Vertiv™ Liebert® EXL S1 UPS

GUIDE SPECIFICATIONS
for a 250-1200kVA 480V 60Hz
Single-Module or Multi-Module (Distributed Static Switch)
Uninterruptible Power System

1.0 GENERAL

1.1 Summary

These specifications describe requirements for a continuously rated, solid state Uninterruptible Power System (UPS) optimized for maximum efficiency and power density. The UPS utilizes a double-conversion, transformer-free topology, whereby the output power supplied is derived directly from the UPS without the need for an internal step-up output transformer. The UPS will be used to operate in conjunction with the existing building supplies and shall provide high quality power distribution for critical loads. All performance values specified shall be for the equipment needed to operate at the same voltage as the electrical system. The UPS, with the exception of the battery system and maintenance bypass, shall be factory-assembled and tested at the specified system voltage and reconnected on site without addition of field-supplied power conductors.

The manufacturer shall design and furnish all materials and equipment to be fully compatible with electrical, environmental and space conditions at the site. The UPS shall include all equipment to integrate the AC power source to the intended load and be designed for unattended operation.

1.2 Standards

The UPS and all associated equipment and components shall be manufactured in accordance with the following applicable standards:

- The UPS shall be UL listed per UL Standard 1778, latest edition, Uninterruptible Power Supplies, and shall be CSA certified.
- The UPS shall be provided with a Short Circuit Withstand Rating label denoting the maximum source fault short circuit current that is applicable to the unit. The withstand rating shall be independently verified by a nationally recognized third-party lab. Self-certification shall not be acceptable.
- The UPS shall withstand input surges to both the rectifier and bypass, when configured as a dual-input unit, without damage per the criteria listed in ANSI C62.41, Category B3 (6kV). The manufacturer shall provide evidence of compliance and test data upon request.
- The UPS shall be provided with electrostatic discharge (ESD) immunity per IEC 61000-4-2 Level 2 (4kV) contact; Level 3 (8kV) air.
- (Optional) The UPS shall comply with FCC Rules and Regulations, Part 15 Subpart B §15.107 Conducted Limits Class A. This compliance is legally required to prevent interference with adjacent equipment. The UPS shall have a label stating FCC compliance. The manufacturer shall provide evidence of compliance upon request.
- The UPS shall be compatible with the wiring practices, materials and coding in accordance with the requirements of the National Electrical Code, OSHA and applicable local codes and standards. Overcurrent devices provided in the UPS shall include trip functions as indicated on the project drawings. Provisions shall be made in the cabinets to permit installation of input, output and external control cabling, using raceway or conduit for top and bottom access to input, output, bypass and DC connections. Connection cabinets shall provide for wiring gutter and wire bend radius as defined by the NEC and UL.

- The UPS (250-600kVA ratings) shall be seismically certified in accordance with the 2015 International Building Code (IBC), 2016 California Building Code (CBC), and American Society of Civil Engineers (ASCE) Minimum Design Loads, with seismic performance of S_{ds}=1.61, I_p=1.5 and z/h=0. Optional seismic brackets shall be available from the UPS manufacturer for use in compliance with this certification.
- The UPS(625-1200kVA ratings) shall be seismically certified in accordance with the 2015 International Building Code (IBC), 2016 California Building Code (CBC), and American Society of Civil Engineers (ASCE) Minimum Design Loads, with seismic performance of S_{ds}=1.43, I_p=1.5 and z/h=0. Optional seismic brackets shall be available from the UPS manufacturer for use in compliance with this certification.
- The matching Battery Cabinets shall be certified to the International Building Code (IBC) 2012 with seismic performance of Sds=2.00, Ip=1.5 and z/h=1.0. Optional seismic brackets shall be available from the UPS manufacturer for use in compliance with this certification.
- The Quality System for the engineering and manufacturing facility shall be certified to conform to Quality System Standard ISO 9001 for the design and manufacture of power protection systems for computers and other sensitive electronics.

1.3 System Description

1.3.1 Design Requirements

- The UPS shall be sized to provide a minimum of _____kVA/kW output (Unity Load Power Factor Rating).
- The UPS shall be able to supply all required power to full rated output kVA loads with power factor from 0.7 leading to 0.4 lagging.
- Load voltage and bypass line voltage shall be 480VAC, three-phase, three-wire plus ground. Input voltage shall be 480VAC, three-phase, three-wire plus ground. The UPS shall not require nor or use an input neutral for normal operation. The design intent shall be to maintain reliability while delivering maximum efficiency as indicated in Section 1.3.5 AC Output - E.
- The AC input source shall be a solidly grounded wye service. If the optional common mode choke is installed in the UPS input/output cabinet, dual asynchronous AC input sources shall be acceptable.
- The VRLA battery shall support the UPS at 100% rated kW load for at least _____ minutes at startup (Initial Run Time) and _____ minutes at end of life (EOL Run Time) at 77°F (25°C).
- The Lithium-ion battery shall support the UPS at 100% rated kW load for at least _____ minutes at startup (initial run time) and _____ minutes at end of life (EOL Run Time) at 77°F (25°C).
- The UPS shall have an active power factor corrected three-level IGBT rectifier, capable of maintaining input power factor and input THDi within specifications without an additional input filter.
- The UPS shall be of transformer-free design, requiring no internal transformer in the main power path for the basic operation of the module. Optional transformers in cabinets or otherwise external to the basic UPS module shall be permissible to provide isolation and/or voltage transformation.

1.3.2 Modes of Operation

The UPS shall operate as an on-line reverse transfer system in the following modes:

1. Normal (VFI Mode)

The critical AC load shall be continuously powered by the UPS inverter. The rectifier shall derive power from the utility AC source and supply DC power to the inverter and DC-DC converter, which simultaneously float charges the battery. Float charging shall be continuous without cycling to be in compliance with the battery manufacturer's published float service warranty requirements.

2. (Optional) ECO Mode (VFD Mode)

The system control shall offer a method to increase maximum efficiency when conditions permit by automatically placing the load on the bypass source when the voltage and frequency of that source are within acceptable parameters. The load shall be transferred to the inverter automatically and without interruption should the bypass source be outside the acceptable parameters. The UPS must maintain a constant float voltage to the batteries during this mode.

3. (Optional) Dynamic Online Mode (VI Mode)

Dynamic Online is a high efficiency mode of operation to allow an increase in efficiency without compromising reliability. Dynamic Online mode offers up to 99% efficiency without decreasing reliability. In fact, while operating in Dynamic Online the UPS is able to maintain the output voltage within the IEC 62040-3 Class 1 specification in all operating conditions. When the quality of the supply network is within tolerances the UPS activates Dynamic Online mode. In this mode the energy is supplied by the network to the load through the static bypass switch and the UPS inverter will function as an active filter, providing the reactive power necessary to compensate load THDi and load Power Factor. In case of network parameters outside tolerances the UPS will instantly activate double conversion mode (VFI) with a Class 1 transfer.

4. (Optional) Intelligent Paralleling Mode (Multi-Module Systems Only)

The system control shall offer a method to increase maximum efficiency when conditions permit by automatically adapting power capacity to meet immediate load requirements by switching excess UPS units to standby mode, while ensuring continued system availability. Intelligent paralleling shall allow each UPS to operate in standby mode for an equal length of time, ensuring equal lifespans of module components, and will optimize efficiency at partial load operation achieving superior running cost savings.

5. Emergency

Upon failure of utility AC power, the critical AC load shall be powered by the inverter which, without any switching, shall obtain its power from the battery plant via the DC-DC converter. There shall be no interruption in power to the critical load upon failure or restoration of the utility AC source.

6. Recharge

Upon restoration of the utility AC source, the rectifier shall derive power from the utility AC source and supply DC power to the inverter and DC-DC converter, which simultaneously float charges the battery. This shall be an automatic function and shall cause no interruption to the critical AC load.

7. Bypass

If the UPS must be taken out of service for maintenance or repair, the static transfer switch shall transfer the load to the bypass source. The transfer process shall cause no interruption in power to the critical AC load. An optional external wrap-around maintenance bypass shall be used to ensure full isolation of the unit for the service of internal components.

8. Battery Unavailable

If the battery is unavailable, the UPS shall continue to function and meet all of the specified steady-state performance criteria except for the power outage backup time capability.

1.3.3 Performance Requirements

The UPS shall be able to support 100% critical load and maintain full battery charging when the following conditions exist simultaneously:

- Any altitude, within the specified operating range up to an elevation of 3300 ft. (1000 m)
- Any ambient temperature, within the specified operating range of 32°F to 104°F (0°C to 40°C)
- Any input voltage within the specified range, +10% to -10% of nominal
- Air filters 50% blocked per the criteria included in UL1778

1.3.4 AC Input

1. Overload Capacity: With nominal input voltage and without the battery connected, the rectifier shall be capable of supplying the inverter with the power needed to operate over the full inverter overload range.
2. Voltage: Rectifier and Bypass AC Input shall be 480V, three-phase, three-wire-plus-ground
3. Voltage Range: +10%, -10% of nominal without discharging batteries
4. Frequency Range: ±5Hz
5. Fixed Time Rectifier Walk-In: 0% to 100% of full rated load over 1-300 seconds (adjustable)
6. Minimum Frequency Walk-In: 0% to 100% of full rated load in minimum time possible while maintaining a minimum generator frequency of 57 Hz to 60 Hz (adjustable)
7. Rectifier Start Delay: Programmable from 0-240 seconds before walk-in begins (adjustable)
8. Maximum Inrush Current: UPS inrush current shall not exceed four times the nominal input current for a maximum of 10 milliseconds
9. Power Factor: Minimum 0.99 at full load with nominal input voltage
10. Current Distortion: Less than or equal to 3% input current THD at full load input current (nominal input voltage, <1% input voltage THD, and <1% input voltage imbalance)
11. Rectifier and Bypass Surge Protection: Sustains input surges without damage per criteria listed in ANSI C62.41, category B3 (6kV)
12. Withstand Rating: Units shall carry a 100kA standard short circuit withstand rating with fuses. All withstand ratings shall be UL-tested and certified, and a label shall be applied to the unit clearly identifying this rating as required by the National Electric Code.

