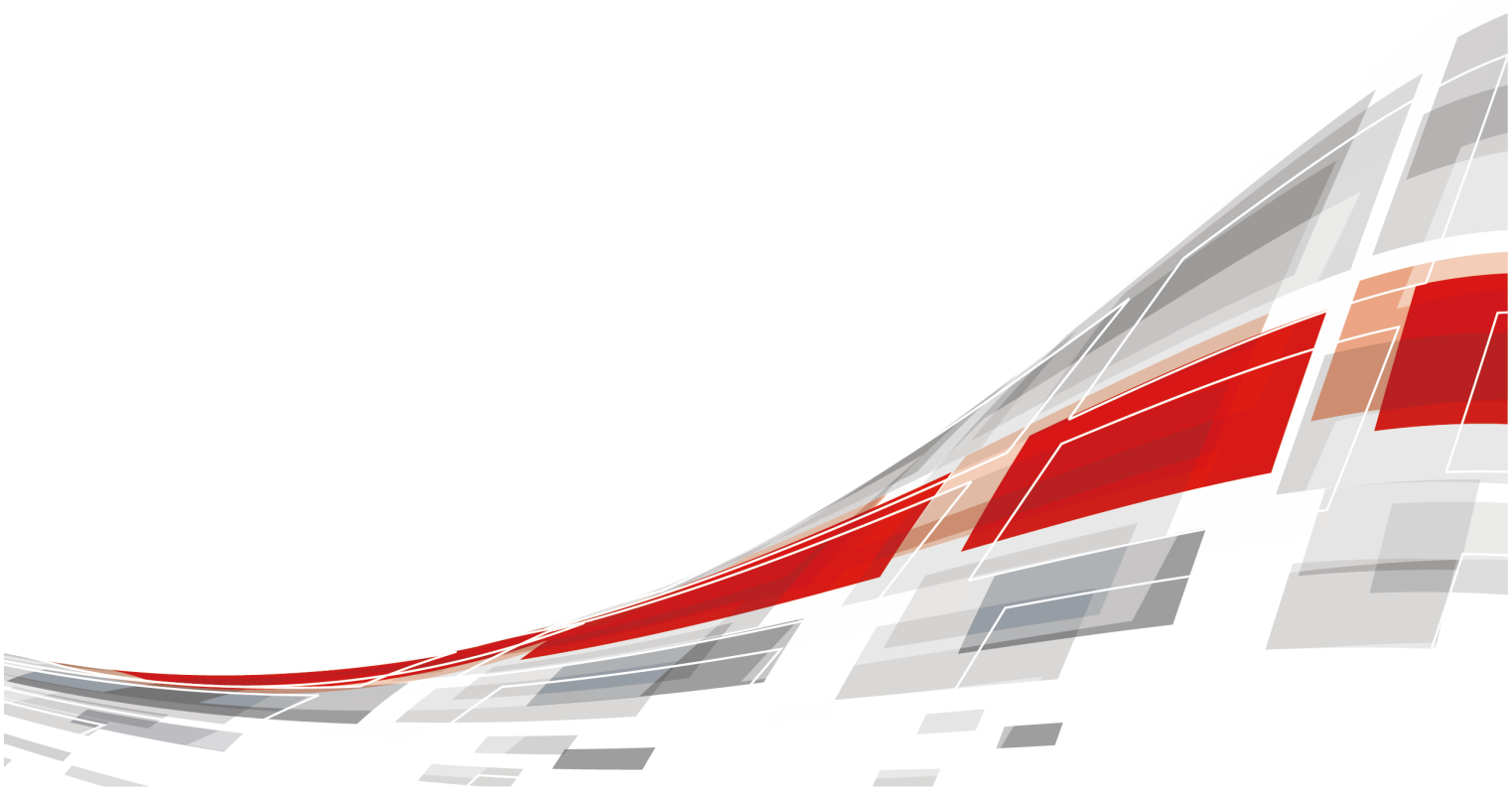
PHD1500S12-B2 PSU

Technical Manual

Issue 03

Date 2026-01-20



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About This Document

Purpose

This document describes the PHD1500S12-B2 power supply units (PSUs), including the functions and applications of their pins, as well as their heat dissipation and storage requirements.

The figures provided in this document are for reference only.

Intended Audience

This document is intended for pre-sales 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.

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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 5°C to 55°C (41°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, 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.
- The voltage between the L or N terminal of the PSU and the PE terminal cannot exceed 318 V AC.
- 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 PHD1500S12-B2 can convert AC into DC, and supports AC input ranging from 180 V to 264 V and HVDC input ranging from 260 V to 400 V. The PSU provides one output and supports three output modes (MV12, SV12 and MV6). The rated output power is 1500 W.

The PSU is hot-swappable, equalizes current, and supports 1+1 or 2+2 parallel connection.

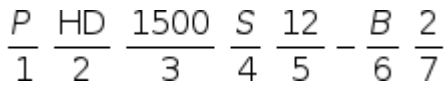
The PSU provides an I2C communication function for reporting the vendor, model, version and other information. It provides a black box and supports online upgrade. The PSU is designed according to the safety requirements and complies with the information technology equipment safety standards.

Figure 2-1 PHD1500S12-B2



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Model Naming Convention



No.	Description	No.	Description
1	Embedded power	2	HVDC input
3	Output power: 1500 W	4	Single output
5	Output voltage: 12 V DC	6	Platinum energy efficiency certification
7	Serial number	-	-

Features

- Efficiency: ≥ 94% (T_A = 25℃ (77℉); V_{in} = 230 V AC; P_{out} = 750 W; without a fan).
- Dimensions (L x W x H): 183.00 mm x 68.00 mm x 40.50 mm (7.205 in. x 2.677 in. x 1.594 in.).
- Weight: < 2 kg
- Supports input protection for overvoltage and undervoltage. Supports output protection for overvoltage, overcurrent, short circuit, and overtemperature.
- I2C for control, programming, and monitoring.
- AC: TUV, CE, NRTL, CCC certification and CB report available.
- 336HVDC: NRTL+TUV+CCC+CB+CE report available.
- 80 PLUS platinum energy efficiency certification.
- IEC 60950-1; IEC 62368-1; EN 60950-1; EN 62368-1; NRTL 60950-1; NRTL 62368-1 and GB 4943.1compliant.
- RoHS 6 compliant
- 2002/95/EC compliant

Application Scenario

Servers

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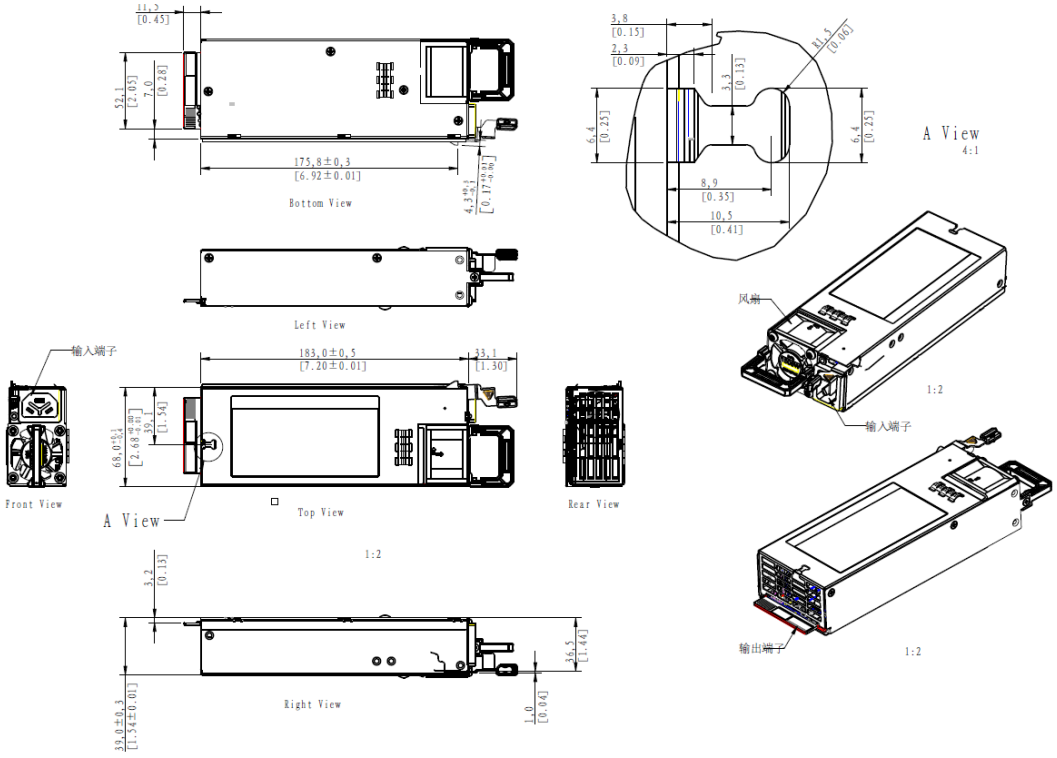
3 Product Structure Overview

3.1 Structural Dimensions

3.2 External Ports

3.1 Structural Dimensions

Dimensions (D × W × H) : 183.0 mm×68.0 mm×40.5 mm (7.20 in.×2.68 in.×1.59 in.)



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3.2 External Ports

Figure 3-1 Output port (top view)

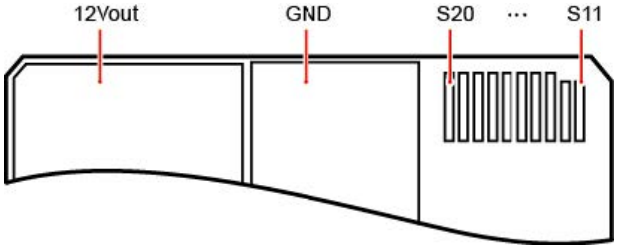
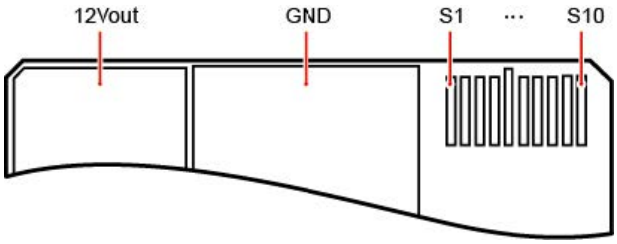


Figure 3-2 Output port (bottom view)



Pin	Name	Description
P1-P6, P21-P28	V12	PSU 12 V main output
P7-P20	RTN	PSU output GND
S20	OPOK	Signal for indicating whether the main output is normal
S19	IPOK	Signal for indicating whether the input is normal
S18	IPOK Link	Signal for indicating whether the input of the redundant PSU is normal
S17	SMART_ON	Signal for waking up the cold standby power mode
S16	SHLFBB_SF1	Reserved
S15	INSTALLED54#	Reserved
S14	IP PRESENT	SV12 control signal
S13	PSON12V#	MV12 remote on/off control signal

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Pin	Name	Description
S12	INSTALLED#	PSU installation signal
S11	PRESENT#	PSU presence signal
S10	I-MON	Current sharing signal
S9	EFUSEV	System E-Fuse voltage
S8	CYC_PWR#	Power supply cycle power signal
S7	PS_INTERRUPT#	PSU alarm interruption signal
S6	SDA	I2C data cable
S5	I2C Sig GND	I2C signal ground
S4	SCL	I2C Serial Clock Line
S3	ADD2	Address cable 2
S2	ADD1	Address cable 1
S1	ADD0	Address cable 0

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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	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
Operating temperature (T_A)	5	25	50	℃	• The PSU is able to start at -10°C (14℉), but there are no requirements on the PSU performance. • When the temperature is 60°C (140°F), the PSU can run reliably at half load.
Storage temperature	-40	25	85	℃	-
Relative humidity	5	-	95	%RH	Non-condensing. The PSU can work properly.
Altitude	-60	-	5000	m	5000 m (16,404 ft) in CCC certification. When the PSU is not working, it can be placed at an altitude of 15,000 m (49,212 ft).

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Parameter	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
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 and 336 V DC. • 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°F) for every increase of 220 m (721.78 ft).

4.2 Input Characteristics

Parameter	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
AC input voltage (V_{in})	180	220	264	V	-
Rated AC input voltage	200	220	240	V	-
AC input voltage frequency	47	50/60	63	Hz	-
HVDC input voltage range	260	380	400	V	The PSU can still work normally even in the case of reverse polarity wiring.
THDi (MV12)	-	-	-	%	No requirement at below 200 W Pload.
	-	-	20	%	T_A = 25°C (77°F), V_{in} = 208 V AC (60 Hz) or 230 V AC (50 Hz), and 200 W load.
	-	-	10	%	T_A = 25°C (77°F), V_{in} = 208 V AC (60 Hz) or 230 V AC (50 Hz), and 400 W load.

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Parameter	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
	-	-	5	%	T_A = 25℃ (77℉), V_{in} = 208 V AC (60 Hz) or 230 V AC (50 Hz), and ≥ 600 W load.
THDv	-	-	10	%	The PSU operation should not be affected if the THDv is 10%.
Power factor (MV12)	0.94	-	-	-	T_A = 25℃ (77℉), V_{in} = 208 V AC (60 Hz) or 230 V AC (50 Hz), and 10% load.
	0.96	-	-	-	T_A = 25℃ (77℉), V_{in} = 208 V AC (60 Hz) or 230 V AC (50 Hz), and 20% load.
	0.98	-	-	-	T_A = 25℃ (77℉), V_{in} = 208 V AC (60 Hz) or 230 V AC (50 Hz), and 50% load.
	0.98	-	-	-	T_A = 25℃ (77℉), V_{in} = 208 V AC (60 Hz) or 230 V AC (50 Hz), and 100% load.
Maximum AC input current	-	-	10	A	V_{in} = 200 V AC, rated load output
HVDC input current	-	-	10	A	V_{in}=336 V DC, rated load output.
AC input DC bias	-	-	50	mA	Rated input, full-range output
Input inrush current	-	-	30	A	Complies with ETSI 300132-3
Standby power	-	-	3	W	● T_A = 25°C (77°F), V_{in} = 230 V AC/336 V DC. ● The fan is shut down, output disabled. The power factor correction (PFC) is disabled. The PSU is in deep sleep mode (parallel connection condition).
	-	-	5	W	● T_A = 25°C (77°F), V_{in} = 230 V AC/336 V DC. ● Lowest fan speed, output disabled. The PSU is in cold standby state.

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Parameter	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
	-	-	10	W	• T_A = 25°C (77°F), V_{in} = 230 V AC/336 V DC. • Lowest fan speed, Iout = 0 A. The PFC is enabled. MV12 operation mode (parallel connection condition).
Harmonic current	-	-	-	-	T_A = 25°C, meets the test requirements of class A equipment.
C32 trip prevention characteristic	-	-	-	-	If an internal fault occurs in the PSU, the upstream C32 circuit breaker is not allowed to trip.

4.3 Output Characteristics

Parameter	Output	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
Number of outputs	-	-	-	Single route	-	There is a single output. The output mode can be MV12 (V_{out} = 12 V DC), SV12 (V_{out} = 12 V DC) or MV6 (V_{out} = 7.6 V DC).
Output power	MV12	-	-	1500	W	V_{in} = 180–264 V AC or V_{in} = 260–400 V DC
	MV6	-	-	60	W	V_{in} = 180–264 V AC or V_{in} = 260–400 V DC
Output voltage setpoint	MV12/SV12	12.27	12.30	12.33	V	T_A = 25℃ (77℉), rated input, I_{out} = 3 A
	MV6	7.3	7.6	7.9	V	T_A = 25℃ (77℉), rated input, I_{out} = 3 A
Output	MV12/SV12	11.7	12.3	12.6	V	From 0% load to full load; area I. This parameter value is tested when the load is higher than the minimum value.

