normally and ensure long-term reliability within the DC voltage input range. Both the L and N lines of the AC input must be able to connect to the positive or negative terminal of the DC input.
- The PSU cannot be damaged or locked up due to repeated power-on and power-off during any ON/OFF cycle. It can automatically restore and work normally after the cycle.
- AC dynamic characteristics:

  The AC input dynamic characteristics include AC sag and AC surge shock. The requirements in the form **Table 4-1** must be met.
- AC leakage current:

  The leakage current should not exceed 0.875 mA (testing condition: 264 V AC/60 Hz).
- The PSU can withstand the input voltage of 318 V AC (effective value) for 48 hours.

Table 4-1 AC input dynamic characteristics

AC Input Sag (with a 10-Second Interval Between Each Sag)				
Duration	Sag	Operating Voltage	AC Frequency	Performance Criteria

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0-1/2 AC cycle	95%	Rated AC input range	50/60 Hz	Working normally
> 1 AC cycle	> 30%	Rated AC input range	50/60 Hz	Abnormal working is allowed, but the PSU can recover automatically after the abnormal input is removed.
AC Input Surge Shock (with a 10-Second Interval Between Each Shock)				
Duration	Shock	Operating Voltage	AC Frequency	Performance Criteria
Continuous	10%	Rated AC input voltage	50/60 Hz	Working normally
0-1/2 AC cycle	30%	1/2 of the rated AC input range	50/60 Hz	Working normally

4.3 Output Characteristics

Parameter	Output	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
Number of outputs	-	-	-	Single route	-	Single output.
Output power	+12 V DC	-	-	1600	W	180 V AC to 264 V AC 180 V DC to 320 V DC
	+12 V DC	-	-	1000	W	90 V AC to 132 V AC
Output voltage range	+12 V DC (dynamic)	11.6	12.2	12.8	V DC	The PSU output voltage (including peak ripple and noise) measured at the output connector should remain within the specified voltage range when the PSU operates

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Parameter	Output	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
	+12 V DC (static)	11.8	12.2	12.6	V DC	under steady state and dynamic load conditions.
Output current	+12 V DC	1	-	132	A	180 V AC to 264 V AC 180 V DC to 320 V DC
	+12 V DC	1	-	82	A	90 VAC to 132 VAC
Output ripple and noise (peak to peak)	+12 V DC	-	-	120/105	mV	Method 1: Add a 2200 μF solid aluminum capacitor and a minimum load of 1 A. Acceptance method: Before the coaxial cable test, use coaxial cables to connect a 10 μF electrolytic capacitor and a 0.1 μF ceramic capacitor in parallel. Set the oscilloscope bandwidth to 20 MHz. The peak-to-peak value is 120 mV at full input voltage range, full temperature range, and full output current range. Method 2 (recommended): Add a 270 μF polymer capacitor, a 10 μF ordinary aluminum electrolytic capacitor, and a 0.1 μF ceramic capacitor with a minimum load of 1 A. Set the oscilloscope bandwidth to 20 MHz. The peak-to-peak value is 105 mV at full input voltage range, full temperature range, and full output current range.

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Parameter	Output	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
Load dynamic response	+12 V DC	11.6	-	12.8	V	Dynamic change slope: 2.5 A/µs Dynamic load frequency range: 50 Hz to 10 kHz Under the following test conditions, the voltage cannot exceed 11.6 V to 12.8 V. The dynamic load response capability of the PSU should cover the range from 0% to 100% (with a change rate of 2.5 A/µs). The 12 V output voltage must be within the range of 11.2 V to 13.0 V. Dynamic response test allows for a maximum of 8800 µF of ordinary aluminum electrolytic capacitor to be added. When the input voltage is 115 V AC/230 V AC: ● Load change range: 3 A at 40% load ● Current change stepping value: 60% load
Capacitive load requirement	-	2200	-	30000	uF	In cold standby mode, the minimum capacitive load on the 12 V output is needed to maintain output voltage regulation during PSU faults or hot swapping.
Earth impedance	-	-	-	1	m?	The voltage output ground (GND) should be connected to the system protection earth ground.
Output common mode noise	-	-	-	350	mV	10 Hz to 20 MHz

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Parameter	Output	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
Loop stability	-	-	-	-	-	The PSU should maintain loop stability under all operating conditions, requiring at least 30 degrees of phase margin and -6 b of gain margin.
Anti-interference capability for output residual voltage in standby mode	-	-	-	500	mV	When the PSU generates 500 mV at the power output port during standby operation, the PSU should remain unaffected.
Power consumption at 0% load	-	-	-	15	W	-

NOTE

Refer to the test specifications for detailed +12 V DC turn-on and turn-off waveforms.

4.4 Efficiency Characteristics

Parameter	Output	Min.	Typ.	Max.	Unit	Remarks
+12 V DC output efficiency	AC input	88	-	-	%	Output at 10% load, without fans.
		94	-	-	%	Output at 20% load, without fans.
		94	-	-	%	Output at 50% load, without fans.

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Parameter	Output	Min.	Typ.	Max.	Unit	Remarks
		91	-	-	%	Output at 100% load, without fans.
		V_{in} = 230 V AC, without fans, at room temperature (efficiency measured after the PSU operates for 20 minutes at 20°C to 25°C or 68°F to 77°F). Meet the requirement of 80 PLUS platinum energy efficiency certification.				
	DC input	88	-	-	%	Output at 10% load, without fans.
		93	-	-	%	Output at 20% load, without fans.
		94	-	-	%	Output at 50% load, without fans.
		91	-	-	%	Output at 100% load, without fans.
		V_{in} = 270 V DC, without fans, at room temperature (efficiency measured after the PSU operates for 20 minutes at 20°C to 25°C or 68°F to 77°F).				

4.5 Protection Characteristics

Table 4-2 Input protection characteristics

Parameter	Min.	Typ.	Max.	Unit	Remarks
Input overvoltage protection threshold	301	305	309	V AC	-
Input overvoltage recovery threshold	290	295	300	V AC	-
Input undervoltage protection threshold	70	-	80	V AC	-
Input undervoltage recovery threshold	80	-	90	V AC	-

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Parameter	Min.	Typ.	Max.	Unit	Remarks
HVDC overvoltage protection threshold	336	340	344	VDC	-
HVDC overvoltage recovery threshold	325	330	335	VDC	-
HVDC undervoltage protection threshold	155	-	167	VDC	_
HVDC undervoltage recovery threshold	167	-	180	VDC	-
Input overcurrent/ short circuit protection	Use fast-blow fuses that comply with the safety requirements. Unless a component in the PSU fails, the AC inrush current and all protection circuits in the PSU, including DC output overloads or output short circuits, should not cause the fuse to blow under any circumstances. For the 1+1 redundancy mode, in the event of an internal failure, the fuse in the PSU should blow before the circuit breaker (C32 circuit breakers such as Schneider iC65 series, ABB S260 series, ABB S201 C32A, ABB S202M C32) disconnects.				

Table 4-3 Output protection characteristics

Parameter	Min.	Typ.	Max.	Unit	Remarks
+12 V DC output overvoltage protection threshold	13.5	-	15	V DC	Latch off.
+12 V DC output undervoltage protection threshold	10	-	10.9	V DC	-

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Parameter	Min.	Typ.	Max.	Unit	Remarks
+ 12 V DC output overvoltage unlock mode	1. Reconnect the AC input after disconnecting it for 2s. The PSU can be unlocked (in single-node or parallel scenarios). 2. Change the PSON12V# signal from low level to high level and then back to low level (in parallel scenario). If either of the above two conditions is met, the PSU can be unlocked.				
Overcurrent protection	See **Table 4-4** for overcurrent protection lockouts.				
+12 V DC output short circuit	Latch off.				
+12 V DC output overcurrent/short circuit unlock mode	1. Reconnect the AC input after disconnecting it for 2s. The PSU can be unlocked (in single-node or parallel scenarios). 2. Change the PSON12V# signal from low level to high level and then back to low level (in parallel scenario). If either of the above two conditions is met, the PSU can be unlocked.				
Ambient overtemperature alarm	61	-	-	℃	An overtemperature alarm must be generated before overtemperature protection starts.
Ambient overtemperature protection	65	-	-	℃	Ambient temperature detection accuracy: ±3°C. The PSU has an overtemperature protection function. When the temperature drops to the allowable operating range, the PSU can automatically recover.

Table 4-4 Overcurrent protection

Range of input voltage	-	Min.	Typ.	Max.	Warning	OCP
180 V AC to 264 V AC/180 V DC to 320 V DC	Rated current	-	-	132	-	-
	OCW	110%	115%	120%	> 60 ms	No protection.
	OCP1	120%	130%	140%	> 60 ms	>11.1s
	OCP2	140%	145%	150%	> 60 ms	> 100 ms

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	OPP	150%	-	-	> 3 ms	> 5 ms
90 V AC to 132 V AC	Rated current	-	-	82 A	-	-
	OCW	105%	107%	110%	> 60 ms	No protection.
	OCP1	110%	115%	120%	> 60 ms	> 100 ms
	OCP2	120%	-	-	> 3 ms	> 5 ms

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5 Feature Curves

Working condition: T_A = 25°C (77°F) unless otherwise specified.

Figure 5-1 Efficiency curve

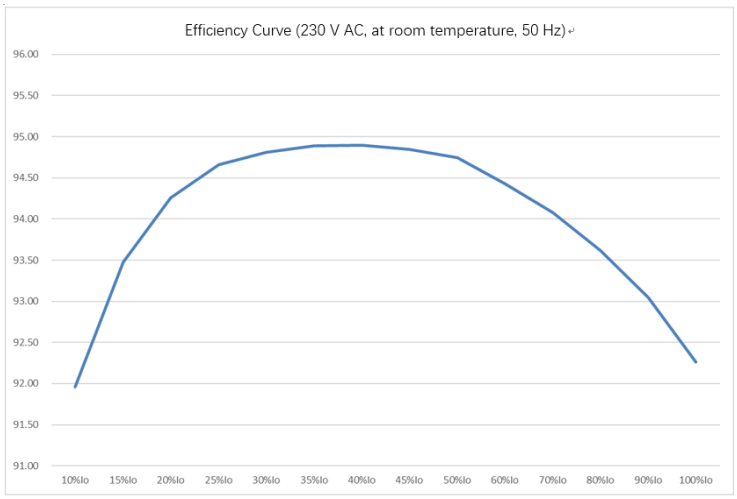
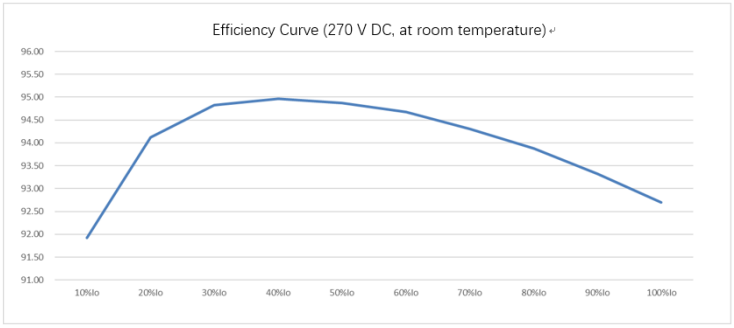