1.3.5 AC Output

1. **Load Rating**
   - 100% continuous load rating at 104°F (40°C) for any load from 0.7 leading to 0.4 lagging
2. **Voltage Regulation:**
   - < 1% RMS average for a balanced three-phase load
   - < 2% RMS average for 100% unbalanced load for line-to-line imbalances
3. **Voltage Adjustment Range:**
   - ±5% for line drop compensation adjustable by factory service personnel
4. **Frequency Regulation:**
   - ±0.1%
5. **Efficiency**
   - Defined as output kW/input kW at 1.0 power factor load, measured at 25%, 50%, 75%, and 100% of nominal load, with energy storage disconnected or at float, DC-DC converter running.

Rating (kVA/kW)	25% Load	50% Load	75% Load	100% Load
250	≥ 94.9%	≥ 96.5%	≥ 96.8%	≥ 96.8%
300	≥ 95.4%	≥ 96.7%	≥ 96.9%	≥ 96.7%
400	≥ 96.1%	≥ 96.8%	≥ 96.7%	≥ 96.6%
500	≥ 95.6%	≥ 96.6%	≥ 96.6%	≥ 96.5%
600	≥ 96.1%	≥ 96.7%	≥ 96.6%	≥ 96.3%
625	≥ 95.6%	≥ 96.8%	≥ 96.9%	≥ 96.8%
750	≥ 96.1%	≥ 96.9%	≥ 96.8%	≥ 96.6%
800	≥ 96.3%	≥ 96.9%	≥ 96.8%	≥ 96.5%
1000	≥ 95.7%	≥ 96.8%	≥ 96.8%	≥ 96.6%
1100	≥ 96.0%	≥ 96.8%	≥ 96.8%	≥ 96.6%
1200	≥ 96.2%	≥ 96.8%	≥ 96.8%	≥ 96.5%

6. **Phase Imbalance:**
   - Balanced loads: 120° ±1°
   - 50% unbalanced loads: 120° ±2°

7. **Voltage Transients (Average of All Three Phases):**

Voltage transients shall be limited to a maximum deviation from nominal system output volts as specified below, with recovery to within 2.5% of output voltage within four (4) electrical cycles for each of the below conditions. Limits shall apply to any UPS load within the UPS rating, and frequency shall be maintained at 60 Hz ±0.1 Hz. The system shall not transfer to bypass under these conditions.

- Add or remove module from parallel system: ±6% (RMS average for one cycle)
- 100% load step: ±4% (RMS average for one cycle)
- 50% load step: ±4% (RMS average for one cycle)
- Loss of/return to AC input power: ±4% (RMS average for one cycle)

8. **Voltage Harmonic Distortion:**
   - Maximum 1.5% RMS total (linear load)
   - Maximum 5% RMS total for up to 100 kVA non-linear load, per IEC 62040-3
9. **Overload at Nominal Output Voltage with ±1% Voltage Regulation:**
   - 110% of full load continuously at 77°F (25°C) ambient
   - 125% of full load for 10 minutes at 77°F (25°C) ambient
   - 150% of full load for a minimum of 60 seconds at 77°F (25°C) ambient
   - 200% of full load for a minimum of 200 milliseconds at 77°F (25°C) ambient
10. **Current Limit:**
    - Up to 200% of full load current
11. **Fault Clearing:**
    - Inverter Only: 200% of normal full load current for 200 milliseconds.
    - Bypass Available: 500% for (10) cycles in inverter pulse-parallel operation when bypass is available for more rapid fault clearance downstream of the UPS.

1.3.6 Grounding

The UPS chassis shall have an equipment ground terminal.

1.4 Environmental Conditions

The UPS shall be able to withstand the following environmental conditions without damage or degradation of operating characteristics:

1. **Operating Ambient Temperature**
   - UPS: 32°F to 104°F (0°C to 40°C) without de-rating at 100% load. 1.5% maximum kW de-rating per °C up to 122°F (50°C). 122°F (50°C) absolute maximum with de-rating.
   - Lead-Acid Battery: 72°F to 82°F (22°C to 28°C)
   - Samsung Lithium-ion Battery: 64°F to 82°F (18°C to 28°C)
   - Vycon Flywheel: -4°F to 104°F (-20°C to 40°C)
2. **Storage/Transport Ambient Temperature**
   - -13°F to 158°F (-25°C to 70°C)

3. Relative Humidity

- 0 to 95%, non-condensing

4. Altitude

- Operating: To 3300 ft. (1000m) above mean sea level without de-rating. 1% maximum kW de-rating per 1000 ft. rise between 3300 and 10,000 ft. (305m rise between 1000 and 3000m).
- Storage/Transport: To 50,000 ft. (15,000m) above mean sea level.

1.5 Parallel Systems

1. Parallel Configurations

Up to eight (8) UPS module outputs may be connected in parallel to provide up to 8X maximum output for capacity and 7X maximum output with redundancy.

2. Inter-Module Communications

The UPS module shall communicate via a redundant cable system based on a bi-directional loop such that any single break or disconnection of the cable system shall generate an alarm, but shall not interfere with the parallel operation of the system.

3. Paralleling Switchgear

The outputs of the UPS modules shall be connected to an output switchboard containing a common output bus. The switchboard shall be provided with Module Output Breakers (MOB) for each module to permit isolating any module from the output bus. Each MOB shall be equipped with 1A/1B auxiliary contacts to communicate breaker status. The MOB shall be selected to work with current levels that may occur when switching a module onto the active bus. Breakers with adjustable instantaneous settings shall be adequate to achieve this. As an option, paralleling switchgear may be integrated with UPS modules at the factory for system testing.

4. Individual UPS Module Startup in a Parallel System

When multiple UPS modules are connected in parallel to support a common load the system startup may be performed by starting a single UPS module inverter while the remaining UPS module inverters remain off.

5. Individual UPS Module Shutdown in a Parallel System

When multiple UPS modules are connected in parallel to support a common load, a single UPS module inverter may be shut down while the remaining parallel system UPS module inverters supply the load if the load does not exceed the combined power capacity of the remaining parallel system UPS modules.

6. Parallel System Load Bank Testing

When multiple UPS modules are connected in parallel to support a common load, the parallel system may be tested with a load bank while the load is supplied by an external maintenance bypass.

7. Individual UPS Module Load Bank Testing in a Parallel System

A single UPS module may be disconnected from the parallel system and tested with a load bank while the remaining parallel system UPS modules support the load.

A Load Bank Breaker (LBB) shall be connected upstream of the Module Output Breaker (MOB). When the LBB is closed and the MOB is open, a test operation mode may be enabled from the UPS module HMI, allowing the UPS module inverter to start and transfer to bypass to test the full functionality of the UPS module.

8. Load Sharing on Inverter

When multiple UPS modules are connected in parallel and powering a common load, load sharing shall not differ by more than 5% for each UPS module.

9. Load Sharing on Bypass

Load sharing when on bypass is solely controlled by the impedance (measured from the bypass source connection to the critical bus connection) difference between parallel modules. For example, when the impedance difference between two parallel modules is 10%, one bypass carries 107% of the load and the other bypass carries 94%. This sharing difference could cause sharing transients when the critical bus is transferred from bypass to the inverter. Poorly matched bypass path impedances may also cause one or more modules to inhibit a transfer to inverter due to being overloaded. The UPS shall have a factory default setting of 109% (adjustable 100% to 110%) nominal load for inhibiting manual and automatic transfers from bypass to inverter. If the UPS modules in the parallel system are loaded below 109%, manual and automatic transfers from bypass to inverter shall not be inhibited.

Cabling impedances can be controlled by providing similar lengths of cable to and from each UPS module. The cabling impedance for a parallel system should be matched as closely as possible. Vertiv recommends carefully controlling the cabling differences so that the maximum difference does not exceed 5% of average cable length. In addition to cabling impedance, the impedance differences caused by elements in the input and output switchgear (e.g., bus bar and breakers) must be taken into consideration to calculate the total impedance for each bypass path.

Vertiv offers optional sharing inductors (installed in the UPS bypass path within the UPS) that will reduce the load sharing difference caused by an impedance mismatch in parallel module bypass paths. The sharing inductors' impedance compensates for reasonable impedance system mismatches. If the total planned system load exceeds more than 85% per module, Vertiv recommends installing bypass sharing inductors. When sharing inductors are used, cabling differences should be maintained within 20% of average cable length.

Average cable length difference is calculated by subtracting the total average kW from the module kW, dividing the result by the average kW and multiplying by 100%.

Average cable length difference is calculated by subtracting the average cable length from the module cable length, dividing the result by the average cable length and multiplying by 100%.

