UNINTERRUPTIBLE POWER SUPPLY (UPS)

SMS SERIES
G SERIES • Z SERIES

CAT®

Contents

Foreword

This section of the Application and Installation Guide generally describes Uninterruptible Power Supply. Additional engine systems, components and dynamics are addressed in other Application and Installation Guides.

Additional information and data is available from a variety of sources. Refer to the Introduction section (LEBW4951) for additional references. Systems and components described in this guide may not be available or applicable for every UPS.

Document Scope

The purpose of this document is to provide an overview of the configuration and operation of the Single Module System (SMS) UPS and Multiple Module System (MMS) G Series and Z Series UPS to present issues that are likely to be encountered in applying the product in a range of typical applications. This document is not intended to replace or supersede the OMM and service manuals for the product. It is intended only for internal use by Caterpillar and Cat dealers and is not intended for distribution to customers, consultants, contractors or other outside parties. It is intended for use by engineering professionals within the Caterpillar organization and Caterpillar sales and applications personnel who are generally familiar with electrical power systems concepts and with the product line. Nothing in this document shall be construed as superseding codes or regulations of any governmental or inspection authority having local jurisdiction, nor does this document supersede the published specifications for the product. This is a living document which is always changing. We welcome comments on any errors, improvements, or updates.

Figure 1: Multiple Module UPS

System Overview

Configurations

The Cat flywheel based UPS is a fully integrated three-phase line-interactive system using spinning flywheels to store mechanical energy. During a utility power interruption, the UPS converts mechanical energy stored in the spinning flywheel into electrical energy. This energy is supplied to the external load until one of the following conditions occurs:

- The emergency standby generator (if available) assumes the load;

- The utility power is restored and the UPS ramps onto it ("walks in");

- The flywheels run out of energy

Once utility power returns, the system transfers the load back to utility power without interruption. The UPS can be used in a wide range of commercial power applications. The system provides voltage regulation and protection from power outages. This provides well-regulated power to cover critical loads during sags, surges, or outages.

The components of the UPS are housed in free-standing steel cabinets. The system consists of several cabinets depending on the model. All systems can have either top or bottom cable entry.

Depending on kVA rating, the UPS is either a Single Module System (SMS) or a Multi-Module System (MMS). The SMS system has only one flywheel and cannot parallel with another SMS or MMS.

The table below contains the available SMS and MMS model ratings and voltages at 50 and 60 Hz.

UPS Ratings				
480V 60 Hz UPS				
Model	SMS 300	300 Z	600 Z	900 Z	1200 Z
		300 G	600 G		
Rating	300 kVA	300 kVA	600 kVA	900 kVA	1200 kVA
	240 kW	240 kW	480 kW	720 kW	960kW
380/400/415V 50 Hz UPS				
Model	SMS 250i	250 iZ	500 iZ	750 iZ	1000 iZ
		250 iG	500 iG		
Rating	250 kVA	250 kVA	500kVA	750 kVA	1000 kVA
	225 kW	225 kW	450 kW	675 kW	900 kW

Table 1: Table of Standard UPS Model Ratings

The **SMS** UPS has one flywheel only and all components are contained in the flywheel cabinet or bypass cabinet.

Figure 2: Single Module System SMS

The MMS systems can have multiple flywheels for higher capacity and include the following cabinets:

- The Input/Output (I/O) Cabinet – contains power cable connections

- The System Cabinet – contains electronic components, touch screen, and breakers

- The Multiple Module Unit (MMU) Cabinet(s) – contains the flywheel and vacuum pump

IMPORTANT: The I/O cabinet is standard on all systems for use in the United States. In certain locations, the Z Series UPS systems may be installed without an input/output cabinet when connected to switchgear.

Note: MMS with one flywheel cabinet shown

Figure 3: Multi Module System UPS

MMS systems are capable of paralleling with the same Series. **The G series can ONLY parallel with the G series. The Z Series can ONLY parallel with the Z Series.** Special hardware options are required for paralleling. Up to 7 systems can be paralleled.

Paralleling would normally only be required when the load exceeds the capacity of a single unit, the UPS loads cannot be divided in some way, or paralleling is required by specification to provide system redundancy. An example of this would be UPS system redundancy to protect a highly critical load.

