



UNINTERRUPTIBLE POWER SUPPLY

MODEL

9800AE

MULTI MODULE SYSTEM
SPECIFICATIONS

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SECTION 16610
UNINTERRUPTIBLE POWER SUPPLY MULTI-MODULE SYSTEM (UPS MMS)

1. GENERAL

1.1. SUMMARY

- A. This specification describes a three-phase, continuous duty, on-line solid-state Uninterruptible Power Supply Multi-Module System, hereafter referred to as the UPS MMS and a Critical Load Cabinet (CLC) that parallel connects individual UPS Module power circuits to offer system capacity or redundancy to support the critical load.
- B. The UPS shall operate utilizing the existing power distribution system to provide a high quality, reserve source of power to electronic equipment loads. The system shall consist of a rectifier, system battery; solid-state inverter, automatic static bypass transfer circuit and integral maintenance bypass circuit.
- C. The manufacturer shall design and furnish all materials and equipment to be fully compatible with electrical, environmental, and space conditions at the site. It shall include all equipment to properly interface the AC power source to the intended load and be designed for unattended operation. The CLC cabinet shall be manufactured with a modular design to allow for ease of system expansion with the addition of like rated UPS Modules.

1.2. STANDARD

The UPS MMS has been designed in accordance with and complies with the following standards:

- A. UL 1778 - (Underwriters Laboratories) Standards for UPS Equipment.
- B. CSA 22.2 - (Canadian Standards Association - CUL Equivalent). [UL1778 and CSA 22.2 labels attached to each UPS Module.]
- C. IEC - (International Electro-technical Commission) Semiconductor Converter Standards (#62040-3.2.16).
- D. IEEE 587, ANSI C62.41 1991 Standards for Surge Withstand Ability.
- E. UL 891 [CLC manufactured for UL891 compliance]
- F. ISO 9001 Quality Assurance program.

1.3. UPS MMS SYSTEM DESCRIPTION

1.3.1. Components

The UPS system shall consist of the following major equipment and can be divided into two sections and shall be comprised of the following:

- A. Hybrid Converter Section:
 - 1. AC input
 - 2. Converter input contactor
 - 3. Converter input fuses
 - 4. Input harmonic filter
 - 5. Hybrid converter utilizing high power diode bridge rectifier insulated Gate Bipolar transistor (IGBT) applied charger/booster.

- B. DC Input and associated Battery System
(including battery disconnect circuit breaker).
- C. Inverter Section:
 - 1. Solid-state Pulse Width Modulation (PWM) inverter utilizing IGBT
 - 2. Inverter input fuses
 - 3. Isolation transformer
 - 4. Inverter output contactor
- D. Bypass Static Switch Circuit (sized to provide fault clearing):
 - 1. Bypass input
 - 2. Bypass static switch with primary contactor.
- E. UPS Module Control and Monitoring:
Converter, Inverter and independent automatic bypass static switch circuit operation control.
- F. UPS MMS Control, incorporating:
 - 1. UPS MMS Bypass Operation Control.
 - 2. UPS MMS Parallel Operation Control.

THE UPS MMS Control governs multiple UPS Module parallel operation and associated UPS MMS operational conditions

- G. Interface terminal for connecting control cables between each individual UPS Module (for UPS MMS Control):
 - 1. Cross Current Control signal cable
 - 2. Inverter Operation Logic signal cable
- H. Operation/Display panel incorporating:
 - 1. Graphic Operator Terminal Liquid Crystal Display (LCD): 5.7 inch Monochrome touch screen with high communication capability. Ethernet (10Base-T) utilized for Monitoring System Optional Expansion Bus Interface for field network connectivity available.
 - 2. LED indication.
 - 3. Emergency Power Off (EPO) button (for UPS Module shutdown).
- I. UPS Module status and function interface.
 - 1. UPS MMS Bypass Operation Control
 - 2. UPS MMS Parallel Operation Control.
- J. Additional UPS Module Monitoring functions:
 - 1. Via Personal Computer (PC) - Mitsubishi Electric Diamond Link Software
 - 2. Via Netcom (SNMP/Web Card)

1.3.2. Critical Load Cabinet (CLC)

The CLC shall be comprised of Power Section and the Monitoring Section. The CLC shall incorporate a modular design to allow ease of system expansion.

- A. CLC Power Section
The Power Section shall consist of the following:

1. UPS Module output circuit breakers - 52L1, 52L2 up to 52L8 depending on system UPS Module quantity.
2. Bypass Circuit Load Sharing Reactors (if required) ACL1, ACL2 up to ACL8 depending on system UPS Module quantity.
3. Parallel bus power circuit.
4. Neutral Bar (if required).
5. Load bank test circuit (Option)
6. System Maintenance Bypass circuit breaker (SMB) and power circuit.
7. System Output circuit breaker (52L).
8. System output power circuit and terminals.
9. SMB, 52L Interlock System.
10. Interface terminal for CLC circuit breaker status.

B. CLC Monitoring Section

The Monitoring Section shall be located in a separate enclosure to the Power Section. The Monitoring Section incorporates a Monitoring System that consists of the following:

1. Main Graphic Operator Terminal (GOT)
2. Programmable Logic Controller (PLC).
3. Ethernet Hub (N Port depending on system UPS quantity).
4. GOT screen display software.
5. System Emergency Power off (System EPO) push button that will shutdown all system UPS Modules. The CLC System EPO contacts will be hard wired to each system UPS Module external signal terminal block (Input terminal – Remote EPO).

1.4. UPS MMS OPERATION

The UPS shall be designed to operate continuously at rated capacity as an on-line, automatic reverse transfer system and will supply uninterruptible power to the critical load in the following modes;

- A. Normal - The inverter continuously supplies AC power to the critical load. The rectifier converts a utility AC power source to regulated DC power which then serves as the inverter input and, simultaneously, as a float charge input to the storage battery.
- B. Emergency - In the event of a utility AC power failure, UPS Module inverter input is derived from the system batteries, therefore providing uninterrupted power to the critical load. This transition occurs with no interruption of power to the critical load from either failure or the restoration of utility AC power.
- C. Recovery Charge - Subsequent to restoration of utility AC power and prior to the system battery final voltage, each UPS Module hybrid converter (rectifier and charger/booster) automatically reactivates and provides DC power to the inverter, simultaneously recharging the system battery. This occurs automatically and without interruption to the critical load.
- D. Normal, Emergency and Recovery Charge Parallel Operation - UPS MMS Control, incorporating UPS MMS Parallel Operation Control in each UPS Module utilizes cross current control signals between the UPS Modules to calculate and perform fast simultaneous inverter reference voltage and phase waveform control. This Instantaneous UPS MMS Parallel Operation Control ensures that at all times the load is shared equally

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between the UPS Module inverters and that the inverter outputs are synchronized.