Figure 5-2 Efficiency curve



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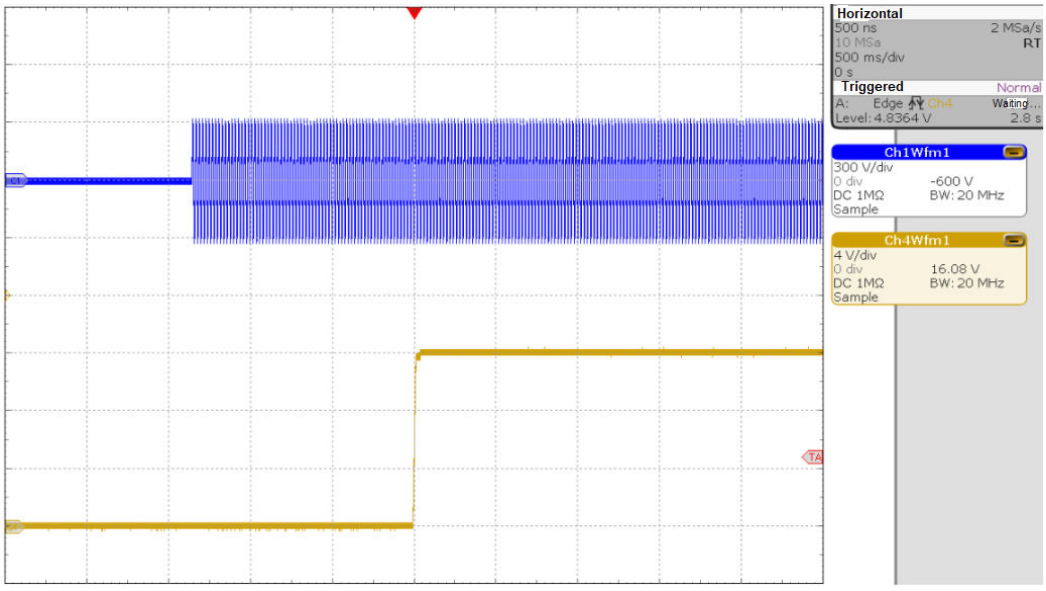
6 Typical Waveforms

6.1 Turn-On/Turn-Off
6.2 Output Voltage Dynamic Response
6.3 Output Voltage Ripple

6.1 Turn-On/Turn-Off

Working condition: T_A = 25°C (77°F) unless otherwise specified.

Figure 6-1 Turn-on waveform (V_{in}=220 V AC, I_{out}=132 A)



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Figure 6-2 Turn-off waveform (V_{in}=220 V AC, I_{out}=132 A)

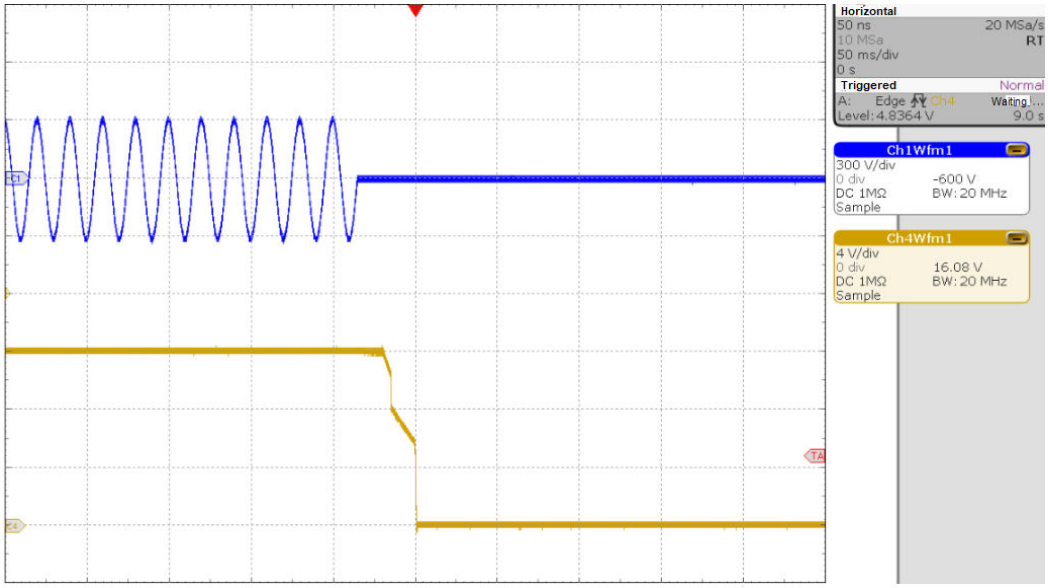
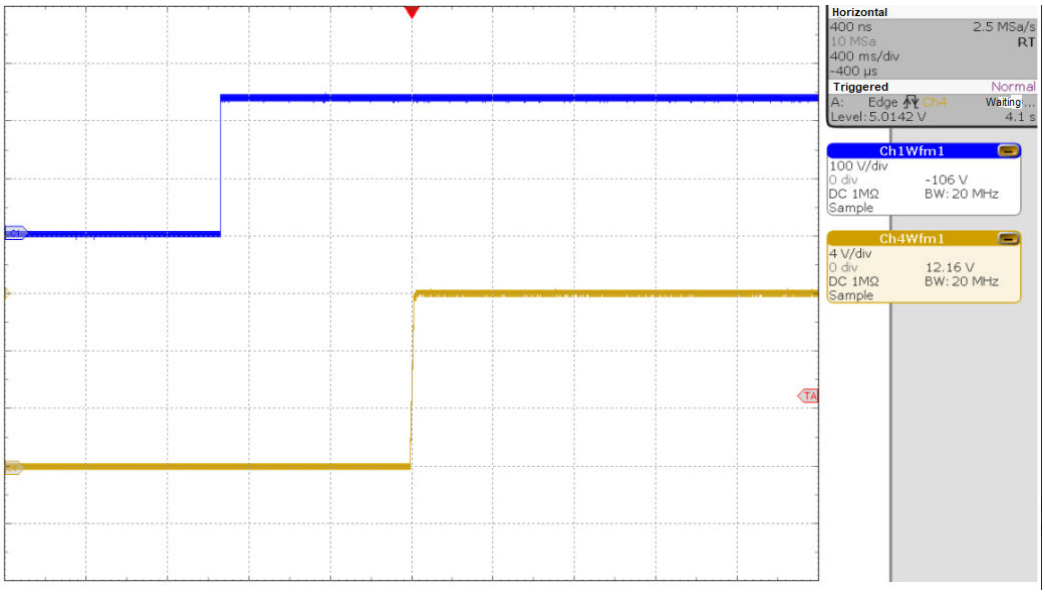
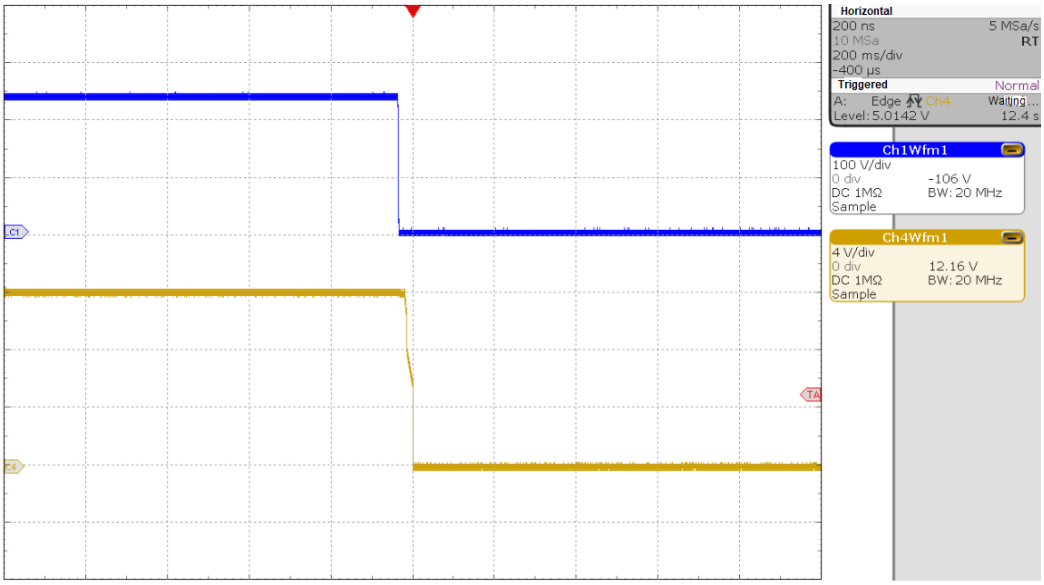


Figure 6-3 Turn-on waveform (V_{in}=240 V DC, I_{out}=132 A)



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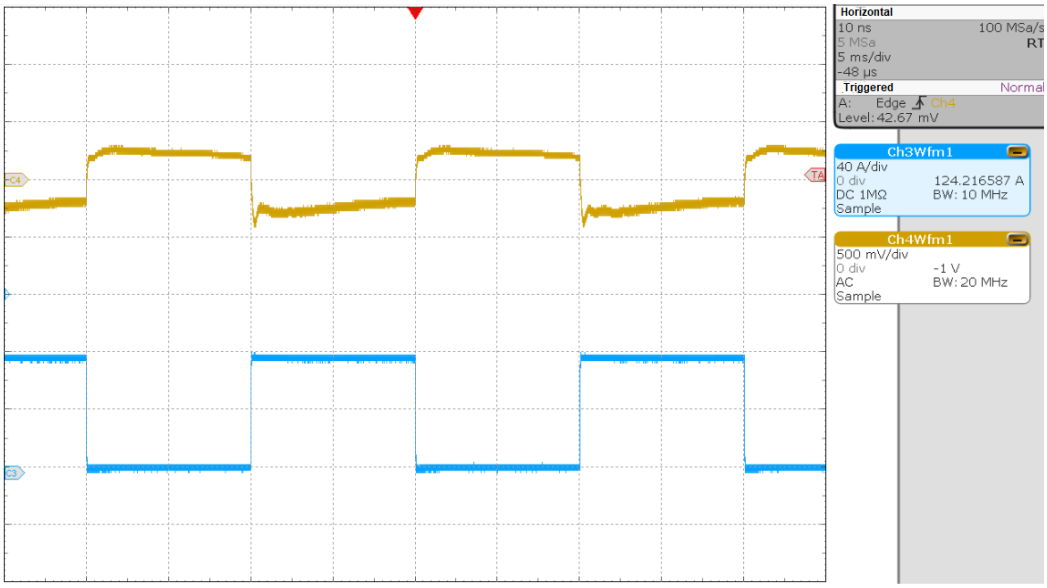
Figure 6-4 Turn-off waveform (V_{in}=380 V DC, I_{out}=132 A)



6.2 Output Voltage Dynamic Response

Working condition: T_A = 25°C (77°F) unless otherwise specified.

