



UNINTERRUPTIBLE POWER SUPPLY

MODEL

9900A

MULTI MODULE SYSTEM
SPECIFICATIONS

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DIVISION 263353
STATIC UNINTERRUPTIBLE POWER SUPPLY SYSTEM

PART 1 GENERAL

1.1 SUMMARY

- A. This specification describes a three-phase, continuous duty, on-line solid-state Uninterruptible Power Supply(UPS) Multi-Module System(MMS), hereafter referred to as the UPS MMS and a Parallel Cabinet 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 parallel 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 has been designed in accordance with and complies with the following standards:

- A. UL 1778 (Underwriter Laboratories) Standard for UPS Equipment.
- B. CSA 22.2 (Canadian Standards Association – cUL Equipment).
- C. IEC (International Electro-technical Commission) Semiconductor Converter Standards.
- D. EMI compatibility: FCC Title 47, Part 15, Subpart B
- E. IEEE 587, ANSI C62.41 1991 Standard for Surge Withstand Ability.
- F. ISO 9001 Quality Assurance program.

1.3 MMS SYSTEM DESCRIPTION

1.3.1 UPS Module 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. Converter Section:
 - 1. AC input
 - 2. Converter input contactor
 - 3. Converter output fuses
 - 4. Solid-state Pulse Width Modulation (PWM) converter utilizing Insulated Gate Bipolar transistor (IGBT)

- B. DC Input and associated Battery System
(Including battery disconnect circuit breaker)
- C. Inverter Section:
 - 1. Solid-state PWM inverter utilizing IGBT
 - 2. Inverter input fuses
 - 3. Inverter output contactor
- D. Bypass Static Switch Circuit (sized to provide fault clearing):
 - 1. Bypass input
 - 2. Bypass static switch with primary contactor
 - 3. Wrap-around contactor
- E. 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
- F. 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
- G. Operation/Display panel incorporating:
 - 1. Graphic Operator Terminal Liquid Crystal Display (LCD): 3.8 inch Monochrome touch
 - 2. LED indication
 - 3. Emergency Power Off (EPO) button (for UPS Module shutdown)
- H. Additional UPS Module Monitoring functions:
 - 1. Via Personal Computer (PC) - Mitsubishi Electric DiamondLink Software
 - 2. Via Netcom (SNMP/Web Card)

1.3.2 Parallel Cabinet Components

The parallel cabinet shall consist of the following:

- 1. UPS Module output circuit breakers - 52L1, 52L2, 52L3, 52L4 depending on system UPS Module quantity
- 2. Parallel bus power circuit
- 3. Load bank test circuit (Option)
- 4. System Maintenance Bypass circuit breaker (SMB) and power circuit
- 5. System Output circuit breaker (52L)
- 6. System output power circuit and terminals
- 7. SMB, 52L Interlock System
- 8. System Emergency Power off (System EPO) push button that will shutdown all system UPS Modules. The System EPO contacts will be hard wired to each system

UPS Module external signal terminal block (Input terminal – Remote EPO).

1.3.3 MMS Mode of Operation

The UPS shall be designed to operate continuously at rated capacity as an on-line, automatic reverse transfer system in the following modes:

- A. Normal - The inverter continuously supplies AC power to the critical load. The converter 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, the inverter shall derive its input from the system battery, therefore providing uninterrupted power to the critical load. This transition shall be accomplished without any switching or coupling, and with no interruption of power to the critical load from either a failure or restoration of the utility AC power.
- C. Recharge - Subsequent to restoration of utility AC power, the converter shall automatically reactivate and provide 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 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 share the total load current (Individual bypass distribution lengths to each UPS Module in the MMS should be within $\pm 10\%$ for acceptable load sharing levels. Optional reactors can be provided if necessary - consult MEPMI). 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 parallel cabinet 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 parallel cabinet 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 system's 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 system's 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.
- 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 redundant configuration and load demand of the system must be taken into consideration very carefully prior to individual UPS Module Maintenance Operation. In addition, it is recommended that parallel operation of the system is checked prior to placing the maintained UPS back on line, following SMB procedures.
- 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 parallel cabinet System EPO button.