- E. UPS-MMS Bypass Operation - Each UPS Module contains an independent automatic bypass static switch circuit and associated control circuitry (UPS Module Control and UPS MMS Bypass Operation Control). The same bypass source shall be connected to each UPS Module bypass input, with each UPS Module bypass static switch circuit utilized during UPS MMS Bypass Operation. For uninterrupted transfer of the load to the bypass source and to UPS MMS Bypass Operation, the bypass source must be available. If the bypass source has failed or is abnormal, the bypass source will be deemed unavailable and an uninterrupted transfer of the critical load to the bypass source is not guaranteed. In the event that the UPS MMS must be transferred from UPS MMS Inverter Operation due to a system overload condition or for System Maintenance Bypass requirements, the critical load shall be transferred without interruption to the bypass source via each UPS Module bypass static switch circuit. The UPS MMS Bypass Operation Control in each UPS Module will signal to the UPS Module Control to initiate transfer to bypass operation. A paralleling, wrap-around contractor shall be used in each UPS Module bypass static switch circuit to maintain the bypass source. Each UPS Module bypass circuit will equally share the total load current. This condition is referred to as UPS MMS Bypass Operation and should only be initiated during automatic emergency or manually controlled events.
- F. System Maintenance Bypass/ Operation – System Maintenance Bypass Operation shall allow total system repair and testing for parallel operation as well as individual UPS Module repair and testing without affecting load operation. The CLC contains as standard a System Maintenance Bypass circuit breaker (SMB) and power circuit, and a System Output circuit breaker (52L) and output power circuit. SMB shall be a Make-Before-Break, zero energy type circuit breaker to ensure maximum load reliability and personnel safety. The system bypass source is a common feed to the UPS Module bypass inputs and also the CLC System Maintenance Bypass input. An electro-mechanical interlock system will prevent closure of the SMB circuit breaker and subsequent opening of 52L circuit breaker unless UPS MMS Bypass Operation is active. This interlock system removes any possibility of connecting together out of phase sources and additionally ensures a safe operating practice and isolation procedure for system maintenance requirements.
- G. Inverter and Bypass Operation Inhibit -The UPS MMS Bypass Operation Control contained in each independent UPS Module ensures that UPS MMS Inverter and UPS MMS Bypass Operation will never occur simultaneously. Bypass operation transfer will be inhibited if any of the systems UPS Modules are providing load power by inverter supply. Re-transfer operation from UPS MMS Bypass Operation to UPS MMS Inverter Operation will be inhibited if any of the systems UPS Modules are providing load power from bypass source supply. The same bypass source (common source) is connected to each UPS Module bypass input therefore synchronization does not need to be considered. For equal load sharing, a load sharing reactor shall be incorporated in each UPS Module circuit to ensure bypass circuit impedance balance and that each bypass circuit supports an equal share of the total load current during bypass operation. Each circuit reactor will be located in the CLC.
- H. Module Maintenance Operation - With the UPS MMS it is possible for individual UPS Modules to be removed from the system for maintenance purposes while the remaining UPS Modules sustain on-line power to the load from inverter supply. The configuration of the system must be taken into consideration very carefully prior to individual UPS Module Maintenance Operation.
- I. Individual UPS Module Emergency Power Off (EPO) - When the UPS Module Emergency

Power Off (EPO) button is activated, the EPO function shuts down the UPS module. The configuration of the UPS MMS will depict the subsequent system operation: The EPO function can be performed both locally at the UPS Module and remotely from the CLC System EPO button. The System EPO button shall be located on the CLC next to the Monitoring System.

- J. Monitoring System Operation - The Monitoring System will monitor all UPS MMS components and display UPS MMS operational status and information on the Human Machine Interface (HMI). UPS MMS operation sequences shall also be possible from the Monitoring System HMI, and system summary alarm and user selectable system alarm contacts available.

1.5. SUBMITTALS

1.5.1. Proposal Submittals

Submittals with the proposal shall include;

- A. System configuration with single line drawings.
- B. Functional relationship of equipment including weights, dimensions, and heat dissipation.
- C. Descriptions of equipment to be furnished, including deviations from these specifications.
- D. Size and weight of shipping units to be handled by installing contractors.
- E. Detailed layout of customer power and control connections.
- F. Detailed installation drawings including all terminal locations

1.5.2. Delivery Submittals

Submittals upon UPS delivery shall include;

- A. Shop Drawings - Submit system configurations with single line diagrams, detailed layout of power and control connections, dimensional data and detailed installation drawings including all terminal locations.
- B. Product Data - Provide product data for UPS and battery including catalog sheets and technical data sheets to indicate electrical performance, UPS type, battery type, detailed equipment outlines, weight, dimensions, control and external wiring requirements, heat rejection and air flow requirements.
- C. Owners and technical manual (1).
- D. Test Report - Submit a copy of factory and field test reports.

1.6. ENVIRONMENTAL CONDITIONS

- A. The UPS shall be capable of withstanding any combination of the following external environment conditions without mechanical damage, electrical failure or degradation of operating characteristics.
 - 1. Operating ambient temperature: 0 degrees C to +40 degrees C (32 degrees F to 104 degrees F) no derating required.
 - 2. Recommended operating temperature range: +20 degrees C to +30 degrees C (68 degrees F to 86 degrees F).