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Parameter	Output	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
voltage	MV6	6.37	7.60	8.20	V	
Output current	MV12	2	-	125	A	V_{in} = 180–264 V AC or V_{in} = 260–400 V DC
	MV6	0.5	-	10	A	-
	SV12	2	-	45	A	-
Source regulation rate	-	-1	-	1	%	-
Output ripple and noise (peak to peak)	MV12	-	-	120	mV	Before the test, connect a 10 μF capacitor and a 0.1 μF ceramic capacitor in parallel at the output end, and set the oscilloscope bandwidth to 20 MHz. Full range of temperature, full input voltage, MV12 24 W or higher, with the minimum capacitive load 540 μF.
	MV6	-	-	360	mV	Before the test, connect a 10 μF capacitor and a 0.1 μF ceramic capacitor in parallel at the output end, and set the oscilloscope bandwidth to 20 MHz. Full temperature range, full input voltage, with the minimum capacitive load 540 μF.
Dynamic overshoot amplitude	MV12	11.4	-	12.6	V	Current change rate: 0.5 A/μs, T = 10 ms (CCDHT1 5 ms, CCDHT2 5 ms); load: 25%–50%–25%; 50%–75%–50%; 50%–100%–50%. Tested with a minimum capacitive load of 540 μF.
	MV6	6.0	-	8.2	V	Current change rate: 0.5 A/μs, T = 10 ms (CCDHT1 5 ms, CCDHT2 5 ms); load: 5 W to 60 W. With the minimum capacitive load 540 μF.

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Parameter	Output	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
Transient impact power overshoot	MV12	11.4	-	12.6	V	Current change rate: 0.5 A/μs, T = 1 s-10 ms-1 s; load: 65%–130%–65%
Overshoot at turn-on/off	-	-5	-	5	%	● The PSU is able to start at -10°C (14°F), but there are no requirements on the PSU performance. ● The performance must be ensured at 5°C (41°F) to 50°C (122°F).
Temperature coefficient	-	-0.02	-	0.02	%/°C	Rated output voltage, rated output current and full range of T_A.
Current share imbalance	-	-5	-	5	%	50%–100% rated load.
Capacitive load	MV12	540	-	22000	μF	● Full range of input voltage, load, and temperature. ● Solid capacitor
	MV6	270	-	1000	μF	
Hot Swap	MV12	11.4	-	12.6	V	The PSU backplane voltage cannot exceed the dynamic specifications of the PSU when the PSU is removed and inserted. The duration when the bus voltage is lower than 11.6 V is less than 200 μs and the voltage cannot be lower than 11.4 V.
	MV6	6.0	-	8.2	-	

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4.4 Efficiency Characteristics

Parameter	Output	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
Efficiency	MV12	87	-	-	%	T_A = 25°C (77°F), V_{in} = 230 V AC, 10% load, without a fan
		91	-	-	%	T_A = 25°C (77°F), V_{in} = 230 V AC, 20% load, without a fan
		94	-	-	%	T_A = 25°C (77°F), V_{in} = 230 V AC, 50% load, without a fan
		91	-	-	%	T_A = 25°C (77°F), V_{in} = 230 V AC, 100% load, without a fan
		85	-	-	%	T_A = 25°C (77°F), V_{in} = 336 V DC, 10% load, without a fan
		89	-	-	%	T_A = 25°C (77°F), V_{in} = 336 V DC, 20% load, without a fan
		92	-	-	%	T_A = 25°C (77°F), V_{in} = 336 V DC, 50% load, without a fan
		89	-	-	%	T_A = 25°C (77°F), V_{in} = 336 V DC, 100% load, without a fan
	MV6	70	-	-	%	T_A = 25°C (77°F), 6 V/4 A, without a fan
		75	-	-	%	T_A = 25°C (77°F), 6 V/8 A, without a fan

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4.5 Protection Characteristics

Table 4-1 Input Protection Characteristics

Parameter	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
AC input overvoltage protection threshold	280	-	-	V	Self-recovery
AC input overvoltage recovery threshold	275	-	-	V	Hysteresis ≥ 5 V
Input undervoltage protection threshold	-	-	175	V	Self-recovery
Input undervoltage recovery threshold	-	-	180	V	Hysteresis ≥ 5 V
Input overcurrent/ short circuit protection	-	-	-	-	Use a fast-blow fuse.
HVDC input overvoltage protection threshold	415	-	-	V	Self-recovery
HVDC input overvoltage recovery threshold	405	-	-	V	Hysteresis ≥ 5 V
HVDC input undervoltage protection threshold	-	-	250	V	Self-recovery

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Parameter	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
HVDC input undervoltage recovery threshold	-	-	255	V	Hysteresis ≥ 5 V

NOTE

- If input overvoltage/undervoltage protection is triggered, both MV12 and MV6 are shut down. The input voltage threshold that causes MV12 to shut down is the same as the input voltage threshold that causes MV6 to shut down.
- If input overvoltage/undervoltage is rectified, both MV12 and MV6 recover. The input voltage threshold that causes MV12 to recover is the same as the input voltage threshold that causes MV6 to recover.

Table 4-2 Output protection characteristics

Parameter	Output	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
Output overvoltage protection	MV12	13	-	15	V	Latch off
	SV12	13	-	15	V	Latch off
	MV6	13	-	15	V	• Latch off • In MV6 mode, if the PSU loop is detected to be open, protection is triggered directly without having to reach the MV6 overvoltage protection threshold.
Output overcurrent protection	MV12	105	-	130	%	Latch off, T ≥ 100 ms
		130	-	150	%	Latch off, T ≥ 4 ms

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Parameter	Output	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
	MV6	11	-	15	A	Response time: 100 ms to 200 ms In MV12 output mode, after PSON12V transitions from high level to low level and then to high level again, the PSU enters MV6 output mode.
	SV12	50	-	-	A	The PSU enters the MV12 mode after it experienced overcurrent in 12VSB mode. The indicator blinks at 1 Hz.
Output short circuit protection	MV12	150	-	-	%	Latch off, T < 500 μs
	MV6	15	-	-	A	Latch off, T < 500 μs
	SV12	-	-	-	-	Latch off

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Parameter	Output	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
Overtemperature protection	-	50	-	-	℃	● The PSU can be protected against overtemperature and shut down only when the ambient temperature is higher than 50°C (122°F). Overtemperature protection can be automatically restored. The hysteresis for restoration must be greater than 5°C (41°F). ● The environment protection threshold of the PSU must be set to 70°C (158℉) or higher. ● If overtemperature occurs in MV12 mode, the output is switched to the MV6 mode (even if PSON12V is at low level). If the overtemperature fault is rectified and PSON12V is at low level, the MV12 output is restored. ● If overtemperature occurs in MV6 mode, the output is disabled. If the overtemperature fault is rectified, the output is first restored to MV6 mode. If PSON12V is at a low level at this point, the output switches back from MV6 to MV12. ● The hysteresis for restoration must be greater than 5°C (41℉).

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NOTE

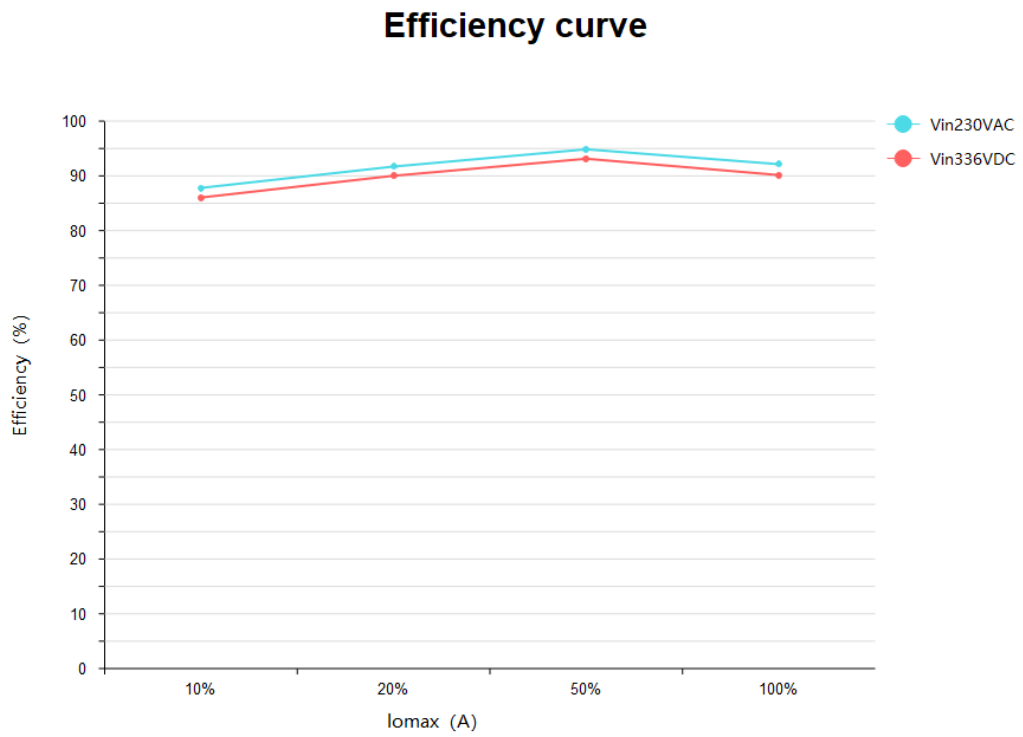
- MV12/MV6/SV12 overvoltage protection unlock mode (unlocked if any of the following conditions is met):
  - AC input is recovered after it is disconnected for 15s, and the PSU can work normally. (In a parallel system, if output overcurrent occurs on one PSU, recover the power after the AC input is disconnected. The PSU can be unlocked within 2s.)
  - INSTALLED# changes from low level to high level.
  - PSON12V# changes from high level to low level.
  - IP PRESENT signal changes from low level to high level twice within 30s.
- MV 12 output overcurrent/short circuit protection unlock mode (unlocked if any of the following conditions is met):
  - AC input is recovered after it is disconnected for 15s, and the PSU can work normally. (In a parallel system, if output overcurrent occurs on one PSU, recover the power after the AC input is disconnected. The PSU can be unlocked within 2s.) (In a parallel system, if output overcurrent occurs on one PSU, recover the power after the AC input is disconnected. The PSU can be unlocked within 2s.)
  - INSTALLED# changes from low level to high level.
  - PSON12V# changes from high level to low level. After PSON12V# changes to high level for more than 500 ms and then changes to low level, the PSU can be unlocked (MV12 output overcurrent).
  - IP PRESENT signal changes from low level to high level twice within 30s.
- SV12 output overcurrent/short circuit protection unlock mode (unlocked if any of the following conditions is met):
  - AC input is recovered after it is disconnected for 15s, and the PSU can work normally. (In a parallel system, if output overcurrent occurs on one PSU, recover the power after the AC input is disconnected. The PSU can be unlocked within 2s.)
  - INSTALLED# changes from low level to high level.
  - When overcurrent occurs in SV12 mode and does not cause the PSU to shut down, the PSU can be unlatched after the IP PRESENT signal is set from low level to high level once. When overcurrent occurs in SV12 mode and the PSU shuts down, the PSU can be unlatched after the IP PRESENT signal is set from low level to high level twice consecutively within 30s.
- MV6 output overcurrent/short circuit protection unlock mode (unlocked if any of the following conditions is met):
  - The input is reconnected 15s after being disconnected.
  - INSTALLED# changes from low level to high level.
  - PSON12V# changes from high level to low level.
- (In a parallel system, if output overcurrent occurs on one PSU, recover the power after the AC input is disconnected. The PSU can be unlocked within 2s.)

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5 Feature Curves

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

Figure 5-1 Efficiency curve



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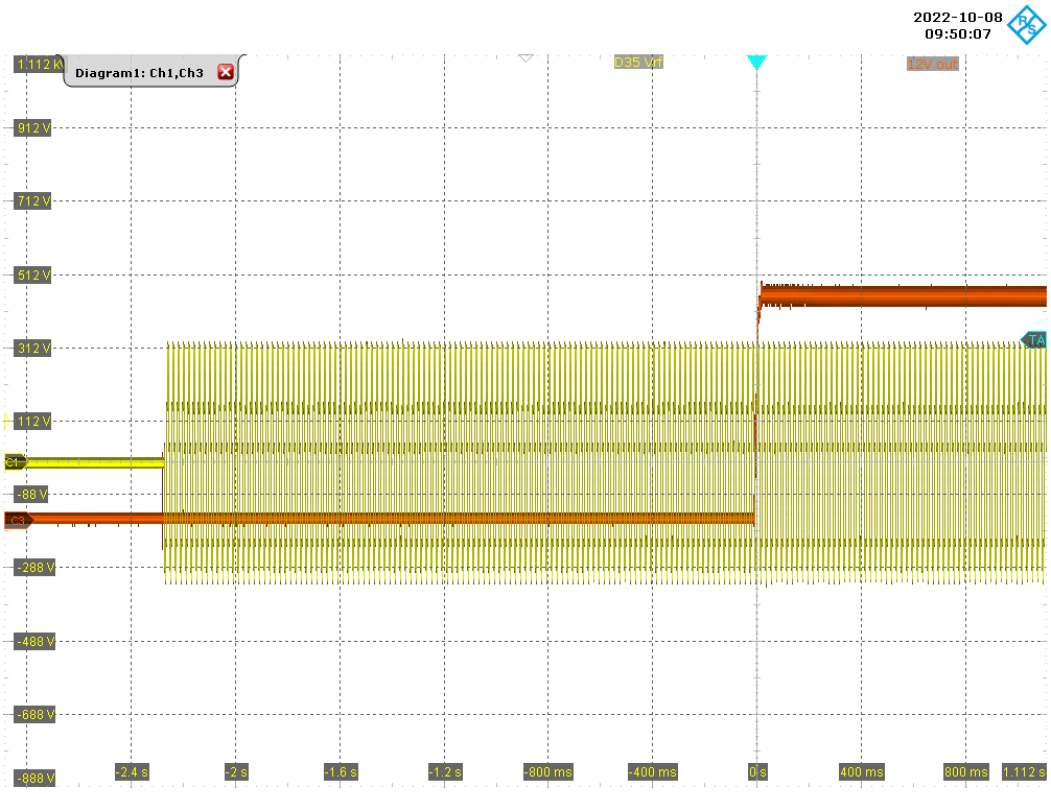
6 Typical Waveforms

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

6.1 Turn-On/Turn-Off

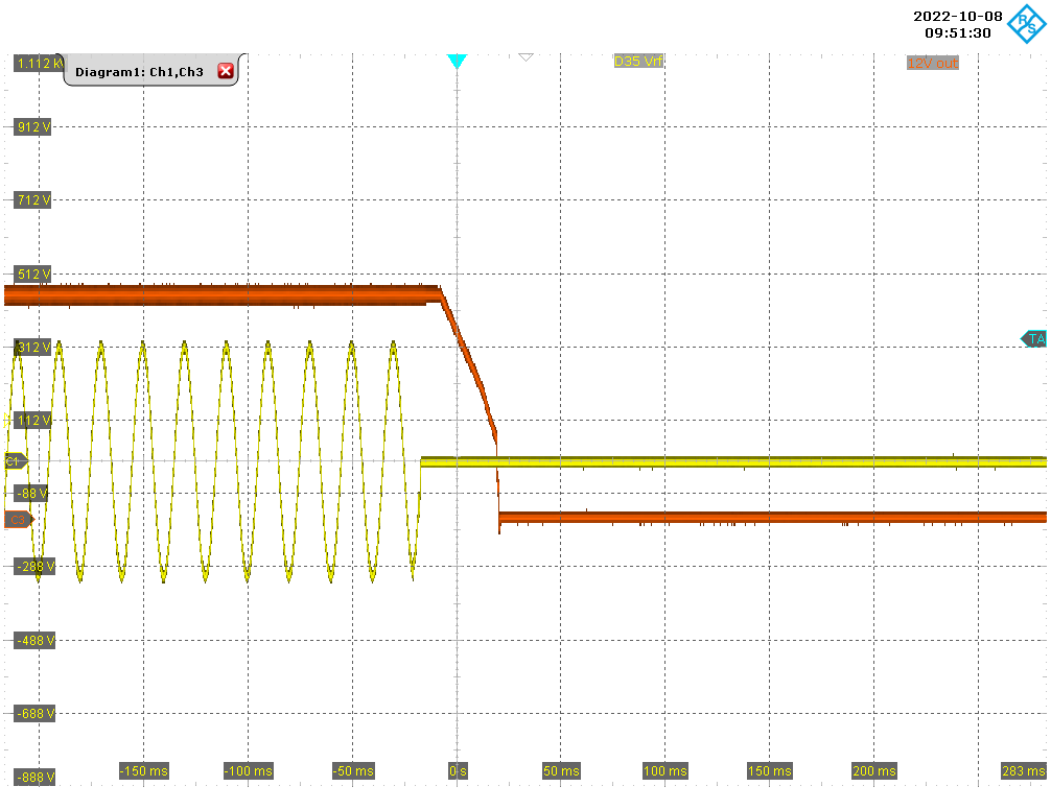
Conditions: T_A = 25°C (77°F) unless otherwise specified.