- Module Cable Length Difference = (Cable Length – Average Cable Length)/Average Cable Length * 100%

Load sharing percentage is calculated by subtracting the total average kW from the module kW, dividing the result by the average kW and multiplying by 100%.

- Total Percent Load Sharing = (Module kW – Average kW)/Average kW * 100%

The individual phase power shall also be balanced within ±10% on any given module. Module-to-module individual phase power shall be within 15%.

- Phase A Percent Load Sharing = (Module Phase A kW – Average Phase A kW)/Average Phase A kW * 100%
- Phase B Percent Load Sharing = (Module Phase B kW – Average Phase B kW)/Average Phase B kW * 100%
- Phase C Percent Load Sharing = (Module Phase C kW – Average Phase C kW)/Average Phase C kW * 100%

1.6 Submittals

1.6.1 Proposal Submittals

Submittals with the proposal shall include:

- Descriptions of equipment to be furnished, including deviations from these specifications
- Document stating compliance with FCC requirements
- Document stating listing to UL, including edition used for listing
- Document showing compliance with required short circuit withstand rating and labeling
- System configuration with single-line diagrams
- Detailed layouts of customer power and control connections
- Functional relationship of equipment, including weights, dimensions and heat dissipation
- Information to allow distribution system coordination, including any overcurrent device in the bypass, and the manufacturer's part number or trip curve
- Size and weight of shipping units to be handled by contractor

1.6.2 Order Submittals

Submittals produced for the order shall include:

- All the documentation presented with the proposal, per Section 1.6.1 above.
- Detailed installation drawings including all terminal locations.
- Interconnect wiring diagrams showing terminal numbers for each wire.

1.6.3 UPS Delivery Documents

Submittals upon UPS delivery shall include:

- A complete set of submittal drawings
- The latest installation manual is available via the Vertivco.com product Web page. Each UPS module serial label includes a QR code and instructions for accessing the product Web page. Manuals shall include receiving and handling instructions.
- The latest instruction manual is available via the Vertivco.com product Web page. Each UPS module serial label includes a QR code and instructions for accessing the product Web page. Manuals shall include a functional description of the equipment, safety precautions, instructions, step-by-step operating procedures and routine maintenance guidelines, including illustrations.

1.7 Warranty

1.7.1 UPS Warranty

The UPS manufacturer shall warrant the unit against defects in workmanship and materials for 12 months after initial startup or 18 months after the shipping date, whichever comes first.

1.7.2 Warranty - End User

Warranties associated with items not manufactured by the UPS supplier, but included as part of the system, such as switchgear and batteries, shall be passed through to the end user.

1.8 Quality Assurance

1.8.1 Manufacturer's Qualifications

The manufacturer shall have a minimum of 20 years of experience in the design, manufacture and testing of solid-state UPS systems.

The quality system for the engineering and manufacturing facility shall be certified to conform to Quality System Standard ISO 9001 for the design and manufacture of power protection systems for computers and other sensitive electronics.

1.8.2 Factory Testing

Before shipment, the manufacturer shall test the UPS fully and completely to ensure compliance with the specification.

The UPS unit shall be tested at the system-specified capacity. Testing shall be done using load banks at both part-load and the full kW rating of the unit.

Operational discharge and recharge tests shall be performed to ensure guaranteed rated performance.

System operations such as startup, shutdown and transfers shall be demonstrated.

Additional optional factory testing for single module and distributed bypass UPS systems shall include the following:

- Switchgear integration testing with single module and distributed bypass UPS systems
- Factory witness testing (multiple levels of testing available depending on needs)
- Custom factory witness testing
- Factory heat run testing
- Factory burn-in testing (with or without data logging)

A certified copy of test results shall be available for each system as indicated on the order.

2.0 PRODUCT

2.1 Fabrication

2.1.1 Materials

All materials of the UPS shall be new, of current manufacture and high-grade. They shall not have been in prior service except as required during factory testing. All active electronic devices shall be solid-state. All power semiconductors shall be sealed. Control logic and fuses shall be physically isolated from power train components to ensure operator safety and protection from heat.

2.1.2 Capacitor Assemblies

All power, AC and DC capacitors shall be mounted allowing field replacement of the capacitors separately from power switching controls and components. All AC and DC capacitors shall have a 15-year design life.

2.1.3 UPS Internal Wiring

Internal power wiring shall be extra flexible terminated with compression type lugs. Lugs shall be attached with a hardware method that ensures long-life integrity. All factory-installed electrical power connections shall be torqued to the required value and marked with a visual indicator. All power connections not serviceable from the front or top of the unit shall be permanent, without any need for periodic tightening.

2.1.4 Field Wiring

Wiring practices, materials and coding shall be in accordance with the requirements of the National Electrical Code, OSHA and applicable local codes and standards. All bolted connections of busbars, lugs and cables shall be in accordance with requirements of the National Electric Code and other applicable standards.

All field wiring power connections shall be to tin-plated copper busbars for connection integrity. Busbars shall have adequate space to allow two-hole, long-barrel, compression-type lugs forming a permanent connection between field wiring and field-installed lugs.

Provisions shall be made in the cabinets to permit installation of input, output and external control cabling, using raceway or conduit. Provision shall be made for top and bottom access to input, output, bypass and DC connections. In conformance with NEC, connection cabinets shall provide for adequate wire bend radius.

Control wiring shall be stranded tinned conductors.

2.1.5 Construction and Mounting

The UPS shall be in a NEMA Type 1 enclosure, designed for floor mounting. The UPS shall be structurally adequate and have provisions for hoisting, jacking and forklift handling. Maximum cabinet height for all UPS power ratings shall be 79.1 in. (2009mm).

For UPS power ratings 250-400kVA, maximum cabinet width shall be 51.3 in. (1304mm). If the UPS is furnished with a back-feed disconnect, sharing inductors, or a combination of these devices, maximum cabinet width shall be 63.2 in. (1605mm).

For UPS power ratings 500-600kVA, maximum cabinet width shall be 63.0 in. (1600mm). If the UPS is furnished with a back-feed disconnect, sharing inductors, or a combination of these devices, maximum cabinet width shall be 74.8 in. (1900mm).

For UPS power ratings 625-800kVA, maximum cabinet width shall be 78.8 in. (2002mm). If the UPS is furnished with a back-feed disconnect, sharing inductors, common mode choke, or any combination of these devices, maximum cabinet width shall be 109.3 in. (2776mm).

For UPS power ratings 1000-1200kVA, maximum cabinet width shall be 104.5 in. (2654mm). If the UPS is furnished with a back-feed disconnect, sharing inductors, common mode choke, or any combination of these devices, maximum cabinet width shall be 128.1 in. (3254mm).

The UPS shall be NEMA Type 1-compliant, with front doors open to enable safe change of air filters without the need for shutdown.

2.1.6 Cooling

Forced redundant air cooling will ensure that all the components are operated within their specification. Airflow will be controlled according to load demand. The UPS will be capable of preserving normal operations even with multiple cooling fans out of operation (due to failure) with 100% of the output nominal load at 86°F (30°C) ambient temperature as long as there is only one failed fan per converter cell. If these conditions are not met (with one failed fan per converter cell), the UPS will supply the load through the static bypass if an overheating of the converters occurs. The failed fan condition will be immediately notified by the UPS through all the user interfaces and through Vertiv™ LIFE™ Services. The cooling air entry will be on the front and the air exit at the top of the UPS. The UPS will be installed with at least 24 inches of overhead clearance in order to allow cooling air to exit unhindered.

An internal, factory-mounted sensor for room ambient temperature shall be provided to give an alarm if the temperature of the inlet air to the UPS is above specified limits.

Air filters shall be located at the point of air inlet and shall be changeable. No service clearance or ventilation shall be required in the rear of the system.

2.1.7 Long-Life Components

The UPS shall incorporate long life components to streamline maintenance, maximize uptime and minimize total cost of ownership.

2.2 Equipment

2.2.1 UPS System

The UPS system shall consist of an IGBT power factor-corrected rectifier, DC-DC converter and three-phase, transformer-free inverter, bypass static transfer switch, bypass synchronizing circuitry, protective devices and accessories as specified. The inverter and rectifier shall be of three-level converter design for maximum efficiency. The specified system shall also include a battery disconnect breaker and battery system.

2.2.2 System Efficiency

The UPS module shall be provided with a high-efficiency mode of operation to increase the module efficiency when the bypass source is within voltage and frequency tolerance of the load. When the bypass power quality goes outside the adjusted limits, the inverter shall assume the load in a seamless fashion without any interruption. During operation in high-efficiency mode the rectifier shall continuously charge the battery and the inverter shall demonstrate synchronism with the bypass. The inverter is not isolated from the load by mechanical means during high-efficiency mode operation.

2.2.3 System Protection

1. Surge Protection

The UPS shall have built-in protection against surges, sags and overvoltage from the AC source. The protection shall meet the requirements of ANSI C62.41 B3 including:

- 6kV, 100kHZ ring wave, line-to-line, line-to-neutral, line-to-ground and neutral-to-ground
- 6kV, combined wave, line-to-line, line-to-neutral, line-to-ground and neutral-to-ground

2. Output Protection

The UPS shall be protected against sudden changes in output load and overload at the output terminals. The UPS shall have built-in protection against permanent damage to itself and to the connected load for all predictable types of malfunctions. Fast-acting current-limiting devices shall be used to protect against cascading failure of solid-state devices. Internal UPS malfunctions shall cause the module to trip off-line with minimum damage to the module and provide maximum information to maintenance personnel regarding the reason for tripping off-line. The load shall be automatically transferred to the bypass line without any interruption for an internal UPS malfunction. The status of protective devices shall be indicated on a graphic display screen on the front of the unit.

