Power Supply Unit (PSU)

User Manual

Specification Number: 1R505500E4
Model Number: R50-5500E4

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Technical Support Site

If you encounter any installation or operational issues with your product, check the pertinent section of this manual to see if the issue can be resolved by following outlined procedures.

Visit https://www.vertiv.com/support/ for additional assistance.

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Admonishments Used in this Document

DANGER! Warns of a hazard the reader ***will*** be exposed to that will ***likely*** result in death or serious injury if not avoided. (ANSI, OSHA)

WARNING! Warns of a potential hazard the reader ***may*** be exposed to that ***could*** result in death or serious injury if not avoided. This admonition is not used for situations that pose a risk only to equipment, software, data, or service. (ANSI)

CAUTION! Warns of a potential hazard the reader ***may*** be exposed to that ***could*** result in minor or moderate injury if not avoided. (ANSI, OSHA) This admonition is not used for situations that pose a risk only to equipment, data, or service, even if such use appears to be permitted in some of the applicable standards. (OSHA)

ALERT! Alerts the reader to an action that ***must be avoided*** in order to protect equipment, software, data, or service. (ISO)

ALERT! Alerts the reader to an action that ***must be performed*** in order to prevent equipment damage, software corruption, data loss, or service interruption. (ISO)

FIRE SAFETY! Informs the reader of fire safety information, reminders, precautions, or policies, or of the locations of fire-fighting and fire-safety equipment. (ISO)

SAFETY! Informs the reader of general safety information, reminders, precautions, or policies not related to a particular source of hazard or to fire safety. (ISO, ANSI, OSHA)

Important Safety Instructions

Safety Admonishments Definitions

Definitions of the safety admonishments used in this document are listed under “Admonishments Used in this Document” on page iv.

General Safety

DANGER! YOU MUST FOLLOW APPROVED SAFETY PROCEDURES.
Performing the following procedures may expose you to hazards. These procedures should be performed by qualified technicians familiar with the hazards associated with this type of equipment. These hazards may include shock, energy, and/or burns. To avoid these hazards:

a) The tasks should be performed in the order indicated.

b) Remove watches, rings, and other metal objects.

c) Prior to contacting any uninsulated surface or termination, use a voltmeter to verify that no voltage or the expected voltage is present. Check for voltage with both DC voltmeters prior to making contact.

d) Wear eye protection.

e) Use certified and well maintained insulated tools. Use double insulated tools appropriately rated for the work to be performed.

Voltages

AC Input Voltages

DANGER! This system operates from AC input voltage capable of producing fatal electrical shock.

DC Output and Battery Voltages

DANGER! This system produces DC power and may have a battery source connected to it. Although the DC voltage is not hazardously high, the Power Supply Units and/or battery can deliver large amounts of current. Exercise extreme caution not to inadvertently contact or have any tool inadvertently contact an output terminal or battery terminal or exposed wire connected to an output terminal or battery terminal. NEVER allow a metal object, such as a tool, to contact more than one termination or battery terminal at a time, or to simultaneously contact a termination or battery terminal and a grounded object. Even a momentary short circuit can cause sparking, explosion, and injury.

Hazardous Voltage

DANGER! HAZARD OF ELECTRICAL SHOCK.
More than one disconnect may be required to de-energize the system before servicing.

Handling Equipment Containing Static Sensitive Components

ALERT! Installation or removal of equipment containing static sensitive components requires careful handling. Before handling any equipment containing static sensitive components, read and follow the instructions contained on the Static Warning Page.

Static Warning

This equipment contains static sensitive components. The warnings listed below must be observed to prevent damage to these components. Disregarding any of these warnings may result in personal injury or damage to the equipment.

1. Strictly adhere to the procedures provided in this document.
2. Before touching any equipment containing static sensitive components, discharge all static electricity from yourself by wearing a wrist strap grounded through a one megohm resistor. Some wrist straps have a built-in one megohm resistor; no external resistor is necessary. Read and follow wrist strap manufacturer's instructions outlining use of a specific wrist strap.
3. Do not touch traces or components on equipment containing static sensitive components. Handle equipment containing static sensitive components only by the edges that do not have connector pads.
4. After removing equipment containing static sensitive components, place the equipment only on static dissipative surfaces such as conductive foam or ESD bag. Do not use ordinary Styrofoam or ordinary plastic.
5. Store and ship equipment containing static sensitive components only in static shielding containers.
6. If necessary to repair equipment containing static sensitive components, wear an appropriately grounded wrist strap, work on a conductive surface, use a grounded soldering iron, and use grounded test equipment.

1 Introduction

1.1 Overview

The R50-5500E4 Power Supply Unit provides load power and battery recharge current (if applicable) during normal operating conditions. The Power Supply Unit is rated at its maximum output power 5500W. This means that, within the normal operating ambient temperature range and input voltage range, the maximum available output power is 5500W. If ambient temperature rises above or input voltage falls below specified values, the Power Supply Unit continues to operate but at derated output power levels.

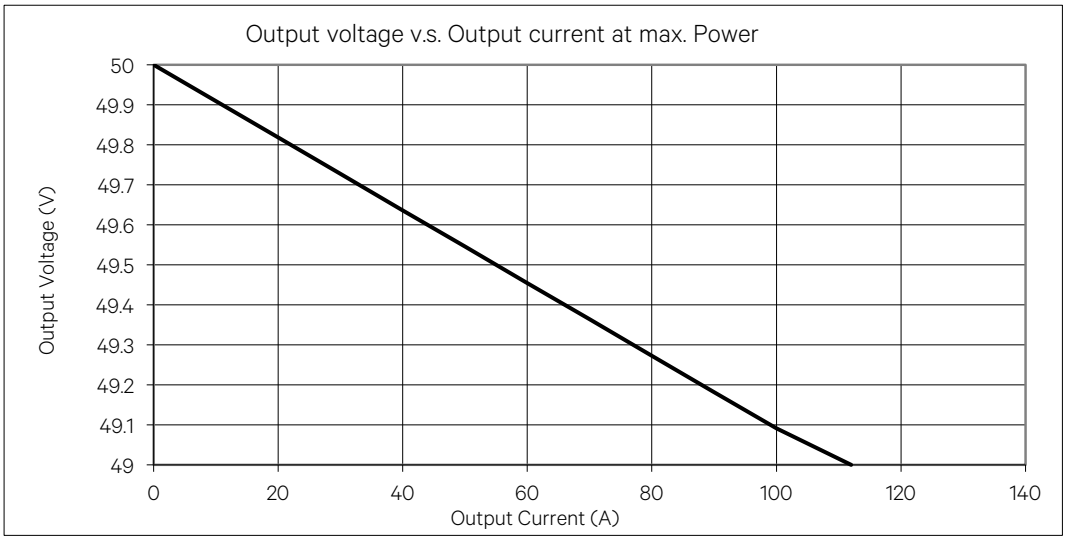
The default DC output voltage of the Power Supply Unit is fixed at 50V @NL and 49V@FL while in normal operation. It supplies rated power for the entire range of DC output voltage.

1.2 Specifications

1.2.1 DC Output Ratings

- Voltage: The default DC output voltage of the Power Supply Unit is fixed at 50 V @NL and 49 V@FL while in normal operation., negative ground. The Power Supply Unit output voltage set point is adjustable from 48 V to 51 V.
- Output Power and Current: 5500W (112A) @ 220 Vac,230 Vac,240Vac or 277Vac nominal input and +49VDC output.
- Output Characteristics: Refer to **Figure 1.1** for a graph of output voltage vs. output current.