Figure 6-1 Startup by power-on (V_{in}=220 V AC , MV12)



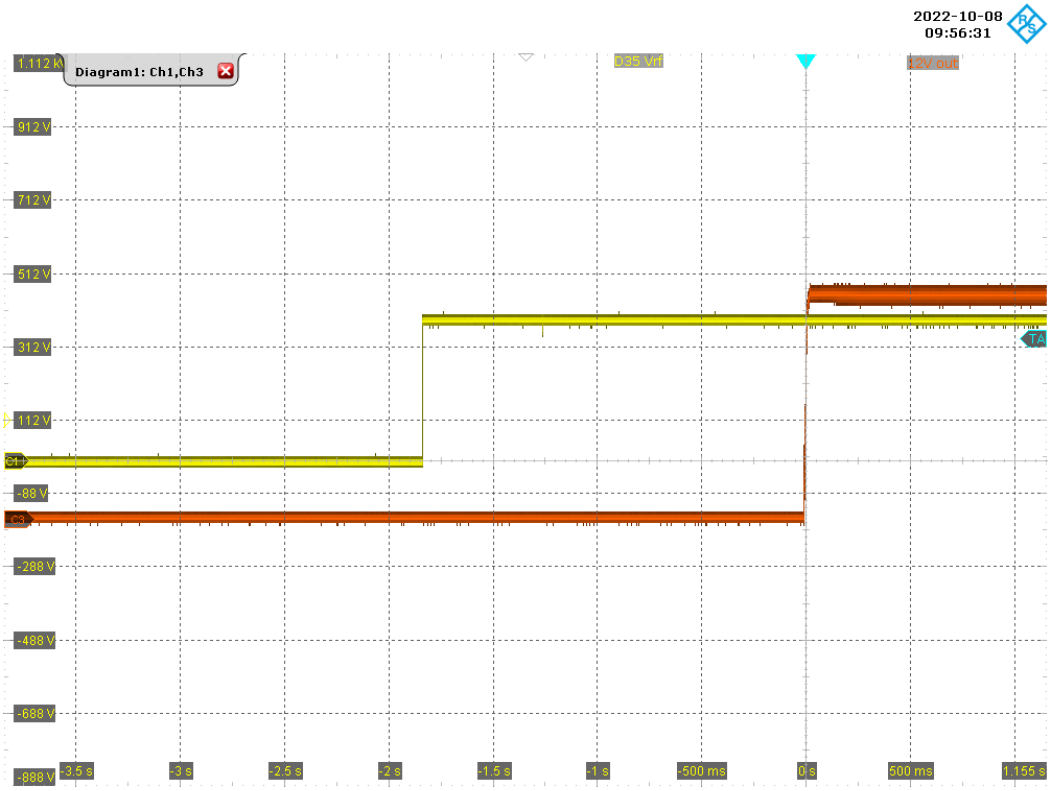
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Figure 6-2 Shutdown by power-off (V_{in}=220 V AC , MV12))



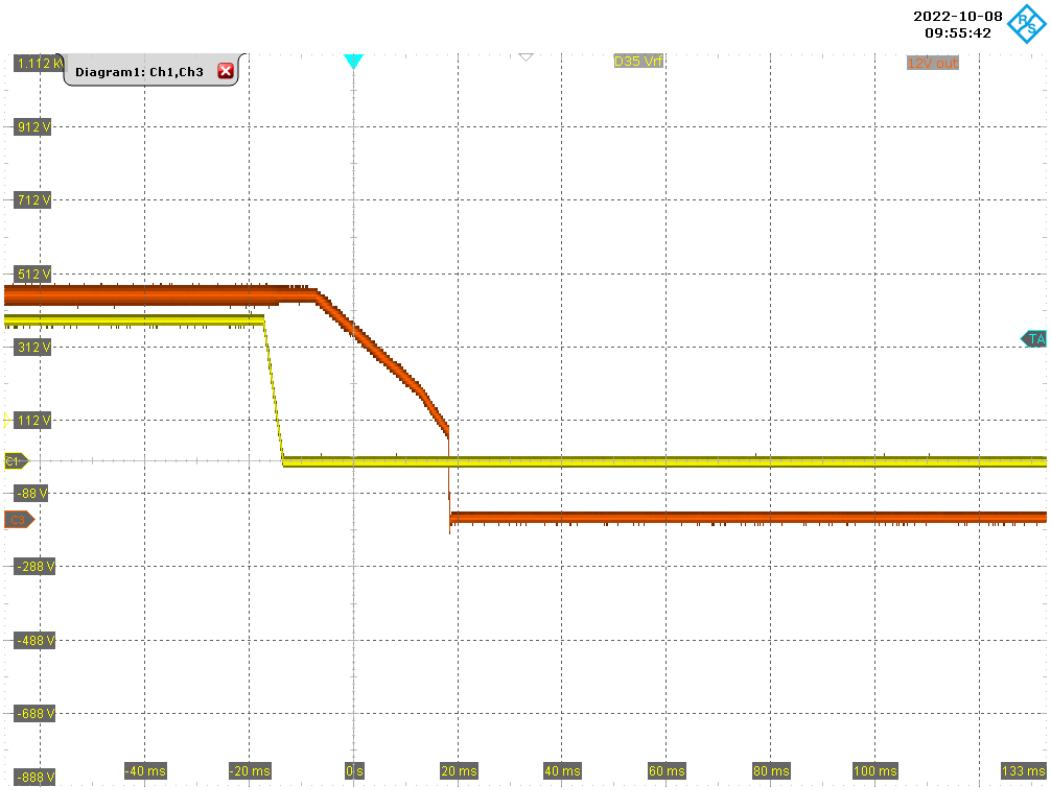
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Figure 6-3 Startup by power-on (V_{in}=380 V DC , MV12))



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Figure 6-4 Shutdown by power-off (V_{in}=380 V DC , MV12))



6.2 Output Voltage Dynamic Response

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

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Figure 6-5 Output voltage dynamic response (V_{in}=220 V AC ; load : 25% ~ 50% ~ 25% ; 0.5 A/μs ; T=10 ms ; MV12))

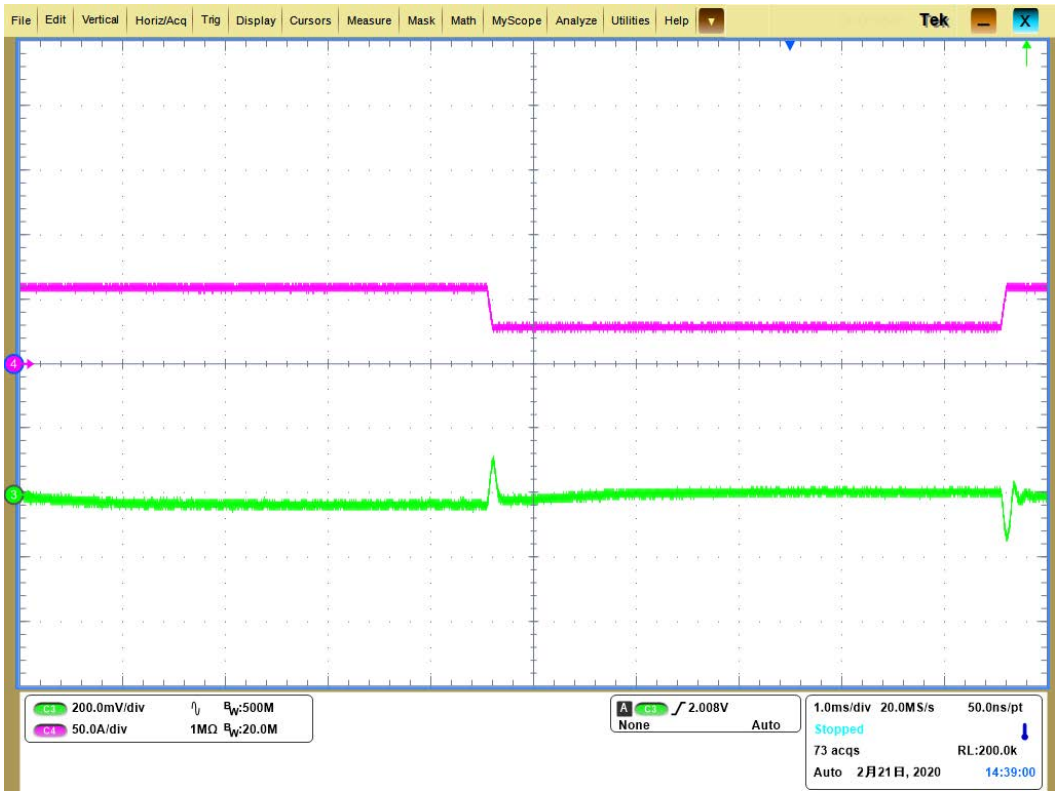
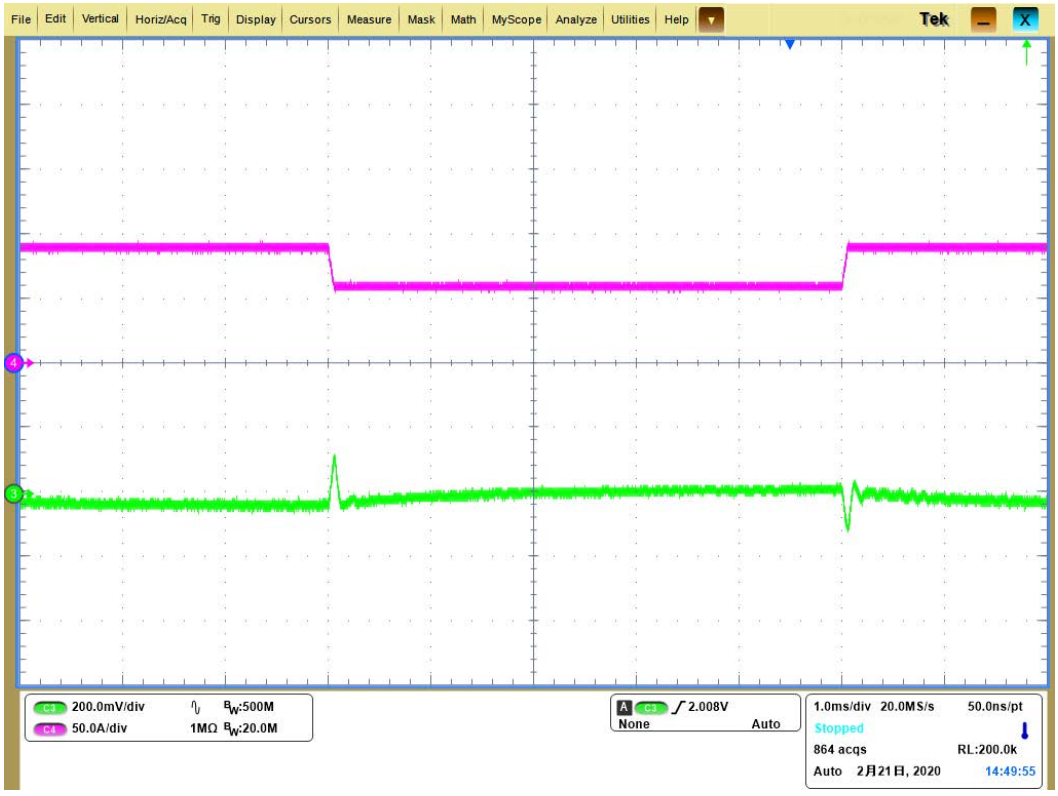


Figure 6-6 Output voltage dynamic response (V_{in}=220 V AC ; load : 50% ~ 75% ~ 50% ; 0.5 A/μs ; T=10 ms ; MV12))



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Figure 6-7 Output voltage dynamic response (V_{in}=220 V AC ; load : 50% ~ 100% ~ 50% ; 0.5 A/μs ; T=10 ms ; MV12))

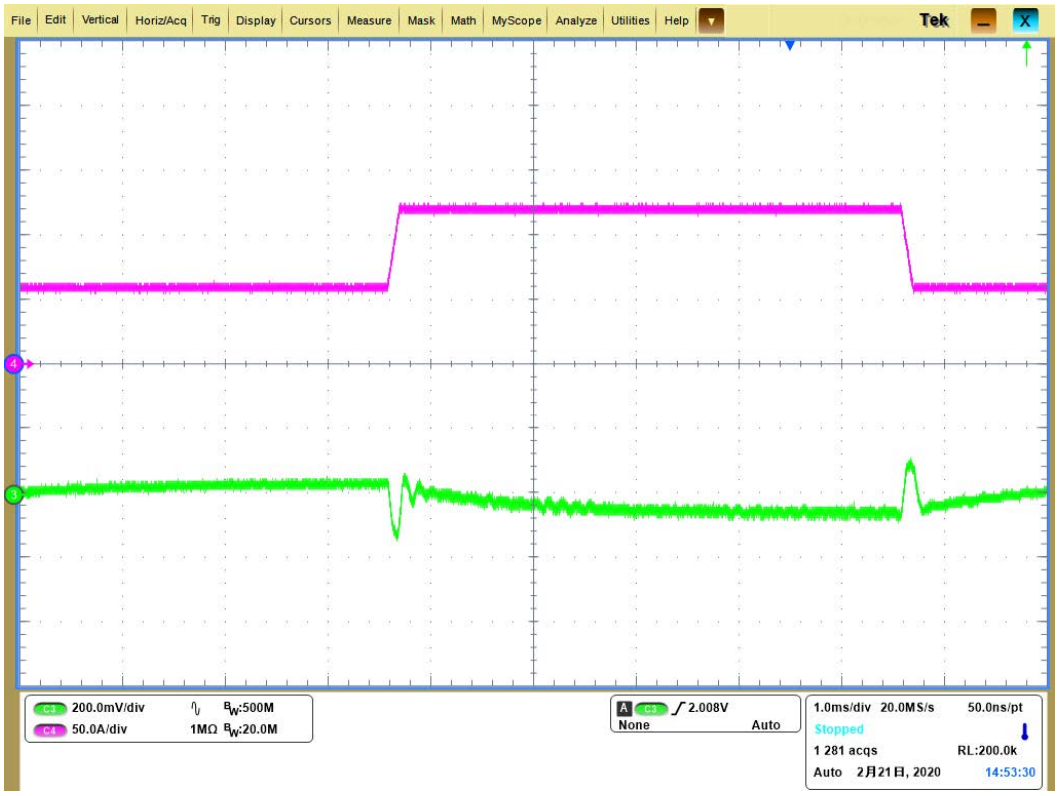
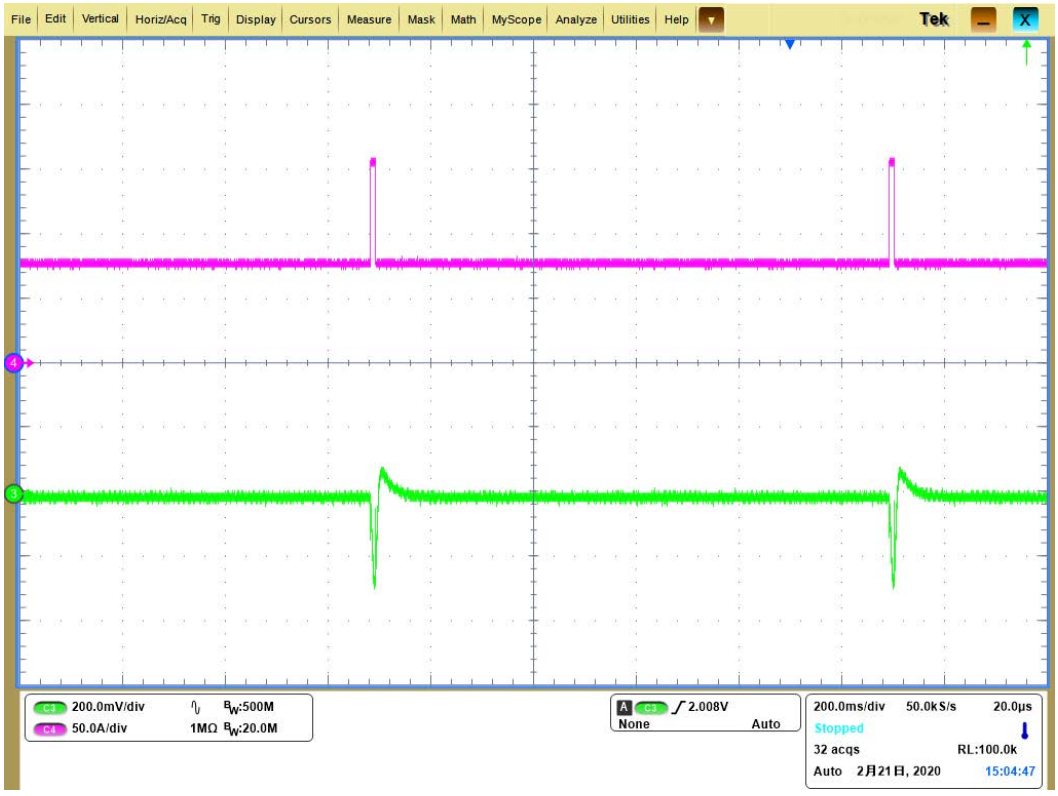