1.4 SUBMITTALS

1.4.1 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.

1.4.2 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. Owner's and Technical Manual (1).
- D. Test Report.
Submit a copy of factory and field test reports.

1.5 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: +15 degrees C to +25 degrees C (59 degrees F to 77 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 2250 meter (7400ft).
 - 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 generated by the UPS, when operating under full rated load, at a distance of one meter from any UPS operator surface, shall not exceed 70dB 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.

1.6 WARRANTY

The UPS manufacturer 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 thirty-six (36) months from the date of installation or forty-two (42) months from the date of shipment of the Product, whichever comes first, at the premises of the original end-user.

1.7 QUALITY ASSURANCE

1.7.1 Reliability

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. Total single module UPS system output (includes reliability of bypass circuit):

3,000,000 MTBF hours.

- B. Single module UPS operation (represents UPS module operation only):

140,000 MTBF hours.

1.7.2 Maintainability

MTTR of the UPS shall not exceed four (4) hours including time to replace components.

1.7.3 Factory Test

- A. The manufacturer shall fully and completely test the system 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, AC input failure)
12. Overload testing
13. Transfer switch operation

PART 2 PRODUCT

2.1 ELECTRIC CHARACTERISTICS

The UPS shall have the following electrical characteristics:

2.1.1 UPS Module Output Capacity

The 9900 Series UPS Module is available in the following sizes:

kVA	kW
80	72
100	90
150	135
225	202

Up to four (4) 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 0.9 pf lagging.

2.1.2 UPS Module AC Input

- A. Nominal input voltage: 480V.
- B. Number of phase: 3 phase, 3 wire, plus ground.
- C. Voltage range: +15%, -20%.
- D. Frequency and range: 60Hz \pm 10%.
- E. Power walk-in time: 20 seconds (0% to 100% load).
- F. Power factor:
 - 1. 0.99 typical at 100% load.
 - 2. 0.99 typical at 50% load.
- G. Reflected input current total harmonic distortion (THD):
 - 1. 3% typical at 100% load.
 - 2. 5% typical at 50% load.

2.1.3 UPS Module Bypass Input

- A. Nominal input voltage: 480V.
- B. Number of phase: 3 phase, 3 wire.
- C. Synchronization voltage range: \pm 10% of nominal.
- D. Frequency tracking range: 60Hz \pm 5% Maximum.
(Bypass synchronous range shall be selectable from 1% to 5% in 0.1% increments)

2.1.4 UPS Module AC output

- A. Nominal output voltage: 480V.
- B. Number of phase: 3 phase, 3 wire, plus ground.
- C. Nominal dynamic Voltage regulation:
 - 1. \pm 1% for balanced load.

- 2. $\pm 2\%$ for unbalanced load.
- D. Voltage balance: 1%
- E. Manually adjustable output voltage: $\pm 5\%$ range.
- F. Voltage transient response:
 - 1. 100% step load: $\pm 2\%$.
 - 2. Loss or return of AC input: $\pm 1\%$.
 - 3. Retransfer from bypass to inverter: $\pm 3\%$
 (Voltage transient response shall not exceed the above and shall recover to within nominal voltage regulation tolerance within 20 msec.)
- G. Frequency (inverter synchronous): 60 Hz (tracks frequency of static bypass source).
- H. Free running output frequency (asynchronous): 60 Hz $\pm 0.01\%$.
- I. Frequency slew rate (inverter synchronized to static bypass): 1 to 5Hz/second (selectable).
- J. Output voltage harmonic distortion:
 - 1. 2% maximum at 100% linear load.
 - 2. 5% maximum at 100% non-linear load.
 (Load power factor range of 0.9 lagging to 1.0 within kW rating of UPS. Crest factor 2.3)
- K. Voltage phase angle displacement:
 - 1. ± 1 degree for 100% balanced load.
 - 2. ± 3 degree for 100% unbalanced load.
- L. Overload capability:
 - 1. 105% to 125% for 2 minute(s) (Voltage regulation maintained).
 - 2. 126% to 150% for 1 minute(s) (Voltage regulation maintained).
- M. Fault clearing: Typically 1000% for 1 cycle (utilizing bypass source).

