

APC by Schneider Electric

APC SYMMETRA MW

400 kW to 1600 kW

Multi-Module

Uninterruptible Power Supply

THIS GUIDE SPECIFICATION IS WRITTEN IN ACCORDANCE WITH THE CONSTRUCTION SPECIFICATIONS INSTITUTE (CSI) MASTERFORMAT. THIS SECTION MUST BE CAREFULLY REVIEWED AND EDITED BY THE ARCHITECT OR THE ENGINEER TO MEET THE REQUIREMENTS OF THE PROJECT. COORDINATE THIS SECTION WITH OTHER SPECIFICATION SECTIONS IN THE PROJECT MANUAL AND WITH THE DRAWINGS.

WHERE REFERENCE IS MADE THROUGHOUT THIS SECTION TO "PROVIDE", "INSTALL", "SUBMIT", ETC., IT SHALL MEAN THAT THE CONTRACTOR, SUBCONTRACTOR, OR CONTRACTOR OF LOWER TIER SHALL "PROVIDE", "INSTALL", "SUBMIT", ETC., UNLESS OTHERWISE INDICATED.

THIS SECTION IS WRITTEN TO INCLUDE THE 2004 MASTERFORMAT AND THE 1995 MASTERFORMAT VERSIONS. WHERE APPLICABLE, THESE ITEMS ARE BRACKETED AND, IN EACH CASE, UNLESS OTHERWISE INDICATED, THE FIRST CHOICE APPLIES TO THE 2004 MASTERFORMAT AND THE SECOND CHOICE APPLIES TO THE 1995 MASTERFORMAT.

SECTION [26 33 53] [16611]

STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 SUMMARY

- A. **Scope:** Provide design and engineering, labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, erection, and installation for a static uninterruptible power supply (UPS) as required for the complete performance of the work and as shown on the Drawings and as herein specified.
- B. **Section Includes:** The work specified in this Section includes, but shall not be limited to, a continuous duty, three-phase, solid state, static UPS.
 - 1. The UPS control logic shall incorporate state of the art digital signal processing. The inverters shall utilize high speed pulse width modulation and shall be constructed of IGBTs. The UPS shall be part of a multi-module system, and function as described in this Section.
 - 2. In addition, this Section describes the performance, functionality, and design of the UPS maintenance bypass cabinet, hereafter referred to as the MBC, the battery system, UPS paralleling gear, external bypass static switch (EBS), and other such electrical distribution as described in this Section.
 - 3. The UPS and associated equipment shall operate in conjunction with a primary power supply (utility and/or on-site generation) and an output distribution system to provide quality uninterrupted power for mission critical, electronic equipment load.
 - 4. Owner-selected accessories, programming, and miscellaneous components for a fully operational system as described in this Section shall be supplied as part of the UPS at no additional cost.

1.2 REFERENCES

- A. **General:** The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.
- B. **Federal Communications Commission (FCC):**
 - 1. FCC 47 CFR Part 15, "Radio Frequency Devices."

- C. **Institute of Electrical and Electronics Engineers, Inc. (IEEE):**
1. ANSI/IEEE 519, "Guide for Harmonic Control and Reactive Compensation of Static Power Converters" (copyrighted by IEEE, ANSI approved).
- D. **International Electrotechnical Commission (IEC):**
1. IEC 60950, "Information Technology Equipment - Safety."
 2. IEC 61000, "Electromagnetic Compatibility."
 3. IEC 61000-2-2, "Electromagnetic Compatibility - Compatibility Levels for Low-Frequency Conducted Disturbances and Signaling in Public Low-Voltage Power Supply Systems."
 4. IEC 61000-3-5, "Electromagnetic Compatibility - Limitation of Voltage Fluctuations and Flicker in Low-Voltage Power Supply Systems for Equipment with Rated Current Greater than 75 A."
 5. IEC 61000-4-2, "Electromagnetic Compatibility - Testing and Measurement Techniques; Electrostatic Discharge Immunity Test."
 6. IEC 61000-4-3, "Electromagnetic Compatibility - Testing and Measurement Techniques; Radiated, Radio Frequency, Electromagnetic Field Immunity Test."
 7. IEC 61000-4-4, "Electromagnetic Compatibility - Testing and Measurement Techniques; Electrical Fast Transient/Burst Immunity Test."
 8. IEC 61000-4-5, "Electromagnetic Compatibility - Testing and Measurement Techniques; Surge Immunity Test."
 9. IEC 62040, "Uninterruptible Power Systems (UPS)."
 10. IEC 62040-1, "Uninterruptible Power Systems - General and Safety Requirements for UPS."
 11. IEC 62040-2, "Uninterruptible Power Systems - Electromagnetic Compatibility (EMC) Requirements,"
 12. IEC 62040-3, "Uninterruptible Power Systems - Method of Specifying the Performance and Test Requirements."
- E. **International Organization for Standardization (ISO):**
1. ISO 9001, "Quality Management Systems - Requirements."
 2. ISO 14001, "Environmental Management Systems - Requirements With Guidance for Use."
- F. **Underwriters Laboratories, Inc. (UL):**
1. UL 891, "Standard for Dead-Front Switchboards" (copyrighted by UL, ANSI approved).
 2. UL 1558, "Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear."
 3. UL 1778, "Standard for Uninterruptible Power Supply Equipment" (copyrighted by UL, ANSI approved).

1.3 SYSTEM DESCRIPTION

A. **Design Requirements:**

INSERT APPLICABLE VALUES IN THREE SUBPARAGRAPHS BELOW.