3. AC Ground Fault Detection

The UPS is a three-wire system and shall have the capability to detect and annunciate AC phase-to-ground faults when the UPS is powering the load from the battery or other DC source. If an AC ground fault occurs between a phase and ground, a message shall be displayed on the operator screen indicating that the fault condition exists. The UPS shall also have as standard the ability to indicate this condition via a programmable contact in order to actuate a third-party device, such as a warning light or audible alarm system.

4. (Optional) DC Battery Ground Fault Detection

The UPS shall provide a method to detect and annunciate battery DC ground faults, in order to facilitate proactive resolution of such ground faults. The UPS can be configured to allow the circuit breaker to open or remain closed upon detection of a ground fault.

5. Disconnects

The UPS shall provide, as an option, the ability to control remote breakers, furnished by others, located in the input switchboard for rectifier input feed and/or the back-feed protection function, instead of locating such breakers within the UPS cabinet. The remote back-feed breaker shall be controlled by a shunt trip mechanism. The UPS shall provide, as an option, a 120VAC shunt trip power supply mounted in the UPS input/output cabinet. Remote feeder breaker and remote back-feed breaker status is supported through the use of 1A/1B auxiliary contacts.

6. Automatic Transfer Switches

If the UPS is fed from an automatic transfer switch, the UPS shall be capable of transferring to and from an alternate out-of-phase source in double conversion mode without applying a break-before-make delay to the automatic transfer switch operation. For a make before break transition (closed transition), the two sources must be synchronized to 30 degrees or less.

2.3 Components

2.3.1 Rectifier

The term *rectifier* shall denote the solid-state equipment and controls necessary to convert alternating current to regulated direct current to supply the inverter and the DC-DC converter. The DC output of the rectifier shall meet the input requirements of the inverter without the battery being connected.

1. Input Current Harmonic Distortion

The rectifier shall actively control and reduce input current distortion over the full operating range of the UPS without the need for an additional passive input filter. Input current THD shall be less than or equal to 3% at full rated output load with nominal input voltage.

2. AC Input Current Limiting

The rectifier shall include a circuit to limit AC input current to a factory-set level of 110% (adjustable) of the full input current rating.

3. Fixed Time Input Current Walk-In Control

The rectifier shall provide a feature that limits the total initial power requirement at the input terminals to 0% of rated load and gradually increases power to 100% of full rating over the 300-seconds (adjustable) interval.

4. Minimum Frequency Input Current Walk-In Control

The minimum frequency input current walk-in control is an alternative to a fixed time walk-in control. The rectifier shall provide a feature that limits the total initial power requirement at the input terminals to 0% of rated load and gradually increases power to 100% of full rating in the minimum time possible while maintaining a minimum generator frequency of 57 Hz to 60 Hz (adjustable).

5. Step Loads Following Completion of Walk-In with Minimum Frequency Input Current Walk-In Control Enabled

Step (up) loads shall not require a full walk-in as would be required by a fixed time walk-in control. The minimum frequency input current walk-in control algorithm shall initiate an incremental walk-in, beginning at the current load level, to reach the new load level while ensuring the generator frequency does not fall below the minimum frequency setpoint of 59 Hz (adjustable). This method shall ensure walk-in occurs in the minimum time possible and minimize energy consumption from the batteries. The amount of time required for the walk-in solely depends on the setpoint frequency and the relative power rating of the generator as compared to the UPS load.

6. Rectifier Fuse Protection

Each rectifier AC phase shall be individually fused with fast-acting fuses so that loss of any semiconductor shall minimize cascading failures. Fuses shall be bolted to busbars at both ends to ensure mechanical and electrical integrity. The display panel on the front of the unit shall indicate a blown fuse occurring on any phase of the rectifier.

2.3.2 DC-DC Converter

The term *DC-DC converter* shall denote the equipment and controls to regulate the output of the rectifier to the levels appropriate for charging the battery and to boost the battery voltage to the level required to operate the inverter. The DC-DC converter shall be solid-state, shall be capable of providing rated output power, and for increased performance shall be a pulse width-modulated design and shall utilize insulated gate bipolar transistors (IGBTs). The DC-DC converter shall control charging of the battery. The AC ripple voltage of the DC-DC converter shall not exceed 1% RMS of the float voltage.

1. Battery Recharge

In addition to supplying power for the load, the rectifier shall be capable of supplying a minimum of 5% of the module full load power rating for recharging the battery. After the battery is recharged, the rectifier/charger shall maintain the battery at full charge until the next emergency operation. A charging circuit that shuts off or does not maintain float charge at all times shall not be acceptable.

2. Battery Equalize Charge

A manually initiated equalize charge feature shall be provided to apply an equalize voltage to the battery. The duration of equalize charge time shall be adjustable from 0 to 200 hours. A method shall be available to deactivate this feature for valve-regulated battery systems.

3. Battery Charge Current Limiting

The DC-DC converter shall include a circuit to limit battery charging current to an adjustable level of 0% to 10% of nominal input current. A second circuit shall provide an additional selection (0% to 10%) when signaled by an external contact (e.g., operation of generator). Battery charge current limit shall be factory-set at 10% for normal operation and 0% for generator operation. The DC-DC converter shall use full float charging technology. Charging technologies that do not maintain constant float charge during normal operating conditions shall not be acceptable.

4. Thermal Runaway Protection and Battery Charger Control (Lead-Acid Batteries Only)

The UPS shall provide temperature-compensated charging. This function requires that the UPS be equipped with temperature sensors in each cabinet and an interface scheme provided by the UPS manufacturer. The UPS shall adjust the battery charging voltage based on the battery temperature reported from external battery temperature sensors. Temperature sensors shall be monitored for faulty measurements and shall be ignored if a fault is detected to prevent overcharging or undercharging the battery. When multiple sensors are used, the voltage shall be based on the average temperature measured. Excessive difference in the temperature measurements shall be reported and the charging voltage adjusted to protect the batteries from excessive current. In addition, the UPS shall be programmable so that a battery over-temperature condition can be detected in any single battery cabinet and a three-stage response shall be initiated:

- When the temperature in the cabinet reaches 100°F (38°C) (adjustable), battery charging shall not increase, and a warning shall be generated.
- When the temperature in the cabinet reaches 109°F (43°C) (adjustable), the charger will shut off completely and the UPS can be configured to trip open the circuit breaker for any individual overtemperature battery cabinet or string to isolate that cabinet or string only and retain reduced battery protection for the UPS. This condition shall be displayed on the UPS HMI screen and in the event log.
- Once the breaker on the affected cabinet or string has been tripped, the UPS shall resume normal charging with the remaining battery cabinets or strings.

The system shall meet the requirements of the IFC 2012 for preventing thermal runaway battery protection for the UPS. This condition shall be displayed on the UPS HMI screen, and in the event log.

Battery charging may also be stopped by an external signal that may be activated by a contact closure to indicate “on generator” operation or other condition (including battery overtemperature, presence of excessive hydrogen, or failure of the room ventilator fan) under which battery charging is undesirable or inadvisable.

5. Overvoltage Protection

There shall be DC overvoltage protection so that if the DC voltage rises to the pre-set limit, the UPS shall shut down automatically and initiate an uninterrupted load transfer to bypass, or shall disconnect the battery via the DC breaker(s) in the battery string.

6. Battery Load Testing (Lead-Acid Batteries Only)

The UPS shall be capable of performing battery load testing under operator supervision. To accomplish this, the rectifier shall reduce charging voltage to force the batteries to carry the load for a short time. If the curve of battery voltage drop indicates diminished battery capacity, the UPS shall display an alarm message. If the voltage drop indicates battery failure, the UPS shall terminate the test immediately and annunciate the appropriate alarms.

2.3.3 Inverter

The term *inverter* shall denote the equipment and controls to convert direct current from the rectifier or battery via the DC-DC converter to precise alternating current to power the load. The inverter shall be solid-state and capable of providing rated output power. The inverter shall be a pulse-width-modulated design and shall utilize insulated gate bipolar transistors (IGBTs). The inverter shall be fully self-protected from load changes and an output short circuit. To further enhance reliable performance and efficiency, the inverter shall not require an inverter output series static switch/isolator for the purposes of overload or fault isolation or transfers to bypass.

1. Overload Capability

The inverter shall be able to sustain an overload across its output terminals while supplying full rated voltage for up to 150% for 60 seconds at nominal voltage and 86°F (30°C) ambient. The inverter shall be capable of at least 200% current for short-circuit conditions including phase-to-phase, phase-to-ground and three-phase faults. After the fault is removed, the UPS shall return to normal operation without damage. If the short circuit is sustained, the load shall be transferred to the bypass source and the inverter shall disconnect automatically from the critical load bus.

2. Transformer Energization

The UPS features a rugged inverter design such that a like size transformer can be energized while the UPS is operating on inverter. When the bypass source is available, the UPS will perform Dynamic Line Support for up to 500% of nominal input current for up to 800 milliseconds where the bypass is used in parallel with the inverter to help source the transformer inrush current. When the bypass source unavailable, the inverter will source up to 210% of nominal current for up to 200 milliseconds.