Figure 6-5 Output voltage dynamic response (V_{in}=220 V AC, I_{out}=0 A to 132 A)



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Figure 6-6 Output voltage dynamic response (V_{in}=220 V AC, I_{out}=3 A to 79.2 A)

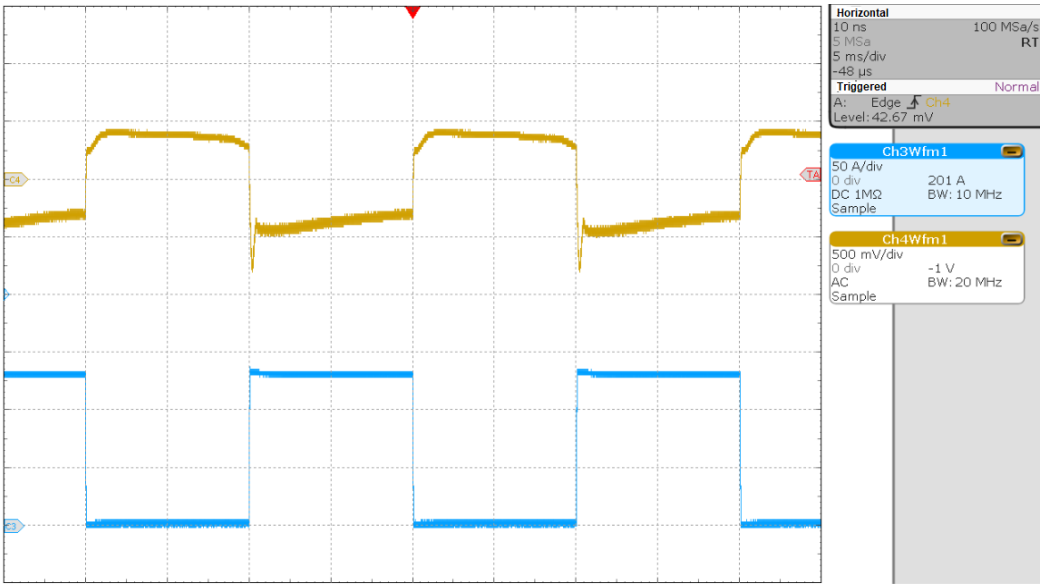
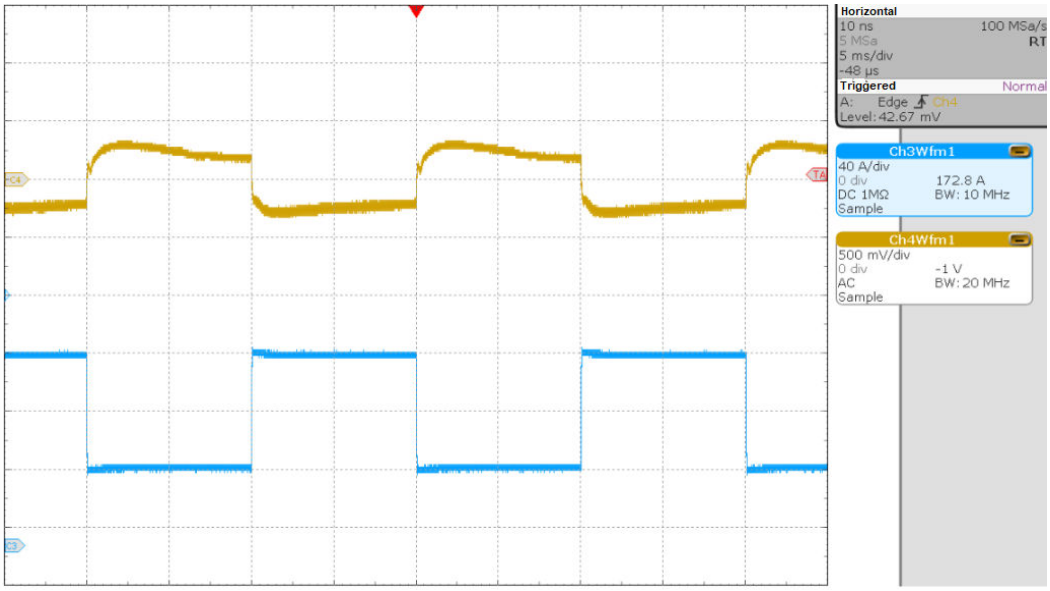


Figure 6-7 Output voltage dynamic response (V_{in}=220 V AC, I_{out}=52.8 A to 132 A)

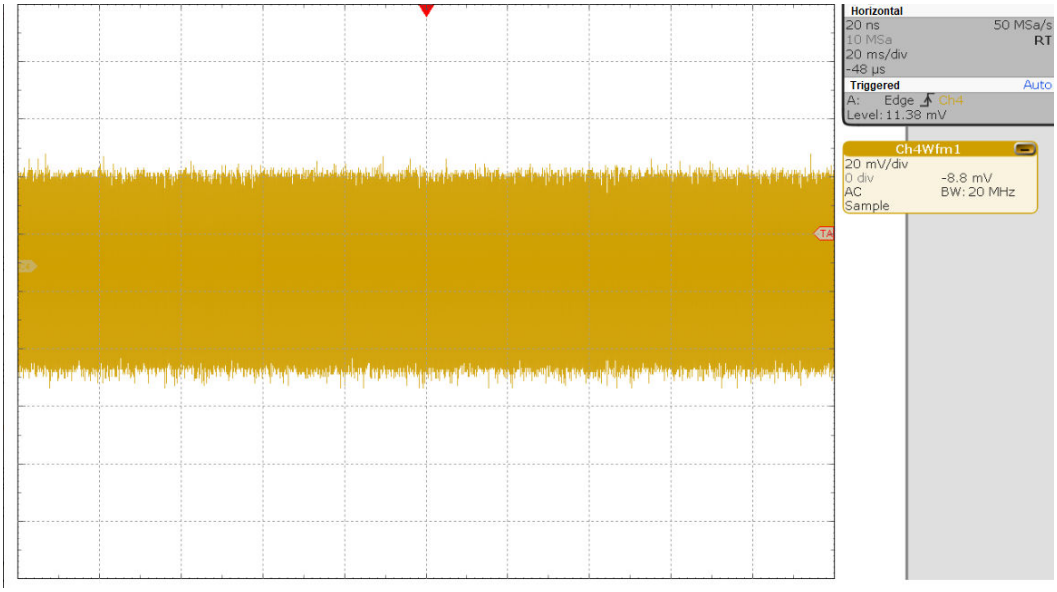


6.3 Output Voltage Ripple

Working conditions: T_A = 25°C (77°F) unless otherwise specified.

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Figure 6-8 Output voltage ripple (V_{in}=220 V AC, 100% load)



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7 Energy Saving Feature

7.1 Active/Standby Power Supply
7.2 Standby PSU Entry Condition
7.3 System Commands for CR Mode
7.4 Conditions for PSU Power-On and Power-Off
7.5 Conditions for Active/Standby Recovery

7.1 Active/Standby Power Supply

- The active/standby power supply is supported for energy saving and PSUs can be configured in 1+1, 2+1, and 2+2 redundancy modes. When the system enters Cold Redundancy (CR) mode, only the PSUs which must operate operate to ensure optimal efficiency and other PSUs enter the Cold Standby state.
- The CR-BUS signals whose level is controlled by PSUs instead of the system of parallel PSUs are connected in parallel. One of the conditions for the system to enter the CR mode is that the level of the CR-BUS signal is high. By default, the power system starts in Standard Redundancy mode. (The default value of the Cold_red_config register is 0x00h.) The system needs to send a command to enter the CR mode.
- Whether the power system is operating in standard redundancy mode or CR mode, at least one PSU is operating in cold redundancy activation mode or standard redundant mode so that other PSUs can operate in cold standby mode.
- Active/Standby energy saving control means that in a redundant power system, one PSU outputs at the default set point (active power supply), and the system lowers the output voltage of other PSUs.

7.2 Standby PSU Entry Condition

The PSU enters CR mode when the following three conditions are met:

1. The PSON12V # signal is at low level.
2. Cold Redundancy Bus signal is at high level.

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3. The system sends a command to the Cold_red_config (0X02/0X03/0X04/0X05).

7.3 System Commands for CR Mode

The system configures the operating mode of the PSU through the Cold_Redundancy_Config (D0h) register.

Table 7-1 Cold_Redundancy_Config (D0h) register configuration

Register Value	State	Description
00h	Standard redundant configuration (power-on default)	After the PSU is powered on, it will default to standard redundant load balancing mode. The CR_BUS signal for the PSU should be in a tri-state, but if a fault occurs and activation of any PSUs still in cold standby mode is required, the bus will be pulled low.
01h	Active PSU in the cold standby mode	Define this PSU as always on in a cold redundant configuration.
02h	Standby PSU 1 in the cold standby mode	Define this PSU as the first to turn on in a cold redundancy configuration when the load increases.
03h	Standby PSU 2 in the cold standby mode	Define this PSU as the second to turn on in a cold redundancy configuration when the load increases.
04h	Standby PSU 3 in the cold standby mode	Define this PSU as the third to turn on in a cold redundancy configuration when the load increases.
05h	Always-standby PSU in the cold standby mode	Define this PSU as always in a cold redundant configuration regardless of load conditions.
06h--FFh	Reserved	-

NOTE

- The default value of the D0h register is 0x00h.
- When the working PSU experiences an AC power failure or other faults, the CR-BUS signal changes from high level to low level (the fault delay time on the Cold-BUS is less than 10 μs). The PSU in Cold Standby mode must supply power to the load within a response time of 100 μs.
- If the system is operating in cold redundancy mode and the active PSU does not pull the CR-Bus voltage to a high level, all PSUs are required to be in normal working mode to avoid system power-off caused by misoperations.
- Jump-sequence control is not allowed on the standby PSU. (01h paired with 03h or 01h paired with 04h will cause repeated entry and exit from standby mode.)