3. Non-operating and storage ambient temperature: -20 degrees C to +70 degrees C (-4 degrees F to 158 degrees F).
 4. Operating relative humidity: 5% to 95 %, non-condensing.
 5. Recommended operating relative humidity: 30 % to 90%.
 6. Operating altitude: Sea level to 2700 meter (9000ft).
 7. There should be no inflammable / explosive gas.
 8. Dust in the room where the UPS is installed must not exceed normal atmospheric dust levels. In particular, that dust should not include iron particles, oils or fats, or organic materials such as silicone.
- B. Audible acoustical noise: Noise generate by the UPS, when operating single module under full rated load, at a distance of one meter from any UPS operator surface, shall not exceed dB as measured on the A scale of a standard sound level meter at slow response.
- C. Input surge withstand capability: The UPS shall be in compliance with IEEE C62.41, Category B.

1.7. WARRANTY

The UPS manufacture shall warrant to the original end user that the Uninterruptible Power Supply System sold by Mitsubishi Electric Power Products, Inc. (the "Product") shall be free from defects in material and workmanship under normal use and service for a period of twenty four (24) months from the date of installation or thirty months (30) months from the date of shipment of the Product, whichever comes first, at the premises of the original end user.

1.8. QUALITY ASSURANCE

1.8.1. Reliability and Maintainability

The UPS equipment reliability shall be represented in terms of theoretical Mean –Time – Between - Failures (MTBF). The UPS manufacturer shall, as a minimum, provide the following capability:

- A. UPS module output includes reliability of bypass circuit: 1,000,000 MTBF hours.
- B. UPS module operation output, without bypass circuit: 120,000 MTBF hours.

1.8.2. Maintainability

MTTR of the UPS shall not exceed 1 hour including time to replace components.

1.8.3. Factory Test

- A. The manufacturer shall fully and completely test the UPS module to assure compliance with the specifications, before shipment.
- B. All UPS units shall come equipped with one (1) factory test report included in the UPS enclosure. The factory test report shall include the following:

1. Series / kVA
2. Serial Number
3. Date of test
4. Approved by / Inspected by / Tested by
5. Inspection of construction
6. Checking of wiring (Black/Red marking on each connection point)
7. Grounding Continuity
8. Insulation strength test
9. Control Circuit Operation
10. Measurement of steady state characteristics (Voltage/ current/ efficiencies)
11. Transient characteristics (0-100% step load, without batteries/ voltage fluctuation)
12. Overload Testing
13. Transfer switch operation

2. PRODUCT

2.1. THE UPS SHALL HAVE THE FOLLOWING ELECTRICAL CHARACTERISTICS

2.1.1. UPS MMS Capacity

The 9800A Series UPS Module is available in the following sizes:

kVA	kW
100	80
150	120
225	180
300	270
375	337.5
500	450
750	675

Up to Eight (8) UPS Modules of equal kVA size may be paralleled together to provide the required UPS MMS capacity or redundancy.

UPS Module output capacities are in accordance with the following power factors:

- A. 100 kVA ~ 225 kVA 0.8 pf lagging
- B. 300 kVA ~ 750 kVA 0.9 pf lagging

2.1.2. UPS Module AC Input Specification

- A. Configuration: 3-phase, 3-wire
- B. Nominal Input Voltage: 480V
- C. Input Voltage Range: +15%, -15%
- D. Input Frequency and Range: 60 Hz \pm 5%
- E. Input Power Factor: 0.98 (Typical) at 100% Load, 0.90 (Typical) at 50% Load
- F. Reflected Input Current: 6% (Typical) at 100% Load, 9% (Typical) at 50% Load

2.1.3. UPS Module Bypass Input Specification

- A. Configuration: 3-phase, 4-wire

- B. Nominal Input Voltage: 480V, 600V
- C. Input Synchronization Voltage Range: $\pm 10\%$ of Nominal
- D. Input Frequency Tracking Range: 60 Hz $\pm 5\%$ Maximum [Bypass Synchronous range shall be selectable from 1% to 5% in 1% increments]

2.1.4. UPS Module Output Specification

- A. Configuration: 3-phase, 4-Wire
- B. Nominal Output Voltage: 480V, 600V
- C. Nominal Dynamic Voltage Regulation: $\pm 1\%$ for Unbalanced Load
- D. Manually Adjustable Output : $\pm 5\%$, Voltage Range:
- E. Voltage Transient Response:
 - 1. 100% Step Load: $\pm 2\%$
 - 2. Loss or Return of AC Input: $\pm 1\%$
 - 3. Inverter \leftrightarrow Bypass Transfer: $\pm 5\%$

[Voltage Transient Response shall not exceed the above and shall recover to within: Nominal Voltage Regulation tolerance within 16.7 msec.]
- F. Output Frequency: 60 Hz [$\pm 0.05\%$ UPS Module in asynchronous mode - bypass source unavailable] (Synchronization Master UPS Module)
- G. Output Frequency Slew Rate: 1 through 10 Hz/second [Selectable in 1 Hz/second increments] [UPS Module inverter main synchronization reference - bypass source] (Synchronization Master UPS Module)
- H. Voltage Phase Angle Displacement:
 - 1. $\pm 1^\circ$ for 100% balanced Load
 - 2. $\pm 3^\circ$ for 100% unbalanced Load
- I. Output Voltage Total Harmonic Distortion:
 - 1. 2% Maximum at 100% Linear load
 - 2. 5% Maximum at 100% Non-linear load
- J. Output Overload Capability:
 - 1. 105% to 125% for 10 minutes (Voltage Regulation maintained)
 - 2. 126% to 150% for 1 minute (Voltage Regulation maintained)
- K. Output Fault Clearing:
 - 1. Typically 1000% for 1 cycle (Utilizing bypass source)(100kVA to 225kVA)
 - 2. Typically 500% for 1 cycle (Utilizing bypass source)(300kVA to 750kVA)

2.1.5. UPS Module DC Input and Battery System Specification

- 1. Voltage: 480V DC Nominal, 400V DC Minimum
- 2. DC Ripple (Normal Operation): Less than 2% of DC Voltage
- A. The Battery System shall be sized to provide the specified back-up time to the inverter when the UPS is supplying 100% rated load.
- B. Each Battery System shall include a disconnect 600V DC circuit breaker to facilitate isolation of UPS Module DC Input and the Battery System. The DC Circuit breaker shall incorporate an UVT relay and auxiliary contact connections to the UPS Module control for prevention of incorrect start up and shutdown sequencing.
- C. The battery system shall be capable of operating in an average ambient temperature of 25°C, with excursions of 16°C to 32°C and shall be sized as follows:
 - Float Voltage: 545V DC (2.25 to 2.27 V/cell)