Figure 1.1 Output Voltage vs. Output Current



- The Power Supply Unit is capable of supplying full rated output power over single phase input voltage range of 198V AC - 305V AC, frequency of 47 Hz -63 Hz and 240VDC to 410VDC. The relationship between the output power and input voltage is illustrated in **Figure 1.2.** and **Figure 1.3**.
- The Power Supply Unit includes a soft start that promptly resets at any input AC loss > 20ms. The Power Supply Unit shuts down if the input voltage is over 345V for 20ms or 309V for 50ms.
- Input voltage protection: Low voltage disable point: 177V±3V; Hysteretic at least 14Vac for restart (Sine wave). High voltage disable point:309V±3V; Hysteretic at least 19Vac for restart (Sine wave).

Figure 1.2 Power Based on Input Voltage at Temp≤45°C and Vo =50V from 180Vac to 305Vac

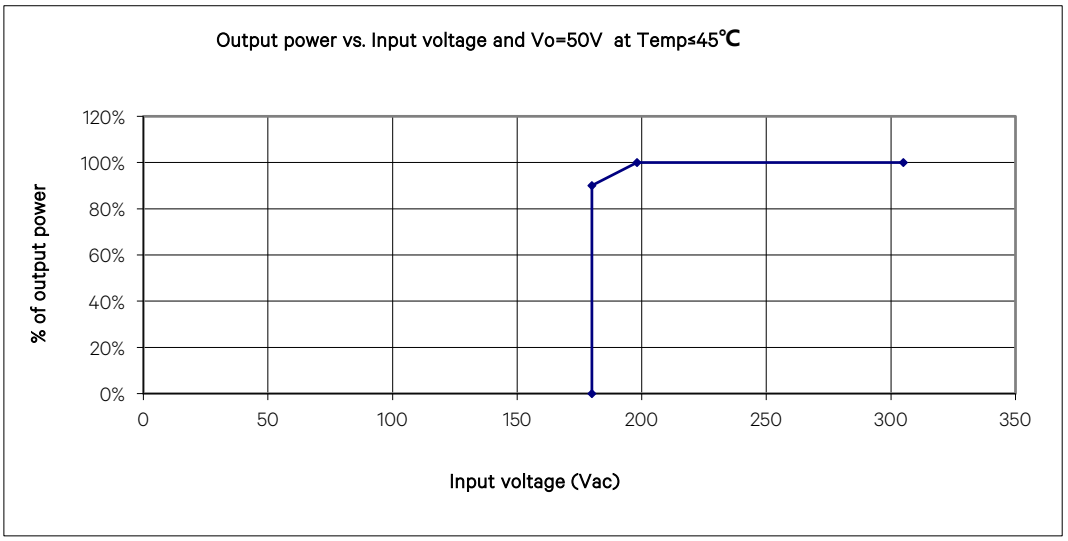
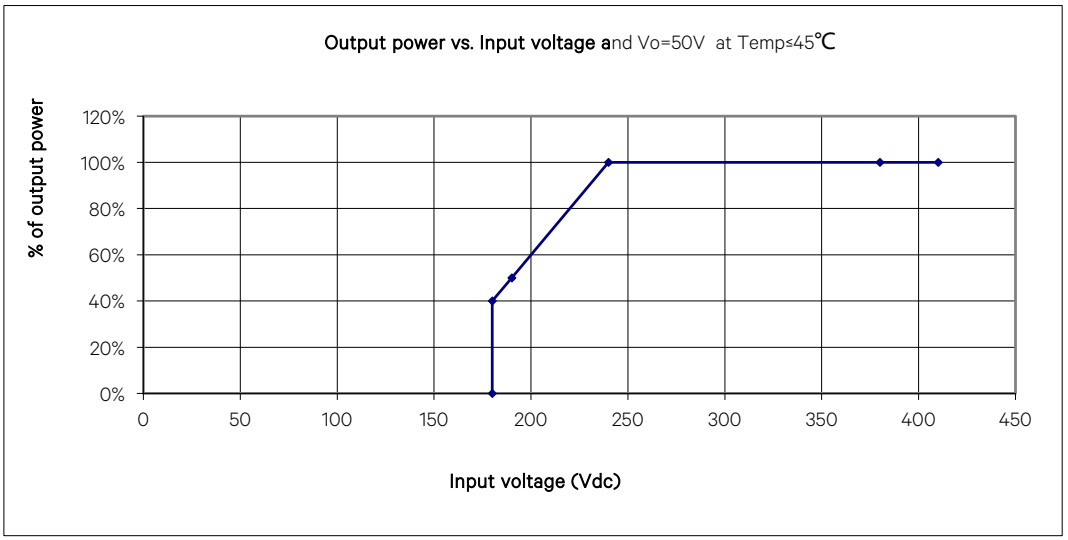


Figure 1.3 Power Based on Input Voltage at Temp≤45°C and Vo =50V from 180Vdc to 410Vdc



- Power Derating Based on Temperature: The Power Supply Unit delivers full power when operating at an ambient temperature of +45°C (+113°F) or below. Each Power Supply Unit continuously monitors the ambient temperature surrounding the power conversion circuit. If this temperature for any reason (such as a high ambient temperature) increases above approximately +45°C (+113°F), the Power Supply Unit will not shut down. Rather, the Power Supply Unit limits its maximum output power to maintain the temperature of the power conversion circuit within design parameters. Operation between +45°C (+113°F) and +65°C (+149°F) will result in output power being decreased. Full power capability is restored when the temperature decreases to below approximately +45°C (+113°F). Refer to **Figure 1.4** to view the relationship between the output power and the ambient temperature.

  Other power rating values are as follows (refer to **Figure 1.4**):

  a) At an ambient temperature of +45°C (+113°F), the power delivered by the Power Supply Unit is 5500W.

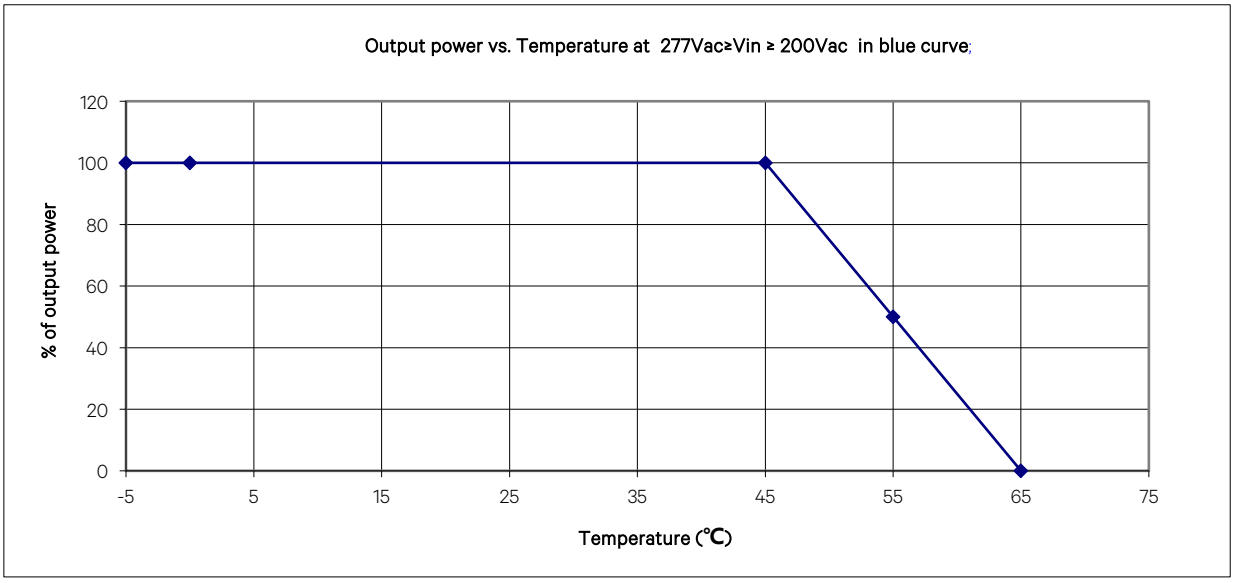
  b) At an ambient temperature of +55°C (+131°F), the power delivered by the Power Supply Unit is 2750W.

  c) At an ambient temperature of +65°C (+149°F), the power delivered by the Power Supply Unit is 0W.