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7.4 Conditions for PSU Power-On and Power-Off

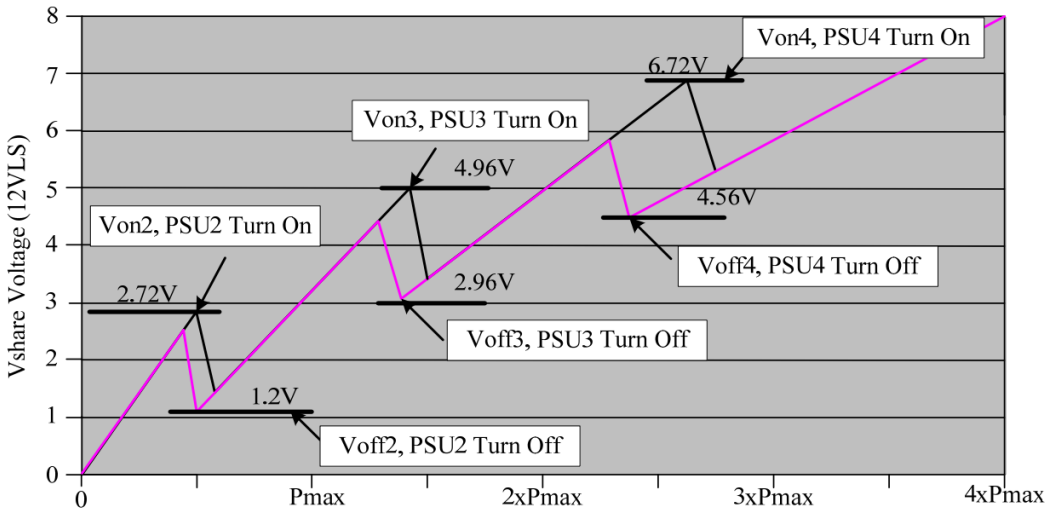
The PSU can enter or exit the Cold Standby mode based on the total load status (monitoring the I-MON voltage) and the preset conditions. These conditions include the ratio of the actual load of the PSU to the total power supply from the power supply system. The ratio can be adjusted through the configuration file.

For example, when four PSUs are connected in parallel and the system enters the cold redundancy mode:

- When the Vshare Voltage (12VLS) rises to 2.72 V, start PSU 2 using the **E1h** command (Von/Voff).
- When the Vshare Voltage (12VLS) rises to 4.96 V, start PSU 3 using the **E1h** command (Von/Voff).
- When the Vshare Voltage (12VLS) rises to 6.72 V, start PSU 4 using the **E1h** command (Von/Voff).
- When the Vshare Voltage (12VLS) drops to 4.56 V, shut down PSU 4 using the **E1h** command (Von/Voff).
- When the Vshare Voltage (12VLS) drops to 2.96 V, shut down PSU 3 using the **E1h** command (Von/Voff).
- When the Vshare Voltage (12VLS) drops to 1.2 V, shut down PSU 2 using the **E1h** command (Von/Voff).

Whether the PSU enters into and exits from the Cold Standby mode is determined by its monitored load status.

- When the load of the PSU increases beyond the set value, the PSU starts in less than 3 ms.
- When the load drops below the set value, the PSU enters the sleep mode in less than 5 ms.



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7.5 Conditions for Active/Standby Recovery

After the PSU enters standby mode, it can exit the cold standby mode if any of the following conditions is met:

- The system issues a command.
- The input power fails.
- PSON12V# changes from low level to high level.
- The active PSU is faulty.
- The load exceeds the level at which the standby PSU exits from the cold redundancy mode. (After the load goes down below the level at which the standby PSU exits from the cold redundancy mode, the standby PSU automatically enters the cold redundancy mode.)
- The single-chip microcomputer of the PSU restarts.
- Cold Redundancy Bus is at low level.
- The PSU triggers a warning.

If the active PSU is faulty (excluding in the case of a short circuit before outputting Oring and overvoltage) and other faults occur, the system should wake up the standby PSU in a timely manner (false wakeup is allowed) and ensure that the 12 V bus voltage is greater than or equal to 11.2 V.

Table 7-2 Power supply features of the active and standby PSUs

Parameter	Unit	Min.	Typ.	Max.	Remarks
Busbar voltage in fault conditions	V	11.2	-	12.8	Maximum load rate in active/ standby mode: 100%
	In a 1+1, 2+1, and 2+2 active/standby power supply scenarios (AC +AC, AC+HVDC, HVDC+HVDC), if any route of the PSU experiences input cable insertion and removal, a power failure or fault (such as input undervoltage, input overvoltage, fan fault, and PSU overtemperature), the output voltage of the 12 V active route should be greater than or equal to 11.2 V (excluding in the case of a short circuit before outputting Oring and overvoltage). **NOTE** The 12 V output of parallel PSUs is equipped with 2200 μF capacitors.				
Standby PSU power consumption	< 5 W				

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8 Hot Swap

Hot swapping is the process of inserting the PSU to and extracting another PSU from a power system. The PSU should meet hot-swapping specifications.

When the PSU operates in load balancing mode, the +12 V DC hot swap voltage fluctuates between 11.6 V and 12.8 V.

The PSU can be hot swapped by the following methods:

- PSU hot swap without AC power applied (The PSU does not work before the insertion or extraction.):
  - Extraction: The AC power is disconnected from the PSU before the PSU is extracted from the system.
  - Insertion: The PSU is inserted into the system without power applied. Then, power is applied after the insertion.
- AC hot swap:
  - Extraction: The PSU is removed from the system with power on.
  - Insertion: The PSU (AC already works) is inserted into the system, and the system can start immediately.
- PSU hot swap through the system processor:
  - Extraction: The system processor removes the PSU by turning off the PSON12V# signal.
  - Insertion: After a PSU is inserted into the system, the system processor queries the system status (ON/OFF) and turns on the PSON12V# signal to enable the PSU to work in main route operation mode.

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9 Parallel Operation

Current Share Design Requirements

The +12 V DC output has an active current share function by connecting the +12VLS signals from all PSUs together.

In the 1+1 redundant power supply system, when each PSU operates at 10% to 20% of its rated load, the current sharing linearity must be less than 10%; when operating at above 20% of the rated load, the current sharing linearity must be less than 5%. A failure of one of the PSUs in redundant standby mode cannot affect the operation and output of the other PSUs. If the current share bus is shorted to ground, the output of the PSU should meet the requirements.

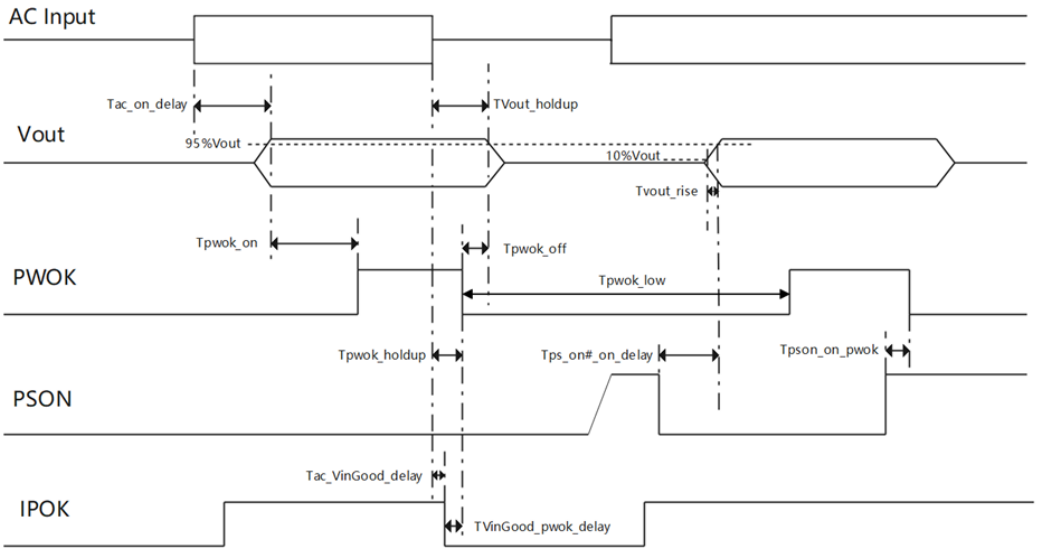
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10 Control Functions

10.1 PSU Timing
10.2 Output 12 V and GND
10.3 PSON12V#
10.4 SMBAlert#
10.5 Vout sense-, Vout sense+
10.6 PRESENT#
10.7 PWOK
10.8 IPOK
10.9 I-MON
10.10 SCL and SDA
10.11 A0 and A1
10.12 Cold Redundancy Bus
10.13 Signal Quality Requirements

10.1 PSU Timing

Figure 10-1 Sequence diagram



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Table 10-1 Output switch timing requirements

Mark	Description	Min.	Max.	Unit
T_{vout_rise}	Output voltage rising time of +12 V DC: from 10% to the regulated voltage range.	2	50	ms
$T_{ac_on_delay}$	Time from power-on to all output voltages rising to the regulated voltage range.	-	3000	ms
$T_{_pwok_holdup}$	From the time when the AC powers off to the time when the PWOK signal changes, at 100% load, 50%load, and 20% load.	12/20/40	-	ms
$T_{_pwok_off}$	Time from the PWOK signal being sent to the output voltage falling below 11.4 V.	1	-	ms
$T_{_ps_on\#_on_delay}$	Time from the PS_ON# signal being valid to the output voltage rising to the regulated voltage range.	5	400	ms
$T_{_ps_on\#_on_pwok}$	Time from PS_ON# signal rise to PWOK signal fall.	-	5	ms
$T_{_pwok_on}$	PWOK delay time after the output voltage reaches the regulated voltage range	100	500	ms
$T_{ac_VinGood_delay}$	Time from AC power off to IPOK signal being enabled	-	4	ms
$T_{VinGood_pwok_delay}$	Time from IPOK signal fall to PWOK signal fall.	1	-	ms
$T_{_pwok_low}$	PWOK response time in case of AC power off or PS_ON signal change.	100	-	ms

10.2 Output 12 V and GND

PSU side: An Oring-FET failure isolation circuit needs to be added inside the PSU for 12 V output. In actual application, PSUs are in 1+1, 2+1, or 2+2 redundancy. If a single PSU is faulty, it is required to automatically exit to avoid busbar abnormality. See the following design:

System side:

- Capacitance at the 12 V input side: The equivalent capacitance should be greater than the PSU's minimum capacitive load 2200 μF multiplied by N (N indicates the number of PSUs in the system), which is less than the maximum capacitive load (30,000 μF) of the PSU.

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- The 12 V load shall be greater than the minimum PSU load 1 A and less than the rated load of the PSU.

10.3 PSON12V#

The PSON12V# signal is an on/off signal that controls the PSU 12 V output remotely. If the PSON12V# signal is at low level and takes effect, the 12 V output of the PSU enters the active 12 V output mode. When the PSON12V# signal is at high level or open, the PSU is turned off.

Table 10-2 PSON12V# signal characteristics

Signal Characteristics	
Signal type	PSU side: This signal is pulled up to the 3.3 V auxiliary power source inside the PSU by a 4.7-kilohm resistor.
PSON12V# = Low level	+12 V DC output mode
PSON12V# = High level/ Open	Turn-off

Table 10-3 PSON12V# Output

PSON12V# Output	**Min.**	**Max.**
Low level voltage (main output enabled)	0 V	0.8 V
High level voltage (main output disabled)	2.2 V	3.465 V
Source current, and PSON12V# = Low level	-	4 mA
Signal rise and fall time	-	500 μs

10.4 SMBAlert#

The SMBAlert# signal is a PSU alarm interruption signal. High level indicates that the power supply is normal, and low level indicates the power supply alarm. The alarm is generated in the case of overtemperature protection, overcurrent protection, or overvoltage protection.