Figure 6-8 Output voltage dynamic response (V_{in}=220 V DC ; load : 65% ~ 130% ~ 65% ; 0.5 A/μs ; T=1s~10 ms~1s ; MV12))



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Figure 6-9 Output voltage dynamic response (V_{in}=220 V AC ; load : 25% ~ 50% ~ 25% ; 0.5 A/μs ; T=10 ms ; MV12))

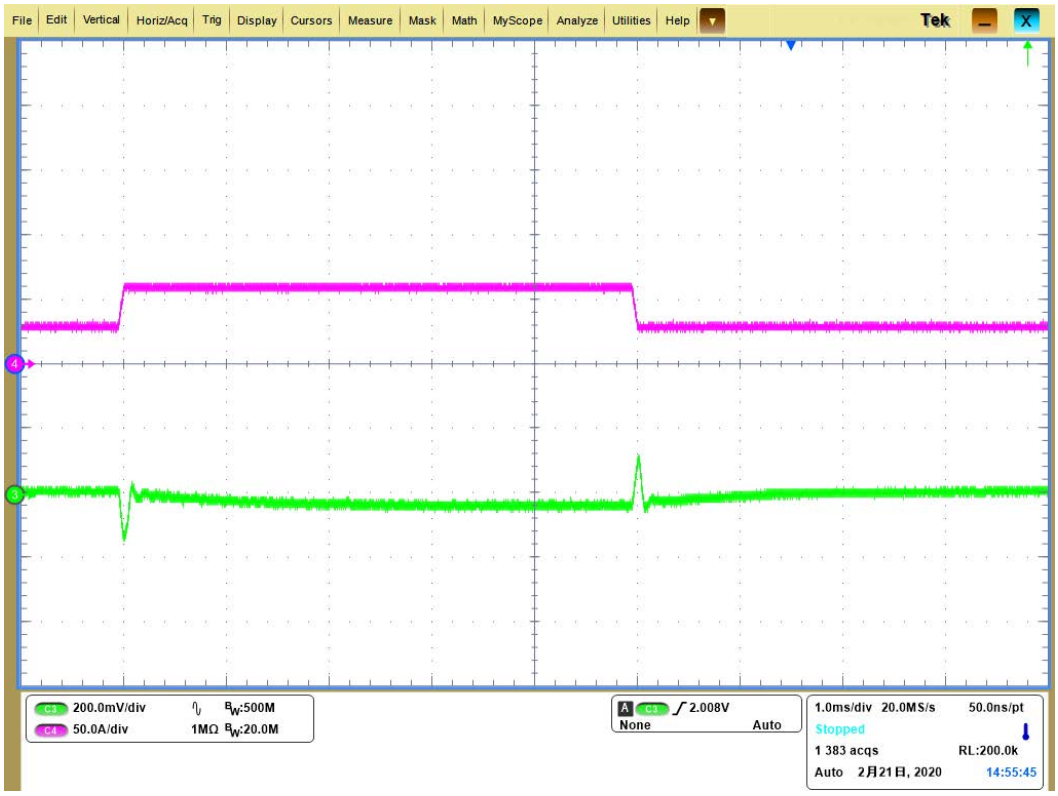
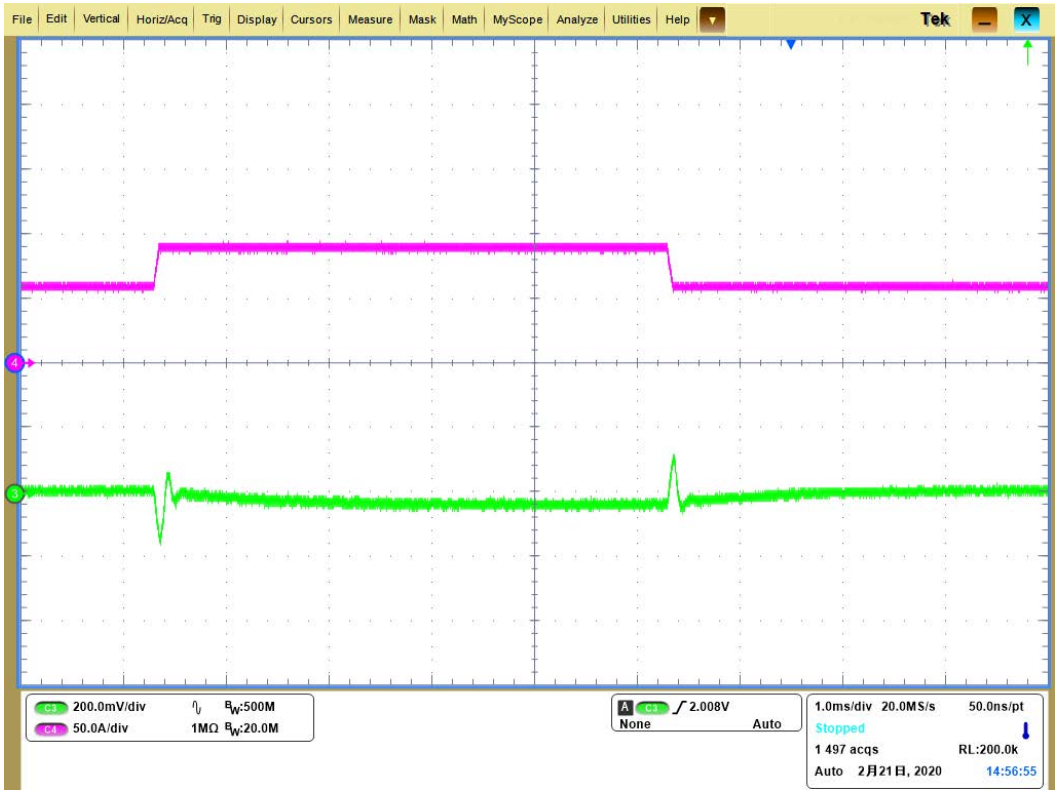


Figure 6-10 Output voltage dynamic response (V_{in}=220 V AC ; load : 50% ~ 75% ~ 50% ; 0.5 A/μs ; T=10 ms ; MV12))



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Figure 6-11 Output voltage dynamic response (V_{in}=220 V AC ; load : 50% ~ 75% ~ 50% ; 0.5 A/μs ; T=10 ms ; MV12))

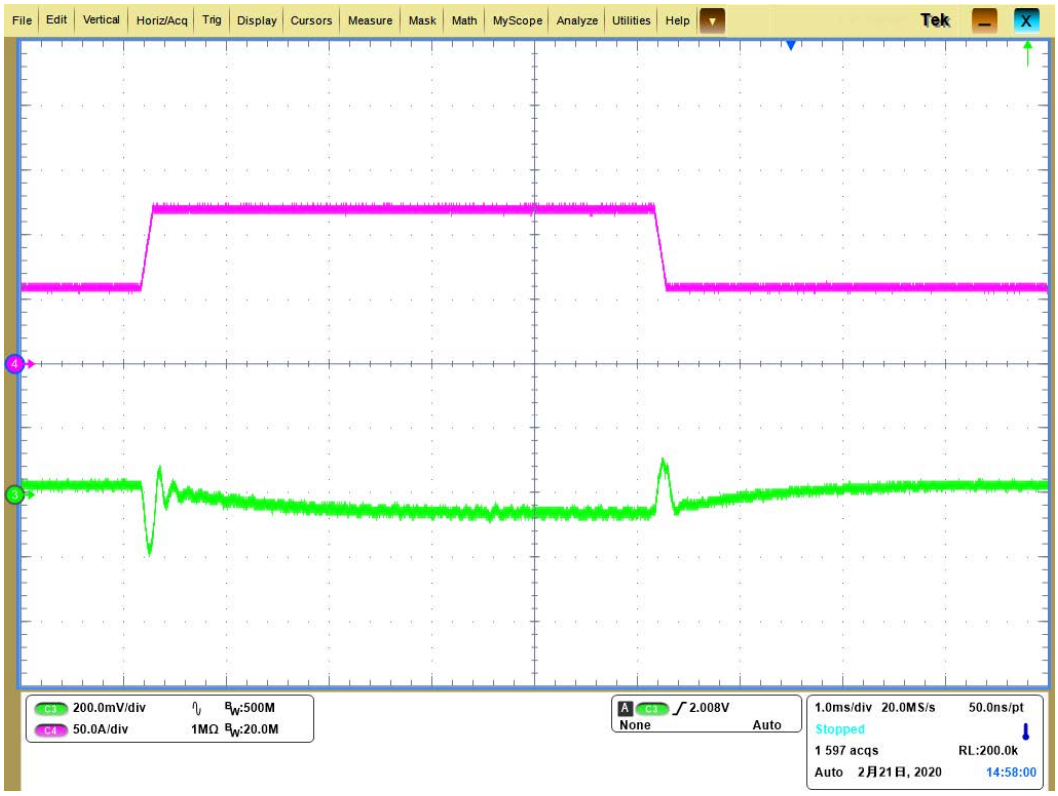
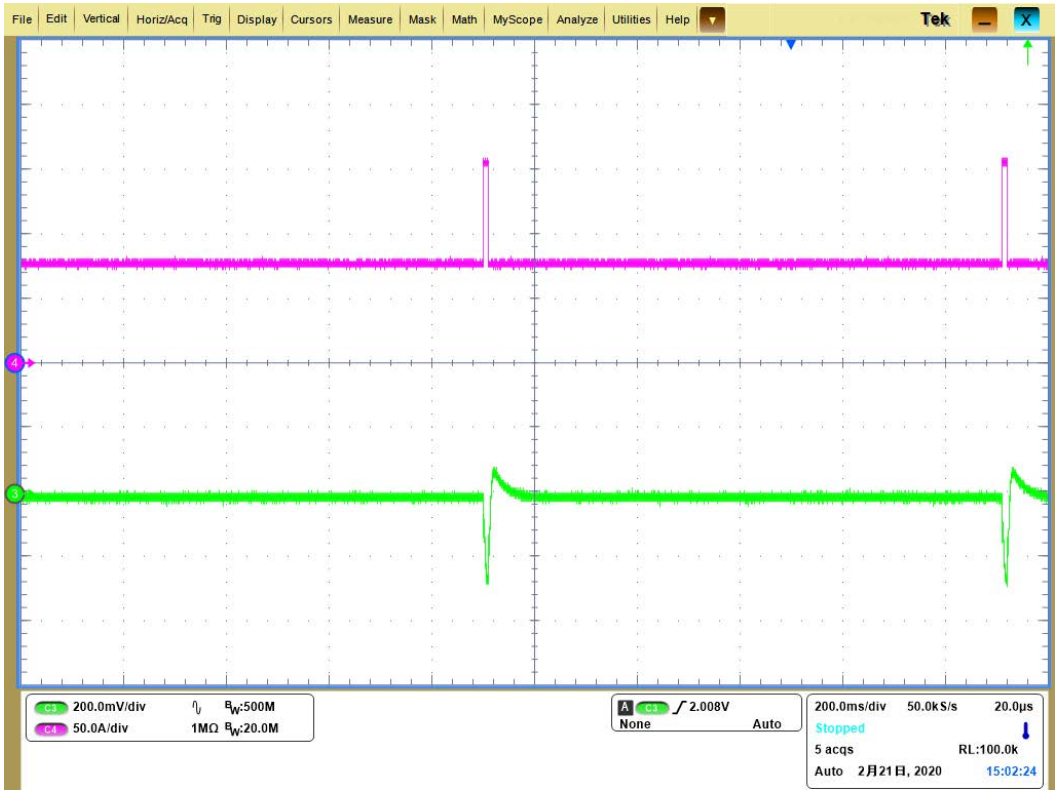


Figure 6-12 Output voltage dynamic response (V_{in}=220 V DC ; load : 65% ~ 130% ~ 65% ; 0.5 A/μs ; T=1s~10 ms~1s ; MV12))

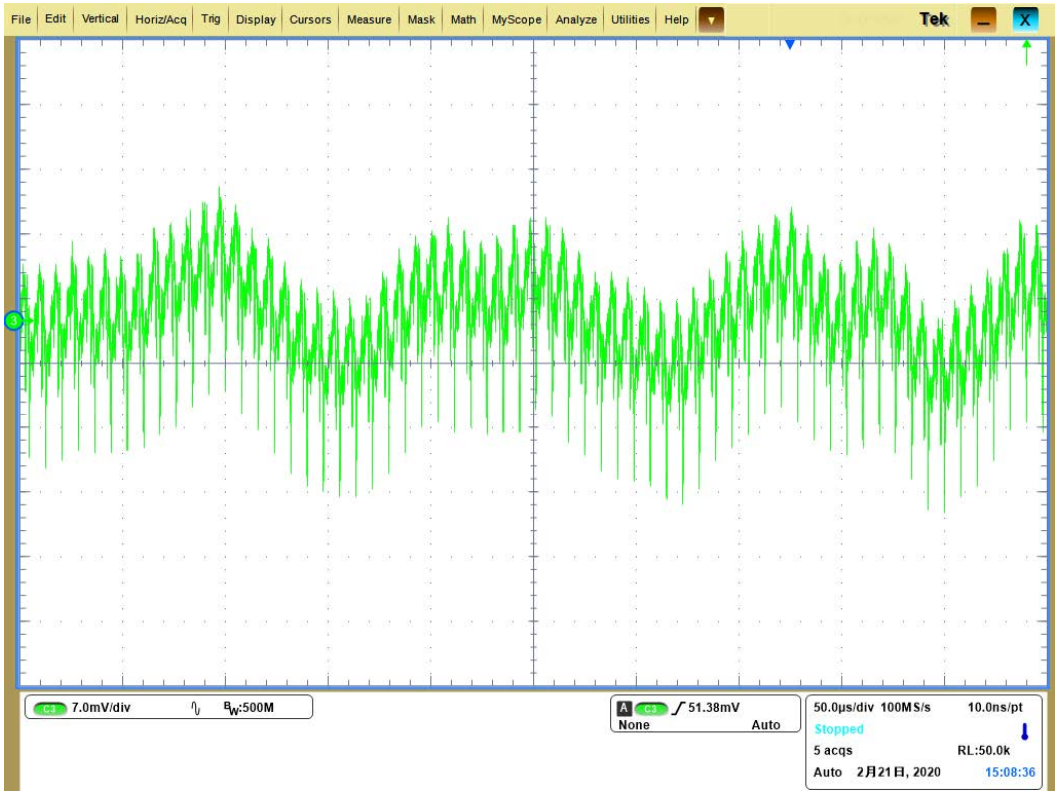


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6.3 Output Voltage Ripple

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

Figure 6-13 Output voltage ripple (V_{in}=220 V AC ; 100% load; MV12))



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7 Energy Saving Feature

7.1 Active/Standby (Hot Standby) Power Supply

7.2 Cold Standby Energy Saving Function

7.3 Deep Sleep Function

7.4 Automatic PFC Shutdown

7.1 Active/Standby (Hot Standby) Power Supply

When PSUs are connected in parallel, the system sets bit 7 of PS_CONTROL (CEh) to 1, and regulates the output voltage of one PSU to 12.05 V using VOUT_COMMAND (21h). The PSU with an output setting voltage of 12.3 V is the active PSU and the PSU with an output setting voltage of 12.05 V is the standby PSU.

