

Vertiv™ Liebert® EXL UPS
Single-Module Uninterruptible Power System
Rated 625-1200kVA/kW
GUIDE SPECIFICATIONS

1.0 GENERAL

1.1 Summary

These specifications describe requirements for an Uninterruptible Power System (UPS) optimized for maximum efficiency. The UPS shall automatically maintain AC power to the critical load within specified tolerances and without interruption during failure or deterioration of the normal power source.

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 required to properly interface the AC power source with the intended load and shall 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:

- UL Standard 1778, 5th Edition
- CSA 22.2, No. 107.1
- ANSI C62.41
- National Electrical Code (NFPA 70)
- OSHA
- FCC
- IFC
- International Building Code 2012

The UPS shall be UL-listed per “UL Standard 1778, 5th Edition, Uninterruptible Power Supplies,” and shall be certified to meet CSA requirements by an authorized certifying body.

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 (625-1200)kW and a minimum of (625-1200)kVA output.
- The UPS shall be able to power loads up to (625-1200)kVA with power factors between 0.7 lagging and 0.7 leading without derating.

- 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 neither require nor use an input neutral for normal operation. The design intent shall be to maintain reliability while delivering maximum efficiency as indicated in Section AC Output -E.
- The AC input source shall be a solidly grounded wye service.
- The battery shall support the UPS at 100% rated kW load for at least ____ minutes at 77°F (25°C) at startup.
- The UPS shall have an active, power factor-corrected, three-level IGBT converter/rectifier that is 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:** The critical AC load shall be continuously powered by the UPS inverter. The rectifier shall derive power from the utility AC source and shall supply DC power to the DC-DC converter, which in turn shall supply the inverter while simultaneously float charging the battery.
2. **Emergency:** Upon failure of utility AC power, the critical AC load shall be powered by the inverter, which, without any switching, obtains 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.
3. **Recharge:** Upon restoration of the utility AC source, the rectifier shall supply power to the output inverter and to the DC-DC converter, which shall simultaneously recharge the battery. This shall be an automatic function and shall cause no interruption to the critical AC load.
4. **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.
5. **Economizer 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 ranges. The load shall be transferred to the inverter automatically and without interruption should the bypass source be outside the acceptable range. The UPS shall maintain a constant float voltage to the batteries during this mode.
6. **Off-Battery:** If the battery only is taken out of service, it shall be disconnected from the DC-DC converter by means of an external disconnect circuit breaker. 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 solid-state power components, magnetics, electronic devices and overcurrent protection devices shall operate within the manufacturer's recommended temperature when the UPS is operating at 100% critical load with the following conditions occurring simultaneously:

- Any altitude within the specified operating range up to 3300 ft. (1000m) elevation
- Any ambient temperature within the specified operating range of 32°F to 95°F (0°C to 35°C)

- Any input voltage within the specified range, +10% to -20% of nominal

Full battery charging current shall be maintained down to -5% of nominal voltage at full kW load, or from +10% to -20% of nominal voltage at 90% kW load.

The UPS shall be capable of starting up a transformer load with a capacity equal to the UPS rating without transferring to bypass.

1.3.4 Input

1. **Voltage Range:** +10%, -20% of nominal voltage at full kW load
2. **Frequency Range:** ± 5 Hz
3. **Rectifier Walk-In:** 0% to 100% of full rated load over 1-30 seconds (adjustable)
4. **Rectifier Start Delay:** Programmable from 0-240 seconds before walk-in begins (adjustable)
5. **Maximum Inrush Current:** UPS inrush current not to exceed four times the rated input current for a maximum of 10 milliseconds
6. **Power Factor:** Minimum 0.99 at full load with nominal input voltage
7. **Current Distortion:** Less than or equal to 5% THD at full load input current on a fully rated module in double-conversion mode
8. **Surge Protection:** Sustains input surges without damage per criteria listed in ANSI C62.41, category A3 and B3 (6kV)
9. **Short Circuit Withstand Rating:** Units shall carry a standard 65kA short circuit current rating and shall have an optional 100kA rating. These ratings shall have been tested and verified as required for listing under UL 1778, 5th edition. A label shall be applied to the unit clearly identifying this rating as required by the National Electrical Code.