WARNING! The module is rated for continuous operation at full output power up to +45°C (+113°F). Operation between +45°C (+113°F) and +65°C (+149°F) is considered abnormal and should be used on a temporary[1] basis only.

- Temporary Operation at Abnormal Temperature: Temporary operation is defined as a period of not more than eight consecutive hours per day, and a total of not more than 15 days in a year. (This refers to a total of 120 hours in any given year, but no more than 15 occurrences in that one-year period.)

Figure 1.4 Power Derating Based on Temperature



NOTE! *5500W @ +45°C (+113°F) and 200Vac < Vin <277Vac*

- Regulation:

a) Static: The Power Supply Unit droop voltage (0%-100%) shall be 1V by default (with the tolerance of ± 0.125V). That means output voltage is 49V at 100% load and 50V at no-load. The droop extends linearly to 150% (it means at 150%, the droop is 1.5V, and voltage is 48.5V)

b) Dynamic: Under these testing conditions, the DC output voltage shall not vary by more than specified for undershoot and overshoot with 3ms settling time (with and without capacitive loading on a single unit of 20 mF). The measurement shall be from the new steady state value (due to droop) to the voltage spike/dip peaks during a transient load.

Table 1.1 Dynamic Response

Step load increase or decrease	Transient load rate	Max undershoot and overshoot
50% step load (10% min. load)	1 A/uSec	0.5 V
90% step load (10% min. load)	1 A/uSec	1 V
140% step load (10% min. load)	1 A/uSec	1.5 V

NOTE! *For single step load from 10% to 100%, the output voltage shall not trigger BBU backup.*

c) Filtering:

The DC output voltage ripple and noise is ≤ 500 mV peak to peak. Ripple and noise are defined as periodic or random signals over a frequency band of 5Hz to 100MHz measured across a steady-state resistive load. Measurements is made differentially using an oscilloscope with 100Mhz bandwidth limit enabled. Compliance is verified using a 0.1uF capacitor connected locally to the oscilloscope probe tips during this measurement.

1.2.2 AC Input Ratings

- Voltage:

  Nominal 220 Vac, 230 Vac, 240Vac or 277Vac, single phase, 50/60 Hz, with an operating range of 180 Vac to 305 Vac. Acceptable input frequency range is 47 Hz to 63 Hz.

- Harmonic Content (iTHD): ≤15% for 5% to 10% load, ≤10% for 10% to 30% load, ≤5% for 30% to 100% load at input voltage of 208~277V for 50Hz,60Hz and at 25°C.

- Inrush Current: Maximum AC inrush current from cold power-on shall be limited to no greater than 55A RMS (38A peak)) at any AC operating voltage and a temperature of 25C. This specified inrush current shall not include the X-Capacitors charging. Under the above conditions, standard AC distribution circuit breakers will not trip.

- Typical Input Data:

  a) Refer to **Table 1.2**.

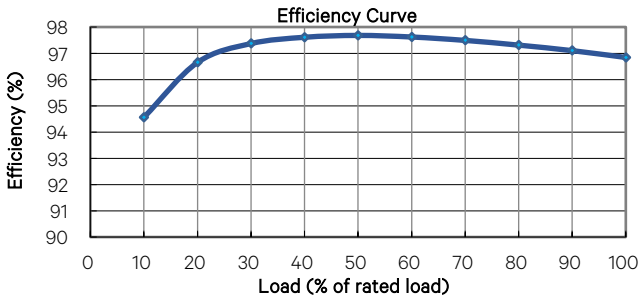
  b) Typical Input Current: Refer to **Table 1.2**.

Table 1.2 Typical Input Data in 220Vac / 230Vac / 240Vac/ 277Vac Input

NOMINAL INPUT VOLTAGE	PERCENT OF FULL LOAD	INPUT CURRENT (AMPERES)	INPUT POWER (WATTS)	EFFICIENCY %	POWER FACTOR	HEAT DISSIPATION (BTU/HR)
220 Vac	10%	2.67	580.69	94.46%	0.988	109.76
	20%	5.18	1135.41	96.57%	0.997	132.87
	30%	7.71	1688.27	97.24%	0.998	158.98
	40%	10.23	2241.5	97.42%	0.999	197.31
	50%	12.75	2792.3	97.46%	0.999	241.98
	60%	15.30	3348.8	97.36%	0.999	301.63
	70%	17.85	3904.8	97.21%	0.999	371.70
	80%	20.43	4464.7	97.01%	0.999	455.46
	90%	23.01	5023.4	96.77%	0.999	553.59
	100%	25.59	5585	96.51%	0.999	665.02
230 Vac	10%	2.57	580.75	94.47%	0.982	109.57
	20%	4.96	1135.31	96.58%	0.993	132.47
	30%	7.37	1687.94	97.26%	0.996	157.79
	40%	9.781	2240.5	97.47%	0.998	193.40
	50%	12.19	2791	97.50%	0.999	238.06
	60%	14.63	3346.9	97.41%	0.999	295.75
	70%	17.06	3902.1	97.27%	0.999	363.45
	80%	19.51	4461.3	97.07%	0.999	445.98
	90%	21.97	5018.9	96.85%	0.999	539.39
	100%	24.45	5580	96.60%	0.999	647.29
240 Vac	10%	2.48	580.7	94.48%	0.977	109.36
	20%	4.76	1135.17	96.60%	0.992	131.68
	30%	7.08	1687.49	97.28%	0.995	156.60
	40%	9.38	2239.6	97.51%	0.998	190.26
	50%	11.68	2789.7	97.55%	0.999	233.19
	60%	14.01	3345	97.47%	0.999	288.74
	70%	16.34	3900.1	97.33%	0.999	355.28
	80%	18.69	4458.5	97.14%	0.999	435.05
	90%	21.04	5015.5	96.92%	0.999	527.05
	100%	23.40	5575.6	96.68%	0.999	631.56
277 Vac	10%	2.21	580.15	94.56%	0.949	107.68
	20%	4.14	1134.54	96.65%	0.986	129.67
	30%	6.14	1685.98	97.37%	0.99	151.28
	40%	8.13	2236.81	97.61%	0.995	182.39
	50%	10.10	2785.7	97.68%	0.997	220.50
	60%	12.10	3339.7	97.62%	0.998	271.19
	70%	14.11	3893.3	97.49%	0.999	333.41
	80%	16.13	4450.5	97.31%	0.999	408.46
	90%	18.15	5006.2	97.10%	0.999	495.33
	100%	20.19	5565.8	96.84%	0.999	600.07

- Efficiency Curve: (Refer to **Figure 1.5**)

Figure 1.5 Efficiency Curve



1.2.3 DC Input Ratings

- Voltage:

  Nominal 240Vdc or 380Vdc, with an operating range of 180 Vdc to 410 Vdc.

- Typical Input Data:

  c) Refer to **Table 1.3**.