1. The UPS system shall be sized for a total load capacity of [____] kW. Each frame shall be rated for [____] kW with [____] redundant UPS modules.
2. Each UPS module shall be sized for a load capacity of [____] kW load and quantity of [____] 200 kW redundant UPS section(s).
3. The UPS battery shall be sized for an output of [____] kW at a power factor of [____] for [____] minutes.

B. **System Characteristics:**

1. **Multi-Module UPS Capacity:** The system shall be rated for full kW output in the following sizes:
 - a. 400 kVA/400 kW.
 - b. 600 kVA/600 kW.
 - c. 800 kVA/800 kW.
 - d. 1000 kVA/1000 kW.
 - e. 1200 kVA/1200 kW.
 - f. 1400 kVA/1400 kW.
 - g. 1600 kVA/1600 kW.

2. **Electrical Input:**
 - a. **AC Input Nominal Voltage:** [_____]

INSERT APPLICABLE VALUE FROM THE LIST BELOW:

 - 1) 480 volts, three-phase, , 3P+GND, 60 Hz.
 - 2) 400 volts, three-phase, 4-wire 3P+PEN or 5-wire 3P+N+GND, 50Hz
 - b. **AC Input Voltage Window:** $\pm 15\%$ of nominal (while providing nominal charging to the battery system).
 - c. **Short Circuit Withstand Rating:** 200,000 symmetrical amperes (200 kA).
 - d. **Maximum Frequency Range:** $\pm 0.5\%$ to 8% of nominal.
 - e. **Input Power Factor:** Approximately ~ 1 at 100% load and shall not be less than 0.97 at loads greater than 25% of system rating with no additional filters.
 - f. **Input Current Distortion:** Maximum 5% with no requirement for optional additional filters.
 - g. **Soft-Start:** Input current shall be linear from 0 to 100% input. This shall take place over a 10 second default time and values from 1 to 60 seconds shall be programmable. The UPS shall exhibit no magnetizing inrush current.
3. **UPS Electrical Output:**
 - a. **AC Output Nominal Output:** [_____]

INSERT APPLICABLE VALUE FROM THE LIST BELOW:

 - 1) 480 volts, three-phase, , 3P+GND, 60 hertz.
 - 2) 400 volts, three-phase, 4-wire 3P+PEN or 5-wire 3P+N+GND, 50Hz
 - b. **AC Output Voltage Regulation:**
 - 1) $\pm 1\%$ for 100% balanced linear load.
 - 2) $\pm 3\%$ for 100% unbalanced linear load.
 - c. **Voltage Transient Response:**
 - 1) $\pm 3\%$ maximum for 50% load step.
 - 2) $\pm 5\%$ maximum for 100% load step.
 - d. **Voltage Transient Recovery:** Within 50 milliseconds.
 - e. **Output Voltage Harmonic Distortion:**
 - 1) 3% THD maximum and 1% single harmonic for a 100% linear load.
 - 2) 5% THD maximum for a 100% non-linear load.
 - 3) UPS shall be able to support unlimited crest factor in normal operation. In battery operation the crest factor is limited to 2.7.
 - f. **Phase Angle Displacement:**
 - 1) 120 degrees, ± 0.1 degree for balanced load.
 - 2) 120 degrees, ± 0.1 degree for 50% imbalanced load.
 - 3) 120 degrees, ± 0.3 degrees for 100% imbalanced load.
 - g. **Overload Rating:**
 - 1) **Normal Operation:**
 - a) 200% for 60 seconds.
 - b) 125% for 10 minutes.
 - c) After an overload event that lasts for the full overload duration, the UPS must cool for 20 minutes before a new overload is allowed, and cooling occurs when the load is less than 100%.
 - 2) **Battery Operation:** 150% for 30 seconds.
 - 3) **Bypass Operation:**
 - a) 125% continuous.
 - b) 1000% for 500 milliseconds.
 - h. **UPS Efficiency:** With nominal voltage and resistive load.
 - 1) The UPS AC-AC efficiency shall be as follows:
 - a) At 100% Load: 97%.
 - b) At 75% Load: 97%.
 - c) At 50% Load: 96%.
 - d) At 25% Load: 94%.
 - 2) The UPS DC-AC efficiency shall be as follows:
 - a) At 100% Load: 96%.
 - b) At 75% Load: 97%.
 - c) At 50% Load: 97%.
 - d) At 25% Load: 96%.

- i. **Output Power Factor Rating:** The UPS output shall not require derating for purely resistive loads (PF of 1). The kW and kVA ratings of the UPS output shall be equal. For loads exhibiting a power factor of 0.9 leading to 0.8 lagging no derating of the UPS shall be required. For loads exhibiting power factors outside this range, the following derating shall apply:
 - 1) 5% derating of the UPS shall apply for 0.7 PF lagging.
 - 2) 10% derating of the UPS shall apply for 0.6 PF lagging.
 - 3) 15% derating of the UPS shall apply for 0.5 PF lagging.
 - 4) 20% derating of the UPS shall apply for a range of 0.4 to 0.1 PF lagging.
- 4. **Design and Construction:**
 - a. **Printed Circuit Boards:** Card edge connected printed circuit boards shall have mechanical interlocks to prohibit a board from being plugged into the wrong place.
 - b. **Electromagnetic Interference:** Radiated and conducted EMI generated within the system shall be suppressed to prevent excessive interference with associated nearby electronic equipment. Radio frequency generating equipment external to the system, such as hand-held portable radios and other electronic devices, shall not cause a malfunction of the system components when enclosures are shut. Compliance shall conform to FCC 47 Part 15 Subpart A.10-1.
 - c. **Finish and Painting:**
 - 1) External welds shall be ground smooth and sharp corners eliminated.
 - 2) Surfaces shall be clean and smooth and cleared of blemishes before application of the finish.
 - 3) Steel enclosures shall have a finish coat of durable baked enamel. The equipment shall be painted in accordance with manufacturer's standard procedure.
 - 4) Primers for steel surfaces shall be suitable for the service and operating temperatures to be encountered during the life of the equipment.
 - 5) Upon request a can of touch-up paint in each color shall be provided.
 - d. **Enclosures:** The UPS assemblies shall be constructed in NEMA Type 1 metal enclosures. Enclosures shall have provisions for forklift handling. The individual enclosures shall be freestanding, capable of side-by-side or back-to-back installation with front access requirements only.