1.3.5 AC Output

1. **Load Rating:** 100% of load rating continuous at 95°F (35°C)
2. **Voltage Regulation:**
 - $\pm 1\%$ RMS average for a balanced, three-phase load
 - $\pm 2\%$ for 50% unbalanced load for line-to-line imbalances
3. **Manual Voltage Adjustment Range:** $\pm 5\%$ for line drop compensation
4. **Frequency Regulation:**
 - Synchronized to bypass: $\pm 0.1-5.0$ Hz in 0.1Hz steps
 - Synchronized to internal clock 0.1%
 - Free running frequency drift shall not exceed 0.1% during any 24-hour period.
 - Total frequency deviation, including short time fluctuations and drift, shall not exceed 0.1Hz from the rated frequency.

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 converters running.)

Rating	25% Load	50% Load	75% Load	100% Load
625kVA	≥ 94.3%	≥96.0%	≥96.5%	≥96.5%
750kVA	≥94.7%	≥96.22%	≥96.5%	≥96.5%
800kVA	≥95.3%	≥96.3%	≥96.5%	≥96.4%
1000kVA	≥94.0%	≥96.0%	≥96.5%	≥96.5%
1100kVA	≥95.1%	≥96.2%	≥96.5%	≥96.5%
1200kVA	≥95.3%	≥96.4%	≥96.5%	≥96.4%

6. **Phase Imbalance:**

- **Balanced loads:** $120^\circ \pm 1^\circ$
- **100% unbalanced loads:** $120^\circ \pm 2^\circ$

7. **Output Voltage Transients Under Step Loads (average of all three phases):**

- a. **0-100% or 100-0%**

- **Response** Meets IEC 62040-3: 2010 Curve 1, Class 1
Meets ITIC and CBEMA Curve Requirements

- b. **0-100% or 100-0%**

- **Transient Voltage Deviation, RMS** 6.5%
- **Step Load Transient Recovery (linear loads)** $\pm 2.5\%$ of nominal at fifth cycle and beyond after transient

The system shall not transfer to bypass under the following conditions.

- 100% load step
- Loss or return of AC input power, momentary sags, surges or spikes on the input to the UPS (all three phases or single phase)

8. **Voltage Harmonic Distortion:**

- Maximum 5% RMS total (linear load)
- Maximum 7% RMS total for up to 100% non-linear load

9. **Overload at full Output Voltage with $\pm 1\%$ voltage regulation:**

- 105% continuously
- 125% of full load for 2 minutes at 77°F (25°C) ambient
- 150% of full load for a minimum of 15 seconds at 77°F (25°C) ambient
- Current Limit: 200% nominal current

10. **Fault Clearing:**

- **Inverter only:** 200% of normal full load current for 200 milliseconds (factory default) or 155% of normal full load current for <5 seconds (when bypass is not available). UPS performance shall be selectable by certified factory service personnel based on an Output Current Limit setting.
- **Bypass available:** 500% for 10 cycles in inverter pulse-parallel operation when bypass is available.

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:** Up to 95°F (35°C) continuously without derating
- **Battery:** 77°F (25°C), ±5°F (±3°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 derating (compliant with IEC/EN 62040-3 at altitudes exceeding 1000m)
- Consult factory for derating above 3300 ft. (1000m) elevation.
- **Storage/Transport:** To 50,000 ft. (15,000m) above Mean Sea Level

1.5 Submittals

1.5.1 Proposal Submittals

Submittals with the proposal shall include:

- Functional relationship of equipment including weights, dimensions and heat dissipation
- Description of equipment to be furnished, including deviations from these specifications
- Size and weight of shipping units to be handled by contractor
- Detailed layouts of customer power and control connections
- Descriptive list of site services and maintenance to be offered

1.5.2 Order Submittals

Submittals supplied at time of order shall include:

- Detailed installation drawings, including all terminal locations
- Interconnect wiring diagrams showing conduit wiring with terminal numbers for each wire
- Descriptive list of site services and maintenance to be offered

1.5.3 UPS Delivery Submittals

Submittals upon UPS delivery shall include:

- A complete set of submittal drawings
- Two (2) sets of instruction manuals. Manuals shall include a functional description of the equipment, safety precautions, instructions, step-by-step operating procedures and routine maintenance guidelines, including illustrations.
- Descriptive list of site services and maintenance to be offered

1.6 Warranty

1.6.1 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.

