Vertiv™ Liebert® APM UPS
Guide Specifications
15-45kVA and 15-90kVA Scalable
Three-phase Uninterruptible Power System

1.0 GENERAL

1.1 Summary

This specification defines the electrical and mechanical characteristics and requirements for a continuous-duty three-phase, solid-state, scalable (field-upgradable) uninterruptible power system (UPS). The UPS shall provide high-quality AC power for sensitive electronic equipment.

1.2 Standards

The UPS shall be designed in accordance with the applicable sections of the current revision of the following documents. Where a conflict arises between these documents and statements made herein, the statements in this specification shall govern.

- UL Standard 1778
- CSA 22.2, No. 107.3, 4th edition
- FCC Part 15, Class A
- IEC 61000-3-4,4-4,4-2,4-3,4-6,2-2
- National Electrical Code (NFPA-70)
- NEMA PE-1
- ISTA_1H
- ANSI C62.41, Categories A3 and B3

The UPS shall be UL and cUL listed per UL Standard 1778.

1.3 System Description

1.3.1 Design Requirements - UPS Module

1. Voltage. Input/output voltage specifications of the UPS shall be:
   - **Rectifier Input**: 208 volts, three-phase, 4-wire-plus-ground
   - **Bypass Input**: 208 volts, three-phase, 4-wire-plus-ground
   - **Output**: 208 volts, three-phase, 4-wire-plus-ground
2. Output Load Capacity. Specified output load capacity of the UPS shall be (_____) kVA at unity power factor.

3. Scalable Output Capacity. UPS rated output capacity will be scalable by Vertiv. Models will be available in two different frames:
    - **45kVA Frame** - Scalable in 15kVA increments with Vertiv™ Liebert® FlexPower™ modules: 15, 30 and 45kVA
    - **90kVA Frame** - Scalable in 15kVA increments with Liebert® FlexPower™ modules: 15, 30, 45, 60, 75 and 90kVA
4. Current Sharing: When multiple UPS modules are connected in parallel and powering a common load, each UPS module output current will not differ by more than 5% of the rated full load current of one UPS module.

1.3.2 Design Requirements - Battery

1. **Battery Cells:** Valve-regulated, lead acid batteries.
2. **Reserve Time:** (_____) minutes at (_____) kVA, unity power factor, with ambient temperature of 77°F (25°C). Unit shall provide terminal for connection of external batteries.

1.3.3 Modes of Operation

The UPS shall be designed to operate as an on-line, double-conversion, reverse-transfer system with the following operating modes:

1. **Normal -** The critical AC load is continuously supplied by the UPS inverter. The rectifier/charger derives power from an AC source and supplies DC power to the inverter while simultaneously float-charging the reserve battery.
2. **Emergency -** Upon failure of utility AC power, the critical AC load is supplied by the inverter, which obtains power from the battery. 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 utility AC power after a utility AC power outage, the rectifier/charger shall automatically restart, gradually ramp up output voltage and assume the inverter and battery recharge loads.
4. **Bypass -** If the UPS must be taken out of service for maintenance or repair or if the inverter overload capacity is exceeded, the static transfer switch shall perform a reverse transfer of the load from the inverter to the bypass source with no interruption in power to the critical AC load.

1.3.4 Performance Requirements

AC Input to UPS

1. Voltage Configuration for Standard Units: 208V, three-phase, four-wire plus ground
2. **Voltage Range:** +15%, -20% of nominal without derating
3. **Frequency:** 40-70Hz
4. **Power Factor:**0.99 full load, 0.98 half load
5. **Inrush Current**: UPS inrush current not to exceed 1.5 times rated input current. Maintenance bypass and distribution cabinet inrush current not to exceed 8 times rated input current.
6. **Current Limit:** 140% of nominal AC input current maximum
7. **Current Distortion:** <3% reflected THD maximum at full load
8. **Surge Protection:** Sustains input surges without damage per criteria listed in IEC 1000-4-5

AC Output, UPS Inverter

1. **Voltage Configuration:** three-phase, 4-wire plus ground
2. **Voltage Regulation:**
   - ±1% three-phase RMS average for a balanced three-phase load for the combined variation effects of input voltage, connected load, battery voltage, ambient temperature and load power factor
   - ±5% three-phase RMS average for a 100% unbalanced load for the combined variation effects of input voltage, connected load, battery voltage, ambient temperature and load power factor
3. **Frequency:**
   - ±0.1% (single Liebert® FlexPower assembly)
   - ±0.25% (six Liebert® FlexPower assemblies)
4. **Frequency Slew Rate:** Selectable from 0.1Hz/sec to 3.0Hz/sec maximum for single unit
5. **Phase Balance:**
   - 120 degrees ±1 degree for balanced load
   - 120 degrees ±1.5 degrees for 100% unbalanced load
6. **Voltage Distortion:**
   - <1% total harmonic distortion (THD) for linear loads
   - <5% THD for 100% nonlinear loads (3:1 crest factor) without kVA/kW derating
7. **Load Power Factor Range:** 0.7 lagging to 0.9 leading without derating
8. **Output Power Rating**: 0.99 full load. 0.98 half load
9. **Overload Capability:**
   - 110% for 60 minutes
   - 125% for 10 minutes
   - 150% for 60 seconds
10. **Voltage Transient Response:** 100% load step, ±5.0%
11. **Transient Recovery Time**: to within 5% of steady state output voltage within half a cycle
12. **Voltage Unbalance**: 100% unbalanced load, ±5%