1.4 SUBMITTALS

- A. **Product Data:** Submit product data showing material proposed. Submit sufficient information to determine compliance with the Drawings and Specifications. Product data shall include, but shall not be limited to, the following:
 - 1. As bid system bill of materials.
 - 2. Product catalog sheets or equipment brochures.
 - 3. Product guide specifications.
- B. **Shop Drawings:** Submit shop drawings for each product and accessory required. Include information not fully detailed in manufacturer's standard product data, including, but not limited to, the following:
 - 1. Installation information, including, but not limited to, weights and dimensions.
 - 2. Information about terminal locations for power and control connections.
 - 3. Drawings for requested optional accessories.
- C. **Wiring Diagrams:** Submit wiring diagrams detailing power, signal, and control systems, clearly differentiating between manufacturer-installed wiring and field-installed wiring, and between components provided by the manufacturer and those provided by others.
 - 1. Submit system single-line operation diagram.
- D. **Operation and Maintenance Data:** Submit operation and maintenance data to include in operation and maintenance manuals, including, but not limited to, safe and correct operation of UPS functions.
 - 1. Submit an installation manual, which shall include, but shall not be limited to, instructions for storage, handling, examination, preparation, installation, and start-up of UPS.

2. Submit an operation and maintenance manual, which shall include, but shall not be limited to, operating instructions.

1.5 QUALITY ASSURANCE

A. Qualifications:

1. **Manufacturer Qualifications:** Manufacturer shall be a firm engaged in the manufacture of solid state UPS of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of 20 years.
 - a. The manufacturer shall be ISO 9001 certified and shall be designed to internationally accepted standards.
2. **Installer Qualifications:** Installer shall be a firm that shall have a minimum of five years of successful installation experience with projects utilizing solid state UPS similar in type and scope to that required for this Project.

B. Regulatory Requirements: Comply with applicable requirements of the laws, codes, ordinances, and regulations of Federal, State, and local authorities having jurisdiction. Obtain necessary approvals from such authorities.

1. Where applicable, the UPS shall also be designed in accordance with publications from the following organizations and committees:
 - a. National Fire Protection Association (NFPA).
 - b. National Electrical Manufacturers Association (NEMA).
 - c. Occupational Safety and Health Administration (OSHA).
 - d. Institute of Electrical and Electronics Engineers, Inc. (IEEE); ANSI/IEEE 519.
 - e. ISO 9001
 - f. ISO 14001
 - g. IEC 60950.
 - h. IEC 61000.
 - i. IEC 61000-2-2.
 - j. IEC 61000-3-5.
 - k. IEC 61000-4-2.
 - 1) **Performance:** Minimum Level 3, Criterion A.
 - l. IEC 61000-4-3.
 - m. IEC 61000-4-4.
 - 1) **Performance:** Minimum Level 3, Criterion A.
 - n. IEC 61000-4-5.
 - 1) **Performance:** Minimum Level 3, Criterion A.
 - o. IEC 62040.
 - p. IEC 62040-1.
 - q. IEC 62040-2.
 - r. IEC 62040-3.
 - s. FCC part 15, sub part J, class A
 - t. UL 1778
 - u. CE
 - v. EN50091-1-1
 - w. EN50091-2
 - x. IEC-1000-4-5
 - y. EN50091-2

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and lot number, if any.
- B. Customer shall provide adequate facility to store materials in their original, undamaged packages and containers, inside a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, and humidity.

1.7 PROJECT CONDITIONS

- A. **Environmental:** Do not install solid state UPS until space is enclosed and weatherproof, wet work in space is completed and nominally dry, work above ceilings is complete, and ambient temperature and humidity conditions are and will be continuously maintained at values near those indicated for final occupancy.
1. **Storage Ambient Temperature:** -15 to 40°C (5 to 104°F)
 2. **Short-term Storage/Transportation Temperature:** -50 to 55°C (-58 to 131°F)
 3. **Operating Ambient Temperature:** 0 to 40°C (32 to 104°F) (25°C [77°F] is ideal for most battery types).
 4. **Relative Humidity:** 0 to 95% non-condensing.
 5. **Altitude:** Maximum installation with no derating of the UPS output shall be 3280 feet (1000 m) above sea level. At higher altitudes the following derating shall apply:
 - a. 1500 m (4921 feet) derating factor of 0.95.
 - b. 2000 m (6562 feet) derating factor of 0.91.
 - c. 2500 m (8202 feet) derating factor of 0.86.
 6. **Audible UPS noise at 1 meter from the cabinet:**
 - a. 400 kW: 72 dBA
 - b. 600 kW: 73 dBA
 7. **Access Requirements:**
 - a. The UPS shall require front access only for installation and field assembly. Servicing of the UPS shall only require front access for commonly serviced components, such as fuses, power modules, control circuits, contactors, and active components. No top, side, or back access shall be required for servicing said components of the UPS.
 - b. Replacement of air filters shall not require the system to be placed into maintenance bypass, nor shall it require personnel to be subjected to live voltage potential.