1.6.2 Warranty – Third-Party Items and Batteries

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

1.7 Quality Assurance

1.7.1 Manufacturer Qualifications

A minimum of 20 years' experience in the design, manufacture and testing of solid-state UPS systems shall be required.

1.7.2 Factory Testing

Before shipment, the manufacturer shall fully and completely test the system to ensure compliance with the specifications. These tests shall include operational discharge and recharge tests to ensure guaranteed rated performance.

2.0 PRODUCT

2.1 Fabrication

2.1.1 Materials

All materials of the UPS shall be new, of current manufacture, high grade and 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. All electronic components shall be accessible from the front without removing subassemblies for service access.

2.1.2 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 electrical power connections shall be torqued to the required value and marked with a visual indicator.

Provision 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 the NEC, connection cabinets shall provide for adequate wire bend radius. All copper busbars for customer power connections shall be tin-plated or silver-plated for connection integrity.

2.1.3 Construction and Mounting

The UPS shall be in NEMA Type 1 enclosures, designed for floor mounting. The UPS shall be structurally adequate and shall have provisions for hoisting, jacking and forklift handling. Maximum cabinet height shall be 78 in. (1990mm).

2.1.4 Cooling

Adequate ventilation shall be provided to ensure that all components are operated well within temperature ratings. All cooling fans shall be monitored by the control system, which shall generate an alarm upon detection of a fan failure. Fans shall be redundant.

Temperature sensors shall be provided to monitor the UPS's internal temperature. Upon detection of temperatures exceeding the manufacturer's recommendations, the sensors shall cause audible and visual alarms to be sounded and illuminated on the UPS control panel. A separate room ambient temperature sensor 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 intake and shall be replaceable. No service clearance or ventilation shall be required in the rear of the system.

2.1.5 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 Protection

1. Surge Protection

The UPS shall have built-in protection against surges, sags and overcurrent 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 short circuits at the output terminals. The UPS shall have built-in protection against permanent damage to itself and 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 shall provide maximum information to maintenance personnel regarding the reason for tripping off-line. The load shall be automatically transferred to the bypass line uninterrupted 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 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. DC Battery Ground Fault Detection

The UPS shall provide, as an option, a method to detect battery DC ground faults, in order to facilitate proactive resolution of such ground faults.

5. Disconnects

All disconnects within the UPS at the rectifier input, inverter output and for backfeed protection shall be circuit breakers. Contactors shall not be used for these functions. 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 backfeed protection function, instead of locating such breakers within the UPS cabinet. The breaker controlling rectifier input shall be controlled by an undervoltage release; the remote backfeed breaker shall be controlled by a shunt trip mechanism. Voltage sensing capability and auxiliary contacts for both of these remote breakers shall be required and supported by the UPS.

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 rectifier shall be designed for maximum efficiency and low installation cost. The DC output of the rectifier shall meet the input requirements of the inverter without the battery being connected.

1. Input Current Harmonic Distortion

Input current THD generated by the UPS shall be less than 5% at full load input current in double-conversion mode for a fully rated module.

2. Input Current Walk-In

The rectifier/charger shall provide a feature that limits, during the transfer from battery mode to line mode, 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 30-second (adjustable) time interval.

3. Dynamic Current Input Limit Reduction

The rectifier, in conjunction with the other UPS controls and circuitry, shall adjust the current demanded for battery charging as a function of UPS wattage load and input voltage level.

4. Two-Step Rectifier Input Current Limit*

Step 1 - Independently adjustable 25-105% of normal full load input current*

Step 2 - Independently adjustable 25-105% for on-generator operation

5. Two-Step Battery Charge Current Limit

Step 1 - Independently adjustable 0-25% of maximum battery discharge current**

Step 2 - Independently adjustable 0-25% of maximum battery discharge current***

*Limits shown are for operating under normal conditions.

**Normal battery charge limit

*** Reduced battery charge limit

6. Fuse Protection

Each AC phase shall be individually fused with fast-acting fuses so that loss of any semiconductor shall not cause 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 an open 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, capable of providing rated output power, and, for increased performance, the inverter shall be a pulse width-modulated design and shall utilize insulated gate bipolar transistors (IGBT's). The DC-DC converter shall control charging of the battery. The AC ripple voltage of the charger DC shall not exceed 1% RMS of the float voltage.