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 Module**: 32°F to 104°F (0°C to 40°C)
   - **Battery:** 77°F ±9°F (25°C ±5°C)

2. **Storage/Transport Ambient Temperature**
    - **UPS Module**: -4°F to 158°F (-20°C to 70°C)
    - **Battery**: -4°F to 86°F (-20°C to 30°C)
3. **Relative Humidity**
    - 0 to 95%, non-condensing
4. **Altitude**
    - **Operating**: 3300 ft. (1000m) above sea level; derate power by 1% per 330 ft. (100m) between 3300 and 6000 ft (1000m and 2000m).
    - **Storage/Transport:** to 40,000 ft. (12,200m) above mean sea level.
5. **Audible Noise**
    - 56 dB (45kW/kVA models)
    - 60 dB (90kW/kVA models)

1.5 Submittals

1.5.1 Proposal Submittals

Submittals with the proposal shall include:

- System configuration with single-line diagrams
- Functional relationship of equipment including weights, dimensions and heat dissipation
- Descriptions of equipment to be furnished, including deviations from these specifications
- Size and weight of shipping units to be handled by installing contractor
- Detailed layouts of customer power and control connections
- Detailed installation drawings including all terminal locations

1.5.2 UPS Delivery Submittals

Submittals upon UPS delivery shall include a complete set of submittal drawings and one (1) set of instruction manuals that shall include a functional description of the equipment with block diagrams, safety precautions, instructions, step-by-step operating procedures and routine maintenance guidelines, including illustrations.

1.6 Warranty

1.6.1 UPS Module

The UPS manufacturer shall warrant the UPS module against defects in materials and workmanship for 12 months after initial startup or 18 months after ship date, whichever period expires first.

1.6.2 Battery

The battery manufacturer's standard warranty 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 is required. The system shall be designed and manufactured according to world-class quality standards. The manufacturer shall be ISO 9001:2000 certified.

1.7.2 Factory Testing

Before shipment, the manufacturer shall fully and completely test the system to assure compliance with the specification.

2.0 PRODUCT

2.1 Fabrication

2.1.1 Materials

All materials of the UPS shall be new, of current manufacture and 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 semi-conductors 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 sub-assemblies 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 Electrical Code and other applicable standards. All electrical power connections shall be torqued to the required value and marked with a visual indicator.

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. All copper busbars for customer power connections shall be tin 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 have provisions for hoisting, jacking and forklift handling. Maximum cabinet height shall be 78.7 in. (2000mm).

2.1.4 Cooling

Cooling of the UPS shall be by forced air using a redundant fan configuration. Fan power shall be provided by the UPS. Vertiv™ Liebert® APM UPS requires 12 inches (305mm) rear clearance for air flow, and the following requirements for top clearance air flow:

- 90kVA UPS with top cable entry: 24" (610mm) clearance
- 90kVA UPS with bottom cable entry: 12" (305mm) clearance
- 45kVA UPS with either top or bottom cable entry: 12" (305mm) clearance

The thermal design, along with all thermal and ambient sensors, shall be coordinated with the protective devices before excessive component or internal cabinet temperatures are exceeded. Air filters shall be located at the point of air inlet and be changeable.

Access shall be:

- **Vertiv™ Liebert® APM UPS:** Front access
- **Liebert® APM maintenance bypass cabinet:** Front access only
- **Liebert® APM battery cabinet**: Front and top access only for service

2.2 Components

2.2.1 Rectifier/Charger

1. General

The term rectifier/charger shall denote the solid-state equipment and controls necessary to convert AC to regulated DC for input to the inverter and for charging the battery.

2. AC Input Current Limiting

The rectifier/charger unit shall be provided with AC input current limiting whereby the maximum input current shall be limited to 140% of the full input current rating.

3. DC Filter

The rectifier/charger shall have an output filter to minimize ripple current into the battery. The AC ripple voltage of the rectifier DC output shall not exceed 1% RMS of the float voltage. The filter shall be adequate to ensure that the DC output of the rectifier/charger will meet the input requirements of the inverter without the battery connected.