Table 7-1 Power supply features of the active and standby PSUs

Parameter	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
12 V output voltage of the standby PSU	11.90	12.05	12.20	V	-

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Parameter	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
No-load powerconsumption of the standby PSU	-	-	10	W	● 1+1 power supply scenario: For the active/standby power supply with rated input of AC+AC, AC+HVDC, HVDC+HVDC, the input power consumption of each standby PSU is lower less than 10 W (The total output load is less than 75% load of a single PSU.) ● 2+2 power supply scenario: For the active/standby power supply with AC +AC, AC+HVDC, and HVDC+HVDC, the input power consumption of each standby PSU is lower less than 10 W (The total output load is less than 70% load of 2 PSUs.)
Busbar voltage in fault conditions	11.4	-	-	V	● In 1+1 active/standby power supply scenarios (AC+AC, AC+HVDC, or HVDC+HVDC) – If one of the PSUs powers off and experiences a fault (such as input power failure, hot swap, input undervoltage, input overvoltage, fan fault, overtemperature, or output overvoltage). – The 12 V busbar voltage cannot be lower than 11.4 V. ● 2+2 active/standby power supply scenario (AC+AC, AC+HVDC, or HVDC+HVDC) – One power input fails (2+2 backup, one power input for two PSUs). – During the swap of a PSU, if a fault (input undervoltage/ overvoltage, fan fault, overtemperature, or output overvoltage) occurs, the busbar 12 V voltage cannot be lower than 11.4 V. **NOTE** ● Exclude the scenario in which a short circuit occurs before ORing-FET. ● The 12 V output of parallel PSUs is equipped with 540μF capacitors.

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Parameter	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
Time for switching to HVDC in the case of intermittent AC disconnection (AC active, HVDC standby, MV12 mode)	10	-	-	ms	AC is active, and HVDC is standby. Output with 900 W load.
	20	-	-		AC is active, and HVDC is standby. Output with 450 W load.
	30	-	-		AC is active, and HVDC is standby. Output with 25% load.
	40	-	-		AC is active, and HVDC is standby. Output with 12.5% load.

NOTE

- The PSU may exit the standby mode if the system sets bit 7 in PS_CONTROL of the standby PSU (CEh) to 0, or the PSU is powered off or restarted, or experiences a communications fault. In other scenarios, the PSU does not exit the standby mode.
- In 2+2 or 2+0 mode, the maximum load is 125 A when the PSU starts at full load.
- The maximum startup load of a single PSU is half load.

7.2 Cold Standby Energy Saving Function

In a 1+1 redundancy system, the cold standby mode is supported when the output mode is MV12.

The PSU can enter cold standby mode if all of the following conditions are met:

- The load is less than 70% rated load of a single PSU.
- The system sends a D0h 0x01 command to set one of the PSUs as the active PSU (SMART_ON changes to high level).
- The system sends D0h 0x02/0x03/0x04 to the other PSU and detects that SMART_ON is high.

The cold standby PSU exits cold standby mode if any of the following conditions is met:

- The system sends the D0h 0x00 command.
- The single-chip microcomputer of the PSU restarts.
- The I2C communication of the PSU is abnormal.
- The MV12/SV12 output of the active PSU encounters a fault, such as input power failure, input overvoltage/ undervoltage, output overvoltage/overcurrent/

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undervoltage (< 11.8 V), overtemperature, and fan fault, which causes SMART_ON to change to low level.

- The PSON12V# signal changes from low level to high level, and the INSTALLED# signal changes from low level to high level.
- The load power is greater than the maximum power supported by cold standby.

The active PSU exits cold standby mode if any of the following conditions is met:

- The system sends the D0h 0x00 command.
- The single-chip microcomputer of the PSU restarts.
- The I2C communication of the PSU is abnormal.
- The 12 V output of the active PSU encounters a fault, such as input power failure, input overvoltage/ undervoltage, output overvoltage/overcurrent/ undervoltage (< 11.8 V), overtemperature, and fan fault.
- The PSON12V# signal changes from low level to high level, and the INSTALLED# signal changes from low level to high level.

Table 7-2 Power consumption of standby PSU in cold standby mode

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Power consumption of standby PSU	-	-	3	W	In 1+1 active/standby power supply scenarios (AC+AC, AC+HVDC, HVDC +HVDC), the input power consumption of each standby PSU must be tested without any load.

7.3 Deep Sleep Function

The PSU supports the deep sleep function. The PSU enters deep sleep mode if bit B of **PS_CONTROL (CEh)** is set to 1.

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NOTE

When PSUs are connected in parallel, if one PSU enters deep sleep mode and the system communicates with it, the PSU input information including input voltage, current, and power is reported as 0, and the output information is reported as 0 (the output voltage and current are reported as 0).

- The deep sleep function is available in both MV12 and MV6 modes.
- In deep sleep mode, the PSU input power is less than 3 W.
- The main power is shut down and MV12/SV12 has no output.
- The PFC is shut down.
- The fan obtains power from the 12 V bus.
- The power control function can be obtained through the 12 V bus.
- The output of all converters can be controlled online and restored to normal.

In a parallel system, the PSU is not allowed to enter deep sleep mode unless all of the following occur:

- The system sets the deep sleep control register to 1.
- EFUSEV is less than or equal to 0.8 V.

The PSU must be able to restore output of converters when any of the following occurs:

- The bus voltage is less than 5.7 V.
- The deep sleep control register is set to 0.
- EFUSEV is greater than 1.0 V.

7.4 Automatic PFC Shutdown

The system can deliver the PFC automatic shutdown command by setting bit 9 of PS_CONTROL (CEh) to 1. If the current system allows the PFC circuit to continue working and the PSU meets the communications protocol requirements, the PFC circuit can remain enabled.

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8 Hot Swap Requirements

Hot swapping is the process of inserting the PSU to and extracting the PSU from a power system. During hot swapping, the PSU output voltage must be within the specification provided in **4.3 Output Characteristics**.

The PSU can be hot swapped by the following methods (The PSU does not work before the insertion or extraction.) :

- PSU hot swap without AC power applied
  - 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.

  The requirements must be met regardless of whether an AC or HVDC input is used.
- PSU hot swap through the management system
  - Extraction: The system processor sets PSON of the PSU to high level, and the PSU is removed from the system.
  - Insertion: After a PSU is inserted into the system, the system processor queries the PSU based on the system state (on or off) and then sets PSON of the PSU to low level to change the PSU status.

The requirements must be met regardless of whether an AC or HVDC input is used.

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9 Parallel Operation

Current Share Design Requirements

- Supports 1+1 or 2+2 backup.
- The current share imbalance of the 12 V main output ≤ ±5% (50%–100% load).
- The total startup load of PSUs in a parallel system is less than the rated load of a single PSU. The startup load of a single PSU is less than half of the load of a single PSU.
- When the PSUs work in 1+1 backup mode, one PSU works in MV6 mode, and the other in MV12 mode. The PSUs can work properly.
- The I-MON signals of two PSUs are connected directly, which should not affect operation of the PSUs.

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10 Control Functions

10.1 Timing Requirements
10.2 ORing-FET
10.3 PSON12V#
10.4 PRESENT#
10.5 INSTALLED#
10.6 OPOK
10.7 IPOK
10.8 IPOK LINK
10.9 IP PRESENT
10.10 CYC_PWR#
10.11 I-MON
10.12 PS_INTERRUPT
10.13 EFUSEV
10.14 SMART_ON

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10.1 Timing Requirements

Figure 10-1 PSU timing diagram

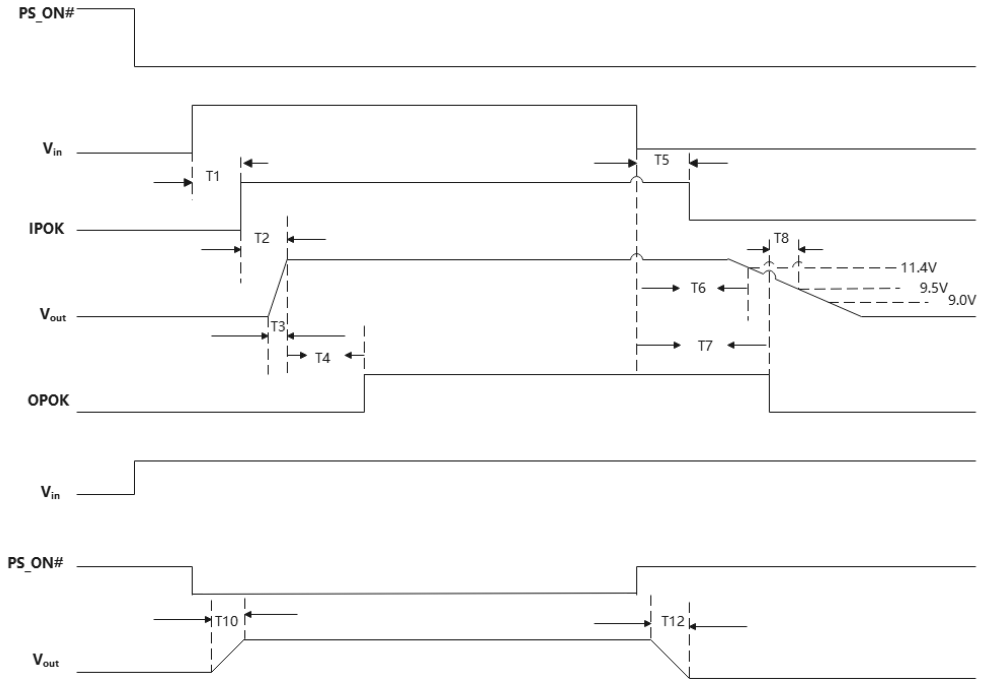


Table 10-1 Output PSU timing requirements

Mark	Description	Min.	Max.	Unit
T1	Time from AC/DC input to when IPOK is at high level	-	2000	ms
T2	Time from when IPOK is at high level to when MV12 output to 11.4 V (PSON12V# is at low level)	-	500	ms
T3	Time for MV6 output to increase from 10% to 90%	5	25	ms
	Time for MV12 output to increase from 10% to 90%	5	25	ms
T4	Delay time for the OPOK to take effect (when MV12/MV6 increases to 90% to when OPOK is at high level)	50	100	ms
T5	IPOK failure delay time (from input outage to low IPOK signal, circuit breaker disconnection not considered, full load test conditions)	-	4	ms
T6	Output hold-up time 1 (from input power failure during normal running to 11 V output, 80% load, DIP performance)	10	-	ms

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Mark	Description	Min.	Max.	Unit
T7	OPOK hold-up time (from AC power failure to low OPOK signal, 80% load)	10	-	ms
	Time from AC power failure to low OPOK signal, 40% load	20	-	ms
	Time from AC power failure to low OPOK signal, 25% load	30	-	ms
	Time from AC power failure to low OPOK signal, 12.5% load	40	-	ms
T8	Duration from the time when the OPOK signal falls to 1.43 V to the time when the 12 V bus voltage drops to 9.5 V	200	-	μs
T10	Delay time for the PSON12V# to change MV6 to MV12 mode (PSON12V# signal runs to 11.4 V.)	80	200	ms
	Time for MV6 OCP or MV12 OTP recovery (MV6 rises to 11 V.)	2.1	3.3	s
T12	Time for MV12 to drop to MV6 mode (with 24 W load)	80	200	ms

NOTE

- The time period of the PSU input failure recorded in the system logs, that is, from MV12 mode to MV6 mode (accept based on the standard of 15 W/300 ms)
- In case of input power failure, the PSU needs 10 ms to 120 ms to set IIC alarm position to 1 at more than half load, and the system needs 20 ms to 120 ms to set IIC alarm position to 1 at below half load (including half load).
- The storage NVDIMM power backup requirement is supported.
  - Scenario: There are timing requirements when the OPOK alarm is caused by input power failure, input overvoltage or undervoltage, fan fault, or overtemperature. There are no timing requirements when the OPOK alarm is caused by output overcurrent/ short circuit, output overvoltage, or output short circuit.
  - The PSU can report the OPOK fault in advance if the fault (such as input power failure, input overvoltage/undervoltage, fan fault, overtemperature, or output undervoltage) can be predicted by the PSU. In this case, the requirement that the output voltage must be less than 11.4 V does not have to be met.
- The test of T1 and T2 requires that the auxiliary power supply be completely powered off.

10.2 ORing-FET

PSU side:

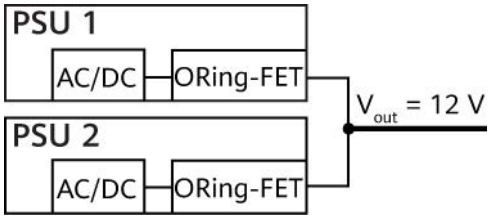
An ORing-FET failure isolation circuit needs to be added to the PSU 12 V output. In the parallel scenario (1+1/2+2 backup), if one PSU experiences an internal fault, it should exit automatically to prevent the bus voltage output from being abnormal.

System side:

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- 12 V input capacitance: The equivalent capacitance needs to be greater than the minimum PSU capacitive load 540 μF x N (N is the number of PSUs configured in the system) and less than the maximum PSU capacitive load 22,000 μF.
- The 12 V load should be greater than the minimum PSU load (2 A) and less than the rated load of the PSU.