1. Battery Float Charging

The DC-DC converter shall operate continuously to provide a constant float voltage to the battery under normal conditions to provide a charging regime consistent with the battery manufacturer's specifications

2. Battery Recharge

In addition to supplying power for the load, the UPS shall have a control to set a charging current limit from 0% to 25% of total rated kW @ 540VDC, provided that feeder breakers and cabling are sized accordingly. After the battery is recharged, the rectifier/charger shall maintain the battery at full charge until the next emergency operation.

3. 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.

4. Stop Battery Charging Function and Thermal Runaway Protection

Battery charging may 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. In order for the UPS to monitor battery temperature, the battery cabinet must be equipped with a temperature sensor, circuit breaker, and circuit breaker control interface to communicate with the UPS supplied by the US manufacturer. In addition, the UPS shall be programmable so that a battery overtemperature condition can be detected in any single battery cabinet and a three-stage response shall be initiated:

- When the temperature in the cabinet reaches 40°C, battery charging shall be stopped and an alarm generated.
- When the temperature in the cabinet reaches 50°C the circuit breaker for that individual battery cabinet or string may be opened, isolating that cabinet or string only and retaining 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.

5. 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.

6. 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 disconnect the battery via the DC breaker(s) in the battery string.

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, capable of providing rated output power, and, for increased performance, the inverter shall be a pulse-width-modulated three-level transformer-free design and shall utilize insulated gate bipolar transistors (IGBT's). To further enhance reliable performance and maximum 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 up to 105% of nominal continuously, up to 125% for 2 minutes and up to 150% for 15 seconds. The inverter shall be capable of at least 200% current for short-circuit conditions. 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. Output Frequency

The inverter shall track the bypass continuously, providing the bypass source maintains a frequency of 60Hz \pm 0.1 -5Hz, and this tolerance shall be adjustable in 0.1Hz steps. The inverter shall change its frequency (slew rate) at less than 1Hz per second (adjustable from 0.1Hz/sec to 3Hz/sec, in 0.1Hz/sec

increments) 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-hour period. Total frequency deviation, including short time fluctuations and drift, shall not exceed 0.1% from the rated frequency.

3. Phase-to-Phase Balance

The inverter shall provide a phase-to-phase voltage displacement of no worse than $\pm 2\%$ with a 100% unbalanced load.

4. Inverter Fault Sensing and Isolation

The UPS shall be provided with a means to detect a malfunctioning inverter and isolate it from the critical load bus to prevent disturbance of the critical load voltage beyond the specified limits.

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. Automatic shutdown based on discharge time shall not be acceptable.

2.3.4 Synchronization with Other UPS Modules

The UPS module shall have an option that enables it to synchronize its output with other like UPS modules, this shall allow up to six UPS modules to support multiple load busses in synchronism for in-phase load transfers, if required. It shall be possible to synchronize up to six systems of six modules each.

2.3.5 Inverter Bypass Operation

For times when maintenance is required or when the inverter cannot maintain voltage to the load due to 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 bypass static switch and an overcurrent protection device to isolate the inverter. The bypass static switch shall denote the solid-state device incorporating SCR's (silicon-controlled rectifiers) that can automatically and instantaneously connect the alternate AC source to the load.

The bypass static switch shall be fully rated for continuous duty at full rated load for the highest reliability without the use of mechanical devices.

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 period 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.

3. Momentary Overloads

In the event of a load current inrush or branch load circuit fault in excess of the inverter 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 after 10 cycles and the load shall remain on inverter power. If the overload remains, then a transfer to the alternate AC source shall be completed.

4. Backfeed Protection

As required by UL1778 and CSA, the static transfer switch shall not back-feed UPS power to the bypass 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 circuit breaker 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 bypass static switch.

5. System Coordination

Any perishable devices (e.g., fuses) used to provide a defined short-circuit current rating in the UPS shall be rated such that system coordination can be achieved based on the ratings of the main overcurrent protection devices (e.g., input and output circuit breakers).

2.4 Display and Controls

2.4.1 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, or Human Machine Interface or HMI) 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 enter setpoints for the battery test (duration and end voltage), display system information, metering data, a one-line diagram of the UPS and battery, active events, event history, startup instructions and transfer and shutdown screens.

No mechanical push buttons shall be used except for emergency functions, such as Emergency Power Off.