- Final Voltage: 400V DC (1.67 V/cell)

2.1.6. UPS Module Efficiency

UPS Module Capacity (kVA)	Battery to AC (100% Load)	AC to AC (100% Load)
100	93.5	93.5
150	93.5	93.5
225	93.0	93.0
300	93.5	93.5
375	93.5	93.5
500	94.0	94.0
750	94.0	94.0

2.1.7. CLC Power Section specification

The CLC Power Section total kVA capability and associated component ampere ratings will be dependent on the total UPS MMS configuration, kVA capacity and output voltage specification. Refer to Mitsubishi Electric CLC Specification for further details. For detailed information including associated KAIC ratings, refer to Mitsubishi Electric CLC Specification, UPS MMS Single Line Diagrams (for system configuration and capacity permutations).

2.1.8. Output Specification

Each system UPS Module shall instantaneously control and equally share the total critical load current within less than +/-5% of UPS Module rated current.

2.2. UPS MODULE COMPONENTS

2.2.1. Hybrid converter shall be comprised of the following;

- A. High Power Diode Bridge Rectifier which converts the utility AC input power into regulated DC power that serves as the inverter input and also as dc charge power to the system battery through the chopper/booster. An AC reactor and capacitor shall filter the harmonic content of rectifier input.
- B. Reflected Harmonic Content in the high power diode bridge rectifier shall typically not introduce more than 6% reflected input current total harmonic distortion (THD) into the utility AC input source at nominal voltage and rated load. The reflected input current shall typically not exceed 9% THD at 50 % load.
- C. The rectifier logic and control circuit power walk in function enables delayed and timed ramping of input current. Subsequent to energizing the rectifier input, initiation of the power walk in function and current ramping shall be delayed by a maximum of 3600 seconds (every 1 second selectable – default at 10 second). Upon initiation of the power walk-in function, the ramping of current shall be timed to gradually increase the load within 10 seconds. This function is included as standard in the rectifier control circuitry.

- D. Converter input contactor, input fuses, and the input current limit control shall provide rectifier protection against excessive input overload conditions.
- E. In the occurrence of a 100% step load change, the UPS Module inverter shall draw power only from the rectifier to provide the required load demand. The charger/booster shall not be utilized and the system batteries will not be cycled at any time during a step load change.

2.2.2. Charger/Booster

- A. The charger/booster utilizes solid state Pulse Width Modulation (PWM) controlled Insulated Gate Bipolar Transistors (IGBT). The charger switching frequency is 10kHz, and the booster switching frequency 2kHz.
- B. The Battery Charge Current charger logic and control circuit DC battery current limiting function enables controlled battery charging. The battery charge current limit will control the recharge current by reducing the rectifier/charger output when the set limit is reached. The following battery current limit shall be provided as a minimum:
 - 1. Battery charge current limit: 10% of battery Ah rate.
 - 2. Maximum charge current: 13% of UPS rated kVA.
(e.g. 13ADC maximum of 100kVA UPS)

- C. Equalize Charge Timer: UPS Module logic and control shall provide an electronic equalize charge timer function (0 to 50 hour selectable - default twenty-four (24) hour). Once activated the timer circuit shall provide a high rate equalizing charge voltage to the system battery for the selected time. The function can be manually activated and de-activated via the UPS Module LCD.

The level of equalizing voltage shall be equal to that stated by the battery manufacturer (typically 0.04 to 0.08 VDC/cell higher than the specified float level). Upon completion of the timer count, the converter output voltage shall return to the specified float voltage (typically 2.25 to 2.27 VDC/cell). An Auto Equalize charge operation is also provided following AC input restoration and subsequent to the power walk in function. This equalizing charge will occur until the battery target voltage is reached (condition is met to end equalizing charge), in which float voltage will be applied.

- D. Battery Temperature Compensation; The UPS shall have as standard a battery temperature compensation function allowing the rectifier voltage to fold-back to a safe value in the event the battery system temperature reaches a pre determined (dangerous) level. Initiation will be by dry contact input from thermocouple sensor (User supplied)
- E. DC Input protection: The DC input circuit shall be protected by a DC circuit breaker. The DC circuit breaker allows complete interruption of DC current and isolation of the UPS Module DC input and the battery system. The DC Circuit breaker shall incorporate an UVT relay and auxiliary contact connections to the UPS Module control for prevention of incorrect start up and shutdown

sequencing. The DC Circuit Breaker shall be provided as standard equipment.

- F. Charger/Booster protection: The DC input to the Charger/Booster shall utilize fuses for overload protection. The fuses shall be fast acting semiconductor type to clear faults on the DC link.
- G. Ripple voltage; The DC (battery) bus RMS ripple voltage shall be less than 2% of the UPS nominal DC voltage level at 100% load. This shall provide for maximum battery life.
- H. Battery Self Test (Diamond-Sense); for a short duration, a small power discharge from the battery is automatically performed. The UPS module, from this small power discharge, evaluates the degradation of the system battery. The following advantages are achieved:
 - 1. The Diamond-Sense Battery Self-Test function can be performed even when load is on inverter.
 - 2. Due to the short duration small power discharge, there is no effect to battery life expectancy.
 - 3. The small power discharge has negligible effect on the overall battery back up time. The small power that is discharged by the battery will quickly be replenished.
 - 4. The Battery Self Test will automatically occur every 720 hour interval. An event alarm will occur and be displayed if battery abnormalities are detected.
- I. Input Current Limit
The rectifier and booster logic and control shall provide an input current limiting function that limits AC input current. Two current transformers in separate locations on the output (and operating separately offering redundancy) shall be employed as means of current sensing.
 - a. Input current limit setting: 110% of nominal rated current.
 - b. The AC input current limit shall be set up so that the rectifier/charger can provide sufficient capacity to the inverter at rated load and have the capability to recharge a discharged battery.
 - c. The input current limit protects hybrid converter components from damage due to excessive input current.
- J. Input Power Demand: The rectifier and booster logic and control shall also be capable of providing auxiliary current limiting when initiated by an external dry contact closure (e.g. in the event power demand is required when the UPS is fed from a motor generator). Power Demand: Adjustable, Maximum 103% of nominal rated current.