2.1.5 UPS Module DC Input and Battery System

- 1. Voltage: 480V DC nominal, 400V DC minimum.
- 2. Voltage 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				AC to AC			
	100%	75%	50%	25%	100%	75%	50%	25%
80	95.6	94.9	94.6	92.9	95.6	95.5	94.9	93.4

100	95.6	95.6	94.9	93.8	95.6	95.5	95.4	94.2
150	96.2	96.2	96.0	95.0	96.2	96.2	96.0	95.2
225	96.4	96.2	96.0	95.5	96.2	96.3	96.3	95.6

2.1.7 Parallel Cabinet Power Section Specification

The Parallel Cabinet 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.

2.1.8 Output Specification

Each system UPS Module shall instantaneously control and equally share the total critical load current within less than $\pm 5\%$ of UPS Module rated current.

2.2 UPS MODULE COMPONENTS

UPS module shall be comprised of the following:

2.2.1 Converter Section

AC input, converter input contactor, input harmonic filter, and converter utilizing:

2.2.1.1 IGBT Converter

A. General

The Converter shall convert the incoming AC power into regulated DC power to supply the inverter input and system battery. The Converter shall utilize the following technologies:

- a. Solid state Pulse Width Modulation (PWM) controlled Insulated Gate Bipolar Transistors (IGBT).
- b. Input Power: Rated kVA at 1:1 ratio.
- c. DSP based control logic.

B. Reflected Harmonic Content

The IGBT converter shall typically not introduce more than 3% 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 5% THD at 50 % load.

C. Automatic Input Power Walk-in

The converter logic and control circuit power walk in function enables delayed and timed ramping of input current. Subsequent to energizing the converter input, initiation of the power walk in function and current ramping shall be delayed by a maximum of 3600 seconds. Upon initiation of the power walk-in function, the ramping of current shall be timed to gradually increase the load within 20 seconds. This function is included as

standard in the converter control circuitry.

D. Input Overcurrent Protection

Converter input contactor, and the input current limit control shall provide converter protection against excessive input overload conditions.

E. Step Load Change Operation (0-100%)

In the occurrence of a 100% step load change, the UPS Module inverter shall draw power only from the converter to provide the required load demand. The system batteries will not be cycled at any time during a step load change.

F. Input Current Limit

The Converter logic shall provide input current limiting by limiting the AC input current. Three (3) line-side current transformers shall be employed as a means of sensing the current amplitude. The DC output current limit values are as follows:

- a. Input current limit setting: 110% of nominal rated current.
- b. The AC input current limit shall be set up so that the converter 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 converter components from damage due to excessive input current.

G. Input Power Demand

The Converter 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 generator).

Power Demand: Adjustable, maximum 110% of nominal rated current.

2.2.1.2 Charger/Booster

A. General

The charger/booster utilizes solid state Pulse Width Modulation (PWM) controlled Insulated Gate Bipolar Transistors (IGBT).

B. Battery Charge Current Limit

The converter 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 converter 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: 20% ampere of UPS rated kVA.

C. Equalize Charge Timer

UPS Module logic and control shall provide an electronic equalize charge timer function (0 to 100hour 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 .04 to .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. Temperature Control Battery Charging

The UPS shall have as standard a battery temperature compensation function allowing the converter voltage to fold-back to a safe value in the event the battery system temperature reaches a predetermined (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 UVR 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. 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.

G. 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 backup time. The small power that is discharged by the battery will quickly be replenished.

The Battery Self-Test will automatically occur every 720-hour interval. An event alarm will occur and be displayed if battery abnormalities are detected.