1.8 WARRANTY

- A. **Special Warranty:** The Contractor shall warrant the work of this Section to be in accordance with the Contract Documents and free from faults and defects in materials and workmanship for period indicated below. This special warranty shall extend the one year period of limitations contained in the General Conditions. The special warranty shall be countersigned by the Installer and the manufacturer.
1. **UPS Module:** The UPS shall be covered by a full parts and labor warranty from the manufacturer for a period of 12 months from date of installation or acceptance by the Owner or 18 months from date of shipment from the manufacturer, whichever occurs first.
 2. **Battery:** The battery manufacturer's warranty shall be passed through to the final Owner and shall have a minimum period of one year.
- B. **Additional Owner Rights:** The warranty shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to and run concurrent with other warranties made by the Contractor under requirements of the Contract Documents.

1.9 MAINTENANCE

- A. A complete offering of preventative and full service maintenance contracts for the UPS system and the battery system shall be available from the manufacturer. Contract work shall be performed by factory-trained service personnel.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. **Basis of Design:** Product specified is “APC Symmetra MW Multi-Module” as manufactured by APC by Schneider Electric. Items specified are to establish a standard of quality for design, function, materials, and appearance. Equivalent products by other manufacturers are acceptable. The Architect/Engineer will be the sole judge of the basis of what is equivalent.

2.2 MODES OF OPERATION

A. Normal:

1. **General:** The main inverter and delta inverter shall operate in an on-line manner to continuously regulate and supply power to the critical load. The input power converter and output inverter shall be capable of full battery recharge while simultaneously providing 100% regulated power to the load bus for all line and load conditions within the range of the UPS specifications.
2. **Recharge:** Upon restoration of the utility or on-site electrical generation AC input source, the input power converter and output inverter shall simultaneously recharge the battery and continue to provide 100% regulated power to the critical load bus.

- B. **Battery:** Upon utility or on-site electrical generation input failure or any out of tolerance condition as defined by this Section of the electrical AC input source, the critical load bus shall continue being supplied by the main inverter, which shall derive its’ power from the battery system. There shall be no interruption of power to the critical load bus during both transitions to battery operation and from battery to normal operation.

- C. **Static Bypass:** The static bypass shall be used to provide a seamless transfer of the critical load bus from the inverter output to the bypass source. This transfer, along with its’ retransfer, shall take place with no power interruption to the critical load bus. A transfer to static bypass may also occur in the event of an extreme overload condition, inverter output voltage out of tolerance condition or if commanded by the operator. This transfer shall be an automatic function with the exception of an operator-initiated transfer. The UPS shall automatically return to normal operation when the overload or out of tolerance condition is cleared.

- D. **Maintenance Bypass:** The UPS system shall be able to support an external MBC to electrically isolate the UPS during routine maintenance and service of the UPS. The MBC shall completely isolate both the UPS(s) input and output connections.

2.3 MODULARITY OF DESIGN

- A. **General:** The UPS shall be of modular design and construction consisting of independent 200 kW power converter sections configured from 400 kW to 1600 kW. Each power section shall consist of three 67 kW independent modules. Each power module shall allow easy frontal drawout accessibility for maintenance or system growth. Each module shall exhibit independent fault tolerance to other modules and shall allow for continuous system operation.

- B. **Redundant Configuration:** The UPS internal design shall allow for the selection of one to seven redundant 200 kW power module sections for Owner-selected redundancy level.

- C. **Fault Protection:** The UPS mechanical and electrical design shall combine to form a fault protection design base. In the unlikely event of an inverter module fault, each module shall be electrically and mechanically protected from the faulted unit and that the faulted unit shall not influence other modules or system operations. Each 200 kW power converter section shall incorporate independent time coordinated fusing with mechanical contactors to facilitate the rapid isolation of a failed section from the input, output, and DC buses, without sacrificing the critical load output bus.

- D. **Redundant Power Supply:** Each of the three 67 kW power converter modules shall contain a DC power supply to power the logic and control circuits of each respective 200 kW section. Loss of one DC power supply per 200 kW section shall not influence the performance of its’ respective 200 kW

section. Redundant power supplies shall be monitored by the UPS's internal and optional external monitoring system.

- E. **Redundant UPS Control Power:** Two main redundant power supplies shall also be provided for main logic circuits and interface signals of the UPS. These power supplies shall have multiple channels, each with their own overcurrent protection to provide fault containment. Each channel shall have tripped indicators to allow for rapid diagnostics and repair by on-site service personnel. UPS control power shall be monitored by the UPS's internal and optional external monitoring system.
- F. **Redundant Fans:** Each 67 kW power module shall contain redundant cooling fans to take in ambient air through filtered inlets on the front of the UPS. The loss of a fan in any or all of the 67 kW power modules shall not cause a derating of the ambient operating temperature of the UPS. Each 200 kW section shall contain four cooling fans and shall operate normally with the failure of any two section fans. Fans shall be monitored by the UPS's internal and optional external monitoring system for operation and speed.
- G. **Scalability:** The UPS shall be designed to allow the 200 kW power module sections to be added to accommodate future increases in load requirements to the maximum UPS frame size.
- H. **Proportional Load Sharing:** Based upon the modular construction of the system, it shall be possible to parallel UPSs of different sizes, or UPS frames with different quantities of power modules, creating a "differential load sharing system." In this manner of operation, each dissimilar UPS shall deliver to the parallel critical load bus up to a maximum of 100% of its capacity rating. In the event of a failure of a 200 kW power module section within the UPS, the UPS shall continue parallel operation and deliver power onto the parallel bus up to the full rating of the remaining power modules in the UPS.
- I. **Serviceability:** The UPS and external static bypass shall be designed to allow and facilitate field service personnel to replace a faulty inverter power module or any printed circuit board to a mean-time of 30 minutes or less. This time assumes on-site personnel with replacement components.