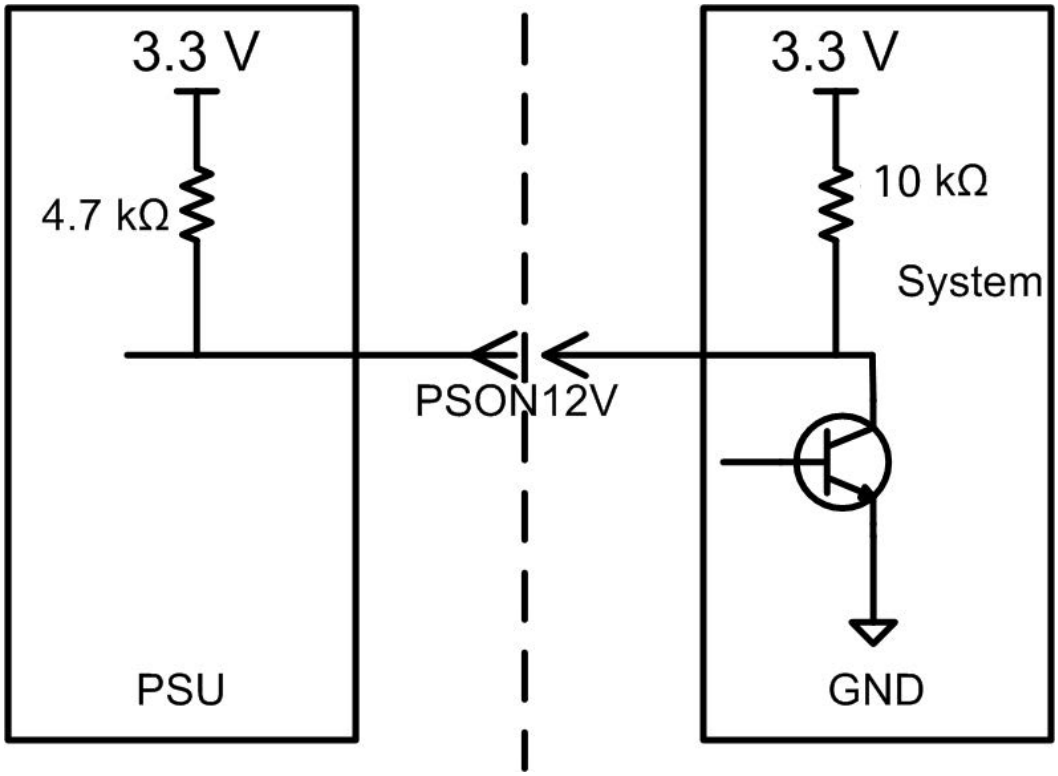
Figure 10-2 ORing-FET circuit



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 PSU 12 V enters MV12 output mode. If the PSON12V# is at high level or left open, the PSU enters MV6 output mode.

Figure 10-3 Interconnect diagram of the PSON12V signal



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Table 10-2 PSON12V signal characteristics

Signal Characteristics	
Signal type	PSU side: This signal is pulled up to 3.3 V by a 4.7-kilohm resistor. System side: This signal is output by CPLD over the drive circuit and pulled up to 3.3 V by a 4.7-kilohm resistor.
PSON12V = Low	MV12 output mode.
PSON12V = High/left open	MV6 output mode.

Table 10-3 PSON12V output

PSON12V Output	Minimum	Maximum
Low level voltage (main output enabled)	0 V	0.8 V
High level voltage (main output disabled)	2.0 V	3.465 V
Source current, Vpson12V = Low	-	1 mA
Signal rise and fall time	-	200 μs

10.4 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 10-4 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.
PRESENT# = Low	PSU is present.
PRESENT# = High	PSU is removed from the system.

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10.5 INSTALLED#

The INSTALLED signal is used by the PSU to determine whether it has been inserted into the system. The signal pin is required to be shorter than other pins on the PSU.

Table 10-5 INSTALLED# 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. System side: This pin is grounded directly.
INSTALLED# = Low	PSU is inserted into the system.
INSTALLED# = High	PSU is not inserted into the system.

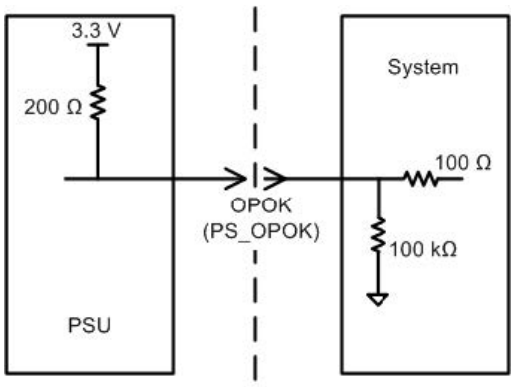
Table 10-6 INSTALLED output

INSTALLED output	**Minimum**	**Maximum**
Low level voltage	0 V	0.6 V
High level voltage	2.0 V	3.465 V
Input sink current, INSTALLED = Low	-	1 mA
Signal rise and fall time	-	200 µs

10.6 OPOK

The OPOK signal is used to detect whether the mains output is normal.

Figure 10-4 Interconnect diagram of the OPOK signal



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Table 10-7 OPOK signal characteristics

Signal Characteristics	
Signal type	PSU side: This signal is output over the drive circuit and pulled up to 3.3 V by a 200-ohm resistor. System side: Pulled down to GND by a 100-kilohm resistor and connected to the system CPLD over a 100-ohm series resistor.
OPOK = High	The MV12 output is normal.
OPOK = Low	The MV12 output is abnormal.

Table 10-8 OPOK output

OPOK output	Minimum	Maximum
Low level voltage	0 V	0.6 V
High level voltage	2.0 V	3.465 V
Source current, OPOK = Low	-	1 mA
Source current, OPOK = High	-	1 mA
Signal rise and fall time	-	200 μs

NOTE

- If the INSTALLED signal is at high level, the OPOK signal is at low level.
- MV12 output mode
  - If the output voltage is greater than 11.5 V, OPOK is at high level.
  - If the output voltage is lower than 11.4 V, OPOK is at low level.
  - The time from when OPOK drops to 1.43 V to when the 12 V bus voltage drops to 9.5 V is greater than 100 μs (this is required in the case of input power failure, input overvoltage/undervoltage, fan fault, overtemperature, and output undervoltage, and is not required in the case of OPOK alarms caused by output overcurrent/short-circuit and output overvoltage).
- MV6 output mode
  - If the output voltage is greater than 5.9 V, OPOK is at high level.
  - If the output voltage is lower than 5.8 V, OPOK is at low level.
- The PSU can report the OPOK fault in advance if the fault can be predicted by the PSU (such as input power failure, input overvoltage/undervoltage, fan fault, overtemperature, or output undervoltage).
- After the input power fails, the OPOK signal changes to low level. The OPOK signal should not changes to high level until the input power recovers.

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10.7 IPOK

The IPOK signal is used to detect whether the PSU input is normal.

Figure 10-5 Interconnect diagram of the IPOK signal

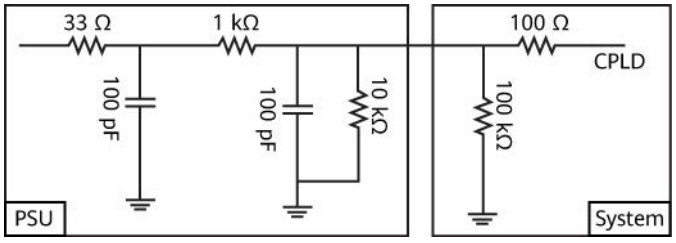


Table 10-9 IPOK signal characteristics

Signal Characteristics	
Signal type	PSU side: This signal is output over the drive circuit and pulled up to 3.3 V by a 200-ohm resistor. System side: Pulled down to GND by a 100-kilohm resistor and connected to the system CPLD over a 100-ohm series resistor.
IPOK = High	The input is normal.
IPOK = Low	The input is abnormal.

Table 10-10 IPOK output

IPOK Output	Minimum	Maximum
Low level voltage	0 V	0.6 V
High level voltage	2.0 V	3.465 V
Source current, IPOK = Low	-	1 mA
Source current, IPOK = High	-	1 mA
Signal rise and fall time	-	200 µs

10.8 IPOK LINK

The IPOK LINK signal is sent by the system to the PSU. It indicates that at least one PSU is present in the system and its input is normal.

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Table 10-11 IPOK LINK signal characteristics

Signal Characteristics	
Signal type (PSU output signal)	PSU side: This signal is pulled up to the 3.3 V auxiliary power source inside the PSU by a 2.49-kilohm resistor. System side: This signal is output by CPLD over the drive circuit and pulled up to 3.3 V by a 4.7-kilohm resistor.
IPOK LINK = High	The standby power supply input is normal.
IPOK LINK = Low	The standby power supply input is abnormal.

Table 10-12 IPOK LINK output

IPOK LINK Output	Minimum Value	Maximum Value
Low level voltage	0 V	0.6 V
High level voltage	2.0 V	3.465 V
Source current, IPOK LINK = Low	1 mA	-
Source current, IPOK LINK = High	-	1 mA
Signal rise and fall time	-	200 μs

10.9 IP PRESENT

The IP PRESENT signal is the received signal of the PSU. The signal is directly connected to the I/O port of the microcontroller unit of the PSU for function expansion.

Table 10-13 IP PRESENT# 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 4.75-kilohm resistor. System side: This signal is output by CPLD over the drive circuit and pulled up to 3.3 V by a 4.7-kilohm resistor.
IP PRESENT# = High	The PSU does not act.
IP PRESENT# = Low	The PSU enters the SV12 output mode.

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Table 10-14 IP PRESENT output

IP PRESENT output	Minimum	Maximum
Low level voltage	0 V	0.6 V
High level voltage	2.0 V	3.465 V
Source current, IP PRESENT = Low	-	1 mA
Source current, IP PRESENT = High	-	1 mA
Signal rise and fall time	-	200 µs

10.10 CYC_PWR#

The CYC_PWR signal is sent to PSUs by the system to shut down or restore the 12 V main output of the PSU.

- The signal is valid if the CYC_PWR signal is at low level for 100–150 ms.
- The CYC_PWR signal is invalid if both the OPOK and CYC_PWR signals are low level.
- The signal is invalid if the CYC_PWR signal is at low level for less than 100 ms.
- The CYC_PWR signal is invalid when a PSU is during delay shutdown or restarting. The CYC_PWR signal is valid after the OPOK signal becomes high level.

Table 10-15 CYC_PWR# 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 2.49-kilohm resistor. System side: This signal is output by CPLD over the drive circuit and pulled up to 3.3 V by resistor greater than 10 kilohm.
CYC_PWR# = High	The PSU does not act.
CYC_PWR# = Low	The PSU enters power supply cycle power mode.

Table 10-16 CYC_PWR output

CYC_PWR output	Minimum	Maximum
Low level voltage	0 V	0.6 V
High level voltage	2.0 V	3.465 V

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CYC_PWR output	Minimum	Maximum
Source current, CYC_PWR = Low	-	1 mA
Source current, CYC_PWR = High	-	1 mA
Signal rise and fall time	-	200 μs

10.11 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 backplane directly connects the I-MON signals of all PSUs together.

10.12 PS_INTERRUPT

The PS_INTERRUPT# signal indicates PSU I2C alarm interruption.

Table 10-17 PS_INTERRUPT# signal characteristics

Signal Characteristics	
Signal type	PSU side: Output over the drive circuit, no pull-up on the PSU side, or directly output by the DSP over a series resistor. System side: Pulled up to 3.3 V level and then reversely sent to the system over the MOSFET transistor.
PS_INTERRUPT= High	The PSU is normal.
PS_INTERRUPT = Low	The PSU generates an alarm.

10.13 EFUSEV

The system samples the input current of the main service load branch (12 V), converts the current to a linear voltage analog signal, and sends the signal to the EFUSEV pin of the PSU. If the value of EFUSEV is greater than 1 V, the main service of the system is working. In this case, the PSU cannot enable deep sleep and automatic PFC shutdown. If the value of EFUSEV is less than 0.8 V, the main service of the system is powered off or does not work. In this case, the PSU can enable deep sleep and automatic PFC shutdown.

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Table 10-18 EFUSEV signal characteristics

Signal Characteristics	
Signal type	PSU side: Send to the PSU DSP by a 100-ohm series resistor. System side: ● If this function is enabled, the system sends the voltage analog signal of the main service circuit to the PSU, or CPLD outputs this signal over the drive circuit and this signal is pulled up to 3.3 V level by a 4.7-kilohm resistor. ● If this function is disabled, this signal is pulled up to 3.3 V level by a 4.7-kilohm resistor.
EFUSEV = High	Disable deep sleep and automatic PFC shutdown.
EFUSEV = Low	Enable deep sleep and automatic PFC shutdown.

Table 10-19 EFUSEV output

EFUSEV Output	Min.	Max.
Low level voltage	0 V	0.8 V
High level voltage	1 V	3.465 V

10.14 SMART_ON

The SMART_ON signal is used to wake up a cold-standby PSU (low level by default).

Table 10-20 SMART_ON signal characteristics

Signal Characteristics	
Signal type	PSU side: This is a low-level signal by default. After the system sends the cold standby command (set the **D0h SMART_ON_CONFIG** to 0x01), this signal will change to high level. System side: The SMART_ON signals of all PSUs are connected together.
SMART_ON = High	The PSU enters cold standby mode.
SMART_ON = Low	The PSU exits from cold standby mode.

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Table 10-21 SMART_ON Output

SMART_ON Output	Minimum	Maximum
Low level voltage	0 V	0.8 V
High level voltage	2.1 V	3.6 V

NOTE

The mixed insertion of this signal will cause other PSUs to work abnormally.

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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 power detection precision	-	20	-	W	V_{in} = 230 V AC/336 V DC, T_A = 25°C-35°C (77°F-95°F), MV12, P_{in} ≤ 20 W
	-10	-	10	W	V_{in} = 230 V AC/336 V DC, T_A = 25°C-35°C (77°F-95°F), MV12, 20 W < P_{in} ≤ 100 W
	-5	-	5	%	V_{in} = 230 V AC/336 V DC, T_A = 25°C-35°C (77°F-95°F), MV12, 100 W< P_{in} ≤ 300 W
	-3	-	3	%	V_{in} = 230 V AC/336 V DC, T_A = 25°C-35°C (77°F-95°F), MV12, P_{in} > 300 W
Output power detection precision	-10	-	10	W	Minimum load > 2 A, V_{in} = 230 V AC/ 270 V DC, MV12, T_A = 25℃-35℃ (77℉-95℉); P_{out} ≤ 100 W

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Parameter	Minimum Value	Typical Value	Maximum Value	Unit	Remarks
	-5	-	5	%	Minimum load > 2 A, V_{in} = 230 V AC/ 270 V DC, MV12, T_A = 25℃-35℃ (77℉-95℉); P_{out} > 100 W

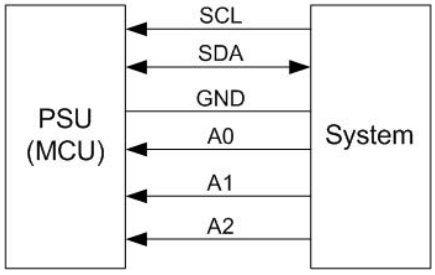
11.2 Data Link Layer Protocol

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 256 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. **Figure 11-1** shows the I2C interface communication diagram.

Figure 11-1 I2C interface



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

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PSU side:	System side:
• SCL and SDA must be pulled up to 3.3 V by a 20-kilohm resistor. • The voltage source must be generated by the auxiliary power source and system-side 12 V bus that supplies power to the secondary MCU at the same time. • When power is supplied from the system side, the fuse or overcurrent/short-circuit protection circuit must be used. • The capacitance on the SCL and SDA in the PSU cannot exceed 66 pF.	The voltage of SCL and SDA is pulled up to 3.3 V by increasing the resistance by 3-10 kilohm.

11.2.2 I2C Address

Addresses A2, A1, and A0 are allocated to a PSU.

PSU side:

- Interconnection in the PSU: A2, A1, and A0 must be pulled up to the internal voltage source through a 10-kilohm (reference value) resistor. The voltage source must be the voltage source that supplies power to the secondary MCU. The voltage source is supplied by the internal auxiliary power source, which is generated by the PSU and system-side 12 V bus at the same time.
- When power is supplied from the system side, the fuse or overcurrent/short-circuit protection circuit must be used.

System side:

If this signal is connected to GND through a 300-ohm resistor, the address bit is 0. If this signal is left open, the address bit is 1.

The I2C addresses of the PSU from high to low are A2, A1, and A0. See **Table 11-2** for details.