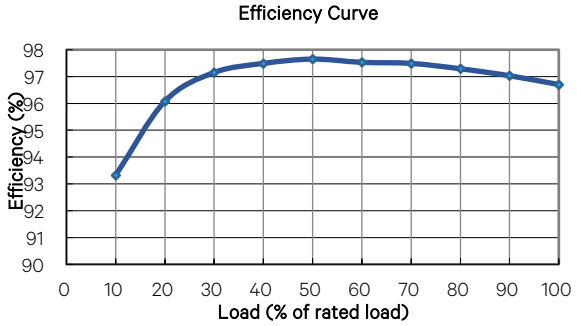
  d) Typical Input Current: Refer to **Table 1.3**.

Table 1.3 Typical Input Data

NOMINAL INPUT VOLTAGE	PERCENT OF FULL LOAD	INPUT CURRENT (AMPERES)	INPUT POWER (WATTS)	EFFICIENCY %	HEAT DISSIPATION (BTU/HR)
240 Vdc	10%	2.21	580.15	94.56%	107.68
	20%	4.14	1134.54	96.65%	129.67
	30%	6.14	1685.98	97.37%	151.28
	40%	8.12	2236.81	97.61%	182.39
	50%	10.10	2785.7	97.68%	220.50
	60%	12.10	3339.7	97.62%	271.19
	70%	14.11	3893.3	97.49%	333.41
	80%	16.13	4450.5	97.31%	408.46
	90%	18.15	5006.2	97.10%	495.33
	100%	20.19	5565.8	96.84%	600.07
380 Vdc	10%	2.54	587.97	93.32%	134.00
	20%	3.54	1142.04	96.08%	152.74
	30%	4.45	1691.1	97.15%	164.44
	40%	5.90	2240.14	97.49%	191.84
	50%	7.34	2787	97.65%	223.45
	60%	8.81	3343.2	97.53%	281.74
	70%	10.26	3893.5	97.49%	333.42
	80%	11.73	4450.9	97.29%	411.53
	90%	13.20	5008.9	97.03%	507.55
	100%	14.70	5574.7	96.70%	627.65

- Efficiency Curve: (Refer to **Figure 1.6**)

Figure 1.6 Efficiency Curve



1.2.4 Environmental Ratings:

- Operating Ambient Temperature Range:

  a) -5°C (23°F) to +45°C (+113°F) with full power performance.

  b) +45°C (+113°F) and +65°C (+149°F) with derated output.

- Storage Ambient Temperature Range: -40°C (-40°F) to +85°C (+185°F).

- Relative Humidity:

  Operational: 10-90% RH non-condensing

  Non-operational: 5-93% RH non-condensing

- Altitude: 3050 m (10006 ft) at full power (power limited for heights above 3050 m).

NOTE! *This level of protection is a widely used standard for power equipment. As with all such equipment, it is the end user's responsibility to provide an adequately sized Surge Suppression Device at the commercial power service entrance of the building that reduces all incoming surges to levels below the classes/categories stated for the equipment.*

- Ventilation Requirements: The Power Supply Units are fan cooled and utilize front to back forced ventilation. A Power Supply Unit must be mounted so ventilating openings are not blocked and temperature of the air entering the Power Supply Unit does not exceed the Operating Ambient Temperature Range stated above.

- Single Power Supply Unit Audible Noise: ≤85dBA when fan modules are running at full speed and operating within the defined environmental envelope.

- High Voltage Category: II.

- Power Distribution System: TN/TT/IT.

NOTE! *The Power Supply Unit module is recommended to be used in an environment with Pollution of Degree 2 or less. Pollution Degree 2 applies where there is only non-conductive pollution that might temporarily become conductive due to occasional condensation (such as the office environment).*

EMI/RFI Suppression: Power Supply Units operating in an approved Power Supply Unit mounting shelf conform to the requirements of European Norm, EN55032, Class A for Radiated and Conducted emissions limits.

1.2.5 Compliance Information

- EMC: The power shelf shall have minimum 6dB margin from the EN 55032 FCC Class A limit for the radiated and conducted emissions.

- Surge Protection: Compliance with EN61000-4-5 (AC Power Line: >2kV (Line-to-line), >4kV (Line-to-earth); Signal Port: >1kV).

- Safety: UL 62368-1 C22.2 NO. 62368-1, EN 62368-1, IEC 62368-1.

1.2.6 Transition and Synchronization Requirements

- Start-up (0V to 50V) Transition procedure

Each PSU has a small circuit to output a SYNC_START signal and all PSUs' SYNC_START signals are connected together on the power shelf backplane.

1)Each PSU sets its SYNC_START signal to high when the PSU is ready to turn on the output.

2)Only PSU in SLOT #1 generates a random timer and set SYNC_START to high when ready and the random timer is finished.

3)The PSUs will turn on the output when the SYNC_START signal is high.

4)If the SYNC_START signal is kept low for 3s more than the max random timer limit (which is 2s without BBU and 5.5s with BBU), the PSU shall turn on immediately.

5)If PSU1 is not installed or its SYNC_START signal is low, the other PSUs shall turn on within 10s. In this case a random timer doesn't exist.

1.2.7 Start-up

- Turn on- Cold Start

The output voltage of the Power Supply Unit shall be monotonic during turn on and turn off, there shall not have any reverse voltage during turn off.

The max capacitive loading on a single unit at power up is 20 mF.

For any loads (from 'no-load' to 'max-load'), the output voltage rises monotonically from 0VDC to 50VDC, without overshoot or ringing, at any turn on following application of AC input voltage, and anytime when the Power Supply Unit resumes operation after an automatic protection condition (including parallel operation). The output voltage falls monotonically from 50VDC to 0VDC, without undershoot or ringing, at any AC loss, and at any turn off caused by an automatic protection condition (including parallel operation).

Output voltage never reverses polarity at the turn off (all conditions).

- Turn on- AC Failure / Recovery

The Power Supply Unit recovers automatically after an AC power failure. The start-up time requirement is the same as that of a cold start specified in section above.

The Power Supply Unit includes a soft-start that promptly resets at any input AC loss > 20ms, or after any automatic protection condition.

1.2.8 Hold-up Time

Hold-up time at different load power is given in the table below. Holdup time is calculated from the time ac input is lost until the time the output voltage is out of acceptable 48V range.

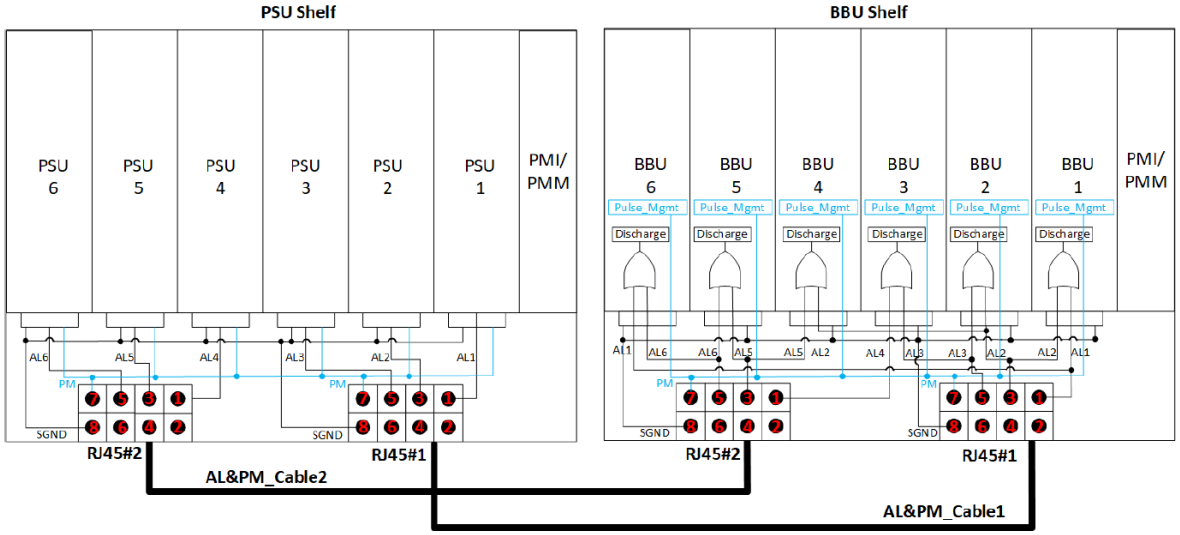
Load Power	Hold-up Time (ms)
100%	20.00
110%	18.18
120%	16.67
130%	15.38
140%	14.29
150%	13.33