2.4 INPUT POWER CONVERTERS

- A. **General:** The input power converter of the UPS system shall constantly monitor and control the power imported from the utility or on-site electrical generation mains input. This monitoring and control function shall provide the necessary UPS power for precise regulation of the DC bus voltage, battery charging, and main inverter output voltage regulation.
- B. **Input Current Total Harmonic Distortion:** The input current THD shall be held to 5% or less while simultaneously providing conditioned power to the critical load bus, and charging the batteries under steady state operating conditions. The 5% maximum THD shall be held while supporting loads of both a linear or non-linear type, from 0 to 100% of the UPS capacity. The 5% maximum THD shall be accomplished with no additional filters, magnetic devices, or other components.
- C. **Soft-Start Operation:** As a standard feature, the UPS shall contain soft-start functionality, capable of limiting the input current from 0 to 100% of the nominal input current with no magnetizing inrush currents over a default 10 second period (with settings ranging from 1 second through 60 seconds). The UPS soft-start feature shall apply from initial UPS start-up and during power protection modes when returning from battery operation. Soft-start function shall be linear operation, not a step function.
- D. **Magnetization Inrush Current:** For ease of device coordination the UPS shall exhibit no inrush current to the electrical supply system as a standard product. If provided with an optional isolation transformer, inrush shall be limited to six times the nominal input current of the transformer.
- E. **Input Current Limit:**
 - 1. The input converters shall control and limit the input current draw from utility to less than 130% of the UPS output rated current whenever the system is in normal operation.

2. In cases where the source voltage to the UPS is nominal [480V][400V] and the applied UPS load is equal to or less than 100% of UPS capacity, input current shall not exceed 115% of UPS rated output current, while providing full battery recharge power.

- F. **Battery Recharge Current Limit:** The UPS shall be capable of limiting the energy sourced from the mains. As a default setting, the battery charge energy shall be set to 100% of its nominal value. When signaled by a dry contact (such as from an emergency generator), the UPS shall be capable of limiting the battery charge energy taken from the mains. This shall take place in Owner-selectable increments of 75%, 50%, 25%, 10%, and 0% of the nominal charge power. Value selectable selection shall be made from the UPS touch screen user interface.
- G. **Battery Charge Inhibit:** In addition to the battery recharge current limit function, a second set of battery charging control inputs shall be provided. When signaled by a dry contact, this second set of inputs shall signal the UPS to turn off battery charging. This option is useful if the UPS is auxiliary powered from a restricted or minimally sized on-site generator.

2.5 MAIN INVERTER

- A. **General:** The UPS output inverters shall continuously recreate the UPS output voltage wave form by converting the DC bus voltage to AC voltage through a set of IGBT driven bi-directional power converters. In both normal operation and battery operation, the output inverters shall create an output voltage independent of the mains input voltage. Input voltage anomalies such as brown-outs, spikes, surges, sags, and outages, shall not affect the amplitude or sinusoidal nature of the recreated output voltage sine wave of the output inverters.
- B. **Overload Capability:** The output power converters shall be capable of 240% sub-cycle for short circuit clearing. Steady state overload conditions, of up to 200% of system capacity, shall be sustained by the inverter for 60 seconds in normal operation. In battery operation the inverter shall be capable of sustaining 150% of system capacity for 30 seconds. Should overloads persist past the outlined time limitation, the critical load shall be seamlessly switched to the automatic static bypass output of the UPS.
- C. **Output Contactor:** The UPS shall be constructed to allow each (200 kW inverter to critical bus) connection to be configured with a mechanical contactor. This will allow for automatic positive physical bus isolation in the event of an inverter malfunction. Each 200 kW inverter section shall operate as an independent unit regardless of operational state of other inverters.
- D. **Fusing:** Each modular inverter shall have high speed time and energy coordinated fusing to provide fault isolation between inverters. Based on this feature, a fault within an individual inverter shall not cause a cascading failure of any other inverter connected to the critical bus of the UPS.
- E. **Battery Protection:** The UPS inverter shall be provided with monitoring and control circuits to limit the level of discharge on the battery system. The UPS logic and control circuits shall monitor the discharge constant, and automatically adjust shutdown level to 1.75 volts per cell for any discharge expected to last longer than approximately 60 minutes.

2.6 STATIC BYPASS

- A. **General:** As part of the UPS system, a system static bypass shall be provided. The system static bypass shall provide no break transfer of the critical load from the inverter output to the static bypass input source. This is beneficial during times when maintenance is required, or the inverter output can not support the critical bus. Such times may be due to prolonged or severe overloads, or UPS failure, causing an insufficient remaining number of UPS power converter modules. The UPS(s) and static bypass switch shall constantly monitor the auxiliary contacts of their respective circuit breakers, as well as the bypass source voltage, and inhibit potentially unsuccessful transfers to static bypass from taking place.
 1. 400kW UPS: Utilizes an internal bypass static switch rated for the full capacity of the UPS (400kW).