Table 11-2 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

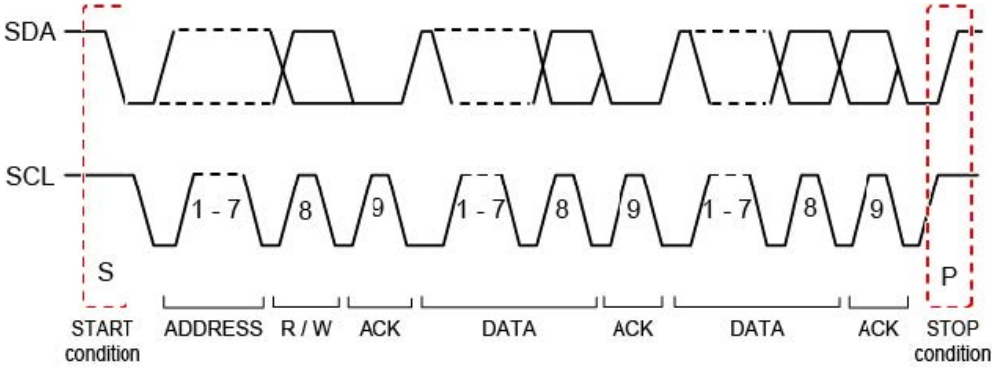
11.2.3 Data Transmission Mode

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,

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ACK/NACK, bus arbitration, clock synchronization, and clock extension (except bus timeout), complies with PSMI. See **Figure 11-2** for the I2C data transmission mode.

Figure 11-2 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.

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.



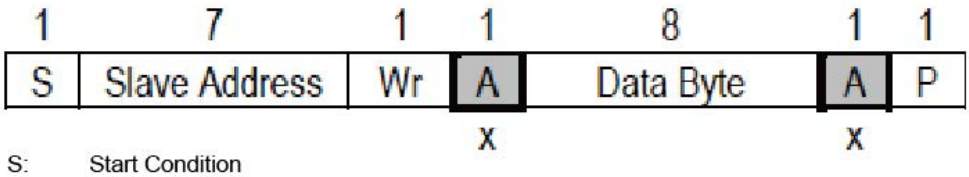
11.3.3 CRC Generation Rules

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

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11.3.4 Data Transmission

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

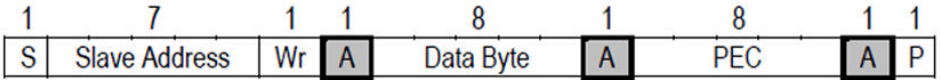


S: Start Condition
Sr: Repeated start condition
Rd: Read (bit value of 1)
Wr: Write (bit value of 0)
x: Shown under a field indicates that field is required to have the value of 'x'
A: Acknowledge (this bit position may be '0' for an ACK or '1' for a NACK)
P: Stop condition
PEC: Packet Error Code
...: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

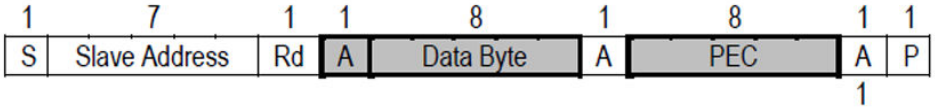
Master-to-Slave

Slave-to-Master

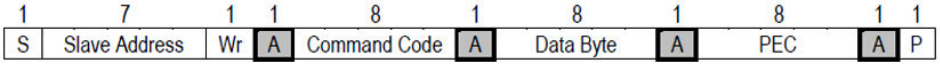
- Send Byte command and response.



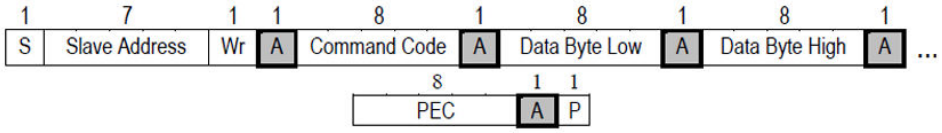
- Receive Byte command and response.



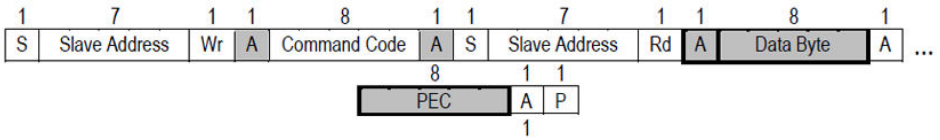
- Write Byte command and response.



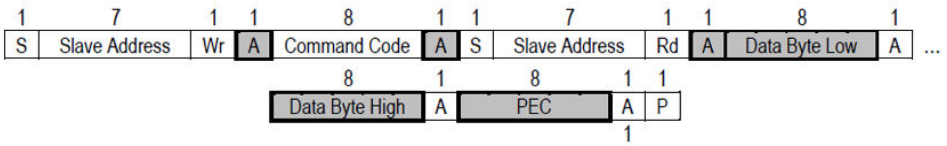
- Write Word command and response.



- Read Byte command and response.

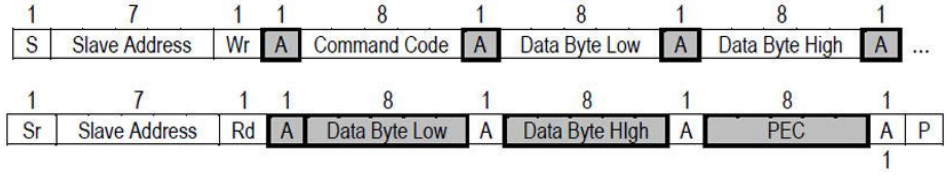


- Read Word command and response.

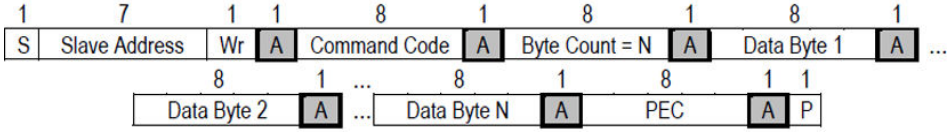


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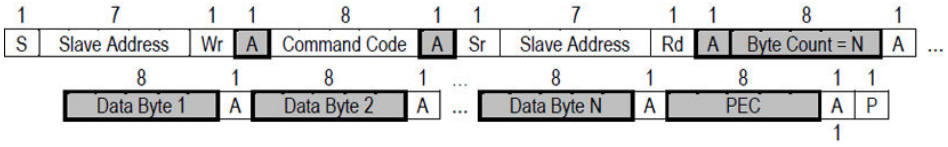
- Process Call command and response.



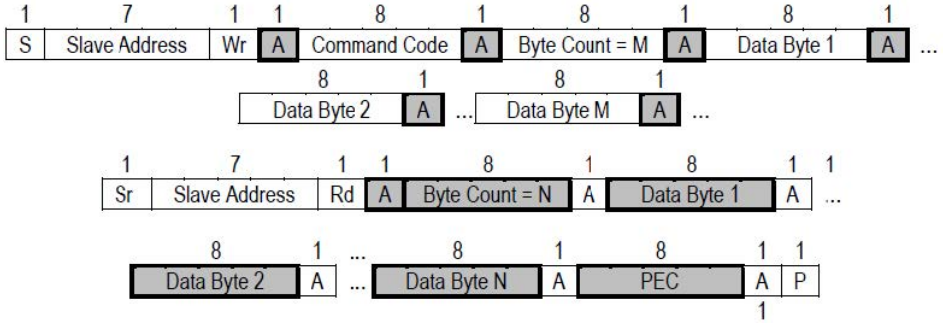
- Block Write command and response.



- Block Read command and response.



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



11.4 Application Layer Protocol

NOTE

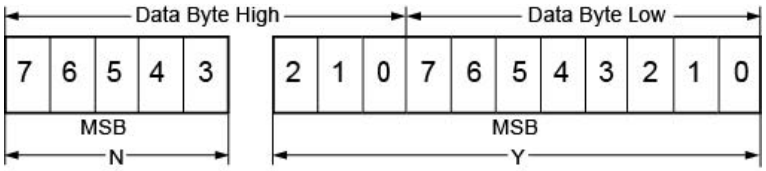
- The PMBus alarm is not latched. If a PSU is faulty, an alarm is reported. After the PSU fault is rectified, the alarm is automatically cleared.
- If the PSU is faulty, the system sends **CLEAR_FAULTS** to clear the alarm. If the alarm persists, the PSU continues to report the alarm.
- The **FAULT** 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 11-3 Linear 11 data format



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

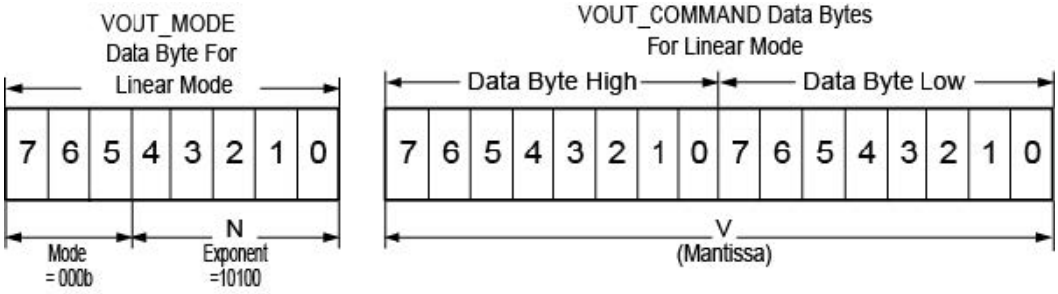
$X = Y \times 2^N$

- 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 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 11-4**.

Figure 11-4 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), and N is –12.

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11.4.2 Commands

Commands

Command ID	Command Name	Data Type	Data Format	Description
0x01	PMBUS_CMD_OPERATION	Read/ Write byte	HEX	Remote startup and shutdown ● 0x80: Start the PSU. ● 0x40: Soft shutdown. The PSOK time sequence meets the requirements. ● 0x00: Reset the PSU.
0x03	PMBUS_CMD_CLEAR_FAULTS	Write byte	HEX	Clearing faults; No parameter available; Sending the command with CRC and clearing the fault alarms after receiving the command.
0x20	PMBUS_CMD_VOUT_MODE	Read byte	HEX	Output mode
0x21	PMBUS_CMD_VOUT_CTRL	Read/ Write word	LINEAR 16 Q12	Output voltage configuration. In non-equipment mode, the voltage range must be 11.97 V to–12.35 V.
0x31	PMBUS_CMD_RATED_POUT	Read word	LINEAR 11	Maximum output power
0x3A	PMBUS_CMD_FAN_CONFIG	Read/ Write byte	HEX	Fan configuration; default value: 0xD0
0x3B	PMBUS_CMD_FAN_COMMAND	Read/ Write word	HEX	Fan speed setting
0x78	PMBUS_CMD_STATUS_BYTE	Read/ Write byte	HEX	Status single-byte
0x79	PMBUS_CMD_STATUS_WORD	Read/ Write word	HEX	Status dual-byte
0x7A	PMBUS_CMD_STATUS_VOUT	Read/ Write byte	HEX	Output voltage status
0x7B	PMBUS_CMD_STATUS_IOUT	Read/ Write byte	HEX	Output current status

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Command ID	Command Name	Data Type	Data Format	Description
0x7C	PMBUS_CMD_STATUS_INPUT	Read/ Write byte	HEX	Input status
0x7D	PMBUS_CMD_STATUS_TEMP	Read/ Write byte	HEX	Temperature status
0x7E	PMBUS_CMD_STATUS_CML	Read/ Write byte	HEX	CMD status
0x80	PMBUS_CMD_STATUS_MFR_SPECIFIC	Read/ Write byte	HEX	MFR status
0x81	PMBUS_CMD_STATUS_FANS	Read/ Write byte	HEX	Fan status
0x88	PMBUS_CMD_READ_VIN	Read word	LINEAR 11	Input voltage
0x89	PMBUS_CMD_READ_IIN	Read word	LINEAR 11	Input current
0x8B	PMBUS_CMD_READ_VOUT	Read word	LINEAR 16	Output voltage
0x8C	PMBUS_CMD_READ_IOUT	Read word	LINEAR 11	Output current
0x8D	PMBUS_CMD_READ_TEMPERATURE_1	Read word	LINEAR 11	Ambient temperature
0x8E	PMBUS_CMD_READ_TEMPERATURE_2	Read word	LINEAR 11	Primary side temperature (MOS1)
0x8F	PMBUS_CMD_READ_TEMPERATURE_3	Read word	LINEAR 11	Secondary side temperature (MOS1)
0x90	PMBUS_CMD_READ_FAN_SPEED	Read word	DEC	Fan speed
0x95	PMBUS_CMD_READ_FREQUENCY	Read word	LINEAR 11	PSU frequency
0x96	PMBUS_CMD_READ_POUT	Read word	LINEAR 11	Output power
0x97	PMBUS_CMD_READ_PIN	Read word	LINEAR 11	Input power

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Command ID	Command Name	Data Type	Data Format	Description
0x98	PMBUS_CMD_PMBUS_REVISION	Read byte	DEC	PMBus version
0x99	PMBUS_CMD_MFR_ID	Read block	ASCII	Vendor name
0x9A	PMBUS_CMD_MFR_MODEL	Read/ Write block	ASCII	PSU name
0x9B	PMBUS_CMD_HARD_VERSION	Read block	ASCII	Hardware version
0x9D	PMBUS_CMD_MFR_DATE	Read/ Write block	ASCII	Production date
0x9E	PMBUS_CMD_MFR_SERIAL	Read/ Write block	ASCII	Product SN
0xBD	PMBUS_CMD_E_LABLE_LENGTH	Read/ Write block	HEX	Length and frame length of the e-label
0xBE	PMBUS_CMD_E_LABLE_INDEX	Read/ Write word	DEC	E-label number
0xBF	PMBUS_CMD_E_LABLE_CONTENT	Read/ Write block	ASCII	E-label content
0xC0	PMBUS_CMD_POWER_CYCLE_TIME	Read/ Write word	DEC	Shutdown delay time ● Bits F–8: PSU shutdown delay time ● Bits 7–0: PSU shutdown time
0xC6	PMBUS_CMD_WARNING_COUNT1	Read/ Write word	DEC	Alarm counter 1; Writing 0x0000 clears the alarm and recounts the alarm. Writing other values does not take effect.