2.2.2 Inverter

A. General

The inverter shall generate AC power derived from DC power supplied from the converter 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 Pulse Width Modulation (PWM) controlled Insulated Gate Bipolar Transistors (IGBT).
2. UPS Module Full Direct Digital Control (DDC) Adoption:
 - a. Field Programmable Gate Array (FPGA) Control.
 - b. DSP based Control

B. Voltage Regulation

The inverter output voltage shall not deviate by more than $\pm 1\%$ 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

The inverter shall have the ability to manually control and adjust the output voltage to within $\pm 5\%$ of the nominal value.

D. Voltage Transient Response

The dynamic regulation and transient response shall not exceed $\pm 2\%$ for 100% step load (applied or removed), $\pm 1\%$ for loss or return of AC input and $\pm 5\%$ for inverter to bypass and vice versa transfer.

E. Transient Recovery

Voltage transient response shall not exceed the above specification and shall recover to within nominal voltage regulation tolerance within 20 ms.

F. Frequency Control

The Inverter output frequency shall be controlled by an oscillator internal to the UPS module logic. It shall be capable of synchronizing to an external reference (e.g. the

bypass source) or operating asynchronously. A message located on the touch screen shall identify the loss of synchronization. Synchronization shall be maintained at 60Hz $\pm 0.01\%$ continuously for the duration of loss of the external reference. The Inverter output frequency shall not vary during steady state or transient operation due to the following conditions:

1. 0 to 100% loading.
2. Inverter DC input varies from maximum to minimum.
3. Environmental condition variations within the specifications defined herein.

G. Output Voltage 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:

- 105% to 125% for 2 minute duration.
- 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 230% of rated load current. Two current transformers in separate locations on the output (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 Output Isolate

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

2.2.3 UPS Module Control and Monitoring

- A. UPS Module Control and Monitoring operates and controls the Converter, Inverter and independent automatic bypass static switch circuit.
- 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. All UPS Module Control and Monitoring printed circuit boards shall be effectively sealed to protect against corrosive vapors.
- D. 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.

2.2.4 UPS Module 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 retransfer 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.

2.2.5 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 system's UPS Modules are providing load power from bypass source supply.
5. 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 $\pm 5\%$ 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.

2.2.6 Operation/Display Panel

The control panel shall employ the use of a touch screen interface which allows lock-out of all UPS control function for security (The Emergency Power Off function shall not be locked out). The operator interface shall provide the following:

1. UPS start-up procedure
2. UPS shutdown procedure
3. Emergency Power Off (EPO)
4. Audible alarm silence
5. System status levels

The UPS module shall be provided with a control/indicator panel. The panel shall be on the front of the UPS module. Controls, meters, alarms and indicators for operation of the UPS module shall be on this panel.

2.2.6.1 Graphic Operator Terminal Liquid Crystal Display (LCD):

- A. 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, 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.
- B. The touch screen area is composed of four MENU sheets: MAIN, MEASUREMENT, OPERATION, and STATUS. 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. MAIN MENU Sheet: The MAIN MENU indicates power flow and measured values. 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:

- a. Converter operation
- b. Battery operation
- c. Load on inverter
- d. Load on bypass
- e. Typical measurement values of Input, Bypass, Battery and Output
- f. Alarm/Fault messages

2. MEASUREMENT MENU Sheet: The MEASUREMENT MENU indicates measured values. The following information is available on the MEASUREMENT MENU Sheet:

Display information:

- a. Input Voltage and Frequency
- b. Bypass Voltage and Frequency
- c. Battery Voltage and Charging/Discharging Current
- d. Output Voltage, Frequency and Current
- e. Output active power
- f. Output power factor

3. OPERATION MENU Sheet: The OPERATION MENU Sheet prompts the user to select specific performance and UPS setting data.
 - a. Start up guidance
 - b. Shut down guidance
 - c. Setup (Remote/Local, Time, Manual Equalizing Charge)
 - d. MMS operation and status (MMS Operation/status from any UPS Module)

4. STATUS MENU Sheet: The STATUS 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. Converter Operation
 - f. Static Bypass Input Out of Range
 - g. Minor Fault Data
 - h. Major Fault Data

2.2.6.2 LED indication

The Operation/Display Panel contains the following LED indication:

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

2.2.6.3 Emergency Power Off (EPO) button

The UPS shall be provided with a set of terminals which may connect to a remote EPO contact signal. Remote contact shall be non-powered normally open. UPS shall also have a unit mounted EPO button.