2.2.3. Inverter

- A. The inverter shall generate AC power derived from DC power supplied from the rectifier or system battery. The inverter shall be capable of providing rated output as specified while operating from any DC voltage within the battery operating range. The inverter shall utilize the following technology:

1. Solid state PWM controlled IGBT power transistors switching at 2 kHz (average switching frequency). Utilizing the adoption of a unique Mitsubishi Electric Modulation method, enabling improved switching frequency (for efficiency improvement) and high-speed response. Switching shall be defined as IGBT turn on and turn off rate. (Apparent doubling of frequency at inverter output due to simultaneous IGBT device activation shall not be considered as the true switching frequency.)
 2. UPS Module Full Direct Digital Control (DDC) Adoption:
 - a. Field Programmable Gate Array (FPGA) Control
 - b. DSP based Control
 - c. DSP Sampling Frequency is 30 kHz, therefore the control samples 500 times in 1 cycle of output voltage. Output voltage is controlled with high precision.
- B. Voltage Regulation
- The inverter output voltage shall not deviate by more than +/- 1% RMS with the following steady state conditions:
1. 0 to 100% loading.
 2. Inverter DC input varies from maximum to minimum.
 3. Environmental condition variations within the specifications defined herein.
- C. Voltage Adjustments
1. The inverter shall have the ability to manually control and adjust the output voltage to within +/-5% of the nominal value.
- D. Voltage Transient Response
1. The dynamic regulation and transient response shall not exceed +/-2% for 100% step load (applied or removed), +/-1% for loss or return of AC input and +/-5% for inverter to bypass and vice versa transfer.
- E. Transient Recovery
1. Voltage transient response shall not exceed the above specification and shall recover to within nominal voltage regulation tolerance within 16.7 ms
- F. Frequency Control
1. The output frequency of the inverter shall be controlled according to the unique synchronization control system incorporated in the UPS MMS Control and the UPS MMS Parallel Operation Control.
 2. The main synchronization reference for the Synchronization Master UPS Module Inverter will be derived from either the bypass source or from the UPS Modules own internal oscillator – clock (depending on bypass source availability). All other system Synchronization Slave UPS Modules will utilize the cross current control signals between the UPS Modules for

synchronization reference by means of fast simultaneous inverter reference voltage and phase waveform control.

3. The lowest number UPS Module operating in the system will be designated as the Synchronization Master. The Synchronization Master UPS Module shall track the bypass source within the selected bypass synchronous range (default 1% - selectable from 1% to 5% in 1% increments).
4. When the Synchronization Master UPS Module is running in asynchronous mode (own oscillator), output frequency specification shall be within nominal $\pm 0.05\%$. The inverter output frequency shall not vary during steady state or transient operation due to the following conditions:
 - a. 0 to 100% loading.
 - b. Inverter DC input varies from maximum to minimum.
 - c. Environmental condition variations within the specifications defined herein.

G. Output Harmonic Distortion

The inverter output shall limit the amount of harmonic content to 2% maximum at 100% linear load, and 5% maximum at 100% non-linear load. The need for additional filtering to limit the harmonic content shall not be required. Therefore high efficiency, reliability and original equipment footprint are maintained.

H. Output Overload Capability

The inverter output shall be capable of providing an overload current while maintaining rated output voltage (and voltage regulation) to:

1. 105% to 125% for 10 minute duration.
2. 126% to 150% for 1 minute duration.

The UPS Module Operation/Display panel LED indication will illuminate to identify an overload condition. If the time limit associated with the overload condition expires or the overload is in excess of the set current, the load power shall be transferred to the bypass source without interruption.

I. Inverter Current Limit

The inverter output current shall be limited to 212% of rated load current. Two current transformers in separate locations on the output (and operating separately offering redundancy) shall be employed as means of current sensing.

The inverter current limit protects inverter components from damage due to excessive over-current (Excessive load, faults and reverse current)

J. Inverter Overload Protection

The inverter output shall utilize the electronic inverter current limiting for protection against overload conditions (excessive overload, faults). The inverter shall utilize a contactor to isolate its output from the critical bus and the load transferred to the bypass source. The bypass static switch circuit shall be sized to provide fault clearing. The inverter output isolation contactor shall be located internal to the UPS module and shall be controlled by the internal UPS

Module control.

The DC input to the Inverter shall utilize fuses for overload protection. Inverter fuses shall be fast acting semiconductor type to clear faults on the DC link.

K. Inverter Output Isolate

The inverter output contactor isolates the inverter from the load and bypass source.

L. Line Drop Compensation

The inverter shall be provided with circuitry such that its output voltage rises linearly with output current. The rise shall be required to achieve this function, and it shall not interfere with other requirements of this specification. The purpose of this feature is to compensate for varying line drop voltage between the inverter and the critical load

M. Inverter Operation Inhibit

The external dry contact can inhibit the inverter operation. When UPS condition is load on inverter, load is transferred to bypass.

2.2.4. UPS Module Control and Monitoring.

A. UPS Module Control and Monitoring operates and controls the hybrid converter, inverter and independent automatic bypass static switch circuit (working in conjunction with UPS MMS Control).

B. The UPS Module control circuitry utilizes Digital Signal Processor (DSP) and Application Specified IC (ASIC) which create advanced controllability and simplify the control circuit. Direct Digital Control (DDC) utilizing DSP and ASIC ensures high reliability, as well as superior functionality and performance

C. The UPS Module utilizes unique Major and Minor Feed Forward Current Loop Control, enabling instantaneous control of UPS Module output. The digitalized UPS Module incorporates Field Programmable Gate Array (FPGA) for Current Minor Loop Control, and DSP based control for Feed Forward Control and Voltage Major Loop Control. DSP Sampling Frequency is 30kHz, therefore the control samples 500 times in 1 cycle of output voltage. Output voltage can therefore be controlled with high precision.

D. The UPS Module inverter utilizes solid state PWM controlled IGBT power transistors, with the adoption of a unique Mitsubishi Electric Modulation method, enabling improved switching frequency (for efficiency improvement) and high-speed response.