- When the SMBAlert# signal is lowered, the indicator is steady orange or blinks orange.
- In the overtemperature pre-alarm scenario, set the SMBAlert # signal and PMBus flags to a low level and do not turn off the PSU.

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- In the overtemperature protection scenario, turn off the PSU and set the PMBus flag to a low level.

Table 10-4 SMBAlert# signal characteristics

Signal Type	
SMBAlert# = High level	The PSU is normal.
SMBAlert# = Low level	The converter has triggered an alarm.

Table 10-5 SMBAlert# output

SMBAlert# output	**Min.**	**Max.**
Signal at low level	0 V	0.4 V
Signal at high level	2.2 V	3.465 V
Sink current, SMBAlert# = low level	-	4 mA
Sink current, SMBAlert# = high level	-	50 μA

10.5 Vout sense-, Vout sense+

The output voltage can be sensed remotely and open. When the remote feedback is open, the +12 V DC output should use local feedback. The PSU uses remote feedback to regulate the voltage drop of the main output, with a maximum drop of no more than 300 mV.

10.6 PRESENT#

The PRESENT# signal is used by the system to detect whether the PSU is present. The signal pin is required to be shorter than other pins on the PSU. The pin is grounded inside the PSU.

Table 10-6 PRESENT# signal characteristics

Signal Characteristics	
Signal type	PSU side: The pin is directly grounded inside the PSU. System side: This signal is pulled up to 3.3 V by a 4.7-kilohm resistor and output to the system CPLD over a series resistor.

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10.7 PWOK

The PWOK signal is used to detect whether the main power supply output is normal. High level indicates that the main power output is normal, and low level indicates that the main power output is abnormal.

Table 10-7 PWOK signal characteristics

Signal Characteristics	
Signal type	Pulled up to the 3.3 V auxiliary power supply inside the PSU and output to the system.
PWOK = High level	The main output is normal.
PWOK = Low level	The main output is abnormal.

Table 10-8 PWOK output

PWOK Output	**Min.**	**Max.**
Logic low-level voltage	0 V	0.4 V
Logic high-level voltage	2.0 V	3.46 V
Source current, PWOK = High level	-	400 μA
Sink current, PWOK = Low level	-	4 mA
Signal rise and fall time	-	100 μs

10.8 IPOK

The IPOK signal is used to detect whether the PSU input is normal. High level indicates that the input is normal, and low level indicates that the input is abnormal.

The IPOK signal must be lowered within 4 ms after the input voltage drops to 0 V.

System side: On the system side, whether the pin is pulled down, pulled up, or left floating, the PSU output, normal functions and performance are not affected.

Refer to **Figure 10-2** for the processing methods of the PSU side and system side.

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Figure 10-2 Interconnection diagram of the IPOK signal

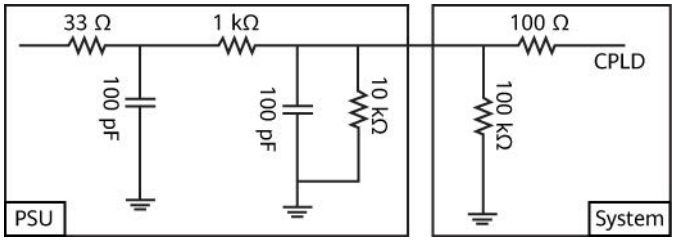


Table 10-9 IPOK signal characteristics

Signal Characteristics	
Signal type	Pulled up to the 3.3 V auxiliary power supply inside the PSU and output to the system.
IPOK = High level	The power input is normal.
IPOK = Low level	The power input is abnormal.

Table 10-10 IPOK output

IPOK Output	Min.	Max.
Logic low-level voltage	0 V	0.4 V
Logic high-level voltage	2.0 V	3.46 V
Sink current, IPOK = Low level	-	4 mA
Source current, IPOK = High level	-	4 mA
Signal rise and fall time	-	500 μs

NOTE

- Normal input: 90 V AC < V_{in} < 264 V AC or 180 V DC < V_{in} < 320 V DC
- Abnormal input: AC input undervoltage/overvoltage protection, or DC input undervoltage/overvoltage protection is triggered.

10.9 I-MON

This signal is a 12 V current sharing signal and is connected to the system backplane.

PSU side: Internal current sharing bus

System side: The 12 V load sharing signals of all PSUs are directly connected together.

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10.10 SCL and SDA

The I2C serial clock line (SCL) and the serial data line (SDA) occupy two signal pins of the output connector.

PSU side**:**

- Interconnection in the PSU: SCL and SDA must be pulled up to 3.3 V by a 10-kilohm (reference value) resistor. Internal series resistance is 10 ohms, and internal filter capacitance is less than 68 pF.
- The voltage source that supplies power to the secondary MCU is generated by the auxiliary power source and system-side 12 V bus at the same time.

System side: Reserve a pull-up position.

10.11 A0 and A1

Addresses A1 and A0 are allocated to a PSU.

PSU side:

- PSU internal connection: A1 and A0 must be pulled up to the internal voltage source respectively by a 10-kilohm (reference value) resistor.
- Addresses A1 and A0 are allocated to a PSU.

System side:

- If this signal is connected to SGND through a 200-ohm (reference value) resistor, the address bit is 0.
- If this signal is left open, the address bit is 1.

10.12 Cold Redundancy Bus

This signal is a redundant backup signal. All cold redundant bus signals are connected together.

When the pin is at high level in cold redundancy mode, the PSU enters the standby mode.

When the pin is at low level, the PSU in cold standby mode enters the normal redundancy mode.

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10.13 Signal Quality Requirements

Table 10-11 Signal quality requirements

Parameter	Test Item	Min.	Typ.	Max.	Remarks
Signal noise	Output edge connector	-	-	300 mV (peak to peak)	Bandwidth: 20 MHz The current sharing signal is not connected to the system and is not required.

NOTE

Conduct a single PSU test (with a 100 nF ceramic capacitor added to the coaxial cable port) or an in-server test on the board for acceptance.

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11 Communication

11.1 Signal Characteristics
11.2 Data Link Layer Protocol
11.3 Network Layer Protocol
11.4 Application Layer Protocol
11.5 PSU Reverse Power Supply

11.1 Signal Characteristics

Table 11-1 PMBus detection precision

Parameter	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
Input voltage detection precision	-5	-	5	%	V_{in} = 110 V AC/220 V AC/240 V DC, T_A = 25°C to 35°C (77°F to 95°F), $P_{out} \leq 5\%$
	-5	-	5	%	V_{in} = 110 V AC/220 V AC/240 V DC, T_A = 25°C to 35°C (77°F to 95°F), $5\% < P_{out} \leq 10\%$
	-5	-	5	%	V_{in} = 110 V AC/220 V AC/240 V DC, T_A = 25°C to 35°C (77°F to 95°F), $10\% < P_{out} \leq 20\%$
	-2	-	2	%	V_{in} = 110 V AC/220 V AC/240 V DC, T_A = 25°C to 35°C (77°F to 95°F), $P_{out} > 20\%$

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Parameter	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
Input current detection precision	-10	-	10	%	V_{in} = 110 V AC/220 V AC/240 V DC, T_A = 25°C to 35°C (77°F to 95°F), P_{out} ≤ 5% **NOTE** When the detection accuracy of the input current is less than 0.2 A, the detection accuracy of 0.2 A is reported.
	-10	-	10	%	V_{in} = 110 V AC/220 V AC/240 V DC, T_A = 25°C to 35°C (77°F to 95°F), 5% < P_{out} ≤ 10%
	-5	-	5	%	V_{in} = 110 V AC/220 V AC/240 V DC, T_A = 25°C to 35°C (77°F to 95°F), 10% < P_{out} ≤ 20%
	-2	-	2	%	V_{in} = 110 V AC/220 V AC/240 V DC, T_A = 25°C to 35°C (77°F to 95°F), P_{out} > 20%
Input average power precision	-10	-	10	%	V_{in} = 110 V AC/220 V AC/240 V DC, T_A = 25°C to 35°C (77°F to 95°F), P_{out} ≤ 5% **NOTE** When the input average power accuracy is less than 10 W, the input average power accuracy of 10 W is reported.
	-5	-	5	%	V_{in} = 110 V AC/220 V AC/240 V DC, T_A = 25°C to 35°C (77°F to 95°F), 5% < P_{out} ≤ 20%
	-2	-	2	%	V_{in} = 110 V AC/220 V AC/240 V DC, T_A = 25°C to 35°C (77°F to 95°F), P_{out} > 20%
Output voltage detection precision	-5	-	5	%	V_{in} = 110 V AC/220 V AC/240 V DC, T_A = 25°C to 35°C (77°F to 95°F), P_{out} ≤ 20%
	-2	-	2	%	V_{in} = 110 V AC/220 V AC/240 V DC, T_A = 25°C to 35°C (77°F to 95°F), P_{out} > 20%
Output current detection precision	-10	-	10	%	V_{in} = 110 V AC/220 V AC/240 V DC, T_A = 25°C to 35°C (77°F to 95°F), P_{out} ≤ 5% **NOTE** When the output current detection precision is less than 1 A, the output current detection precision of 1 A is reported.
	-10	-	10	%	V_{in} = 110 V AC/220 V AC/240 V DC, T_A = 25°C to 35°C (77°F to 95°F), 5% < P_{out} ≤ 10%

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Parameter	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
	-5	-	5	%	V_{in} = 110 V AC/220 V AC/240 V DC, T_A = 25°C to 35°C (77°F to 95°F), 10% < P_{out} ≤ 20%
	-2	-	2	%	V_{in} = 110 V AC/220 V AC/240 V DC, T_A = 25°C to 35°C (77°F to 95°F), P_{out} > 20%
Real-time output power precision	-10	-	10	%	V_{in} = 110 V AC/220 V AC/240 V DC, T_A = 25°C to 35°C (77°F to 95°F), P_{out} ≤ 5% **NOTE** When the real-time output power precision is less than 7 W, the real-time output power precision of 7 W is reported.
	-5	-	5	%	V_{in} = 110 V AC/220 V AC/240 V DC, T_A = 25°C to 35°C (77°F to 95°F), 5% < P_{out} ≤ 20%
	-2	-	2	%	V_{in} = 110 V AC/220 V AC/240 V DC, T_A = 25°C to 35°C (77°F to 95°F), P_{out} > 20%

11.2 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*.

11.2.1 I2C Signal

The PSU includes a main control unit (MCU) used for monitoring and an electrically erasable programmable read only memory (EEPROM) of 2000 bytes used for storing fault records. The PSU can use the 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.

SCL and SDA are the serial clock signal and the serial data signal of the I2C interface.

11.2.2 I2C Address

The I2C addresses of the PSU from high to low are A1 and A0. See **Table 11-2** for details.