The UPS shall support multiple downstream transformers being energized one at a time with a recommended 5-second break between transformer startups. The maximum recommended connected transformer kVA is not to exceed twice the rating of the total connected UPS kVA. When energizing multiple downstream transformers, it is recommended that these transformers be designed for low inrush.

Contact your Vertiv representative for more information or for application specific questions.

3. Output Frequency

The inverter shall track the bypass continuously, provided that the bypass source maintains a frequency of 60Hz ± 5Hz. The inverter shall change its frequency (slew rate) at 0.1Hz (adjustable 0.1 to 5.0Hz) to maintain synchronous operation with the bypass. This shall allow make-before-break manual or automatic transfers. If the bypass fails to maintain proper frequency, the inverter shall revert to an internal oscillator, which shall be temperature-compensated and shall hold the inverter output frequency to 0.1% from the rated frequency for steady-state and transient conditions. Drift shall not exceed 0.1% during any 24-hours period. Total frequency deviation, including short-term fluctuations and drift, shall not exceed 0.1% from the rated frequency.

4. Phase-to-Phase Balance

The inverter shall provide a phase-to-phase voltage displacement of no worse than ±2° with a 50% unbalanced load and up to 125% of the system output rating.

5. Battery Protection

The inverter shall be provided with monitoring and control circuits to protect the battery system from damage due to excessive discharge. Inverter shutdown shall be initiated when the battery voltage has reached the end-of-discharge voltage. The battery end-of-discharge voltage shall be calculated and automatically adjusted for partial load conditions to allow extended operation without damaging the battery.

2.3.4 Bypass Static Switch

When maintenance is required or when the inverter cannot maintain voltage to the load due to inadequate DC power, sustained overload or malfunction, a bypass circuit shall be provided to isolate the inverter output from the load and provide a path for power directly from an alternate AC (bypass) source. The UPS control system shall constantly monitor the availability of the inverter bypass circuit to perform a transfer. The inverter bypass circuit shall consist of a continuous-duty bypass static switch and a (optional) back-feed disconnect (BFD) to isolate the bypass static switch from the bypass source. The bypass static switch shall be a solid-state device consisting of two reverse-paralleled SCR's (silicon-controlled rectifiers) per phase that can automatically and instantaneously connect the alternate AC source to the load or isolate the load from the bypass source.

1. Manual Load Transfers

A manual load transfer between the inverter output and the alternate AC source shall be initiated from the control panel. Manually initiated transfers shall be make-before-break, utilizing the inverter and the bypass static switch.

2. Automatic Load Transfers

An automatic load transfer between the inverter output and the alternate AC source shall be initiated if an overload condition is sustained for a time in excess of the inverter output capability or due to a malfunction that would affect the output voltage. Transfers caused by overloads shall initiate an automatic retransfer of the load to the inverter only after the load has returned to a level within the rating of the inverter source. The UPS system logic shall allow up to five retransfers (adjustable) within any one-hour period to prevent cyclical transfers caused by overloads.

3. Momentary Overloads

In the event of a load current inrush, such as energizing a load with high inrush current or branch load circuit fault in excess of the inverter's total rating, the bypass static switch shall connect the alternate AC source to the load for at least 10 cycles (167 milliseconds), allowing up to 500% of the normal rated output current to flow. Output voltage shall be sustained to the extent the alternate AC source capacity permits. If the overload condition is removed before the end of the 10-cycle period, the bypass static switch shall turn off and the load shall remain on inverter power. If the overload remains, then a transfer to the alternate AC source shall be completed.

4. Back-Feed Protection

As required by UL 1778 and CSA, the static bypass transfer switch shall not back feed UPS power to the bypass input terminals and, therefore, to the distribution system while the UPS is operating on battery during a bypass power outage. The purpose of this requirement is to prevent the risk of electrical shock on the distribution system when the normal source of power is disconnected or has failed. If a shorted SCR is detected, the static transfer switch shall be isolated by an internal automatic back-feed disconnect (BFD) and an alarm message shall be annunciated at the UPS control panel. The load shall remain on conditioned and protected power after detection of a shorted SCR and isolation of the static bypass switch. A device that cycles due to loss of utility and is, therefore, at a higher risk of failure than a device that normally remains closed, is not acceptable. The back-feed prevention disconnect interrupting capacity shall be equal to or greater than the UPS withstand rating. Switching devices with a lower rating or series-rated devices are not acceptable.

5. (Optional) ECO Mode (VFD Mode) Operation

Economy operation shall be provided and shall be selectable by the user.

When selected, this mode of operation shall transfer the load to the bypass source and maintain it there as long as the bypass source frequency, slew rate and voltage are within the adjusted operating parameters. While in this mode, the inverter shall remain operating to demonstrate the ability to instantaneously assume the load without interrupting the output voltage. The UPS shall maintain a constant float voltage to the batteries during this mode. Should the bypass source go outside the adjusted limits, the bypass static switch shall turn off, isolating the load from the bypass while the inverter assumes the full critical load. The load shall be transferred from the bypass source to the inverter without an interruption of the output voltage.

Operating adjustments shall include:

- Limit the frequency of transfer into ECO Mode caused by an out-of-tolerance bypass source.
- Enable and disable ECO Mode operation.

6. (Optional) Dynamic Online Mode (VI Mode) Operation

Dynamic Online is a high efficiency mode of operation to allow an increase in efficiency without compromising reliability. Dynamic Online mode offers up to 99% efficiency without decreasing reliability. In fact, while operating in Dynamic Online the UPS is able to maintain the output voltage within the IEC 62040-3 Class 1 specification in all operating conditions. When the quality of the supply network is within tolerances the UPS activates Dynamic Online mode. In this mode the energy is supplied by the network to the load through the static bypass switch and the UPS inverter will function as an active filter, providing the reactive power necessary to compensate load THDi and load Power Factor. In case of network parameters outside tolerances the UPS will instantly activate double conversion mode (VFI) with a Class 1 transfer.

Operating adjustments shall include:

- Limit the frequency of transfer into Dynamic Online Mode caused by an out-of-tolerance bypass source.
- Enable and disable Dynamic Online Mode operation.

2.3.5 Display and Controls

1. UPS Control Panel

The UPS shall be provided with a microprocessor-based control panel for operator interface (may also be referred to as *user interface*, or *UI*) to configure and monitor the UPS. The control panel shall be located on the front of the unit where it can be operated without opening the hinged front door. A backlit, menu-driven, full-graphics, color touchscreen liquid crystal display shall be used to display system information, metering information, a one-line diagram of the UPS and battery, active events and event history.

No mechanical push buttons shall be used to control the interface. Mechanical EPO (Emergency Power Off) push buttons are acceptable.

2. Logic

UPS system logic and control programming shall reside in a microprocessor-based control system with non-volatile flash memory. Rectifier, inverter, DC-DC converter, static switch and system control logic shall utilize high-speed digital signal processors (DSPs). CANbus shall be used to communicate between the logic and the user interface as well as the options. Switches, contacts and relays shall be used only to signal the logic system as to the status of mechanical devices or to signal user control inputs. Customer external signals shall be isolated from the UPS logic by relays or optical isolation.

3. Metered Values

A microprocessor shall control the display and memory functions of the monitoring system. All three phases of three-phase parameters shall be displayed simultaneously. All voltage and current parameters shall be monitored using true RMS measurements for accurate (±1.5%) representation of non-sinusoidal waveforms typical of computers and other sensitive loads. These parameters shall be displayed:

- Input voltage, line-to-line
- Input current
- Input frequency
- Input kVA/kW
- Battery voltage, each battery string
- Battery charging/discharging current
- Battery temperature, each battery string
- Battery state of charge
- Battery run time
- Bypass input voltage, line-to-line
- Bypass input frequency
- Output voltage, line-to-line
- Output frequency
- Output current
- Output kVA/kW, total and percentage of full load
- Overload time remaining
- Ambient temperature
- Total operating hours

4. Power Flow Indications

A power flow diagram shall graphically depict whether the load is being supplied from the inverter, bypass or battery and provide, on the same screen, the status of these components:

- AC input circuit breaker (remote)
- Battery circuit breaker, each breaker (remote)
- Inverter output circuit breaker (remote)
- Back-feed breaker (remote) or back-feed disconnect (internal)
- Maintenance bypass cabinet breakers (when used)

5. Main Display Screen

The following UPS status indicators shall be displayed:

- Rectifier (Off / Soft Start / Main Input On / Battery Input On)
- Input Supply (Normal Mode / Battery Mode / All Off)
- Battery Self-Test (True / False)
- Input Disconnect (Open / Closed)
- EPO (True / False)
- Charger (On / Off)
- Output Disconnect (Open / Closed)
- Maint. Disconnect (Open / Closed)
- Bypass Disconnect (Open / Closed)
- Inverter (Off / Soft Start / On)
- Bypass (Normal / Unable To Trace / Abnormal)
- Output Supply (All Off / Bypass Mode / Inverter Mode / Output Disable)
- Inverter On (Enable / Disable)

6. Event Log

This menu item shall display the list of events that have occurred recently while the UPS was in operation. The Event Log shall store up to 2048 events, with the oldest events being overwritten first if the log's capacity is reached.

7. Battery Status Indicator

A battery status indicator shall display DC alarm conditions, temperature, battery state of charge, the present battery voltage and battery time remaining during discharge.