E. All UPS Module Control and Monitoring printed circuit boards shall be hermetically sealed to protect against corrosive vapors.

F. The UPS Module Control power supply employs a redundant design configuration, utilizing the UPS AC input (utility), Bypass input and the UPS Module inverter output therefore enhancing reliability.

2.2.5. Bypass and Static Switch

- A. Each UPS Module contains an independent automatic bypass static switch circuit and associated bypass static switch transfer control circuitry (UPS Module Control and UPS MMS Bypass Operation Control). Refer to the previous section UPS MMS Bypass Operation. The bypass circuit shall be the alternate source of power to the critical load other than by inverter supply. The static switch shall be a high speed transfer device comprised of naturally commutated SCR's. The static switch and a wrap around contactor shall be used to feed the critical load during automatic or manual transfers to the UPS Module bypass static switch circuit.
- B. The wrap around contactor shall be electrically connected in parallel to the static switch and shall at the same time as the static switch, be energized and upon closure maintain the critical load feed from the bypass source. The static switch shall only be utilized for the time needed to energize the wrap around contactor therefore increasing reliability. The bypass circuit shall be capable of supplying the UPS rated load current and also provide fault clearing current capabilities. The UPS MMS Bypass Operation Control, will upon signaling the UPS Module Control to initiate transfer to bypass operation, cause the static switch to energize within 150 μ s, therefore providing an uninterrupted transfer to the bypass source (UPS MMS Bypass Operation).
- C. In relation to automatic re - transfer from UPS MMS Bypass Operation to UPS MMS Inverter Operation upon overload clearance. The UPS MMS Bypass Operation and UPS Module Control shall allow a re-transfer to occur three times maximum within a one minute period. Re-transfer shall be inhibited upon the fourth request for protection from a suspect recurring problem at the UPS load distribution.
- D. With each UPS Module incorporating an independent automatic bypass static switch circuit and associated control; system reduction with the capability to utilize the removed UPS Module for Single Module System (SMS) application or other system configurations is possible. This feature results in high system flexibility, with ease of expansion or reduction of the UPS MMS.

2.2.6. UPS MMS Control

UPS MMS Control, incorporating UPS MMS Parallel and Bypass Operation Control in each UPS Module utilizes cross current control and inverter operation logic signals between the UPS Modules to ensure correct UPS MMS operation.

- A. UPS MMS Bypass Operation Control:
 - 1. The UPS MMS Bypass Operation Control contained in each independent UPS Module ensures correct system transfer to and re-transfer from bypass operation and that UPS MMS Inverter and Bypass Operation will never occur simultaneously.

2. Referring to the previous section UPS Module Inverter Shutdown, subsequent to a UPS Module inverter shutdown, the shutdown UPS Module inverter will automatically isolate from the system, with the UPS MMS Bypass Control activating a control sequence that upon completion will signal the UPS Module Control to initiate transfer to bypass operation. The completion of this control sequence and subsequent initiation of transfer to bypass operation will be inhibited while the remaining system UPS Modules can sustain load power from inverter supply.
3. When the UPS MMS Bypass Operation Control in each UPS Module signals the UPS Module Control to initiate transfer to bypass operation and therefore initiate system transfer to UPS MMS Bypass Operation, each UPS Module will transfer to the bypass static switch circuit simultaneously.
4. Re-transfer operation from UPS MMS Bypass Operation to UPS MMS Inverter Operation will be inhibited if any of the systems UPS Modules are providing load power from bypass source supply.
 - a. For bypass operation details, refer to previous section UPS MMS Bypass Operation.

B. UPS MMS Parallel Operation Control

1. UPS MMS Parallel Operation Control in each UPS Module utilizes cross current control signals between the UPS Modules to calculate and perform fast simultaneous inverter reference voltage and phase waveform control. This UPS MMS Parallel Operation Control ensures that at all times:
 - a. Instantaneous equal load sharing between UPS Module inverters is achieved (Less than +/-5% of UPS Module rated current).
 - b. UPS Module inverter outputs are always synchronized. Refer to previous section Inverter Frequency Control.
2. For parallel UPS Module inverter operation details, refer to previous section UPS MMS Inverter Operation.
3. Independent UPS Module MMS Control enhances system reliability and eliminates single points of failure associated with common control circuits.
4. All UPS Module MMS Control printed circuit boards shall be hermetically sealed to protect against corrosive vapors.

2.2.7. Operation/Display Panel incorporates

A. Graphic Operator Terminal Liquid Crystal Display (LCD):

- a. 5.7 inch Monochrome touch screen
- b. High communication capability:
- c. Ethernet (10Base-T) (utilized for Monitoring System interface).
- d. Optional Expansion Bus Interface for field network connectivity available (Profibus, DeviceNet etc.)

1. The LCD touch screen interfaces with the UPS Module Control and main processor board to provide menu-driven operator instructions and UPS Module operation details. The LCD indicates system operation, operational guidance, and measurement data, set up data and alarm messages and logs. All metering shall be digitally displayed on the LCD having an accuracy of 1% or better.
2. The touch screen area is composed of four MENU sheets: MAIN, MEASUREMENT, SET-UP and LOG. Each MENU sheet has a name tab at the top and the four name tabs form an overlap index at the top of the screen area. Touching the name tab of any of the MENU sheets at this index will make that specific MENU be displayed. Each MENU sheet displays specific information and includes touch icons that perform MENU related functions

(1) LCD MAIN MENU Sheet:

MAIN MENU Sheet: The MAIN MENU indicates power flow and measured values, while also offering operator sequence instructions (start/stop function etc. - Password protection possible). The LCD panel allows the user to verify the status and operation of the UPS Module components by the mimic display. The following information is available on the MAIN MENU Sheet:

Display information:

- a. Bypass Voltage and Frequency
- b. Input Voltage and Frequency
- c. Battery Voltage (and charge/discharge current)
- d. Battery capacity remaining during power failure conditions
- e. Output Voltage, Frequency and Current
- f. Rectifier operation
- g. Battery operation
- h. Load on inverter
- i. Inverter synchronized with bypass
- j. Load on bypass
- k. Equalize charge on
- l. Alarm/Fault messages

Available operator sequence instructions:

- a. Inverter start/stop
- b. UPS start up/shutdown
- c. Transfer of critical load to bypass source
- d. Equalize charge to system battery

(2) MEASUREMENT MENU Sheet:

The MEASUREMENT MENU sheet indicates details of measured values. The following data will be displayed on the MEASUREMENT MENU Sheet:

- a. Bypass Voltage and Frequency
- b. Input Voltage and Frequency
- c. Battery Voltage (and charge/discharge current)

- d. Battery capacity remaining during power failure conditions
- e. Output Power (kW)
- f. Output Voltage (all phases including line to line and line to neutral)
- g. Output Frequency
- h. Output Current in RMS Amps and % (all phases including neutral).