1.2.9 PSU-BBU Transition with AC_Loss_L Signal

AC_Loss signals are used with the 5.5kW PSU (Power Supply Unit) and BBU (Battery Backup Unit) and shelves to enable control during AC loss events. Each PSU has an output AC_Loss signal, while each BBU has two input AC_Loss signals. Upon detection of AC loss, the PSUs assert the AC_Loss signal after a validation delay of 4-5ms.

When a BBU receives either one of the active AC_Loss signals, it pulls the Sync_Start_L signal low, allowing the BBU shelf to initiate immediate discharge. The output voltage of the BBU shelf ramps up to the normal setting range within 5ms.

Figure 1.7 AC_Loss &Pulse Management Signals



1.2.10 Forced Discharge Mode

The rack monitor has the capability to send Modbus commands to Power Supply Units (PSUs) in order to toggle the AC_Loss_L signal. This action ensures that the Battery Backup Unit (BBU) will discharge even when AC power is present.

1.2.11 Pulse Load Management Mode

The PSU has the function of pulse load management, especially for GPU-based load possibly with repetitive peak pulse load. A PSU maximum input power limit is adjustable and defined based on specific system requirements.

PSU high-voltage bus capacitance is maximized and utilized for higher buffer energy of supporting the pulse power. In the case of depleting the bus capacitor energy, a dedicated Pulse_Mgmt_L signal could be toggled to request the BBU to share the pulse load.

Physical connections of the Pulse_Mgmt_L signals are illustrated in the Figure 1.7. Each PSU has an output Pulse_Mgmt_L signal and all the Pulse_Mgmt_L signals in one PSU shelf are connected together and sent to a BBU shelf via two RJ45 connectors. The Pulse_Mgmt_L signal on the BBU shelf is rerouted to BBUs and each BBU has an input Pulse_Mgmt_L signal. Upon detection of the pulse load and PSU has depleted the available bulk capacitor's energy, PSU would assert the Pulse_Mgmt_L signal to request load sharing from BBU. When detecting BBU's refusal of the load sharing, PSU shall release or increase the maximum input power limit to carry the load.

1.2.12 Power Supply Unit Physical Addressing

Three Power Supply Unit signal pins are used for the slot physical addressing. There are digital signals that have internal pull up resistors inside the Power Supply Unit. On the power shelf, these pins are grounded (0) or left open (1) to determine Power Supply Unit location as below:

Power Supply Unit slot location 1: 000

Power Supply Unit slot location 2: 001

Power Supply Unit slot location 3: 010

Power Supply Unit slot location 4: 011

Power Supply Unit slot location 5: 100

Power Supply Unit slot location 6: 101

For shelf design with more than 1-row Power Supply Units, a 4th bit and signal pin might be defined.

1.2.13 Random Timer and Synchronization

Under any conditions of dissipative load, capacitive load, temperature, with or without backup voltage connected to the PSU:

- Max time for PSU to be 'power-up ready' after AC voltage starts is 2.5s.
- After 'power-up ready':
- When there is no dc voltage on the bus (first AC turn on) the power shelf shall be randomized with 0~2 second window to give each power shelf a random turn-on time (six PSU turn-on is synchronized).
- When there is dc voltage on the bus higher than 44V for 0.1 sec (BBU is discharging), the power shelf shall be randomized with 0~5.5 second window to give each power shelf a random turn-on time (six PSU turn-on is synchronized).
- The power shelf shall turn on with only 1 PSU inserted into any slot.

NOTE! *The random numbers above shall be dynamically generated immediately after each AC recycle, and not generated one time and then stored in the EEPROM for future usages.*

Table 1.4 Random Timer and Synchronization

Item	Description	Min	Max	Units
T_power-up_ready	Time for PSU to be power-up ready	1	3	seconds
T_random_noBBU	0-2 second initial turn on random delay without BBU discharging	0	2	seconds
TON_noBBU	Time 50VDC turns on after the shelf receives AC input without BBU discharging.	1	4.5	seconds
T_random_BBU	0-5.5 second turn on random delay after BBU discharging	0	5.5	seconds
TON_BBU	Time 50VDC turns on after the shelf receives AC input with BBU discharging.	1	8	seconds
TSYNC	After all PSUs in the shelf are ready to start till when 50VDC will start	2	5	msec
T-Max_ON_noBBU	Max PSU turn-on time without BBU in case of sync failure	6	7.5	seconds
T-Max_ON_BBU	Max PSU turn-on time with BBU in case of sync failure	9.5	11.0	seconds

1.2.14 Black Box Function

The black box function stores important data when a fault occurs:

- The black box stores data in memory and be able to withstand several read/write cycles.
- The PSU is able to store failure data before the PSU turns off/fails even in catastrophic failure events both on primary and secondary side. Hold up time of the Blackbox microcontroller is able to store all the information and then shutdown.
- Last 4 events stored in memory.
- AC input current, AC input voltage, Input Power, Power factor, iTHD, DC output voltage, DC output current,
- Temperature readings, fan Speed, input voltage, output voltage, bulk voltage, various error codes from all the different converters (OTP, OVP, OCP, UVP), and warnings.
- Total run time of PSU
- Run time since last turn on
- Real time stamping
- Number of AC power cycles
- Number of AC outages (can be determined by going into backup without counting the battery test conditions)

Power supply event data is saved to the Black Box for the following events:

Any events that caused the Main Output to shut down:

- Main Output over voltage fault
- Main Output under voltage fault
- Main Output over current fault
- Main Output short circuit fault
- Fan failure
- Over temperature fault

Any events that caused the AC input to be bad:

- AC Input under voltage fault
- AC Input over voltage fault
- AC Input out of range frequency fault

1.2.15 Metering Function

- Reporting Accuracy

  Accurate reporting of input power (power factor, input current, input current harmonics and voltage) and output power (output current and voltage)

  readings are reported via communication system at all rated voltage.

  The accuracy is maintained across the operating temperature range and between 200 VAC and 305 VAC.