The UPS shall provide the operator with controls to perform the following functions:

- Configure and manage manual battery test
- Start battery test
- Monitor test status and progression
- Stop battery test
- Battery test status

8. Events

The control panel shall report the system-level events listed below. All events shall be displayed in text form.

Component	Type	Text Display
Battery	Status	Battery Warning
Battery	Status	Battery Fault
Battery	Status	Battery Idle
Battery	Status	Battery is Discharging
Battery	Status	Automatic Battery Test Started
Battery	Status	Battery Test Requested
Battery	Status	Battery Test Failed
Battery	Status	Battery Test Idle
Battery	Status	Battery Test Start Pending
Battery	Status	Battery Test Stop Pending
Battery	Status	Battery Non-Blocking Fault
Battery	Status	Battery Not Connected
Battery	Status	Battery is Charging
Battery	Status	Battery Test Running
Battery	Status	Battery Test Not Allowed
Battery	Status	Battery Test Finished OK
Battery	Status	Battery Test Cancelled
Battery	Status	Battery Test Interrupted
Battery	Status	Battery Test Stopped by User
Battery	Alarm	Battery Under Voltage
Battery	Alarm	High Battery Temperature
Battery	Alarm	Battery Temperature Out of Range
Battery	Alarm	Temperature Probe Broken
Battery	Alarm	Battery Switch Wiring Fault
Battery	Alarm	Cubicle Battery Switch Open
Battery	Alarm	Battery is Not Connected
Battery	Alarm	Imminent End of Autonomy - Volt
Battery	Alarm	Imminent End of Autonomy - Time
Battery	Alarm	BCB Breaker Open
Battery	Alarm	Battery Breaker Open
Battery	Fault	Battery Test Failure
Battery	Fault	Battery Overcurrent Fault
Battery	Fault	Battery Ground Fault
Bypass	Status	Bypass is Not Present
Bypass	Status	Bypass is On

Component	Type	Text Display
Bypass	Status	Bypass is Off
Bypass	Status	Bypass is Stopped Due to a Fault
Bypass	Status	Bypass Not Prepared
Bypass	Status	Bypass Fault
Bypass	Status	Bypass Warning
Bypass	Status	Bypass Available with Delay
Bypass	Status	Parallel Bypass OK
Bypass	Status	Parallel Bypass One Fault
Bypass	Status	Parallel Bypass at Least One OK
Bypass	Status	Parallel Bypass Fault
Bypass	Status	Undelayed Bypass Ref. Failure
Bypass	Status	Bypass is Centralized
Bypass	Status	Bypass Non-Blocking Fault
Bypass	Status	Bypass Global On Request
Bypass	Status	Bypass Global On
Bypass	Status	Bypass Global Off
Bypass	Status	Bypass Mains is Out of Tolerance
Bypass	Alarm	Bypass Input Switch Open
Bypass	Alarm	Bypass Mains Failure
Bypass	Alarm	Bypass in Overload Condition
Bypass	Alarm	Bypass Disabled
Bypass	Alarm	Bypass Overtemperature
Bypass	Alarm	Bypass Mode Not Auto
Bypass	Alarm	Parallel Bypass Failure
Bypass	Alarm	Bypass Wrong Phase Rotation
Bypass	Fault	E.P.O.
Bypass	Fault	Bypass Hardware Failure
Bypass	Fault	Backfeed Protection
Bypass	Fault	Overload
Bypass	Fault	Bypass Failure During Line Support
Bypass	Fault	Parallel Failure During Support
Bypass	Fault	Overtemperature
Charger/Booster	Status	Charger in Standby - (not charging)
Charger/Booster	Status	Charger is On
Charger/Booster	Status	Charger is Off
Charger/Booster	Status	Charger Forced On
Charger/Booster	Status	Charger Stopped due to a Fault
Charger/Booster	Status	Charger in Current Limitation

Component	Type	Text Display
Charger/Booster	Status	Charging Status Off
Charger/Booster	Status	Charging Status Init.
Charger/Booster	Status	Charging Status Float 1
Charger/Booster	Status	Charging Status Float 2
Charger/Booster	Status	Charging Status Post
Charger/Booster	Status	Charging Status Pause
Charger/Booster	Status	Charging Status Manual
Charger/Booster	Status	Charging Status Fault
Charger/Booster	Status	Buck-Booster Fault
Charger/Booster	Status	Buck-Booster Warning
Charger/Booster	Status	Booster Off
Charger/Booster	Status	Booster Turning On
Charger/Booster	Status	Booster On
Charger/Booster	Status	Booster Stopped Due to Fault
Charger/Booster	Status	Booster Runs from Battery
Charger/Booster	Status	Buck-Booster Non Blocking Fault
Charger/Booster	Status	DC Bus Too Low to Charge
Charger/Booster	Alarm	Battery Not Connected
Charger/Booster	Alarm	Reversed Polarity
Charger/Booster	Alarm	Buck-Booster DC Voltage Low
Charger/Booster	Alarm	Buck-Booster Overtemperature
Charger/Booster	Alarm	Buck-Booster B Overtemperature
Charger/Booster	Alarm	DC Overvoltage
Charger/Booster	Fault	Charger Temperature High
Charger/Booster	Fault	Temperature Probe Broken
Charger/Booster	Fault	Charger De-Saturation
Charger/Booster	Fault	Charger Redundant Voltage Error
Charger/Booster	Fault	Charger DC Bus
Charger/Booster	Fault	E.P.O.
Charger/Booster	Fault	Charger Voltage Out of Limit
Charger/Booster	Fault	Buck-Booster Overcurrent
Charger/Booster	Fault	Booster Desaturation
Charger/Booster	Fault	Booster and Charger Desaturation
Charger/Booster	Fault	Temp Probe Module B Broken
Charger/Booster	Fault	Charger Desaturation
Charger/Booster	Fault	Booster B Desaturation
Charger/Booster	Fault	Booster and Charger B Desaturation
Charger/Booster	Fault	Fuse Blown Pos Pole

Component	Type	Text Display
Charger/Booster	Fault	Fuse Blown Neg Pole
Charger/Booster	Fault	Fuse Blown Module B Pos Pole
Charger/Booster	Fault	Fuse Blown Module B Neg Pole
General	Status	Warning Pending
General	Status	Fault Pending
General	Status	General Fault
General	Status	Parallel Unit
General	Status	External Synch Enabled
General	Status	Inverter/Rectifier Off Command Issued
General	Status	Inverter on Rectifier
General	Status	Inverter on Battery
General	Status	Parameter Reset Active
General	Status	Intelligent Parallel Not Allowed
General	Status	Core Running
General	Status	Operating Request for VFI
General	Status	SKRU: Inverter Start Inhibited
General	Status	General Warning
General	Status	General Non-Blocking Fault
General	Status	Non-Blocking Fault Pending
General	Status	General Core Summary Warning
General	Status	General Core Summary Fault
General	Status	General Core Non-Blocking Fault
General	Status	Manual Mode Command Pending
General	Status	Synchronize Rectifier Mains Failure
General	Status	One or More Fans Not Working
General	Status	BCB: Trip Command Issued
General	Status	Operating Request for Intelligent ECO
General	Status	Core Sleeping
General	Status	Intelligent ECO Enabled
General	Status	Intelligent Parallel Enabled
General	Status	Fan Test in Progress
General	Alarm	System Power Up
General	Alarm	Commissioning / Test Mode
General	Alarm	System Maintenance Bypass Switch Closed
General	Alarm	Synchronization System Fault
General	Alarm	System Shutdown
General	Alarm	The ID Card is Missing
General	Alarm	Calibration is Started

Component	Type	Text Display
General	Alarm	Input Air High Temperature
General	Alarm	System Output Switch Open
General	Alarm	System Bypass Switch Closed
General	Alarm	Detected Cores Mismatch
General	Alarm	Communication Loss BIB
General	Alarm	AC Ground Fault
General	Alarm	Communication Loss MI Ph. U-A
General	Alarm	Communication Loss MI Ph. V-B
General	Alarm	Communication Loss MI Ph. W-C
General	Alarm	Communication Loss MI BB
General	Alarm	Motherboard Overtemperature
General	Alarm	PIB Overtemperature
General	Alarm	Cable Conduit Overtemperature
General	Alarm	MIB Overtemperature
General	Alarm	Duplicated Parallel Unit ID
General	Alarm	Parallel Unit Number Mismatch
General	Alarm	Communication Loss MI-B Ph. U-A
General	Alarm	Communication Loss MI-B Ph. V-B
General	Alarm	Communication Loss MI-B Ph. W-C
General	Alarm	Communication Loss MI-B BB
General	Alarm	Fan Failure Phase U
General	Alarm	Fan Failure Phase V
General	Alarm	Fan Failure Phase W
General	Alarm	Fan Failure Buck-Booster
General	Alarm	Battery Switch Open - Do Not Close
General	Alarm	CPU Time Slice
General	Alarm	Fan Failure Static Switch
General	Alarm	Fan Failure Board Slot
General	Alarm	I/O Transformer Overtemperature
General	Alarm	DC Overvoltage
General	Alarm	Communication Loss PIB-S1
General	Alarm	Communication Loss PIB-S1-I2C
General	Fault	Incorrect Power Class
General	Fault	DSP Signal Hardware Failure
General	Fault	DSAVE Active
General	Fault	Ambient Sensor Broken
General	Fault	Parallel Cable Missing
General	Fault	Parallel Timeout