4. Automatic Rectifier Restart

Upon restoration of utility AC power, after a utility AC power outage and prior to a UPS automatic end-of-discharge shutdown, the rectifier/charger shall automatically restart, walk-in and gradually assume the inverter and battery recharge loads.

5. Overvoltage Protection

There shall be DC overvoltage protection so that if the DC voltage rises to the preset limit, the UPS will shut down automatically and initiate an uninterrupted load transfer to the static bypass line.

2.2.2 Inverter

1. General

The term inverter shall denote the equipment and controls to convert DC from the rectifier/charger or battery to precise AC 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 design and utilize insulated gate bipolar transistors (IGBTs).

2. Overload Capability

The inverter shall be capable of supplying current and voltage for overloads exceeding 100%. The inverter is to provide 150% of full load for 60 seconds, 125% of full load for 10 minutes and 110% of full load for 60 minutes.

A status indicator and audible alarm shall indicate overload operation. The UPS shall transfer the load to bypass when overload capacity is exceeded.

3. Fault Clearing and Current Limit

The inverter shall be capable of supplying an overload current of 150% of its full-load rating for one minute. For greater currents or longer time duration, the inverter shall have electronic current-limiting protection to prevent damage to components. The critical load will be transferred to the static bypass automatically and uninterrupted. The inverter shall be self-protecting against any magnitude of connected output overload. Inverter control logic shall sense and disconnect the inverter from the critical AC load without the requirement to clear protective fuses.

4. Step Load Response

5. Voltage Distortion

- Total harmonic distortion in the output voltage will not exceed 1% for 0% to 100% linear loads.
- Total harmonic distortion in the output voltage will not exceed 4% for 0% to 100% non-linear loads.
- Total harmonic distortion in the output voltage will not exceed 5% for 0% to 100% non-linear, unbalanced loads.

6. Phase Balance

Electronic controls shall be provided to regulate each phase so that an unbalanced loading will not cause the output voltage to go outside the specified voltage unbalance or phase displacement. With 100% load on one phase (and 0% load on the other two phases) or 100% load on two phases (and 0% load on the other phase), the voltage balance is to be within 5% and the phase displacement is to be 120 degrees within a range of ±1.5 degrees.

7. Inverter Shutdown

For rapid removal of the inverter from the critical load, the inverter control electronics shall instantaneously turn off the inverter transistors. Simultaneously, the static transfer switch shall be turned on to maintain continuous power to the critical load.

8. Inverter DC Protection

The inverter shall be protected by the following disconnect levels:

- DC Overvoltage Shutdown
- DC Undervoltage Warning (Low Battery Reserve)—pre-warning time is adjustable
- DC Undervoltage Shutdown (End of Discharge)

9. Output Frequency

The output frequency of the inverter shall be controlled by a high-speed DSP capable of holding the inverter output frequency to within ±0.1% for a single Vertiv™ Liebert® FlexPower™ assembly or ±0.25% for six Liebert® FlexPower™ assemblies during steady state and transient conditions. Total deviation from the rated frequency, including short time fluctuations and drift, shall not exceed 0.1% for a single Liebert® FlexPower™ assembly or 0.25% for six Liebert® FlexPower™ assemblies.

2.2.3 Display and Controls

1. Monitoring and Control

The UPS shall be provided with a microprocessor-based unit status display and controls section designed for convenient and reliable user operation. A graphical liquid crystal display (LCD) shall be used to show a single-line diagram of the UPS and shall be provided as part of the monitoring and controls sections of the UPS. All operator controls and monitors shall be located on the front of the UPS cabinet. Monitoring functions such as metering, status and alarms shall be displayed on the graphical LCD. Additional features of the monitoring system shall include:

- Menu-driven display with pushbutton navigation
- Real-time clock (time and date)
- Alarm history with time and date stamp
- Memory with battery backup

2. Metering

The following parameters shall be displayed:

- Input AC voltage line-to-line
- Input AC current for each phase
- Input frequency
- Battery voltage
- Battery charge/discharge current
- Output AC voltage line-to-line
- Output AC current for each phase
- Output frequency
- Apparent power
- Active power
- Battery time left during battery operation

3. Alarm Messages

The following alarm messages shall be displayed:

- Mains Voltage Abnormal
- Mains Undervoltage
- Mains Freq. Abnormal
- Charger Fault
- Battery Reversed
- No Battery
- Control Power 1 Fail
- Parallel Comm. Fail
- Bypass Unable To Track
- Bypass Abnormal
- Inverter Asynchronous
- Fan Fault
- Control Power 2 Fail
- Unit Over Load
- System Over Load
- Bypass Phase Reversed

- Transfer Time-Out
- Load Sharing Fault
- Bypass Over Current
- Output Ground Fault

4. Status Messages

The following UPS status messages 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)

5. Controls

UPS startup, shutdown and static bypass operations shall be accomplished through pushbutton controls on the front panel. Menu-driven user prompts shall be provided to guide the operator through system operation without the use of additional manuals. Pushbuttons shall be provided to display the status of the UPS and to test and reset visual and audible alarms. A mimic screen shall be available on the LCD to depict a single-line diagram of the UPS with switch positions and power flow.