Table 1.5 Reporting Accuracy Table

Parameter	Load	Accuracy
AC Input Power	<10%	±25W
	10% to 20%	±5%
	20% to 100%	±3%
AC Input Current	<15%	±0.5A
	15% to 30%	±2%
	30% to 100%	±1%
AC Input Current THD (Error difference not %)	<10%	±10%
	10% to 30%	±2%
	30% to 100%	±1%
AC Input Current THD (Error difference not %)	<10%	±10%
	10% to 30%	±2%
	30% to 100%	±1%
AC Input Voltage	0 to 100%	±1%
DC Input Power	<10%	±40W
	10% to 20%	±5%
	20% to 100%	±3%
DC Input Current	<15%	±0.5A
	15% to 30%	±6%
	30% to 100%	±4%
DC Input Voltage	0 to 100%	±1%
Output Voltage	0 to 100%	±0.5%
Output Current	10 to 20%	±10%
	20 to 50%	±5%
	50 to 100%	±1%
Output Power	<10%	±25W
	10 to 20%	±3%
	20 to 100%	±2%

1.2.16 Standard Features

- Type of Power Conversion Circuit: High frequency.
- Working Mode:

  The default DC output voltage of the Power Supply Unit is fixed at 50 V @NL and 49 V@FL while in normal operation. The Power Supply Unit is rated at its maximum output power. This means that, within the normal operating ambient temperature range and input voltage range, the rated output power is 5500 W for long time continuous operation.

- Input Protection:

  a) Input Over/Under Voltage Protection: The Power Supply Unit will shut down at low or high voltage input voltage; based on the following voltage levels:

  1. Low Voltage Disable Point: 177 V AC, ±3 V AC; hysteresis is 14 V AC for restart.
  2. High Voltage Disable Point: 309 V AC, ±3 V AC; hysteresis is 19 V AC for restart.
  3. Low Voltage Disable Point: 180 V DC, hysteresis is 15 V DC for restart.
  4. High Voltage Disable Point: 420 V DC, hysteresis is 15 V DC for restart.

- Output Protection:

  a) Overpower / Current protection: If a Power Supply Unit is overloaded higher than the values listed below, it shall shut down. 5s after an overload shuts down, Power Supply Units shall retry once to sync together and turn on. If the fault still presents, then the Power Supply Unit shall latch off. The latch off can be cleared by AC cycling, reseating or a Modbus command. The OCP retry counter shall be cleared 30 minutes after normal operation.

  Overpower/Current Protection Limits: Average power is more than 115% for 10s; Average power is more than 120% for 100ms; Repetitive pulse power more than the pulse power envelope specified.

  Pulse power requirements: The Power Supply Unit is capable of supporting the following peak pulse load while maintaining output within regulation and input power within the maximum limit. ≤160 %, 400us moving average; ≤136 %, ≤50 ms moving average; ≤100 %, ≥1 s moving average.

  b) Output Short-circuit Protection: The Power Supply Unit employs short-circuit protection to protect the Power Supply Unit and attached load in the case of an output short-circuit or other output overload condition. If the Power Supply Unit voltage is lower than 10V (short circuit condition), the Power Supply Unit shuts off immediately. No component shall be damaged. The Power Supply Unit only retries once to sync start after 5s if detecting 50V bus voltage is still alive. Otherwise, The Power Supply Unit latches off.

  No AC_loss_L signal is asserted during output short-circuit condition to trigger BBU backup. The latch off can be cleared by AC cycling, reseating or a Modbus command. The SCP retry counter shall be cleared 30 minutes after normal operation.

  c) Output Over Voltage Protection:

  The Power Supply Unit shall shut down for DC output voltage exceeding 52.5V and the reacting time shall not exceed 200ms. For DC output voltage shall never exceed 54V (fast OVP).

- Over-Temperature Protection: The Power Supply Unit employs over-temperature protection for both ambient over temperature and internal thermal temperature to protect the Power Supply Unit. The Power Supply Unit shuts down due to an over temperature condition and recovers after a certain period after the over temperature condition is removed. The OTP circuit incorporates built in hysteresis such that the power supply does not oscillate on and off due to temperature recovering condition. The OTP event is reported as a fault.

- Active Load Sharing: The Power Supply Units have a dedicated analog bus with slow bandwidth for active current sharing. With the maximum number of Power Supply Units connected in the system, the current sharing accuracy shall be ± 2% or better for > 50% and ± 5% or better for load from 20% to 50%.

- Hot Swappable: The Power Supply Unit is designed to be plug-and-play. The Power Supply Unit can be inserted or removed from a live DC power system with no damage. When the Power Supply Unit is plugged into the system, the system output voltage will not be affected.

- Cooling: Each Power Supply Unit module contains a fan for front-to-back force air-cooling.

  a) Fan Fault Protection: The Power Supply Unit module shuts down if a fan fails, the rectifier indicates the failure with a signal that is reported via software as well as an LED indicator on the front panel. The rectifier does not need to shut down because of a failed fan and only shuts down if there is a fault, i.e. over-temperature fault. The fan is field replaceable.

  b) Fan Control: Fan speed is continuously variable. When input voltage is within normal range, the built-in processor adjusts fan speed according to the Power Supply Unit module's internal temperature and output power. For example, a higher temperature or output power increases the fan speed. This feature can be disabled via the controller, allowing the fan to run at full speed regardless of temperature.

- Paralleling: Up to 48 Power Supply Units can be connected in parallel in one system.

- Monitoring Function: The Power Supply Unit has a built-in advanced DSP that monitors and controls the operation of the Power Supply Unit. The DSP also communicates with the PMM in real time through the RS485.

- Communication Protocol: The rectifiers are able to communicate on PMBus (up to 100kbps) and ModBus (up to 115kbps).

  At default, Modbus is active and PMBus is hardware only. When the FW update, the rectifier switches to PMbus communication.

  The software interface is operational when the AC input voltage is present or when the DC output bus is powered up by other power sources. Refer to the register maps for fault/read/write registers that PSU should communicate.

- Firmware Upgrade: The interface allows the user to re-flash firmware on the device. Firmware upgrade results in no power interruption on the shelf level (the unit being upgraded can go offline.) Upgrades can be done one Power Supply Unit at a time. PSU output voltage interruption due to FW upgrade is less than 5s.

  The PSU FW maintains regulation on the output during Send, Install and verification of the new FW, and only require a soft reset (that may reset the output for a short period in a few seconds)

1.2.17 Mechanical Specifications

- Dimensions:

  a) Millimeters: 40(Height) X 73.5 (Width) X 640 (Depth)

  b) Inches: 1.6 (Height) X 2.9 (Width) X 25.2 (Depth)

- Weight: 3.2 kg (7.05 lbs)

- Indicators:

  a) LED 1, Blue LED:

  1) Blinking Blue @ 4Hz frequency: Sync Start State, Power Supply Unit is ready to turn on its output and awaiting the sync Start signal

  2) Solid Blue: 50V is ON and available

  3) No LED: 50V output off

  b) LED 2, Amber LED:

  1) Blinking Amber @ 4Hz frequency: Bootloading

  2) Solid Amber: Primary/Secondary/Fan/bootloading Failure and/or loss of DC output▪ (refer to Power Supply Unit Modbus /Pmbus registers for specific failures)

  3) No LED: fault NOT present/condition 1 and 2 are false.

2 Operation

2.1 DC Input Protection Device Requirements/Recommendations

Refer to the system documentation supplied with the system within which the Power Supply Unit is installed.

2.2 Local Indicators

Location and Identification: Refer to **Figure 2.1**.

Description: There are two (2) indicators located on the Power Supply Unit's front panel. The functions of these indicators are as shown in **Table 2.1**.