2. 600kW UPS: Utilizes an internal bypass static switch rated for the full capacity of the UPS (600kW).
 3. 800 to 1600kW UPS: The external bypass static switch shall be available in the following sizes:
 - a. 1000 kW.
 - b. 2000 kW.
 - c. 4000 kW.
 4. External bypass static switch input/output shall be [480 volts AC input, 3 wires plus ground][400VAC input, 4-wire 3P+PEN or 5-wire 3P+N+GND].
- B. **Static Bypass Switch:** The 800 kW to 1600 kW UPS unit shall incorporate freestanding external static bypass switch. The 400 kW to 600 kW UPS shall utilize internal static switches integral to the UPS module. When required, the 400 kW and 600 kW UPS can be configured with an external static bypass switch.
- C. **Design:** The design of the static switch power path shall consist of silicon-controlled rectifiers (SCR) with a continuous duty rating of 125% of the UPS output rating. Each set of SCRs shall be protected with time and energy coordinated fuses to limit the I²T to a value less than the I²T rating of the SCR.
- D. **Automatic Transfers:** The UPS shall be designed to allow a seamless automatic transfer of critical load to static bypass and shall take place whenever the load on the critical bus exceeds the overload rating of the UPS. A seamless automatic transfer of the critical load from static bypass back to normal operation shall take place when the overload condition is removed from the critical output bus of the system. The UPS shall be designed to allow a seamless automatic transfer of critical load to static bypass for any reason the UPS cannot support the critical bus.
- E. **Manual Transfers:** Manually initiated transfers to and from static bypass shall be initiated through the UPS touch screen interface or from the external static bypass touch screen (for UPSs with an external static bypass cabinet).
- F. **Overloads:** The static bypass switch shall be rated and capable of handling continuous overloads equal to or less than 125% of the rated system output current. For instantaneous overloads caused by inrush current from magnetic devices, or short circuit conditions, the static bypass shall be capable of sustaining overloads of 1000% of system capacity for periods of up to 500 milliseconds.
- G. **System Protection:**
1. Each input phase of the static bypass switch shall be protected by both time/energy coordinated fusing, and circuit breakers. Standard circuit breaker protection shall be of a molded case design; options shall be available for insulated case circuit breakers or draw-out power circuit breakers.
 2. As a requirement of UL 1778, back-feed protection in the static bypass circuit shall also be incorporated in the system design. To achieve back-feed protection, the circuit breaker serving as the input disconnect shall be controlled by the UPS/static switch, to open immediately upon sensing a condition where back-feeding of the static switch by any source connected to the critical output bus of the system is occurring.

2.7 PARALLEL OPERATION

- A. **General:** For purposes of load-sharing, the UPS shall contain as a standard feature, the ability to parallel up to four UPS modules (where each module does not have to be of equal size and power handling capacity of the before or after module(s)) plus a system static bypass switch for either increased capacity, redundancy, or both. When utilizing the internal static bypass, the system shall have the capability of paralleling a total of four UPSs for capacity. In this mode of operation, the output voltage, output frequency, output phase angle, and output impedance of each module shall operate in uniformity to ensure correct load sharing. This control function shall not require any additional footprint and shall be an integral function of each UPS.

- B. **Multi-Module UPS:** Multi-module UPSs shall be of the same design, voltage, and frequency. Multi-module UPSs of different size ratings shall be permitted to be paralleled together for purposes of increased capacity or UPS module redundancy.
- C. **Non-Redundant Operation:** In a non-redundant operating mode, all UPS modules shall be required to support their proportioned load of the critical load on its critical bus. In the event of a failure condition that disables one UPS module, the critical load shall be transferred to the static bypass feed should the remaining UPS(s) be overloaded to a level where they can no longer support the critical bus.
- D. **Redundant Operation:** In a redundant operating mode at least one UPS on the critical bus can be removed for maintenance, while the remaining UPS(s) supply the necessary load on the critical bus. In the event of a UPS failure, the failed UPS shall isolate itself through the use of input and output contactors, while the remaining UPS(s) supply load on the critical bus. The UPS system shall not be required to be placed into bypass operation for the removal/restoration of a redundant module to/from the bus.
- E. **Fault Tolerant Operation:** Based upon the modular design of the UPS(s), failure of a component, such as a 200 kW power module section, shall not require the UPS containing a failure to transfer to bypass unless the remaining power modules within the UPS are overloaded. The UPS with a failed power module shall still be capable of supporting load at the level of the remaining power modules on its critical bus. In this manner, differential load sharing may take place, to allow each UPS module to operate up to its capacity and not have to share load equally. In this mode of operation the UPS(s) may contribute load up to 100% of the capacity of the remaining power modules available.
- F. **Parallel Bus Communications:** For purposes of inter-module and static bypass switch communications, parallel UPS shall communicate with each other via a set of redundant parallel buses (PBUS 1 and PBUS 2). Each PBUS communication line shall be divided into two paths-one RS-485 and one controller area network (CAN). Time-critical communications shall be transmitted via the EIA 485 lines at a rate of 1.1 Mbps, and non-time critical data shall be transmitted via the CAN bus at a rate of 500 kbps. In this configuration, loss of one PBUS communication line shall not cause loss of system level communications. The parallel bus shall allow each UPS to exchange synchronization data, operation mode requests, load-sharing, and other such commands. Monitoring of the CAN lines in parallel bus one and parallel bus two shall detect the lack of communications of a given UPS or static bypass switch in the parallel installation.
- G. **Parallel System Controls:** To avoid single points of failure, the UPS system shall have no single dedicated control system designed to control the operation of parallel UPS(s). Control of and direction of parallel UPS shall take place via a master/slave relationship, where the first UPS to receive logic power asserts itself as a master. In the event of a master failure, a slave UPS shall take the role of master and assume the responsibility of the previous master UPS. Regardless of which UPS is master or slave, the owner shall be able to make changes to the system status (such as request for bypass) from any UPS connected to the bus and all UPSs on the bus shall transfer simultaneously.
- H. **Display:** Each UPS and external static bypass switch shall utilize a multi-color LCD touch screen display. Via an active touch screen mimic bus, it shall be capable of showing the quantity of UPS(s) connected to the critical bus, as well as its general status, such as circuit breaker status information.