2.4.2 Logic

UPS system logic and control programming shall reside in a microprocessor-based control system with nonvolatile flash memory. Rectifier, inverter and system control logic shall utilize high-speed digital signal processors (DSPs). CANbus shall be used to communicate between the logic and the UI /HMI 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.

2.4.3 Control System Redundancy

The UPS shall have two separate and independent control systems designed to work in concert to maintain power to the critical load in the event of a failure in either system.

One system shall control the normal functions of the power conversion systems in the UPS, including the inverter, rectifier and DC-DC converter. This system shall have three sources of power, which shall be the rectifier input, the DC bus and bypass input, any one of which shall be sufficient to provide adequate power to the control system for continuous operation and the generation and processing of any related alarms.

The second system shall control the Bypass Static Switch and shall monitor the operation of the power conversion sections of the UPS. This system shall derive its power from the bypass input. In the event of a failure in the power conversion control system, this system shall initiate and execute a transfer of the critical load to the bypass, if the bypass source is available, and shall generate the appropriate alarms. In the event this system encounters a failure or the bypass source is not available, the first system shall determine that the bypass is not available and shall generate the appropriate alarms until the bypass is restored.

2.4.4 Metered Values

A microprocessor shall control the display and memory functions of the monitoring system. The system shall display values within a meaningful or practical range. All three phases of three-phase parameters shall be displayed simultaneously. All voltage and current parameters shall be monitored using true RMS measurements for accuracy to $\pm 1.5\%$ of voltage and AC current and 3% of real and apparent power. The following parameters shall be displayed:

- Input voltage, line-to-line
- Input current
- Input frequency
- Battery voltage, each battery string
- Battery charging/discharging current
- Output voltage, line-to-line
- Output frequency
- Bypass input voltage, line-to-line
- Bypass input frequency
- Load current
- Load Real Power (kW), total and percentage of capacity
- Load Apparent Power (kVA), total and percentage of capacity
- Battery temperature, each battery string
- Battery state of charge

2.4.5 Power Flow Indications

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

- AC Input Circuit Breaker
- AC Output Circuit Breaker (optional)
- Battery Circuit Breaker, each breaker

- Connection of complete battery complement,
- Complete disconnection and
- Partial connection (one or more, but not all, breakers open.)
- Backfeed Breaker
- Maintenance Bypass Status

2.4.6 Main Display Screen

In addition to the power flow diagram described in Section 2.3.4, the main screen shall also provide access to a Metering page and other pages that shall provide the following information:

- kVA
- kW
- % Load
- Event Logs
- Warning Indicator
- Fault Indicator
- Bypass Input Voltage
- Bypass Input Frequency
- Input Voltage Line-to-Line
- Input Frequency
- Output Voltage, Line-to-Line
- Output Current, Per Phase
- Output Frequency
- DC Source Voltage
- DC Source Current

2.4.7 Battery Status Indicator

A battery status indicator shall display DC alarm conditions, battery breaker status, battery state of charge, the present battery voltage, total discharge time and battery time remaining during discharge. A graphical representation of the battery voltage during the discharge shall be displayed. The graphical representation shall remain in the monitoring system memory until the next discharge occurs and shall be available for review of the battery performance.

2.4.8 Alarms

The control panel shall report system-level alarms. An audible alarm shall be activated when an alarm occurs. All alarms shall be displayed in text form.

2.4.9 Controls

System-level control functions shall be:

- UPS/Bypass Transfer Command
- Startup Screen
- UPS/System Shutdown Commands

- Maximum Load Exceeded Setpoint Adjustment
- Manual Transfer - Bypass Voltage High- and Low-Limit Adjustments
- Inlet Air Temperature Warning Setpoint Adjustment
- Battery Test Setpoint Adjustment
- Low Battery Warning (Minutes) Setpoint Adjustment
- Battery Temperature Warning and Limit Adjustments
- Battery Disconnect Open
- Battery Cell Count Adjustment
- Battery Float Voltage Setpoint Adjustment
- Event Mask (Latch, Audible, Event Log) Screen
- System Settings (Time, Date, Password, Audio Level) Adjustments
- Audio Silence Command
- Alarm Reset Command
- Input Contact Isolator Setup Screen (optional)
- Programmable Relay Setup Screen (optional)

2.4.10 Manual Procedures

1. **Startup:** The Startup screen shall be user-interactive on the display panel in text and graphic form and provide a step-by-step guide for the user to bring the UPS module on-line. Push buttons shall be provided to enable the battery breaker.
2. **Load Transfers:** A single button shall provide the means to transfer the load to Bypass and back on UPS. A Sync-scope shall be provided to display the phasing between Bypass and Output in graphical representation.
3. **Shutdown:** Two buttons (UPS and SYSTEM) shall provide the means to shut down the inverter and transfer the load to bypass or shut down the entire system.