Component	Type	Text Display
General	Fault	Parallel Identification Error
General	Fault	Parallel Impossible
General	Fault	E.P.O.
General	Fault	DSP ADC Serial Comm Failure
General	Fault	DSP Signal Software Failure
General	Fault	Fast Desaturation
General	Fault	High Ambient Temperature
General	Fault	Input Contact Wiring Error
General	Fault	SMPS DC Supply Failure
General	Fault	SMPS Single AC Supply Failure
General	Fault	SMPS Double AC Supply Failure
Inverter	Status	Inverter is Off
Inverter	Status	Inverter is Turning On
Inverter	Status	Inverter is On
Inverter	Status	Inverter is Stopped Due to a Fault
Inverter	Status	Inverter Fault
Inverter	Status	Synchronization Source: Bypass
Inverter	Status	Synchronization Source: Output
Inverter	Status	Synchronization Source: Self Clock
Inverter	Status	Synchronization Source: External
Inverter	Status	Inverter Warning
Inverter	Status	Inverter Out of Synchronization
Inverter	Status	Online Operation / VFI
Inverter	Status	VI
Inverter	Status	Intelligent ECO / VFD
Inverter	Status	Intelligent Parallel / CR
Inverter	Status	Operation: ECO mode
Inverter	Status	Inverter in Standby
Inverter	Status	Inverter Ready and Sync
Inverter	Status	Inverter Not Ready
Inverter	Status	Current Limit Last More than 3ms
Inverter	Status	Inverter Non-Blocking Fault
Inverter	Status	Inverter Pending on Command
Inverter	Alarm	Inverter DC Undervoltage
Inverter	Alarm	Inverter Overload
Inverter	Alarm	The Inverter is Off
Inverter	Alarm	Inverter Pending Off Command
Inverter	Alarm	Overtemperature Phase U-A

Component	Type	Text Display
Inverter	Alarm	Overtemperature Phase V-B
Inverter	Alarm	Overtemperature Phase W-C
Inverter	Alarm	Overtemperature B Phase U-A
Inverter	Alarm	Overtemperature B Phase V-B
Inverter	Alarm	Overtemperature B Phase W-C
Inverter	Alarm	DC Overvoltage
Inverter	Fault	E.P.O.
Inverter	Fault	Overtemperature
Inverter	Fault	Overload
Inverter	Fault	DC Overvoltage
Inverter	Fault	Output out of Tolerance
Inverter	Fault	Inverter DC/AC Desaturation
Inverter	Fault	DC Bus Undervoltage
Inverter	Fault	Fuse Blown Phase U-A
Inverter	Fault	Fuse Blown Phase V-B
Inverter	Fault	Fuse Blown Phase W-C
Inverter	Fault	Temp Probe Broken Phase U-A
Inverter	Fault	Temp Probe Broken Phase V-B
Inverter	Fault	Temp Probe Broken Phase W-C
Inverter	Fault	Overtemperature Choke Ph. U-A
Inverter	Fault	Overtemperature Choke Ph. V-B
Inverter	Fault	Overtemperature Choke Ph. W-C
Inverter	Fault	Fuse Blown B Phase U-A
Inverter	Fault	Fuse Blown B Phase V-B
Inverter	Fault	Fuse Blown B Phase W-C
Inverter	Fault	Temp Probe B Broken Phase U-A
Inverter	Fault	Temp Probe B Broken Phase V-B
Inverter	Fault	Temp Probe B Broken Phase W-C
Inverter	Fault	Overtemperature Choke B Ph. U-A
Inverter	Fault	Overtemperature Choke B Ph. V-B
Inverter	Fault	Overtemperature Choke B Ph. W-C
Load	Status	Load Supplied by Bypass
Load	Status	Load Supplied by Maint. Bypass
Load	Status	Load is Currently Not Supplied
Load	Status	Load on Low Priority Line
Load	Status	Load on Phase U-A > 85%
Load	Status	Load on Phase V-B > 85%
Load	Status	Load on Phase W-C > 85%

Component	Type	Text Display
Load	Status	Load Warning
Load	Status	Load Supplied by Battery
Load	Status	Load Secured by Inverter
Load	Status	Load Fault
Load	Status	Load Non-Blocking Fault
Load	Alarm	Output Switch Open
Load	Alarm	Load is Currently Not Supplied
Load	Alarm	Retransfer is Inhibited
Rectifier	Status	Rectifier is Off
Rectifier	Status	Rectifier is Turning On
Rectifier	Status	Rectifier is On
Rectifier	Status	Rectifier Fault
Rectifier	Status	Rectifier Warning
Rectifier	Status	No Precharge in Progress
Rectifier	Status	Precharge in Progress
Rectifier	Status	Walk-in in Progress
Rectifier	Status	Precharge Finished
Rectifier	Status	Rectifier Power Limitation Active
Rectifier	Status	Rectifier Current Limit
Rectifier	Status	Rectifier Non-Blocking Fault
Rectifier	Status	Rectifier Stopped - Fault
Rectifier	Status	Rectifier Inhibited
Rectifier	Status	Rectifier Mains is Out of Tolerance
Rectifier	Alarm	Rectifier Input Switch Open
Rectifier	Alarm	Rectifier Mains Failure
Rectifier	Alarm	Wrong Phase Rotation
Rectifier	Alarm	DC Voltage Low
Rectifier	Alarm	Out of Synchronization
Rectifier	Alarm	Peak Input Voltage
Rectifier	Alarm	Overtemperature Phase U-A
Rectifier	Alarm	Overtemperature Phase V-B
Rectifier	Alarm	Overtemperature Phase W-C
Rectifier	Alarm	Overtemperature B Phase U-A
Rectifier	Alarm	Overtemperature B Phase V-B
Rectifier	Alarm	Overtemperature B Phase W-C
Rectifier	Alarm	DC Overvoltage
Rectifier	fault	E.P.O.
Rectifier	fault	Rectifier Precharge Failure

Component	Type	Text Display
Rectifier	fault	Rectifier Temperature Fault
Rectifier	fault	Rectifier DC Overvoltage
Rectifier	fault	Rectifier Desaturation Failure
Rectifier	fault	Rectifier Synchronization Failure
Rectifier	fault	Rectifier Overcurrent Failure
Rectifier	fault	Fuse Blown Phase U-A
Rectifier	fault	Fuse Blown Phase V-B
Rectifier	fault	Fuse Blown Phase W-C
Rectifier	fault	Temp Probe Broken Phase U-A
Rectifier	fault	Temp Probe Broken Phase V-B
Rectifier	fault	Temp Probe Broken Phase W-C
Rectifier	fault	Overtemperature Choke Ph. U-A
Rectifier	fault	Overtemperature Choke Ph. V-B
Rectifier	fault	Overtemperature Choke Ph. W-C
Rectifier	fault	Fuse Blown B Phase U-A
Rectifier	fault	Fuse Blown B Phase V-B
Rectifier	fault	Fuse Blown B Phase W-C
Rectifier	fault	Temp Probe B Broken Phase U-A
Rectifier	fault	Temp Probe B Broken Phase V-B
Rectifier	fault	Temp Probe B Broken Phase W-C
Rectifier	fault	Overtemperature Choke B Ph. U-A
Rectifier	fault	Overtemperature Choke B Ph. V-B
Rectifier	fault	Overtemperature Choke B Ph. W-C

9. Controls

System-level control functions shall be:

- Start Inverter (and transfer to inverter)
- Stop Inverter (after transferring to bypass)
- Startup Screen
- Configure Manual Battery Test
- Initiate Manual Battery Test
- Alarm Silence Command
- Fault Reset Command
- ECO mode
- (Optional) Emergency Power Off Push Button with Protective Cover

Administrative control functions shall be:

- System Settings (Time, Date, Language, Password)
- Permissions Settings
- Network Settings

10. Manual Procedures

- Load Transfers: HMI buttons (INVERTER ON, INVERTER OFF) shall provide the means for the user to transfer the load to bypass and back onto the UPS.

2.3.6 Self-Diagnostics

- Event Log File - The control system shall maintain a log of the event conditions that have occurred during system operation. Each log shall contain the event name, event time/date stamp and a set/clear indicator.

2.3.7 Remote Monitoring Capability

Network Communication

The UPS shall be equipped with provisions for remote communication. IP20 isolation, to avoid exposure to any energized part, shall be provided during installation and configuring of the communication card.

Standard communication protocols shall be Vertiv Protocol, Remote Service Delivery Protocol and HTTP Web. Communication shall be compatibility with DCIM Vertiv™ Liebert® *Trellis*™ platform and Vertiv™ Liebert® Nform management software.

Two of three optional protocols shall be supported with simultaneous communication - SNMP, BACnet IP, Modbus IP/485.

2.3.8 Optional Features

1. Remote Service Delivery

The UPS manufacturer shall provide remote monitoring capability with a user-supplied (outbound only) secure internet connection for remote diagnosis and monitoring of the UPS system to provide early warning of UPS and single module alarm conditions and out-of-tolerance conditions. The UPS manufacturer shall maintain a monitoring center staffed by trained experts 24 hours a day, 7 days a week, 365 days per year. The experts on staff shall be capable of interpreting reports from the UPS and assessing areas in need of attention. This shall allow effective, proactive maintenance and fast incident response. First year operation remote monitoring service shall be included.