(3) SET UP MENU Sheet:

The SET UP MENU Sheet prompts the user to select specific performance and UPS setting data. (remote or local start & stop operation, date & time adjustment, battery equalizing charge availability etc.)

(4) LOG MENU Sheet:

The LOG MENU Sheet indicates event and alarm/fault information and battery discharge records. A maximum of 50 events can be displayed. The following alarm/status information shall be available as a minimum:

- a. Load on Inverter
- b. Battery Low Voltage
- c. Battery Operation
- d. Output Overload
- e. Rectifier Operation
- f. Inverter Running Synchronously
- g. Static Bypass Input Out of Range
- h. Minor Fault Data
- i. Major Fault Data

B. LED indication

The Operation/Display Panel contains the following LED indication:

- | | |
|----------------------|----------|
| a. Load on Inverter | (Green) |
| b. Battery operation | (Yellow) |
| c. Load on Bypass | (Green) |
| d. Overload | (Red) |
| e. LCD Fault | (Red) |
| f. UPS Fault | (Red) |

C. Emergency Power Off (EPO) button

When the UPS Module Emergency Power Off (EPO) button is activated, the EPO function shuts down the UPS module. The configuration of the UPS MMS will depict the subsequent system operation. Refer to previous section Individual UPS Module EPO. The EPO function can be performed both locally at the UPS Module and remotely from the CLC System EPO button. When remote EPO is performed, all system UPS Modules will be shutdown and the critical load dropped.

2.2.8. UPS status and function interface

In addition to the communication capabilities of the UPS Module LCD, the following communication methods are available: RS-232C/RS-422

Communication Port: The UPS Module will have as standard a RS-232C/RS-422 port allowing the user to interface to the UPS module offering the following functions:

2.2.9. Additional UPS Module Monitoring functions

1. Via Personal Computer (PC) - Mitsubishi Electric Diamond Link Software
2. Via Netcom (SNMP/Web Card)

2.2.10. Service functions via PC

Waveform capture trace information: Upon UPS failure, a trigger will initiate capture of UPS Module Waveform, logic and control signals. The capture duration will be for 10 cycles, 5 cycles pre trigger and 5 cycles post trigger. The sampling frequency shall be 7.2kHz, therefore a total of 120 samples per cycle will be taken. The captured data can be downloaded to a PC and displayed on Mitsubishi Electric Software. The Software allows selection of UPS Module Waveform, logic and control signals for display and zoom functions. Waveform capture information assists service personnel for troubleshooting and undertaking UPS Module failure root cause analysis.

Download Alarm and System Event log to PCRS 232 Communication

2.2.11. External signal interface terminal

The UPS Module is equipped with a series of input/output terminals for external annunciation of alarms and for remote access of certain UPS functions.

A. Terminals OUT 1 to OUT 6 are user programmable, with the default settings:

- a. OUT 1: Load on Bypass
- b. OUT 2: Load on Inverter
- c. OUT 3: Battery Operation
- d. OUT 4: Rectifier Operation
- e. OUT 5: Battery Low Voltage
- f. OUT 6: Overload

B. Terminals IN 1 to IN 5 offer the following remote functions:

- a. IN 1: Remote Start
- b. IN 2: Remote Stop
- c. IN 3: Battery Temperature Abnormal
- d. IN 4: Input Power Demand
- e. IN 5: Remote Emergency Power Off) (EPO)

2.2.12. (OPTION) DiamondSync

The UPS manufacture shall offer a Sync circuit which shall allows any two or more different UPS modules to sync into a master Sync source. The circuit allows both UPS modules to operate in to a common output transfer cabinet and allows the load continue to operate without any degradation to the load.

2.2.13. (OPTION) Common Battery

The customer is to advise if each UPS module is to have its own dedicated smaller battery bank or if one large battery bank is required to operate the entire load.

2.3. CLC COMPONENTS

For additional information to below, refer to the Mitsubishi Electric CLC Specification.

2.3.1. CLC Power Section

Bypass Load Sharing Reactors (ACL1, ACL2 up to ACL8 depending on system UPS Module quantity)

For equal load sharing, a load sharing reactor shall be incorporated in each UPS Module circuit to ensure bypass line impedance balance and that each bypass line supports an equal share of the total load current during bypass operation. Each UPS Module circuit reactor will be located in the CLC. Refer to previous section UPS MMS Bypass operation.

2.3.2. SMB and 52L circuit breaker and associated power circuits

The CLC contains power circuit. The system bypass source is a common feed to the UPS Module bypass inputs and also the CLC System Maintenance Bypass input. An electro-mechanical interlock system will prevent closure of the SMB circuit breaker and subsequent opening of 52L circuit breaker unless UPS MMS Bypass Operation is active. Refer to previous section System Maintenance Bypass Operation.

System Maintenance Bypass Operation shall allow total system repair and testing for parallel operation as well as individual UPS Module repair and testing without affecting load operation as standard a System Maintenance Bypass circuit breaker (SMB) and power circuit, and a System Output circuit breaker (52L) and output

A. SMB/52L Interlock System:

An electro-mechanical interlock system will be included as standard. The Interlocking System shall be used for controlling initiation of System Maintenance Bypass Operation and offer the following safety functions:

B. Interlock Principle:

To prevent the closure of System Maintenance Bypass Circuit Breaker SMB while the system is operating on UPS Inverter mode. (Possible connection of out of phase sources).

To force sequence of operation to isolate UPS MMS (UPS Modules) from System Maintenance Bypass power supply for maintenance and testing requirements.