2.4.11 Self-Diagnostics

1. **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.

2.4.12 Remote Monitoring Capability

The following remote monitoring and communication capabilities are available for the UPS (for further information refer to Section 2.3.9 “Optional Accessories and Features.”)

- Remote Service Delivery
- Communication cards for SNMP, Modbus 485, Modbus IP, Telnet, Web management and others
- Remote Alarm Contacts (Up to 16 channels)
- Customer Contact Inputs (Up to 16 channels)
- Remote Alarm Panel

2.5 Optional Accessories and Features

1. Remote Input and Backfeed Breakers

The UPS shall have, as an option, the ability to control remote breakers furnished by others located in the input switchboard for rectifier input feed and/or the backfeed protection function. Requirements are shown in Section 2.2.2, Item 5.

2. 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.

3. Communication Cards

The UPS can be equipped with up to two optional communication card(s) including:

- Optional SNMP Web Card, providing SNMP, Telnet and Web-management capability
- Optional SNMP and Modbus 485 or Modbus IP Card
- Remote Service Delivery supported by one of the cards installed.

4. Remote Alarm Contacts

Two Remote Alarm Contact assemblies, rated at 30VDC, 1A, shall be provided, as an option, for customer signaling. A set of Form C contacts shall be provided for each of eight alarm signal channels per assembly. The activation for each alarm signal channel shall be customer-selected for up to four individual alarms or as a summary of all alarms.

5. Customer Input Contact Assemblies

Up to two Customer Input Contact Assemblies shall be provided, as an option, for the input and display of customer-supplied alarm points or to initiate pre-assigned UPS operations. Each assembly shall provide eight channels, with a 24VDC, 100mA signal to be triggered by an isolated, normally open contact. When an assembly is selected for a customer-named event, the customer may assign a name of up to 19 characters and the following actions individually to each alarm:

- Annunciate horn while alarm is present
- Latch horn on and display alarm until manually reset
- Include this alarm in the summary alarm
- Freeze the history status file
- Initiate external communication
- Delay action from this signal for 0 to 99.9 seconds

When a channel is selected as a pre-assigned UPS operation, the following actions shall be initiated:

- Reduced Rectifier Input Current
- Reduced Battery Charge Current
- Stop Battery Charging

6. Remote Alarm Panel

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

- Load on UPS
- Load on Bypass
- Battery Discharging
- Low Battery Warning
- Overload Warning
- Ambient Overtemp Warning
- UPS Alarm Condition
- New Alarm Condition (for a second UPS alarm condition)
- Audible Alarm with Reset Push Button Lamp Test/Reset Push Button

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 Vertiv 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 manufacturer's requirements as noted in 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 control wiring connections for tightness.
- Check all power wiring connections for tightness.
- Check all 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.
- Ensure connection and voltage of the battery string(s).

4.2 Unit Startup

- Energize control power.
- Perform control/logic checks and adjust to meet 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 Perform manual transfers and returns.
- Simulate utility outage at no load.
- Verify proper recharge.

4.3 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 a day, 7 days a week, 365 days a year. If emergency service is required, the manufacturer shall offer contracts to provide on-site response time within 4 hours or less within 150 miles of one of the manufacturer's service centers.

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. Automated Site Monitoring

The UPS manufacturer shall provide, as an option, an automated site monitoring service free for one year. This service shall be staffed by qualified support personnel 24 hours a day, 7 days a week, 365 days a year. The technical experts shall be able to analyze the information provided by the UPS to diagnose issues and advise and equip the customer engineer with the parts and tools necessary to address the issue. At the detection of an alarm within the UPS, the controls shall initiate communication with the monitoring service. The monitoring service shall be capable of interpreting the communicated alarms to allow dispatch of a service engineer.

3. Replacement Parts Stocking

Parts shall be available through an extensive logistical network to ensure round-the-clock parts availability throughout the country.

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