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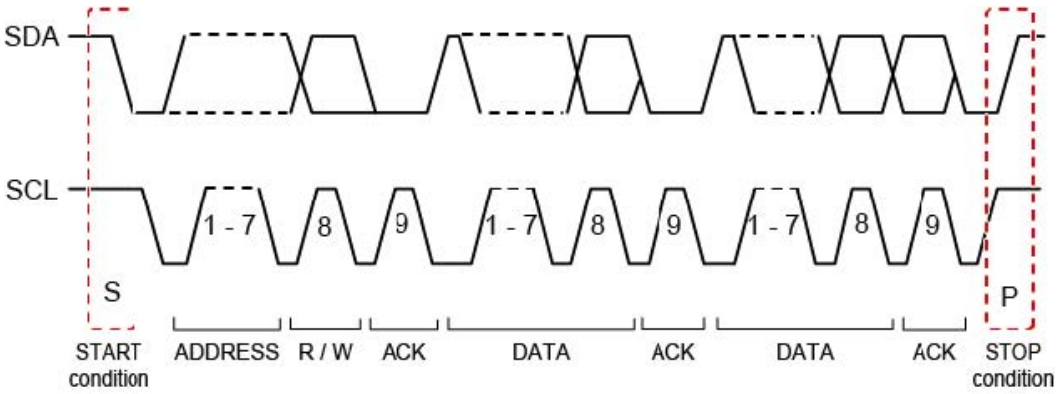
Table 11-2 I2C Address

Address A1/ Address A0	0/0	0/1	1/0	1/1
PMBus address	B0h/B1h	B2h/B3h	B4h/B5h	B6h/B7h
EEPROM Address	A0h/A1h	A2h/A3h	A4h/A5h	A6h/A7h

11.2.3 Data Transmission Mode

The I2C transmission standard is used. Data transmission rate is 100 Kbit/s. 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 SMBus. See **Figure 11-1** for the I2C data transmission mode.

Figure 11-1 I2C data transmission mode



11.2.4 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.

11.3 Network Layer Protocol

11.3.1 Secondary Addressing Method

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

11.3.2 Data Packet Verification Mode

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

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The last byte of each sent and received communication is the CRC code of this signal.

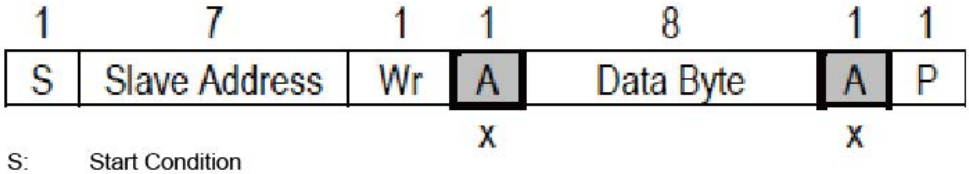
- When the primary device sends data to a secondary device, PEC (CRC) contains the address byte, read/write bit, command byte, and multiple pieces of data to be sent.
- The primary device obtains data from a secondary device: PEC (CRC) sent by the secondary device contains the address bytes obtained by the secondary device, read/write bits, command codes, and data bytes sent by the secondary device.

11.3.3 CRC Generation Rules

The generator polynomial is $x^8 + x^2 + x^1 + 1$, and the CRC code is 100000111.

11.3.4 Data Transmission

PMBus communication supports 10 data formats in total. All data formats adopt PEC verification.

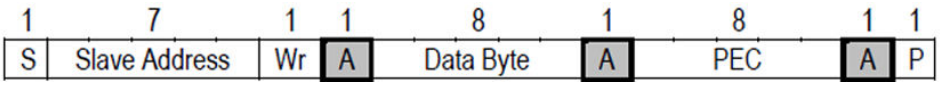


S: Start Condition
Sr: Repeated start condition
Rd: Read (bit value of 1)
Wr: Write (bit value of 0)
x: Shown under a field indicates that field is required to have the value of 'x'
A: Acknowledge (this bit position may be '0' for an ACK or '1' for a NACK)
P: Stop condition
PEC: Packet Error Code
...: Continuation of protocol

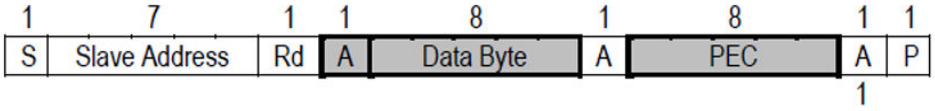
Master-to-Slave

Slave-to-Master

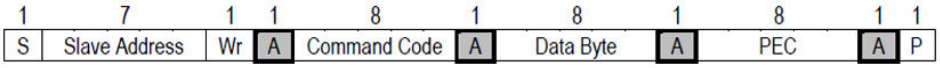
- Send Byte command and response.



- Receive Byte command and response.

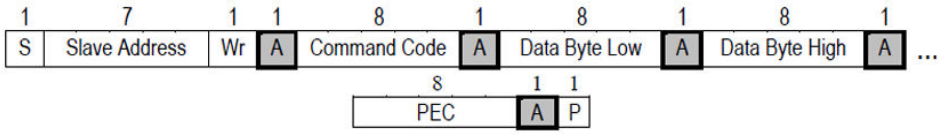


- Write Byte command and response.

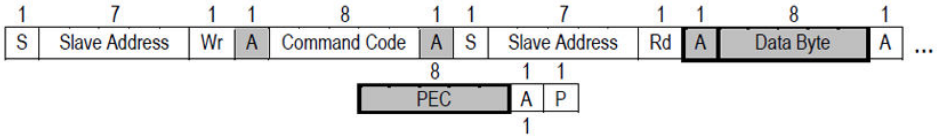


- Write Word command and response.

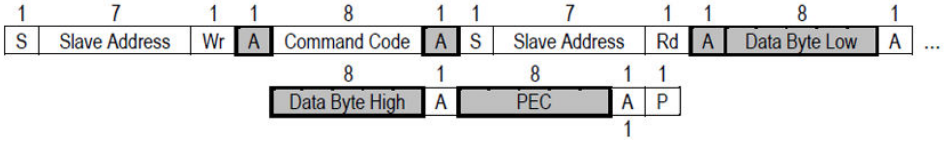
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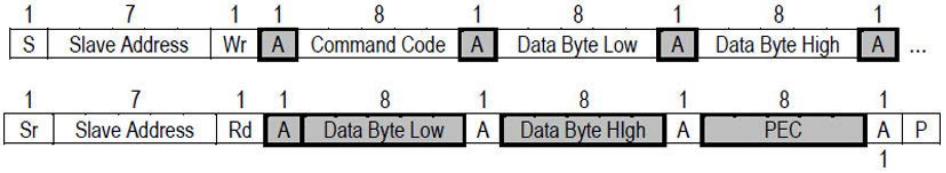
- Read Byte command and response.



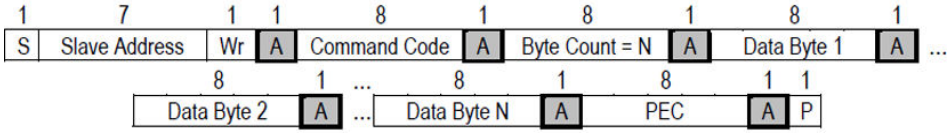
- Read Word command and response.



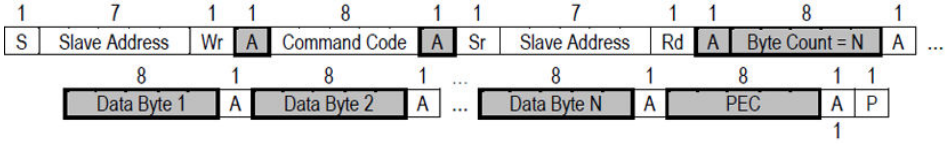
- Process Call command and response.



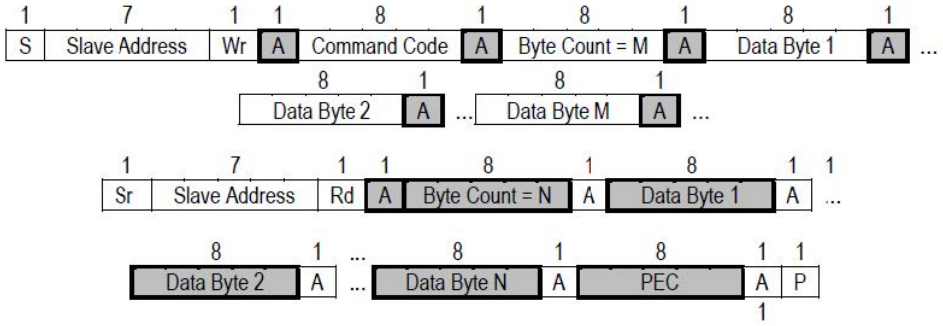
- Block Write command and response.



- Block Read command and response.



- Block Read – Block Write Process Call command and response.



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11.4 Application Layer Protocol

NOTE

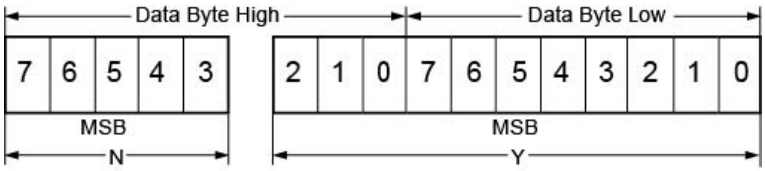
- The PMBus alarm is not latched. If a PSU is faulty, an alarm is reported. After the PSU fault is rectified, the alarm is automatically cleared.
- If the PSU is faulty, the system sends **CLEAR_FAULTS** to clear the alarm. If the alarm persists, the PSU continues to report the alarm.
- The **FAULT** alarm and the **WARNING** alarm are mutually exclusive.

11.4.1 Data Format

Linear 11 Data Format

The Linear 11 data format is a two-byte value with an 11-bit binary signed mantissa (two's complement) and a 5-bit binary signed exponent (two's complement), as shown in **Figure 1 Linear 11 data format**.

Figure 11-2 Linear 11 data format



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

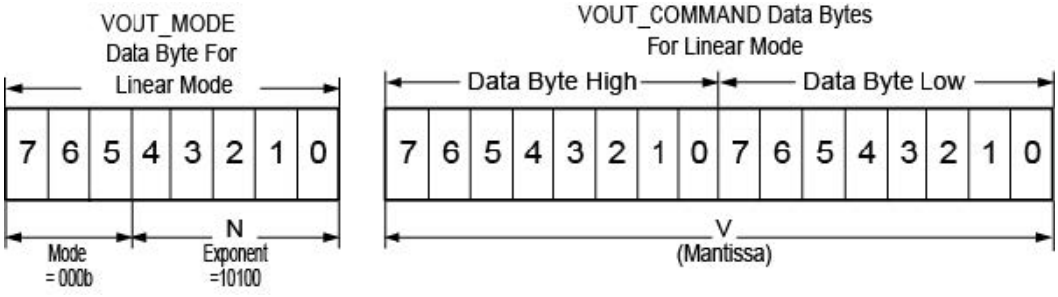
$X = Y \times 2^N$

- 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 16 data format is a two-byte value with a 16-bit binary unsigned mantissa and a 5-bit binary signed exponent (two's complement), as shown in **Figure 11-3**.