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Command ID	Command Name	Data Type	Data Format	Description
0xC7	PMBUS_CMD_WARNING_COUNT2	Read/ Write word	DEC	Alarm counter 2; Writing 0x0000 clears the alarm and recounts the alarm. Writing other values does not take effect.
0xC8	PMBUS_CMD_WARNING_COUNT3	Read/ Write word	DEC	Alarm counter 3; Writing 0x0000 clears the alarm and recounts the alarm. Writing other values does not take effect.
0xCC	PMBUS_CMD_MAX_VIN	Read/ Write word	LINEAR 11	Maximum input voltage; Writing 0x0000 clears the alarm, writing other values does not take effect.
0xCD	PMBUS_CMD_MAX_IIN	Read/ Write word	LINEAR 11	Maximum input current; Writing 0x0000 clears the alarm, writing other values does not take effect.
0xCE	PMBUS_CMD_PS_CONTROL	Read/ Write word	HEX	PSU control register; default value: 0x0000
0xCF	PMBUS_CMD_READ_POWER_TYPE	Read word	HEX	PSU types Currently, the PSU always reports 3, that is, AC & 240HVDC. The meanings of the data are as follows: ● 0: AC ● 1: 48 V DC ● 2: HVDC ● 3: AC & 240HVDC ● 4: AC & 240HVDC & 380HVDC
0xD0	PMBUS_CMD_SMART_ON_CONFIG	Read/ Write byte	HEX	Cold standby configuration command

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Command ID	Command Name	Data Type	Data Format	Description
0xD4	PMBUS_CMD_SET_PSALERT	Read/ Write byte	HEX	Forcible alarm command. ● Write 0x20 to forcibly interrupt the signal alarm. ● Write 0x00 to clear the software control and restore the PSU normal control. ● Writing other values is invalid.
0xD6	PMBUS_CMD_MAX_PIN	Read/ Write word	LINEAR 11	Maximum input power
0xD7	PMBUS_CMD_MAX_POUT	Read/ Write word	LINEAR 11	Maximum output power
0xD8	PMBUS_CMD_MAX_TEMP_MONITOR	Read/ Write word	LINEAR 11	Maximum temperature of the PSU air intake vent
0xDB	PMBUS_CMD_MAX_12V_IOUT	Read/ Write word	LINEAR 11	Maximum output current
0xDE	PMBUS_CMD_READ_PART_NUMBER	Read/ Write block	ASCII	xFusion number
0xDF	PMBUS_CMD_READ_INPUT_TYPE	Read word	HEX	Input voltage type PSU real-time input status: ● 0: no input or input voltage abnormal ● 1: AC input ● 2: HVDC ● 3: low-voltage DC (no such input is available)
0xE0	PMBUS_CMD_WRITE_EVENT_INDEX	Write byte	DEC	Black box No.
0xE0	PMBUS_CMD_READ_EVENT_LOG	Read block	HEX	Black box content
0xE1	PMBUS_CMD_WRITE_EVENT_LOG	Write word	HEX	Writing logs

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Command ID	Command Name	Data Type	Data Format	Description
0xE4	PMBUS_CMD_DCDC_SOFT_VER	Read word	HEX	DCDC software version
0xE7	PMBUS_CMD_PFC_SOFT_VER	Read word	HEX	DCDC software version
0xED	PMBUS_CMD_LED_CTRL	Read/ Write byte	HEX	LED control If bit 0 and bit 1 are written to 1 at the same time, the command is invalid. ● Bit 7: 1 indicates active PSU control (the indicator is valid), and 0 indicates PSU automatic control. ● Bit 1: 1 indicates that the orange LED indicator is on, and 0 indicates that it is off. ● Bit 0: 1 indicates that the green LED indicator is on, and 0 indicates that it is off.
0xEE	PMBUS_CMD_LOAD_SHARE_SCALE	Read/ Write byte	DEC	Coefficient of proportionality for current sharing, default value: 1. Value range: 1 to 8. For example, 1 indicates 1:1 and 4 indicates 1:4.
0xFA	PMBUS_CMD_UPDATE_TIME	Write block	TIME	Time serving
0xFB	PMBUS_CMD_LOAD_PARAM	Read block	HEX	Load parameters
0xFC	PMBUS_CMD_LOAD_START	Read/ Write word	HEX	Load commands
0xFD	PMBUS_CMD_LOAD_DATA	Write block	HEX	Load data

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11.4.3 Command Descriptions

PMBUS_CMD_STATUS_BYTE (0x78)

Bit Address	Command Name
7	Reserved
6	Reserved
5	VOUT_OV_FAULT
4	IOUT_OC_FAULT
3	VIN_UV_FAULT
2	TEMPERATURE
1	CML
0	Reserved

PMBUS_CMD_STATUS_WORD (0x79)

Bit Address	Command Name
(Low) 7	Reserved
6	Reserved
5	VOUT_OV_FAULT
4	IOUT_OC_FAULT
3	VIN_UV_FAULT
2	TEMPERATURE
1	CML
0	Reserved
(High) 7	VOUT
6	IOUT/POUT
5	INPUT
4	MFR_SPECIFIC
3	Reserved
2	FANS
1	Reserved
0	Reserved

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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	Reserved
0	Reserved

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	Reserved
2	Reserved

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Bit Address	Command Name
1	Reserved
0	Reserved

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_FANS (0x81)

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

PMBUS_CMD_STATUS_CML (0x7E)

Bit Address	Command Name
7	Reserved

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Bit Address	Command Name
6	Reserved
5	Packet Error Check Failed
4	Memory Fault Detected
3	Processor Fault Detected
2	Reserved
1	Other Communication Fault
0	Reserved

PMBUS_CMD_MFR_SPECIFIC (0x80)

Bit Address	Command Name
7	PSON12V#
6	INSTALLED#
5	IPOK
4	OPOK
3	OPERATION OFF
2	SET Interrupt
1	PFC ENABLED
0	PFC BUS UV

11.4.4 Online Upgrade

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

11.4.5 Black Box Function

The PSU has 440-byte space for storing fault logs. The PSU provides a read channel for external systems by the **Read Event Log** command.

11.4.5.1 Runtime Counter

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

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11.4.5.2 Calibration

The PSU can store the calibration information (such as power calibration and output current calibration) in the event log.

0x1D is the calibration key of the EEPROM. Calibration data is stored in 0x21 to 0x27 (seven bytes in total). The PSU vendors decide the locations of the calibration information to be stored. Only when the value of the calibration key register is **0x4B**, can the PSU write the calibration data into the registers from 0x21 to 0x27 by writing a command. If the value of the calibration key is **0x4B**, the PSU is also allowed to write data into all read-only (RO) registers in the fault records, by which means the PSU can clear the logs after its production test completes. The PSU can write barcode and production date to the offset 0–23. The PSU must clear the **0x1D** register every time the MCU is powered on again, and then the data is **0x00**.

11.4.5.3 Event Log Update

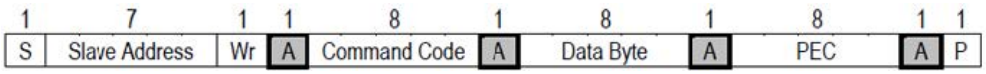
The PSU maintains a circular event log of the last ten records. Before saving the event log, the PSU shall set the event update flag in the event log to 1. Each log shall start with an event number followed by a 4-byte runtime (measured in seconds). The total runtime must be updated before the log is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

The PSU abnormality alarm status, input voltage, input current, output voltage, output current, temperature, fan speed, maximum input voltage, maximum output current, PS control, and other information will be stored in the fault record register. No output due to the hot swap, the switch PSU output operation and the **CYC_PWR** issued by the system cannot be saved by the PSU fault record function. Faults including input power failure, input overvoltage, input undervoltage, output overvoltage, output overcurrent/short-circuit, overtemperature, fan fault, and PSU damage will be stored. 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.

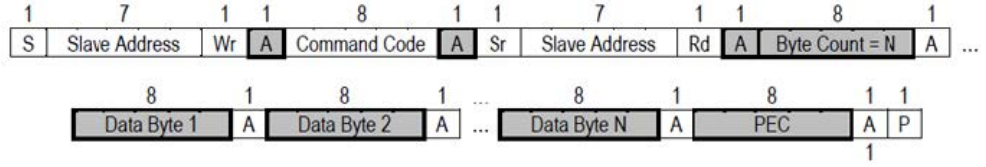
The runtime counter shall be updated every time an event occurs regardless of whether the event is written into the event log. When there are more than 10 events, the 11th event shall overwrite the 1st event, the 12th event shall overwrite the 2nd event, and so on.

11.4.5.4 Format of Reading Logs

- Write Byte Index (0–10)



- Read Block (N = 40)



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:

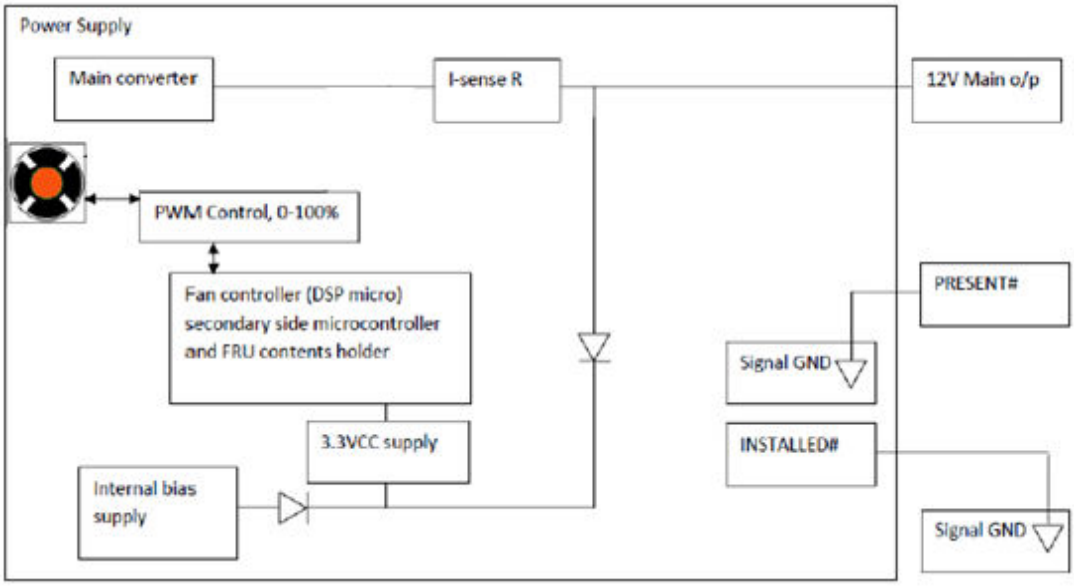
- When the PSU is in MV6 mode, the fan operates at the lowest rotational speed. Overtemperature protection cannot be triggered.
- When the PSU is in MV12 mode, the fan operates at the required rotational speed. Ensure that overtemperature protection will not be triggered.
- The fan cannot stop rotating in the case of reverse power supply.
- The fan must work at full speed before the PSU triggers overtemperature protection.

Fan Power Supply Mode

- The fan obtains power from the output busbar. PSU swap, fan startup and shutdown, and fan faults should not cause the system busbar to drop out of the regulated voltage precision.
- If the fan of a PSU is faulty, the fan needs to be isolated.
- During the system test, a command can be sent to shut down the fan.

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Figure 12-1 Fan power supply circuit



Noise Requirements

Air Intake Vent Temperature	Load	Maximum Value	Test Method
25°C (77°F)	100%	65 dBA	The test should be conducted at 1 m away from the PSU. The noise sensor should face the air exhaust vent of the fan.
25°C (77°F)	40%	50 dBA	The test should be conducted at 1 m away from the PSU. The noise sensor should face the air exhaust vent of the fan.

Fan Protection

- When PSUs work in parallel, if a fan and its power supply circuit are short-circuited or opencircuited, and the output voltages of 12 V or 6 V is normal, the system still works properly.
- When the fan fault detection board detects a fan or fan circuit fault and the fault lasts for over 20 seconds, it reports a fault.

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 20s.

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- In a 1+1 parallel system, if the fan module of a PSU is faulty and the output is shut down, the output of the active circuit will restore after the faulty fan restores.

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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.

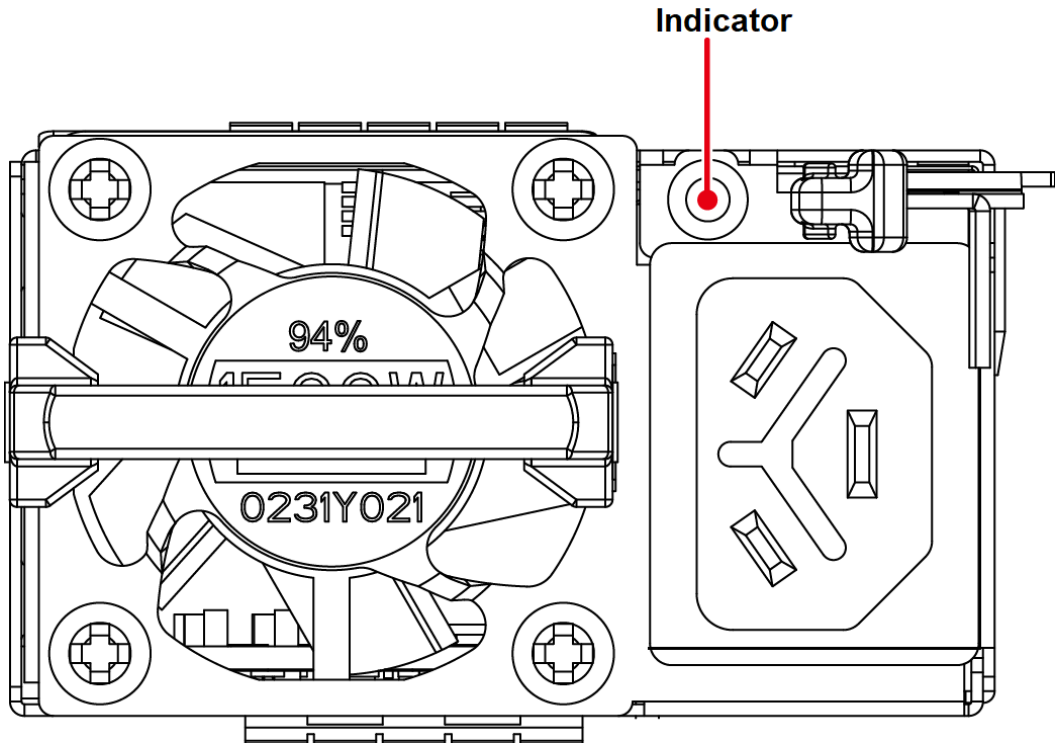


Table 13-1 Indicator on the panel

Indicator	Status	Description
Power status	Steady green	The input and mains MV12 output are normal.

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Indicator	Status	Description
indicator	Blinking green at 1 Hz	● The input is normal, and the PSU shuts down MV12 output due to the INSTALLED# signal. ● The input is normal. The PSU enters MV6 mode because the PSON12V# signal is at high level. ● Input undervoltage occurs. ● The standby PSU is in cold standby mode. ● The PSU enters deep sleep mode. ● The input is normal, and the PSU enters SV12 mode because the IP PRESENT signal is at low level.
	Steady orange	The input is normal. There is no output due to overtemperature protection, output overcurrent/short circuit, output overvoltage, short-circuit protection, or component failure (excluding failure of all components).
	Off	No input.
	Blinking green at 4 Hz	Online upgrade is in progress.

Table 13-2 Panel indicator luminance

Indicator	Meaning	Luminance Range
Green	Normal	> 36cd/m^2
Orange	Normal	> 36cd/m^2

NOTE

- For normal startup, the green indicator should be on and should not blink. For normal poweroff, the power indicator should be off and should not be steady red or blinking red.
- The position of the LED indicator should meet the ESD requirements.
- The indicator uses the Φ3 mm bi-color indicator.
- An I2C communication fault is not indicated by the indicator status.
- 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 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 14-1 Enclosure protection level

Item	Requirement
Enclosure protection level	IP20 (normal maintenance surface)

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A Appendix

A.1 EMC Requirements

Parameter	Conditions	Criterion
Conducted emission (CE)	6 dB	EN 55032, class A
Radiated emission (RE)	6 dB	EN 55032, class A
	6 dB, 30 MHz–1 GHz	FCC Part 15, class A
ESD	Contact: 6 kV, air: 8 kV	IEC 61000-4-2, criterion B
	Contact: 8 kV, air: 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	Conditions	Criterion
Power magnetic susceptibility (PMS)	30 A/m	IEC 61000-4-8: 2001, criterion A
Surge	AC input port: ● Differential mode: ±2.5 kV for L to N (1.2/50 μs, 2 ohms) ● Common mode: ±2.5 kV for L to PE, N to PE, and L and N to PE (1.2/50 μs, 12 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: 5000 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 61000-4-11, criterion B
	Dip to 70% UT, hold-up time: 1 ms/3 ms/10 ms/30 ms/100 ms/300 ms/1,000 ms	IEC 61000-4-11, criterion B
	Dip to 0% UT, hold-up time: 1 ms/3 ms/10 ms/30 ms/100 ms/300 ms/1,000 ms	IEC 61000-4-11, criterion B

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Parameter	Conditions	Criterion
	Dip to 80% UT, hold-up time: 100 ms/300 ms/1000 ms/ 3000 ms/10,000 ms	IEC 61000-4-11, criterion A
	Dip to 120% UT, hold-up time: 100 ms/300 ms/1000 ms/ 3000 ms/10,000 ms	IEC 61000-4-11, 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	GND of the 12 V output and the PE are short-circuited 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	Maximum Test Voltage	Test Current	Maximum Resistance	Test Duration
PE input and shell	12 V	25 A	0.1 ohm	Until the readings are stable.

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NOTE

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

A.3 Reliability

Parameter	Min.	Typ.	Max.	Unit	Notes & Conditions
Mean time between failures (MTBF)	-	500,000	-	Hours	Telcordia SR332, V_{in} = 230 V AC/ 240 V DC; rated load, T_A = 25ºC

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