2.8 DISPLAY AND CONTROLS

- A. **Touch Screen Interface:** A multi-color LCD touch screen user interface shall be supplied with both the UPS and external static switch cabinets, for the purposes of retrieving information from the UPS/static switch and providing control functionality. Data shall be transmitted between the UPS/static switch and the user interface via the system CAN bus.
- B. **Mimic Bus:** The default screen of the touch screen interface shall be a mimic bus of the installation, showing only those circuit breakers applicable to system operation on the UPS system. The mimic

bus shall depict power flow through the system and shall automatically change status to reflect any change in power flow through normal operation, static bypass operation, maintenance bypass operation, or battery operation. Parallel modules connected to the system shall be depicted at the display of each UPS. Specific details of a given UPS can only be accessed from the touch screen at that UPS.

1. The mimic bus power flow highlighting shall be color-coded green, for power flow through the UPS power conversion path, and yellow for static bypass or maintenance bypass operation. Changes in status of circuit breaker operation shall also be depicted on the mimic bus. The mimic bus shall also provide information such as power flow, voltage and current for the UPS input, output, bypass and battery.

C. **Metered Data:** Data shall be available in graphic and alphanumeric form. Input and output voltage and current wave forms shall be displayed. The following metered data shall be available on the UPS touch screen interface.

1. Input current.
2. Input current total harmonic distortion (THD_I).
3. Input crest factor.
4. Input voltage.
5. Input voltage total harmonic distortion (THD_V).
6. Input active power per phase.
7. Input apparent power per phase.
8. Total input active power.
9. Total input apparent power.
10. Input power factor.
11. Output current.
12. Output current Total Harmonic Distortion (THD_I).
13. Output crest factor.
14. Output voltage.
15. Output voltage total harmonic distortion (THD_V).
16. Output active power per phase.
17. Output apparent power per phase.
18. Total output active power.
19. Total output apparent power.
20. Output power factor.
21. Bypass current.
22. Bypass current total harmonic distortion (THD_I).
23. Bypass crest factor.
24. Bypass voltage.
25. Bypass voltage total harmonic distortion (THD_V).
26. Bypass active power per phase.
27. Bypass apparent power per phase.
28. Total bypass active power.
29. Total bypass apparent power.
30. Bypass power factor.
31. DC voltage.
32. DC current.
33. DC power.
34. Estimated charge time.
35. Estimated charge percentage.
36. Run time.
37. Ambient temperature.
38. Static bypass ambient temperature.

D. **Alarms:** Alarms shall be visible when active, from the user interface, by one pushbutton sequence on the touch screen interface. The alarm log shall show each entry with corresponding date and time stamp. The level of criticality shall also be displayed with each entry and shall be color-coded green, yellow, or red, based on their respective severity. This information can be transmitted locally

via the network management system. The following minimum set of alarm messages shall be available to depict the status of the UPS/static switch:

1. High battery temperature.
2. Battery grounding error.
3. Positive battery breaker open.
4. Negative battery breaker open.
5. Low battery warning.
6. High battery warning.
7. Low DC shutdown.
8. High DC shutdown.
9. Battery fault.
10. Input power failure.
11. Main static switch fan fault.
12. Input fuse fault.
13. Input power module section fuse fault.
14. Output fault.
15. Output off.
16. Output fuse fault.
17. Output section fuse fault.
18. Bypass synchronization error.
19. Bypass fault.
20. Bypass static switch fan fault.
21. Bypass static switch fuse fault.
22. Bypass static switch thyristor fault.
23. Bypass static switch back-feed protection activated.
24. Bypass static switch power supply fault.
25. Bypass temperature fault.
26. Inverter temperature fault.
27. Overload.
28. Inverter fan fault.
29. Inverter fuse fault.
30. Inverter fault.
31. EPO activated.
32. Output current limiter active.
33. High delta transformer temperature.
34. High switch choke temperature.
35. Power supply fault.
36. DC fuse fault.
37. Parallel communication error.
38. Parallel unit disabled.
39. Master changed.

E. **Controls:**

1. Control functions such as start-up, transfer to bypass, and parameter changes shall be accessible from the touch screen user interface. Operations such as start-up shall have step-by-step instructions from the user interface to ensure correct sequencing of operations. To further minimize operator error, the touch screen shall highlight in green, functions that have been completed. The current step in process shall also be outlined to ensure easy operation. One such user interface shall be part of both the UPS cabinet, and the static bypass cabinet, each sharing similar functions.
2. Intelligent logic shall also inhibit any state change such as “transfer to bypass” in the event bypass is unavailable, or a circuit breaker in the event the bypass power path is open. Also available, in addition to the touch screen user interface, shall be three clearly marked buttons, with a clear plastic hinged cover to prevent unintentional operation of such buttons. These buttons shall be located on both the UPS cabinet and the static bypass cabinet. Their functions shall be as follows:
 - a. **Green Button:** Shall turn UPS output on.
 - b. **Red Button:** Shall turn UPS output off.

- c. **Yellow Button:** Emergency module off button. Shall trip AC Input, output, and DC circuit breakers of that respective UPS.
3. An event log shall record event history that has taken place since the UPS was started, or since the last time the log was erased by the Owner. This log shall provide a date and time stamp of up to 1024 events which shall be removed in a first-in, first-out format.