Figure 11-3 Linear 16 data format



The output voltage is calculated as follows:

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Voltage = V x 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), and N is –12.

11.4.2 Commands

Commands

Command ID	Command Name	Data Type	Data Format	Description
0x00	PAGE	RW	BYTE	PAGE operation
0x01	OPERATION	RW	BYTE	Remote startup and shutdown
0x02	ON_OFF_CONFIG	RW	BYTE	Output power-off enable control
0x03	CLEAR_FAULTS	W	BYTE	Clearing faults
0x05	PAGE_PLUS_WRITE	W	BLOCK	PAGE WRITE
0x06	PAGE_PLUS_READ	R	BLOCK R-W	PAGE READ
0x19	CAPABILITY	R	BYTE	Communication query
0x1A	QUERY	R	BLOCK R-W	Reading CMD data format
0x1B	SMBALERT_MASK	R	BLOCK R-W	Masking SMBAlert alarm **NOTE** Read the SMBAlert# signal alarm MASK value to check whether the corresponding alarm is masked when the SMBAlert# signal action is triggered. The temperature, input, and output current alarm words can be masked.

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Command ID	Command Name	Data Type	Data Format	Description
		W	WORD	Masking SMBAlert alarm **NOTE** Mask the enabling SMBAlert# signal during alarms. You can configure whether to mask the SMBAlert# signal action for each specific alarm. You can configure the temperature, input, and output current alarm words. When masking alarms, you are advised to mask pre-alarms to prevent the SMBAlert# signal from reversing caused by pre-alarms (for the system).
0x20	VOUT_MODE	R	BYTE	Output mode
0x21	VOUT_COMMAND	RW	WORD	Output voltage configuration
0x30	COEFFICIENTS	R	BLOCK R-W	DIRECT parameter COEFFCIENTS
0x3A	FAN_CONFIG	RW	BYTE	Fan configuration
0x3B	FAN_COMMAND	RW	WORD	Fan speed setting
0x60	AUTO_TURNON_DELAY	RW	WORD	Setting the restart time
0x78	PMBUS_CMD_STATUS_BYTE	RW	BYTE	Status single-byte
0x79	STATUS_WORD	RW	WORD	Status dual-byte
0x7A	PMBUS_CMD_STATUS_VOUT	RW	BYTE	Output voltage status
0x7B	STATUS_IOUT	RW	BYTE	Output current status
0x7C	STATUS_INPUT	RW	BYTE	Input status
0x7D	STATUS_TEMP	RW	BYTE	Temperature status
0x7E	PMBUS_CMD_STATUS_CML	RW	BYTE	CML status

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Command ID	Command Name	Data Type	Data Format	Description
0x80	INPUT_TYPE	R	BYTE	Input voltage type
0x81	STATUS_FANS_1_2	RW	BYTE	Fan status
0x83	PMBUS_CMD_READ_IOUT_1	R	WORD	Sampling of output current 1
0x86	READ_EIN	R	BLOCK	Accumulated input power
0x87	READ_EOUT	R	BLOCK	Accumulated output power
0x88	READ_VIN	R	WORD	Input voltage
0x89	READ_IIN	R	WORD	Input current
0x8A	READ_VCAP	R	WORD	Voltage of the PFC storage capacitor
0x8B	READ_VOUT	R	WORD	Output voltage
0x8C	READ_IOUT	R	WORD	Output current
0x8D	READ_TEMPERATURE_1	R	WORD	Ambient temperature
0x8E	READ_TEMPERATURE_2	R	WORD	PSU internal hot spot temperature 1 (secondary side)
0x8F	READ_TEMPERATURE_3	R	WORD	PSU internal hot spot temperature 2 (primary side)
0x90	READ_FAN_SPEED_1	R	WORD	Fan speed
0x96	READ_POUT	R	WORD	Output power
0x97	READ_PIN	R	WORD	Input power
0x98	PMBUS_REVISION	R	BYTE	PMBus version
0x99	MFR_ID	R	BLOCK	Vendor name
0x9A	MFR_MODEL	RW	BLOCK	PSU name
0x9B	MFR_REVERSION	R	BLOCK	PSU version
0x9C	MFR_LOCATION	R	BLOCK	Manufacturer location
0x9D	MFR_DATE	RW	BLOCK	Production date

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Command ID	Command Name	Data Type	Data Format	Description
0x9E	MFR_SERIAL	RW	BLOCK	Product SN
0x9F	APP_PROFILE_SUPPORT	R	BYTE	PSU configuration parameters
0xA0	MFR_VIN_MIN	R	WORD	Minimum input voltage
0xA1	MFR_VIN_MAX	R	WORD	Maximum input voltage
0xA2	MFR_IIN_MAX	R	WORD	Maximum input current
0xA3	MFR_PIN_MAX	R	WORD	Maximum input power
0xA4	MFR_VOUT_MIN	R	WORD	Minimum output voltage
0xA5	MFR_VOUT_MAX	R	WORD	Maximum output voltage
0xA6	MFR_IOUT_MAX	R	WORD	Maximum output current
0xA7	MFR_POUT_MAX	R	WORD	Maximum output power
0xA8	MFR_TAMBIENT_MAX	R	WORD	Maximum operating ambient temperature
0xA9	MFR_TAMBIENT_MIN	R	WORD	Minimum operating ambient temperature
0xAA	MFR_EFFICIENCY_LL	R	BLOCK	Low-voltage input efficiency
0xAB	MFR_EFFICIENCY_HL	R	BLOCK	High-voltage input efficiency
0xC0	MFR_MAX_TEMP_1	R	WORD	Maximum temperature of hot spot 1
0xC1	MFR_MAX_TEMP_2	R	WORD	Maximum temperature of hot spot 2
0xC2	MFR_MAX_TEMP_3	R	WORD	Maximum temperature of hot spot 3
0xD0	CR_Mode	RW	BYTE	Cold standby control command
0xD2	MFR_PSU_Defined	R	BYTE	Version definitions of input, fan and switch

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Command ID	Command Name	Data Type	Data Format	Description
0xD4	MFR_HX_COMPATIBILITY	R	WORD	Loading hardware version feature
0xD5	MFR_FWUPLOAD_CAPABILITY	R	BYTE	Loading feature
0xD6	MFR_FWUPLOAD_MODE	RW	BYTE	Entering loading mode
0xD7	MFR_FWUPLOAD	W	BLOCK	Delivering loading data
0xD8	MFR_FWUPLOAD_STATUS	R	WORD	Data loading status
0xD9	MFR_FW_REVISION	R	BLOCK	Reporting software version
0xDB	MFR_FRU_PROTECTION	RW	BYTE	FRU write protection
0xDC	MFR_BLACKBOX	R	BLOCK	Reading all black box data
0xDD	MFR_REAL_TIME_BLACK_BOX	RW	BLOCK	Time serving
0xDE	MFR_SYSTEM_BLACK_BOX	RW	BLOCK	System data storage
0xDF	MFR_BLACKBOX_CONFIG	RW	BYTE	Black box enabling
0xE0	MFR_CLEAR_BLACKBOX	W	BYTE	Clearing black box data
0xE1	CR VonVoff	RW	BLOCK	Current share bus voltage when entering or exiting the cold standby mode
0xE2	PSU units	RW	BYTE	Number of PSUs
0xE3	OUT COUNT	R	BYTE	Number of main output channels of the PSU
0xEA	FW_SPEC	R	BLOCK	Software specifications

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Command ID	Command Name	Data Type	Data Format	Description
0xF0	MFR_PWOK_WARNING_TIME	RW	WORD	Setting the PWOK alarm time
0xF1	MFR_MAX_IOUT_CAPABILITY	R	BLOCK	Reporting maximum current capability

11.4.3 Command Descriptions

PMBUS_CMD_STATUS_BYTE (0x78)

Bit Address	Command Name
7	BUSY
6	OFF
5	VOUT_OV_FAULT
4	IOUT_OC_FAULT
3	VIN_UV_FAULT
2	TEMPERATURE
1	CML
0	NONE OF THE ABOVE

PMBUS_CMD_STATUS_WORD (0x79)

Bit Address	Command Name
15	VOUT
14	IOUT/Pout
13	INPUT
12	MFR_SPECIFIC
11	POWER_GOOD#
10	FANS
9	OTHER
8	UNKNOWN

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Bit Address	Command Name
7	BUSY
6	OFF
5	VOUT_OV_FAULT
4	IOUT_OC_FAULT
3	VIN_UV_FAULT
2	TEMPERATURE
1	CML
0	NONE OF THE ABOVE

PMBUS_CMD_STATUS_VOUT (0x7A)

Bit Address	Command Name
7	VOUT_OV_FAULT
6	VOUT_OV_WARNING
5	VOUT_UV_WARNING
4	VOUT_UV_FAULT
3	Reserved
2	Reserved
1	Reserved
0	Reserved

PMBUS_CMD_STATUS_IOUT (0x7B)

Bit Address	Command Name
7	IOUT_OC_FAULT
6	Reserved
5	IOUT_OC_WARNING
4	Reserved
3	Reserved
2	Reserved
1	IOUT_OP_FAULT

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Bit Address	Command Name
0	IOUT_OP_WARNING

PMBUS_CMD_STATUS_ INPUT (0x7C)

Bit Address	Command Name
7	VIN_OV_FAULT
6	VIN_OV_WARNING
5	VIN_UV_WARNING
4	VIN_UV_FAULT
3	VIN_ACOFF
2	IIN_OC_FAULT
1	IIN_OC_WARNING
0	PIN_OP_WARNING

PMBUS_CMD_STATUS_TEMP (0x7D)

Bit Address	Command Name
7	OT_FAULT
6	OT_WARNING
5	Reserved
4	Reserved
3	Reserved
2	Reserved
1	Reserved
0	Reserved

PMBUS_CMD_STATUS_CML (0x7E)

Bit Address	Command Name
7	Invalid/Unsupport ed Command
6	Invalid/Unsupport ed Data

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Bit Address	Command Name
5	Packet Error CheckFailed
4	Memory Fault Detected
3	Processor Fault Detected (Reserved)
2	Reserved
1	Other Communication Fault
0	Other Memory Or Logic Fault has occurred (reserved)

PMBUS_CMD_STATUS_FANS_1_2 (0x81)

Bit Address	Command Name
7	Fan 1 Fault
6	Reserved
5	Fan 1 Warning
4	Reserved
3	Reserved
2	Reserved
1	Reserved
0	Reserved

11.4.4 Online Upgrade

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

11.4.5 Black Box Function

This specification defines the requirements for power supplies with PMBus capability to store PMBus and other data into non-volatile memory inside the power supply. The data shall be saved to the non-volatile memory upon a critical failure that caused the power supply to shutdown.