2.3.3. CLC Monitoring Section

A. The Monitoring System main Graphical Operator Terminal (GOT) shall be the

Monitoring System Human Machine Interface (HMI) and shall be located on the CLC door exterior. All information will be displayed and operator control sequences initiated from the HMI. The GOT will be directly interfaced to each UPS Module LCD via Ethernet (10Base-T and Hub) and will have access to all system UPS Module data via this network. The GOT will be serial connected to the Monitoring System PLC.

- B. The PLC performs logic functions required for the HMI screen display requirements and also for performing operator sequences. The PLC inputs will also accept the CLC circuit breaker status contacts for HMI display information. The PLC outputs shall be utilized for system summary alarm and user selectable system output alarms (selectable from the HMI). GOT software (for HMI screen display information and touch screen functions), and the PLC ladder sequence control program will create the Monitoring System user environment and operational architecture. UPS MMS configuration, UPS Module and UPS quantity will be selectable for HMI display information.
- C. The HMI (GOT) displays different screen information according to user request. Typical information screens are:
 - 1. Main Overview:
 - a. Total UPS MMS mimic display and power flow.
 - b. UPS Module component and CLC CB color status indication.
 - c. System input and output measurement data.
 - d. Screen selection icons
 - 2. Individual UPS Module information:
 - a. UPS Module mimic display and power flow.
 - b. UPS Module component color status indication.
 - c. UPS Module input and output measurement data.
 - d. UPS Module Battery Data
 - e. Screen selection icons
 - 3. System Event and Alarm information (History log).
 - a. UPS Module Alarm and event Groups.
 - b. Alarm and event history
 - 4. System Alarm Output Selection - PLC Output. PLC Outputs can be configured to give dry contact signals for alarm purposes:
 - a. Summary alarm
 - b. UPS Module Alarm
 - c. System Sync to Bypass
 - d. System Overload
 - 5. Operator sequence function screen (Password protected). (UPS MMS Inverter Operation ⇔ UPS MMS Bypass Operation)
 - 6. All individual UPS Module LCD display information is available for display on the HMI, with the GOT accessing the data via the Ethernet. Refer to the previous section UPS Module Operation/Display Panel LCD for detailed information on available UPS Module data.
 - 7. The CLC Monitoring System GOT can also be remotely monitored on a

web browser. No additional software will be required for the remote PC, with Internet Explorer only required to web monitor. Refer to Monitoring System Operation Manual for further details.

8. System Emergency Power Off (System EPO):
The System EPO button shall be located on the CLC next to the Monitoring System HMI. The System EPO contacts shall be hard wired to each system UPS Module external signal terminal block (Input terminal – Remote EPO). When the System Emergency Power Off (EPO) button is activated, the EPO function will shutdown all UPS Modules and the load will be dropped.

2.4. MECHANICAL DESIGN

2.4.1. Cabinet Structure (Enclosure)

- A. The enclosure shall be primed and painted with the Munsell 5Y7/1 (beige) color. The enclosure shall be free standing floor mount design. The enclosure panels and doors shall consist of minimum 14 gage steel for maximum strength and durability.
- B. The UPS shall be installed in cabinets of heavy-duty structure meeting with NEMA standard for floor mounting. The UPS shall be equipped with standard forklift provisions to allow ease of installation using conventional lifting/moving equipment. The UPS module cabinet shall have hinged and lockable doors on the front only. Operating controls shall be located outside the locked doors. Input, output, and battery cables shall be installed through the top or bottom of the cabinet.

2.4.2. Serviceability

The UPS shall have front access for all servicing adjustment and connections only for maintenance or service. Side access or rear access shall not be accepted. The UPS shall be designed such that its rear can be pressed against a back wall and its sides can be pressed against side walls.

2.4.3. Ventilation

Forced air cooling shall be provided to allow all components to operate within their rated temperature window. Thermal relays, using a latched contact which is capable of being reset, shall be used as overload protection to all cooling fans. Each fan shall employ a separate thermal relay. All air inlets use washable air filters that shall be removable from the front of the UPS without exposure to any electrical hazard. Air filters shall be door mounted to prevent floor dust from being sucked into the unit. Bottom mount air filters shall not be accepted.

2.4.4. Busbar

All busbar used for conductivity within the UPS shall be designed with COPPER ONLY. Aluminum busbar are not acceptable.

2.4.5. (Option) Eyebolts

Eyebolts shall be installed for lifting UPS. Four (4) heavy duty eyebolts will be installed on each corner on top of UPS. Eyebolts are detachable (unscrew manually) once UPS is set in installation area.

3. EXECUTION

3.1. SITE PREPARATION

The owner shall prepare the site for installation of the equipment.

3.2. INSTALLATION

- A. The UPS shall be set in place, wired and connected in accordance with the approved installation drawings and owners/technical manual delivered with equipment.
- B. The equipment shall be installed in accordance with local codes and manufacturer's recommendation.

3.3. FIELD QUALITY CONTROL

- A. The equipment shall be checked out and started by a customer support representative from the equipment manufacturer. Visual and mechanical inspection of electrical installation, initial UPS startup and operational training shall be performed. A signed service report shall be submitted after equipment is operational.
- B. The following inspection and test procedures shall be performed by field service personnel during the UPS startup;
 - 1. Visual Inspection
 - a. Ensure that shipping members have been removed.
 - b. Ensure that interiors are free of foreign materials, tools and dirt.
 - c. Check for damage (dents, scratches, frame misalignment, damage to panel devices, etc)
 - d. Check doors for proper alignment and operation.
 - 2. Mechanical Inspection
 - a. Check all the power wiring connections for tightness.
 - b. Check all the control wiring connections for tightness.
 - 3. Electrical Inspection
 - a. Check input and bypass for proper voltage and phase rotation.
 - b. Check battery for proper voltage and polarity.
 - 4. Start-up
 - a. Energize the UPS.
 - b. Check the DC output voltage and inverter output voltage.
 - c. Check the inverter output voltage on battery operation.
 - d. Check for the proper synchronization.
 - e. Perform manual transfers and returns.
 - f. Perform auto transfers.

g. Check the parallel operation.



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