When the UPS Module EPO button is activated, the EPO function shuts down the UPS module. The EPO function can be performed both locally and remotely. When EPO is performed, all system UPS Modules will be shutdown and the critical load dropped.

2.2.7 UPS Status and Function Interfacing

2.2.7.1 Output Contact

The internal UPS logic shall provide, as standard equipment, a programmable set of eight (8) normally open, A-type dry contact outputs to allow user interfacing of the UPS operating status. The available parameters are identical to the alarm and status

information schedule itemized the following.

- a. Total Alarm
- b. Minor Fault
- c. Alarm
- d. AC Input Abnormal
- e. Bypass Abnormal
- f. Battery Abnormal
- g. Battery Low Voltage
- h. Battery Depletion
- i. Overload
- j. Overload Prealarm
- k. Fault Group 1
- l. Fault Group 2
- m. Synchronous
- n. Asynchronous
- o. Remote Operation Enable
- p. Load on Inverter
- q. Load on Bypass
- r. Load On AC
- s. Battery Operation
- t. Converter Operation
- u. Inverter Operation
- v. CB1 Close
- w. CB2 Close
- x. 52S Close
- y. Power Demand
- z. Equalizing Charge
- aa. Another Bus Synch OK

2.2.7.2 RS 232 Communication

The UPS shall have, as standard equipment, an RS 232 smart port allowing the user to interface the UPS status information to a host computer. "DiamondLink" monitoring software, or equivalent, shall be available to support the specified operating system. Field installed, and field tested RS 232 additions shall not be accepted.

2.2.7.3 Input Ports

The UPS shall have, as standard equipment, EPO (Emergency Power Off) and selectable four (4) input ports. The selectable input ports are the following parameters:

- a. Remote Start
- b. Remote Stop
- c. Power Demand 1
- d. Power Demand 2
- e. Battery Liquid Low
- f. Battery Temperature Abnormal
- g. Generator Operation
- h. Asynchronous Operation

- i. Anther Bus Synch
- j. Remote Inverter Supply (MMS)
- k. Remote Bypass Supply (MMS)
- l. Ext Byp dV Str
- m. Battery Charger Limit 2
- n. Charger Stop
- o. External Alarm
- p. CB2 Ex

2.2.8 Additional UPS Module Monitoring Functions

- A. Via Personal Computer (PC) - Mitsubishi Electric DiamondLink Software
- B. Via Netcom (SNMP/Web Card)

2.2.9 Service Functions via PC

Waveform capture trace information: Upon UPS failure, on battery and overload, 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 is downloaded to a SD Memory Card on the main circuit board. This data can be transferred 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.

2.2.10 (Option) DiamondSync

The UPS manufacturer shall offer a Sync circuit that allows any two or more different UPS modules or systems to synchronize inverter outputs. DiamondSync allows the output of both UPS modules or systems to feed a downstream static transfer switch that required the preferred and alternate input sources to be synchronized.

2.3 PARALLEL CABINET COMPONENTS

2.3.1 SMB and 52L circuit breaker and associated power circuits

The parallel cabinet contains the system output power and bypass circuit. The system bypass source is common feed to the UPS Module bypass inputs and also the 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 without affecting load operation.

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.

2.3.2 Monitoring Section

An optional Power Meter is available on free standing parallel cabinets (Not available on wall mount parallel cabinets)

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 16 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 bottom or right side of the cabinet.

2.4.2 Serviceability

The UPS shall have front access for all servicing adjustments 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 relay, using a latched contact which is capable of being reset, shall be used as overload protection to cooling fan. All air inlets use 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 (Option) Eyebolts

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

PART 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 owner's/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.
- h. (Option) Load bank test.