2. Dual Protocol Web Card

A Web card shall be provided to deliver SNMP, SMS text messaging, Telnet and Web-based management capability for enhanced communication as well as a choice of any two of the following protocols:

- SNMP
- Modbus over IP or RS-485
- BACnet

3. Bypass Sharing Inductors

The UPS shall include a matching input/output cabinet with internal bypass sharing inductors to ensure even load current sharing among parallel UPS while the static bypass switches are active. The inductors shall provide droop type current compensation for the otherwise inherent current dispersion due to SCR and cable impedance differences.

4. Back-Feed Disconnect (BFD)

The UPS shall include a matching input/output cabinet with an internal back-feed disconnect capable of isolating back-feed voltage from the upstream source and eliminating the need for a shunt trip accessory in the external upstream back feed breaker.

5. 120VAC Remote Back-Feed Breaker (RBB) Shunt Trip Power Supply

If the internal Back-Feed Disconnect option is not selected, an RBB (located in customer switchgear) must provide back-feed voltage protection. The UPS shall include a 120VAC RBB shunt trip power supply to control the RBB shunt trip when back-feed voltage is detected by the UPS.

6. Common Mode Choke

The UPS shall include a matching input/output cabinet with an internal common mode choke capable of reducing the third harmonic current during parallel operation of the inverter and bypass. The common mode choke is most commonly used for parallel UPS configurations with dual asynchronous sources.

7. DC Battery Ground Fault Detection

The UPS shall be equipped with DC battery ground fault detection that is capable of detecting and annunciating (through the UPS control panel) battery DC ground faults in order to facilitate proactive resolution of such ground faults.

8. Emergency Power Off

The UPS control panel shall be equipped with a push button with protective cover for emergency situations that require shutdown of the UPS. The emergency power-off push button provides a local method to turn Off the UPS power conversion and bypass.

9. Economizer Mode (ECO Mode)

The system control shall offer a method to increase maximum efficiency when conditions permit by automatically placing the load on the bypass source when the voltage and frequency of that source are within acceptable parameters. The load shall be transferred to the inverter automatically and without interruption should the bypass source be outside of the acceptable parameters. The UPS must maintain a constant float voltage to the batteries during this mode.

10. Intelligent Paralleling

The system control shall offer a method to increase maximum efficiency when conditions permit by automatically adapting power capacity to meet immediate load requirements by switching excess UPS units to standby mode, while ensuring continued system availability. Intelligent paralleling shall allow each UPS to operate in standby mode for equal lengths of time, ensuring equal lifespans of module components, and shall optimize efficiency at partial load operation achieving superior running cost savings.

11. FCC Compliance Filter Compatibility

The UPS shall comply with FCC Part 15, Class A.

12. Load Bus Sync Interface

The Load Bus Sync Interface shall enable independent UPS units to remain synchronized when operating on battery or on unsynchronized input sources.

13. Remote Alarm Status Panel

The remote alarm status panel shall have LED alarm lights. An audible alarm shall sound upon any alarm condition. The surface mounted NEMA 1 enclosed panel shall indicate:

- Load on UPS
- Load on Bypass
- Battery Discharging
- Low Battery Warning
- Overload
- Audible Alarm with Reset

14. Seismic Anchorage Kits

Seismic anchorage kits shall be provided with the UPS unit, and if included the (optional) Matching Battery Cabinet, for use in seismic restraint as required for IBC 2015 certification.

15. Non-Matching Module Battery Disconnect (MBD)

The MBD is an external battery circuit breaker that is used to isolate the UPS module from the battery system. One MBD can be used to disconnect one or more battery strings. Battery Isolation Switches (BIS) are recommended when more than one battery string is used with a common MBD. MBD's can also be provided for each battery string. A non-matching MBD requires a battery interface box (BIB) to monitor breaker position and to control breaker tripping. When battery charging temperature compensation is needed, a Temperature Sensor can be connected to the BIB associated with the MBD.

16. Non-Matching Battery Isolation Switch (BIS)

The BIS is an external battery circuit breaker used to isolate individual battery strings. When one or more BIS is used, then only a single MBD can be used. The non-matching BIS requires a battery interface box (BIB) to monitor breaker position. When battery charging temperature compensation is needed, a Temperature Sensor can be connected to the BIB associated with the BIS.

17. Battery Interface Box (BIB)

The Battery Interface Box contains a Battery Interface Board. The Battery Interface Box is required when a UPS module is installed with any non- Liebert® battery cabinet, non-matching MBD or Battery Isolation Switch (BIS). One Battery Interface Box is required for each MBD or BIS. Liebert® battery cabinets incorporate Battery Interface Boards and do not require a separate Battery Interface Box.

18. Temperature Sensor

This sensor is needed only for battery solutions utilizing a non- Liebert® battery cabinet, non-matching Module Battery Disconnect (MBD) or Battery Isolation Switch (BIS). Liebert battery packs have built-in temperature sensors. The Temperature Sensor option includes a remote sensor that must be field installed.

19. Battery Junction Cabinet

The Junction Cabinet is used as an intermediate landing point for some battery configurations involving multiple cabinets. It provides additional landing space for the cables from the battery cabinets while reducing the number of cables needed to connect to the UPS. Seismic anchoring kits, including rails and brackets to provide seismic restraint for the junction cabinet as described in *Section 13.2.1.2 of ASCE/SEI 7-05*, are available for this option.

20. Integrated Battery Monitoring, Vertiv™ Liebert ® Alber™ BDSUi

This integrated battery monitoring solution extends and optimizes useful battery life, reduces maintenance costs and increases safety. The monitoring system reports all critical battery parameters, including internal resistance, total voltage, cell voltage, temperature and discharge events. One Vertiv™ Liebert® IS-Unity-DP monitoring card is included in the Control Module.

3.0 STORED ENERGY SYSTEMS

The UPS system shall be provided with a stored energy system that shall comply with the specifications of:

- Flooded-Cell Battery System,
- Valve-Regulated, Lead-Acid Battery System,
- Lithium-Ion Battery System or
- Vycon Flywheel Energy Storage System.

Specifications describing the requirements for the customer-specified stored energy system are contained in SL-25418GS, available at the Liebert Web site.

4.0 EXECUTION

4.1 Field Quality Control

The following inspections and test procedures shall be performed by factory-trained field service personnel during the UPS startup.

1. **Visual Inspection**

- Inspect equipment for signs of damage.
- Verify installation per drawings supplied with installation manuals or submittal package.
- Inspect cabinets for foreign objects.
- Verify that ground conductors are properly sized and configured per the manufacturer's requirements as noted in the manufacturer's drawings supplied with installation manuals or submittal package.
- Inspect electrolyte level in cells (flooded cells only).
- Inspect all cell cases.
- Inspect each cell for proper polarity.
- Verify that all printed circuit boards are configured properly.

2. **Mechanical Inspection**

- Check all accessible control wiring connections for tightness.
- Check all accessible power wiring connections for tightness.
- Check all accessible terminal screws, nuts and/or spade lugs for tightness.

3. **Electrical Inspection**

- Check all fuses for continuity.
- Confirm input and bypass voltage and phase rotation are correct.
- Verify control transformer connections are correct for voltages being used.
- Verify connection and voltage of the battery string(s).

4. **Unit Startup**

- Energize control power.
- Perform control/logic checks and adjust to meet the manufacturer's specification.
- Verify DC float and equalize voltage levels.
- Verify DC voltage clamp and overvoltage shutdown levels.
- Verify battery discharge, low battery warning and low battery shutdown levels.
- Verify fuse monitor alarms and system shutdown.
- Verify inverter voltages and regulation circuits.
- Verify inverter/bypass sync circuits and set overlap time.
- Perform manual transfers and returns.
- Simulate utility outage at no load.
- Verify proper recharge.

4.2 Manufacturer's Field Service

1. Service Personnel

The UPS manufacturer shall directly employ a nationwide service organization, consisting of factory-trained field service personnel dedicated to the startup and maintenance of UPS and power equipment.

The manufacturer shall provide a national dispatch center to coordinate field service personnel schedules. One toll-free number shall reach a qualified support person 24 hours/day, 7 days/week, and 365 days/year. If emergency service is required, on-site response time shall be four hours or less within 150 miles of a Vertiv Services center.

Two local customer engineers shall be assigned to the site with a regional office as a backup. Escalation procedures shall be in place to notify Power Technical Support if a site is not functioning within 24 hours.

2. Vertiv™ LIFE™ Services

The UPS manufacturer shall provide LIFE™ services, which provides 24x7 continuous monitoring of events and parametric data, event and data analysis reports, and dispatch of factory-trained field service personnel. The UPS shall be able to initiate periodic and critical event driven communication with a remote service center to transfer event and parametric data for analysis and action. The remote service center shall be staffed with factory-trained service personnel who are capable of receiving, analyzing and interpreting the communicated events and data. The remote service center personnel shall also be capable of dispatching factory-trained field service personnel to the location of the UPS.

3. Replacement Parts Stocking

Parts shall be available through an extensive network to ensure round-the-clock parts availability throughout the continental United States.

Spare parts shall be stocked by local field service personnel with backup available from regional parts centers and the manufacturing location. A national parts center Customer Support Parts Coordinator shall be on call 24 hours a day, 7 days a week, 365 days a year for immediate parts availability.

4. Maintenance Contracts

A complete offering of preventive and full-service maintenance contracts for both the UPS system and battery system shall be available.