NOTE! *DC voltage must be present at the Power Supply Unit output terminals (from battery or an operating Power Supply Unit) or DC voltage at the input terminals.*

Figure 2.1 Local Indicator Locations

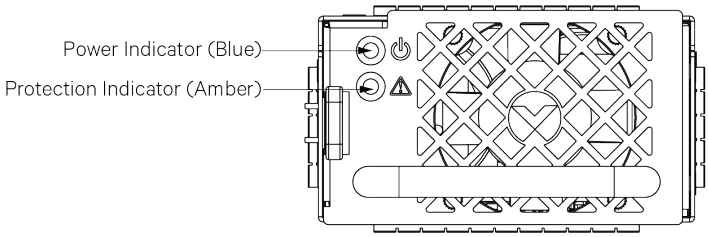


Table 2.1 Power Supply Unit Module Indicators

Indicator	Normal State	Alarm State	Alarm Cause
Power (Blue)	On	Off	No input voltage.
		Blinking	Sync Start State, the Power Supply Unit is ready to turn on its output and awaiting the sync Start signal
Protection (Amber)	Off	On	Primary/Secondary/Fan/boot loading Failure and/or loss of DC output
		Blinking	Boot loading

2.3 Power Supply Unit High Voltage Shutdown and Lockout Restart

Procedure

Turn the power to the Power Supply Unit off or remove the Power Supply Unit, wait 30 seconds or more (until the LEDs on the Power Supply Unit extinguish), then turn the power to the Power Supply Unit on or re-insert the Power Supply Unit.

2.4 PSU Connector PIN Assignment

Figure 2.2 PIN Assignment

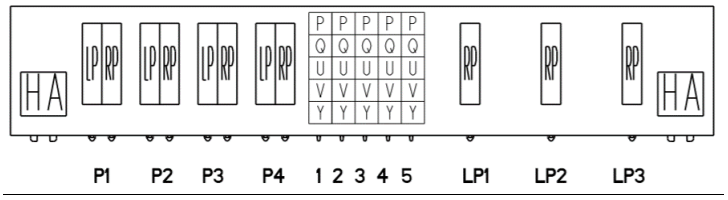


Table 2.2 PIN Definition

Pin	Name	Description
P1 & P2	48V positive	/
P3 & P4	48V return	/
LP1	Earth	/
LP2	AC phase	/
LP3	AC phase	/
P1	PSU_A0	Address 0 - PSU ID A0, Internal pull up 10k to 3.3V
P2	PSU_A1	Address 1 - PSU ID A1, Internal pull up 10k to 3.3V
P3	PSU_A2	Address 2 - PSU ID A2, Internal pull up 10k to 3.3V
P4	Busbar_Clip+_Temp	Busbar clip + contact temperature sensor
P5	Busbar_Clip-_Temp	Busbar clip - contact temperature sensor
Q1	Ground	
Q2	Alert	Logic “Low ”= Fault or Waring Logic “High ”= OK
Q3	Reset_Latch_Fault	high for 1-2s = clear faults and start PSU if not operating due to a fault
Q4	Shelf_addr_Int_A0	Internal pull up 100k to 3.3V
Q5	Shelf_addr_Int_A1	Internal pull up 100k to 3.3V
U1	Shelf_addr_Int_A2	Internal pull up 100k to 3.3V
U2	AC_Loss_L	Low: AC loss
U3	PSKILL (Short Pin)	Logic “Low ”= Output Turn on Logic “High ”= Output Turn off Quick shut down Output, mitigate hot unplug arcing. Internal pull up 10k to 3.3V.
U4	RS485A	
U5	RS485B	
V1	Present_L	1. 10Ω pull-down inside PSU/BBU module. 2. 4.7k pull-up inside PMM. 3. Connecting to PMM edge connector pin A27/B27/A28/B28/A29/B29 respectively. Low: PSU/BBU present
V2	I2C_SDA	I2C Data
V3	I2C_SCL	I2C Clock
V4	Ground	I2C ground
V5	reserved	
Y1	ISHARE	Main Output current share bus
Y2	AC_Fault_CLR	clear latch off flag after ac fault event Open-collector/drain output; Internal pull up 100k and a diode to 3.3V
Y3	SYNC_START	Synchronizing turn-on main output, Internal pull up 10k to 3.3V
Y4	Pulse_Mgmt_L	Logic “High”= no request for BBU support of pulse load Logic “Low”= request BBU support for pulse load Open-collector/drain output, internal pull up 100k and a diode to 3.3V
Y5	Ground	Ground

2.5 Installing Power Supply Units

CAUTION! The Power Supply Unit contains double pole, neutral fusing. Disconnect mains before servicing. The fuse is non-replaceable by the customer.

CAUTION! Before using the Power Supply Unit, ensure that the system is reliably grounded. The Power Supply Unit must be replaced by an authorized technician.

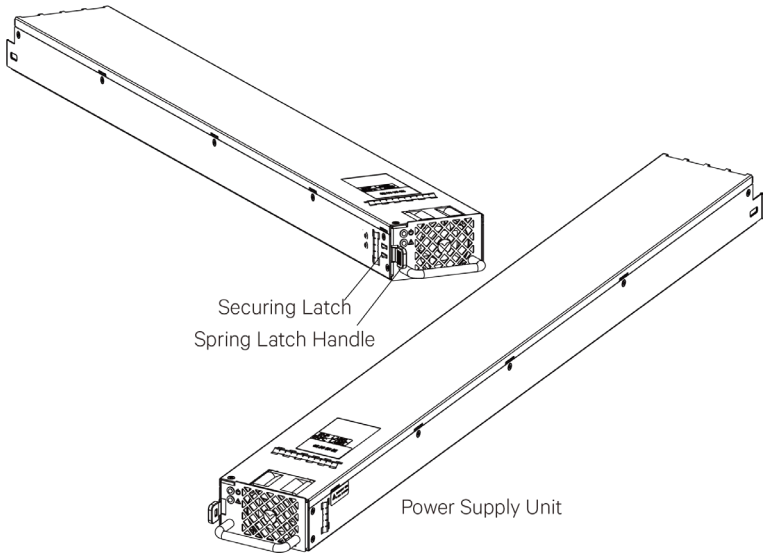
The Power Supply Unit is hot swappable. It can be removed and installed with the system operating and without affecting the output bus.

Procedure

NOTE! *Refer to Figure 2.3 as this procedure is performed.*

1. Unpack the Power Supply Unit.
2. Partially slide the Power Supply Unit into the shelf.
3. Push the spring latch handle located on the front of the Power Supply Unit to the right (this will retract the securing latch located on the side of the Power Supply Unit).
4. Slide the Power Supply Unit completely into the shelf and release the spring latch handle (the securing latch located on the side of the Power Supply Unit will pop into a notch in the shelf to secure the Power Supply Unit to the shelf).
5. After the Power Supply Unit s are physically installed in the mounting shelf(s), they are ready for operation immediately after power is supplied to them.
6. If the system is operating, ensure that there are no local or remote alarms active on the system.

Figure 2.3 Installing Power Supply Unit



3 Troubleshooting and Repair

3.1 Troubleshooting

3.1.1 Power Supply Unit Current Sharing Imbalance

When multiple Power Supply Units are operating in parallel and the load is greater than 20%, if the current sharing imbalance among them is greater than 5%, check if the Power Supply Unit is properly seated in the shelf.

If the current sharing imbalance still persists following the verification suggested above, replace the Power Supply Unit exhibiting the current imbalance.

3.1.2 Power Supply Unit Fault Symptoms and Troubleshooting

- The fault indicators that can be displayed by the Power Supply Unit are as follows. Refer to

Table 3.1 for a list of possible causes and corrective actions.

- Power Indicator (Blue) Off.
- Protection Indicator (Amber) ON.
- Protection Indicator (Amber) Blinking.