6. On-Line Battery Test

The UPS shall be provided with a menu-driven On-Line Battery Test feature. The test shall ensure the capability of the battery to supply power to the inverter while the load is supplied power in the normal mode.

2.2.4 Static Transfer Switch

1. General

A static transfer switch and bypass circuit shall be provided as an integral part of the UPS. The static switch shall be a naturally commutated high-speed static (SCR-type) device rated to conduct full load current continuously. The switch shall have an overload rating to clear a 20-ampere load branch circuit breaker.

The static transfer switch control logic shall contain an automatic transfer control circuit that senses the status of the inverter logic signals and operating and alarm conditions. This control circuit shall provide an uninterrupted transfer of the load to an alternate bypass source without exceeding the transient limits specified herein, when an overload or malfunction occurs within the UPS or to bypass the UPS for maintenance.

2. Uninterrupted Transfer

The transfer control logic shall automatically turn on the static transfer switch, transferring the critical AC load to the bypass source, after the transfer logic senses any of the following conditions:

- Inverter overload capacity exceeded
- Critical AC load overvoltage or undervoltage
- UPS fault condition

The transfer control logic shall inhibit an automatic transfer of the critical load to the bypass source if any of the following conditions are present:

- Bypass frequency out of limits
- Bypass out-of-synchronization range with inverter output

3. Uninterrupted Retransfer

Retransfer of the critical AC load from the bypass source to the inverter output shall be automatically initiated unless inhibited by manual control. The transfer control logic shall inhibit an automatic retransfer of the critical load to the inverter if one of the following conditions exists:

- Bypass out of synchronization range with inverter output
- Inverter/bypass voltage difference exceeding preset limits
- Overload condition exists in excess of inverter full load rating
- UPS fault condition present

2.2.5 Battery Power Pack

The battery power pack shall include valve-regulated, lead-acid battery cells housed in a separate cabinet that matches the UPS cabinet styling to form an integral system lineup. Battery cells shall be mounted on slide-out trays for ease of maintenance. A battery disconnect circuit breaker shall be included for isolation of the battery pack from the UPS module. Casters and leveling feet shall also be provided with the battery power pack cabinet for ease of installation. When the application calls for the battery cabinet to be bolted to the UPS cabinet, an interconnecting cable kit will be available, precut and pre-lugged.

2.2.6 Optional Accessories

1. Vertiv™ Liebert® IntelliSlot Web Card (ISWEB-L)

Provides communication outputs to indicate a change of status of the UPS. Outputs are provided for:

- SNMP
- HTML - Web page
- Allow use of Vertiv™ Liebert® Nform and or network management systems

2. Matching Maintenance Bypass and Distribution Cabinet

A make-before-break maintenance bypass with Solenoid Key Release Unit (SKRU) interlock shall be available in a cabinet that matches and may be bolted up to the right side of the UPS. Installation of the cabinet shall not affect the cooling ability of the UPS. Thermal-magnetic breakers shall be provided for bypass and maintenance isolation.

3.0 EXECUTION

3.1 Field Quality Control

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

3.1.1 Visual Inspection

- Inspect equipment for signs of damage.
- Verify installation per drawings.
- Inspect cabinets for foreign objects.
- Verify neutral and ground conductors are properly sized and configured.
- Inspect battery cases.
- Inspect battery for proper polarity.
- Verify all printed circuit boards are configured properly.

3.1.2 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.

3.1.3 Electrical Inspection

- Check all fuses for continuity.
- Confirm input voltage and phase rotation is correct.
- Assure connection and voltage of the battery string(s).

3.2 Manufacturer's Field Service

3.2.1 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, 365 days/year. If emergency service is required, on-site response time shall be four hours or less within 150 miles of a Vertiv-qualified technician.

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.

3.2.2 Replacement Parts Stocking

Parts shall be available through an extensive 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 center 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.

3.2.3 Maintenance Contracts

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

3.2.4 Automated Site Monitoring

The UPS manufacturer shall provide as an option an automated site-monitoring service. This service shall be staffed by a qualified support person 24 hours/day, 7 days/week, 365 days/year. At the detection of an alarm within the UPS, the controls shall initiate communications with the monitoring service. The monitoring service shall be capable of interpreting the communicated alarms to allow dispatch of a service engineer.