2.9 ACCESSORIES

- A. **Battery Disconnect Breaker:** Each UPS system shall have two, 500 volts DC rated circuit breakers. Each circuit breaker shall have a 24 volts DC under voltage release and 2A/2B auxiliary contacts. The circuit breakers shall be in a separate NEMA 1 enclosure. When open, there shall be no battery voltage in the UPS enclosure. The UPS system shall be automatically disconnected from the battery by opening its breakers, should the UPS be subjected to a low battery shutdown state for an extended period of time, when signaled by a remote emergency power off (EPO) signal, or when the emergency module off button is pressed on the UPS. The battery disconnect enclosure shall also be equipped with the following minimum features:
 1. Controller area network (CAN) card for sending and receiving information to and from UPS.
 2. Lights that illuminate during "OK to Operate" conditions.
- B. **Maintenance Bypass Cabinet (MBC):**
 1. The MBC, purchased separately, shall provide power to the critical load bus from the bypass utility or on-site generation source, during times where maintenance or service of the UPS is required. The MBC shall provide a mechanical means of complete isolation of the UPS(s) from all sources of AC power. The MBC shall be constructed in a freestanding NEMA 1 enclosure unless otherwise stated in this Section.
 2. As a minimum, the MBC shall contain the following features and accessories:
 - a. Circuit breakers of the appropriate frame size, withstand rating (kAIC rating), and trip rating for the system.
 - b. Minimum 2A/2B auxiliary contacts for the purpose of relaying status information of each circuit breaker to each UPS static bypass.
 - c. CAN Interface circuit card to provide an intelligent interface between the switchboard/switchgear enclosure and each UPS and static switch.
 - d. Plated copper bus bar, braced for the appropriate withstand rating of the system.
 3. The following minimum options shall also be available for the MBC:
 - a. Key interlock to prevent out of sequence transfers of MBC from normal operation to bypass operation and back to normal operations.
 - b. Solenoid key release unit (SKRU).
 - c. Mimic bus with light indications for power flow.
 - d. Electrically operated circuit breakers
 4. The MBC shall carry one of the following agency listings:
 - a. UL 891.
 - b. UL 1558.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. **Verification of Conditions:** Examine areas and conditions under which the work is to be installed, and notify the Contractor in writing, with a copy to the Owner and the Architect/Engineer, of any conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.
 1. Beginning of the work shall indicate acceptance of the areas and conditions as satisfactory by the Installer.

3.2 INSTALLATION

- A. **General:** Preparation and installation shall be in accordance with reviewed product data, final shop drawings, manufacturer's written recommendations, and as indicated on the Drawings.
- B. **Factory-Assisted Start-Up:** If a factory-assisted UPS start-up is requested, factory-trained service personnel shall perform the following inspections, test procedures, and on-site training:
 - 1. **Visual Inspection:**
 - a. Inspect equipment for signs of damage.
 - b. Verify installation per manufacturer's instructions.
 - c. Inspect cabinets for foreign objects.
 - d. Verify correct electrolyte level of flooded cells (if applicable).
 - e. Inspect battery cases.
 - f. Inspect batteries for proper polarity.
 - g. Verify printed circuit boards are properly configured.
 - 2. **Mechanical Inspection:**
 - a. Check UPS, external maintenance bypass cabinet, and DC circuit breaker cabinet internal control wiring connections.
 - b. Check UPS, external maintenance bypass cabinet, and DC circuit breaker cabinet internal power wiring connections.
 - c. Check UPS, external maintenance bypass cabinet, and DC circuit breaker cabinet terminal screws, nuts, and/or spade lugs for properly seated or torque.
 - 3. **Electrical Inspection:**
 - a. Check UPS fuses for continuity.
 - b. Verify correct input and bypass voltage.
 - c. Verify correct phase rotation of mains connections.
 - d. Verify correct UPS control wiring and terminations.
 - e. Verify correct termination and voltage of battery strings.
 - f. Verify neutral and ground conductors are properly configured.
 - g. Inspect external maintenance bypass switch for proper terminations and phasing.
 - 4. **Site Testing:**
 - a. Ensure proper system start-up.
 - b. Verify proper control functions.
 - c. Verify proper bypass operation.
 - d. Verify proper maintenance bypass operation.
 - e. Verify system set points.
 - f. Verify proper inverter operation and regulation circuits.
 - g. Simulate utility power failure.
 - h. Verify proper charger operation.
 - i. Document, sign, and date test results.
 - 5. **On-Site Operational Training:** During the factory-assisted start-up, operational training for site personnel shall include, but shall not be limited to, key pad operation, LED indicators, start-up and shutdown procedures, maintenance bypass and AC disconnect operation, and alarm information.

3.3 FIELD QUALITY CONTROL

- A. **Manufacturer Field Service:**
 - 1. **Worldwide Service:** The UPS manufacturer shall have a worldwide service organization available, consisting of factory-trained field service personnel to perform start-up, preventative maintenance, and service of the UPS system and power equipment. The service organization shall offer 24 hours a day, 7 days a week, 365 days a year service support.
 - 2. **Replacement Parts:** Parts shall be available through the worldwide service organization 24 hours a day, 7 days a week, 365 days a year. The worldwide service organization shall be capable of shipping parts within four working hours or on the next available flight, so that the parts may be delivered to the Owner within 24 hours.

3.4 DEMONSTRATION

- A. **General:** Provide the services of a factory-authorized service representative of the manufacturer to provide start-up service and to demonstrate and train the Owner's personnel.
 - 1. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
 - 2. Train the Owner's maintenance personnel on procedures and schedules related to start-up and shutdown, troubleshooting, servicing, and preventive maintenance.
 - 3. Review data in operation and maintenance manuals with the Owner's personnel.
 - 4. Schedule training with the Owner, through the Architect/Engineer, with at least seven day's advanced notice.

- B. **UPS Training Workshop:** A UPS training workshop shall be available from the UPS manufacturer. The training workshop shall include, but shall not be limited to, a combination of lecture and practical instruction with hands-on laboratory sessions. The training workshop shall include, but shall not be limited to, instruction about safety procedures, UPS operational theory, sub-assembly identification and operation, system controls, adjustments, and preventative maintenance.

3.5 PROTECTION

- A. Provide final protection and maintain conditions in a manner acceptable to the Installer, that shall ensure that the solid state UPS shall be without damage at time of Substantial Completion.

END OF SECTION