Table 3.1 Power Supply Unit Module Troubleshooting

Symptom	Alarm Cause	Suggested action(s)
Power (Blue)	No input voltage.	Make sure there is input voltage
	Sync Start State, the Power Supply Unit is ready to turn on its output and awaiting the sync Start signal	
Protection (Amber)	Primary/Secondary/Fan/boot loading Failure and/or loss of DC output	Fan rotor blocked: remove any object that may be blocking the fan or replace the Power Supply Unit
	Boot loading	

3.2 Replacement Procedures

3.2.1 Power Supply Unit Module Replacement

The Power Supply Unit is hot swappable. It can be removed and installed with the system operating and without affecting the output bus.

CAUTION! The Power Supply Unit contains double pole fusing; the fuse is non-replaceable.

Procedure

NOTE! *Refer to Figure 2.3 as this procedure is performed.*

1. Performing this procedure may activate external alarms. Do one of the following. If possible, disable these alarms. If these alarms cannot be easily disabled, notify the appropriate personnel to disregard any alarms associated with this system while this procedure is performed.
2. Push the spring latch handle located on the front of the Power Supply Unit to the right (this will retract the securing latch located on the side of the Power Supply Unit).
3. Pull the Power Supply Unit out of the shelf and release the spring latch handle.

4. Grasp the handle and pull firmly to remove the module from the shelf.
5. Place the replacement Power Supply Unit module into the mounting position without sliding it in completely.
6. Push the spring latch handle located on the front of the Power Supply Unit to the right (this will retract the securing latch located on the side of the Power Supply Unit).
7. Slide the Power Supply Unit completely into the shelf and release the spring latch handle (the securing latch located on the side of the Power Supply Unit will pop into a notch in the shelf to secure the Power Supply Unit to the shelf).
8. After the Power Supply Unit s are physically installed in the mounting shelf(s), they are ready for operation immediately after power is supplied to them.
9. If the system is operating, ensure that there are no local or remote alarms active on the system.

3.2.2 Power Supply Unit Fan Replacement

Each Power Supply Unit uses a fan (P/N: 32011160) for cooling. If fan replacement should become necessary, perform the following procedure.

Refer to **Figure 3.1** as this procedure is performed.

WARNING! In a system with NO redundant Power Supply Unit, battery must have sufficient reserve to power the load(s) while the Power Supply Unit is removed for fan replacement.

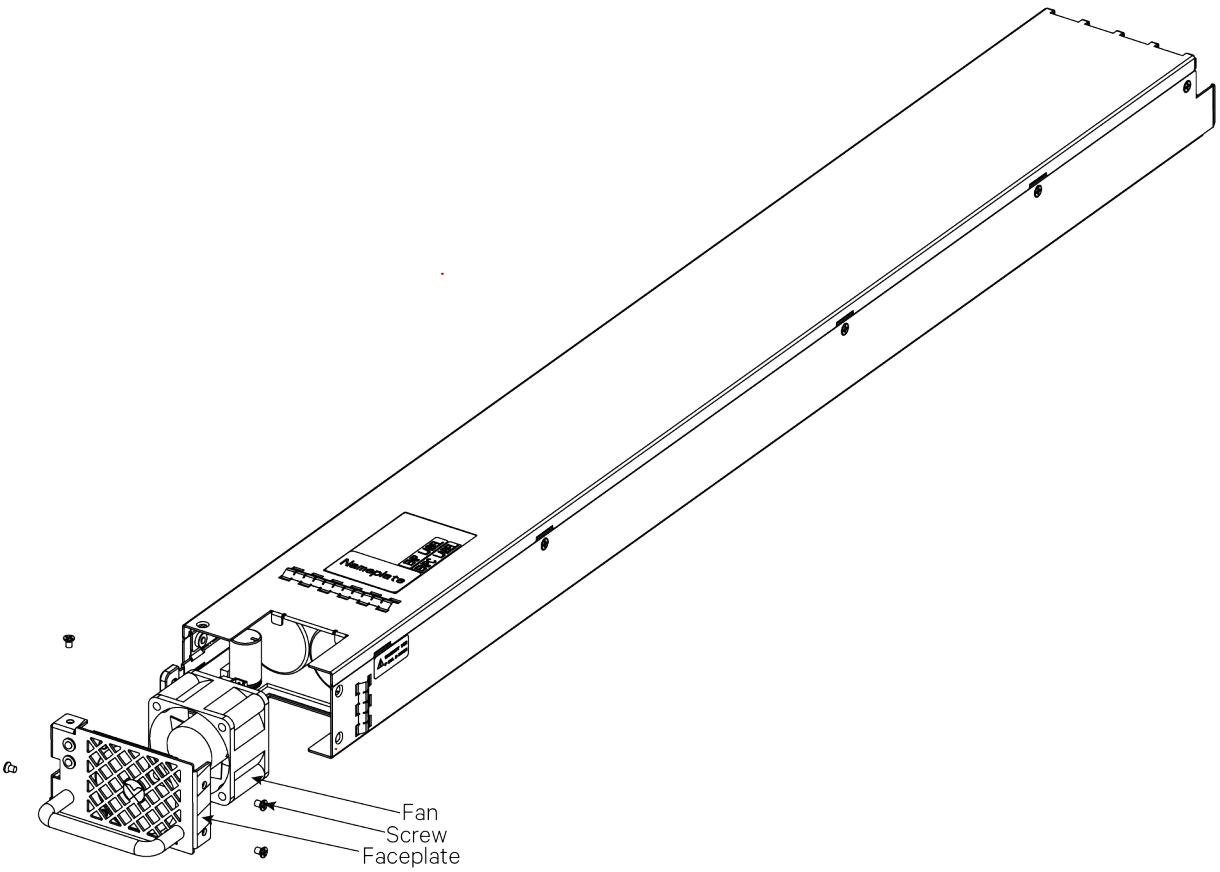
NOTE! *When performing any step in this procedure that requires removal of existing hardware, retain all hardware for use in subsequent steps.*

Procedure

1. Performing this procedure may activate external alarms. Do one of the following. If possible, disable these alarms. If these alarms cannot be easily disabled, notify the appropriate personnel to disregard any alarms associated with this system while this procedure is performed.
2. Remove the Power Supply Unit from the shelf. Refer to a previous procedure for step-by-step instructions.
3. Place the Power Supply Unit on a static-safe work surface. Connect an approved grounding strap to your wrist for the remainder of this procedure.
4. On this Power Supply Unit, remove the front panel by removing the four (4) screws securing the front panel to the chassis.
5. For proper orientation of the new fan, observe the location of the fan wires and the fan rotation and air flow arrows on the old fan.
6. Carefully remove the fan from the Power Supply Unit chassis and unplug the fan power cable from the printed circuit card.
7. Plug the power cable of the replacement fan into the connector on the printed circuit card. Carefully slide the replacement fan into the Power Supply Unit chassis (ensure the fan wires and fan rotation and air flow arrows match the orientation of the old fan).
8. Note that the fan has four holes in the front corners and that the faceplate has four tabs. Carefully slide the faceplate into position, aligning the fan holes with the faceplate tabs. Secure the faceplate to the Power Supply Unit chassis with the four (4) screws previously removed.
9. Replace the Power Supply Unit into the shelf. Refer to the previous procedure for step-by-step instructions.

10. When the fan starts, check to ensure that it is providing front-to-back airflow. If air direction is wrong, immediately remove the Power Supply Unit from the shelf. Repeat previous steps to check fan orientation and correct as necessary. Reinstall the Power Supply Unit and again check for proper airflow.
11. Enable the external alarms or notify appropriate personnel that this procedure is finished.
12. Ensure that there are no local or remote alarms active on the system.

Figure 3.1 Fan Replacement



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