11.4.5.1 When Data is saved to the Black Box

Data is saved to the black box for the following fault events:

- PSU shutdown
- Overvoltage on output
- Overcurrent on output

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- Loss of AC input
- Input voltage fault
- Fan fault
- Overtemperature

NOTE

When the same type of fault occurs continuously, data should be stored to the black box.

11.4.5.2 Black Box Events

There are two types of data saved in the black box:

- System tracking data
- Power supply event data

NOTE

System tracking data is saved to the black box whenever the system powers ON or when a power supply is added to the system.

11.4.5.3 Black Box Process

- System writes system tracking data to the power supply random-access memory (RAM) at power ON.
- System writes the real time clock data to the PSU RAM once every 5 minutes.
- Power supply tracks numbers of PSON and AC power cycles in the EEPROM.
- Power supply tracks ON time in the EEPROM.
- Power supply loads warning and fault event counter data from EEPROM into RAM.
- Upon a warning event, the PSU shall increment the associated counter in RAM.
- Upon a fault event, the PSU shall increment the associated counter in RAM.
- Upon a fault event that causes the PSU to shut-down, all event data in the PSU's RAM is saved to event data (N) in the power supply's EEPROM. This data includes the real time clock, number of AC and PSON power cycle, PSU ON time, warning event counters and fault event counters.

11.5 PSU Reverse Power Supply

- In the case of parallel PSUs, if the system works normally and there is no input from a single PSU, the system must be able to communicate with the PSU normally.
- The voltage source must be generated by the auxiliary power source and system-side 12 V bus that supplies power to the MCU and the EEPROM at the same time.

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12 Heat Dissipation Requirements and Fan Control

The PSU supports forcible air cooling for heat dissipation. The PSU uses 40 mm (W) x 40 mm (H) fans. The air blows in from the rear and blows out from the front.

Heat Dissipation Requirements

The fan should meet the following requirements:

- The PSU has a built-in fan to dissipate heat in air extraction mode. The fan draws air from the rear panel (at the output connector) and blows air out from the front panel (at the input connector).
- The fan must work at full speed before the PSU triggers overtemperature protection.

Fan Power Supply Mode

- Fan faults cannot cause the system bus to drop out of the normal range of the dynamic change voltage.
- If the fan of a PSU is faulty, the fan needs to be isolated.

Fan Protection

- In a parallel system, if the fan power supply circuit is short-circuited or open-circuited, the system bus voltage should not exceed the normal dynamic change voltage restriction. The system operation should not 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 20s. (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 20s.)
- A fan fault can be rectified (except when the fan power supply circuit is short-circuited).

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13 Indicator on the Panel

The power supply of the PSU indicator is the same as that of the secondary MCU, as shown in the **Figure 13-1** below.

Figure 13-1 Position of the indicator on the panel.

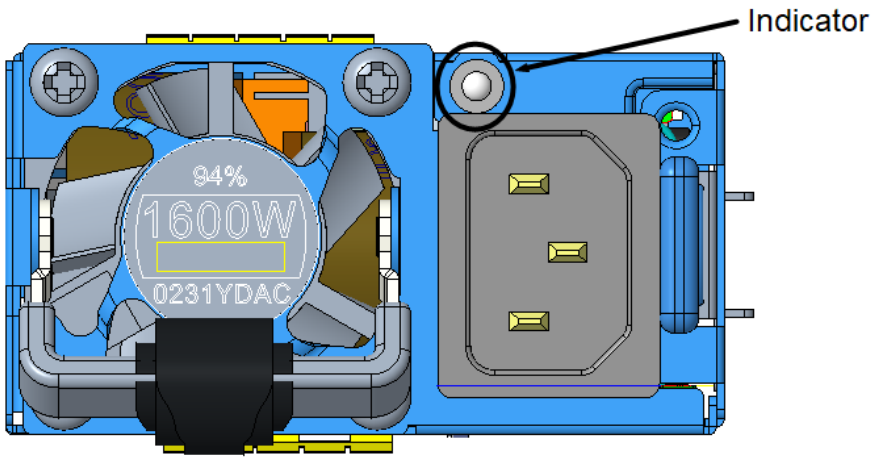


Table 13-1 Indicator on the Panel

Indicator	Status	Luminance	Abnormal Causes
Steady green	Green	> 36 cd/m^2	The input and +12 V DC active output are normal.
Blinking green at 1 Hz	Green	> 36 cd/m^2	• The input is normal. The PSU enters the shutdown mode because the PSON12V# signal is at high level. • The standby PSU is in cold standby mode.

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Indicator	Status	Luminance	Abnormal Causes
Blinking green at 2 Hz	Green	>36cd/m2	Online upgrade is in progress.
Steady orange (or yellow)	Orange	> 36 cd/m^2	● One PSU is powered on and the other is in standby with no input and is in reverse supply mode. ● The input is normal, and the output is protected. No output is generated due to power overtemperature protection, power output overcurrent/short circuit protection, output overvoltage protection, or fan faults.
Blinking orange at 1 Hz	-	> 36 cd/m^2	The output of the PSU is normal, but there are alarms such as: overtemperature alarms, overpower alarms, overcurrent alarms, and fan alarms.
Off	-	-	All PSUs have no power input.

NOTE

The indicator uses the green and orange bi-color indicator. When the indicator is controlled by the main control unit, the indicator status depends on the main control unit command.

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14 PSU Service Life Requirements

A PSU service life assessment report must be provided. The items that need to be mainly assessed include but are not limited to the service life of electrolytic capacitors and fans that significantly affect the PSU service life.

Table 14-1 PSU service life requirements

Evaluation Item	Indicator Requirement	Assessment Conditions	Remarks
Service life of all electrolytic capacitors	5 years	No external cooling measures; air inlet ambient temperature of 55°C (131℉); 20% load for 20% of time; 80% load for 80% of time.	The temperature of electrolytic capacitors must be that presented in the report of actually measured temperatures, which needs to be attached with photos of capacitor temperature test points.
Fan service life	No less than five years	Air inlet ambient temperature of 55°C (131℉); 20% load for 20% of time; 80% load for 80% of time; altitude: 900 m (2952.76 ft)	-

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15 Product Storage, and Transportation

Storage Requirements

The product must be stored in a dry and well-ventilated warehouse where the temperature ranges from –40°C to +85°C (-40°F to +185°F), the relative humidity is not greater than 80%, and no corrosive gas exists.

Transportation Requirements

During transportation, the product must be securely placed in a packing case. The packing case must comply with related international standards and be printed with marks such as "Handle with care" and "Keep dry". The packing case containing the product can be transported by any means. The packing case must be protected against rains, snows, and mechanical impact during transportation.

Enclosure Protection

Table 15-1 Enclosure protection level

Item	Requirement
Enclosure protection level	IP20 (normal maintenance surface)

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A Appendix

A.1 EMC Requirements

Parameter	Indicator Requirement	Criterion
Conducted emission (CE)	6 dB margin	EN 55032, class A
Radiated emission (RE)	6 dB margin	EN 55032, class A
	6 dB margin, 30 MHz–1 GHz	FCC Part 15, class A
ESD	Contact discharge: 6 kV, air discharge: 8 kV	IEC 61000-4-2, criterion B
	Contact discharge: 8 kV, air discharge: 15 kV	IEC 61000-4-2, criterion C
EFT	±2 kV	IEC 61000-4-4, criterion B
RS	10 V/m, 80 MHz to 6 GHz	IEC 61000-4-3, criterion A
CS	10 V, 150 kHz to 80 MHz	IEC 61000-4-6, criterion A

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Parameter	Indicator Requirement	Criterion
Power magnetic susceptibility (PMS)	30 A/m	IEC 61000-4-8: 2001, criterion A
Surge	AC input port: ● Differential mode: ±2 kV for L to N (1.2/50 μs, 2 ohms) ● Common mode: ±2 kV for L to PE, N to PE, and L and N to PE (1.2/50 μs, 2 ohms)	IEC 61000-4-5, criterion B
	HVDC input port: ● Differential mode: ±2 kV for P to N (1.2/50 μs, 2 ohms) ● Common mode: ±2 kV for P to PE, N to PE, and P and N to PE (1.2/50 μs, 12 ohms)	
Voltage fluctuation and flicker	Voltage fluctuation and flicker limit of class A products	IEC 61000-3-3
Current harmonics emission	Harmonic current limit of class A products	IEC 61000-3-2
Dip (AC)	Dip to 0% UT, single PSU 100% load, hold-up time: 10 ms	IEC 61000-4-11, criterion A
	Dip to 0% UT, single PSU 50% load, dual PSUs 100% load, 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 B
	Dip to 0% UT, hold-up time: 5,000 ms	IEC 61000-4-11, criterion C
Dip (HVDC)	Dip to 40% UT, hold-up time: 1 ms/3 ms/10 ms/30 ms/100 ms/300 ms/1000 ms	IEC 61000-4-29, criterion B
	Dip to 70% UT, hold-up time: 1 ms/3 ms/10 ms/30 ms/100 ms/300 ms/1000 ms	IEC 61000-4-29, criterion B
	Dip to 0% UT, hold-up time: 1 ms/3 ms/10 ms/30 ms/100 ms/300 ms/1000 ms	IEC 61000-4-29, criterion B

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Parameter	Indicator Requirement	Criterion
	Dip to 80% UT, hold-up time: 100 ms/300 ms/ 1000 ms/ 3000 ms/10,000 ms	IEC 61000-4-29, criterion A
	Dip to 120% UT, hold-up time: 100 ms/300 ms/ 1000 ms/ 3000 ms/10,000 ms	IEC 61000-4-29, criterion A

A.2 Product Safety Testing

Dielectric Strength Testing

Test Item	Min. Test Voltage	Test Time	Leakage Current	Arching Determination
Input and PE	2500 V DC	1 min	≤ 10 mA	No breakdown or arcing.
	1500 V AC	1 min	≤ 10 mA	No breakdown or arcing.
Input to output	4242 V DC	1 min	≤ 10 mA	No breakdown or arcing.
Output and PE	The 12 V GND is short-circuited to the PE inside the PSU.			

NOTE

Input to output must meet the reinforced insulation requirements after the output ground is disconnected from the PE.

Ground Continuity Testing

Test Item	Max. Test Voltage	Test Current	Max. Resistance	Test Time
PE input and shell	+12 V	25 A	0.1 ohm	Until the readings are stable.

NOTE

This test item is applicable only to power supply devices with metal shells or L-shaped supports that are connected to the PE.

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A.3 Reliability

Parameter	Min.	Typ.	Max.	Unit	Remarks
Mean time between failures (CMTBF)	-	250,000	-	Hours	Telcordia SR332, V_{in} = 230 V AC/240 V DC; rated load, T_A = 25ºC (77°F)

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