The figure below is a simple one line diagram example of the power flow from input to load of multiple UPS systems in parallel.
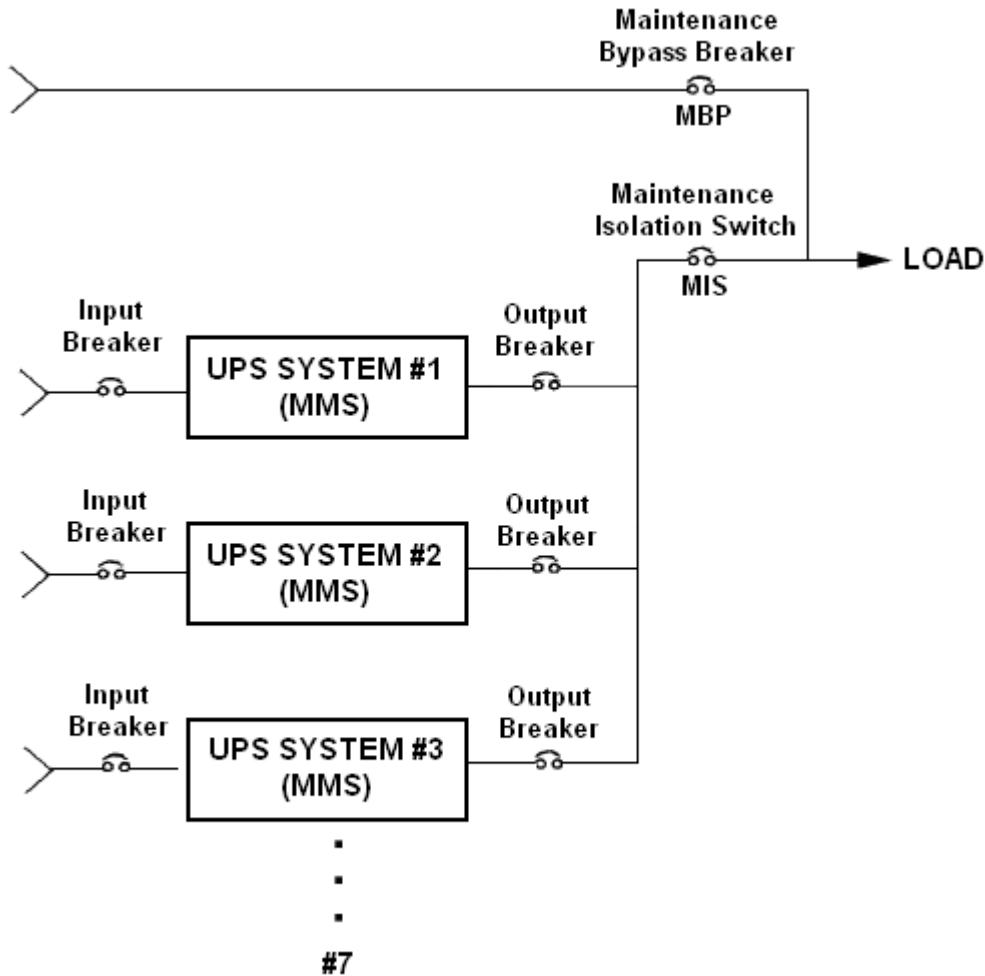
Note: Input breakers, output breakers, MBP and MIS supplied by others.
Note: Up to 7 systems can be in parallel

Figure 4: Paralleled Multi Module Systems (PMMS)

Redundant (N + 1) Flywheel and Power Stage Expansion

The redundant (N + 1) systems are sized with one more MMU than is required to supply the full rated system load to provide redundancy should one MMU fail. In this configuration, the loss of one MMU will not cause the system to drop the critical load or cause a reduction in the UPS rating.

The malfunction of one of the MMUs will cause that MMU to disconnect from the critical load. The remaining MMUs will continue to carry the load. After the MMU has been repaired, the units can be reconnected to the critical load and resume redundant operation.

If more than one MMU is removed from the system and if the load exceeds the capacity of the MMUs remaining on-line, the load will automatically transfer to the bypass line without interruption.

Any redundant MMUs can be taken off the critical load manually by a qualified technician for maintenance without disturbing the critical load bus.

An MMU can be added in the field to an MMS system for a redundant N + 1 configuration (except for a 1200 kVA Z Series UPS or a 1000 kVA Z Series). There is no difference in hardware between an N + 1 Expansion MMU module and a standard MMU.

Note that ride through time is extended but load carrying capability is NOT increased when adding N + 1 redundancy. This is accomplished by running the redundant power stage with its static disconnect switch open.

A power expansion MMU can be added in the field to an MMS system (up to a maximum of 4 MMU per system) as long as the cabling to and from the UPS is properly sized.

UPS firmware will allow the configuration to be switched from N + 1 to increased capacity (with proper cabling) and back as needed. This firmware change must be done by a qualified technician.

IMPORTANT NOTE: When first installing a UPS it is best to provide cabling and any switchgear sized for the maximum load expected to reduce future upgrade costs.

Major Component Line Diagram

The following figure shows a simplified line diagram of the system. The nodes determine the state of the system. The input node (1) and the output node (7) are externally available. These nodes are used in order to attach the system to a power source and to the load. The inverter node (5) is used internally by the system.

The DC Bus (10) is used as a power source for the field coil currents. The mode of the system determines if the bus is used as a power source for the flywheel or as a power source for the utility inverters.
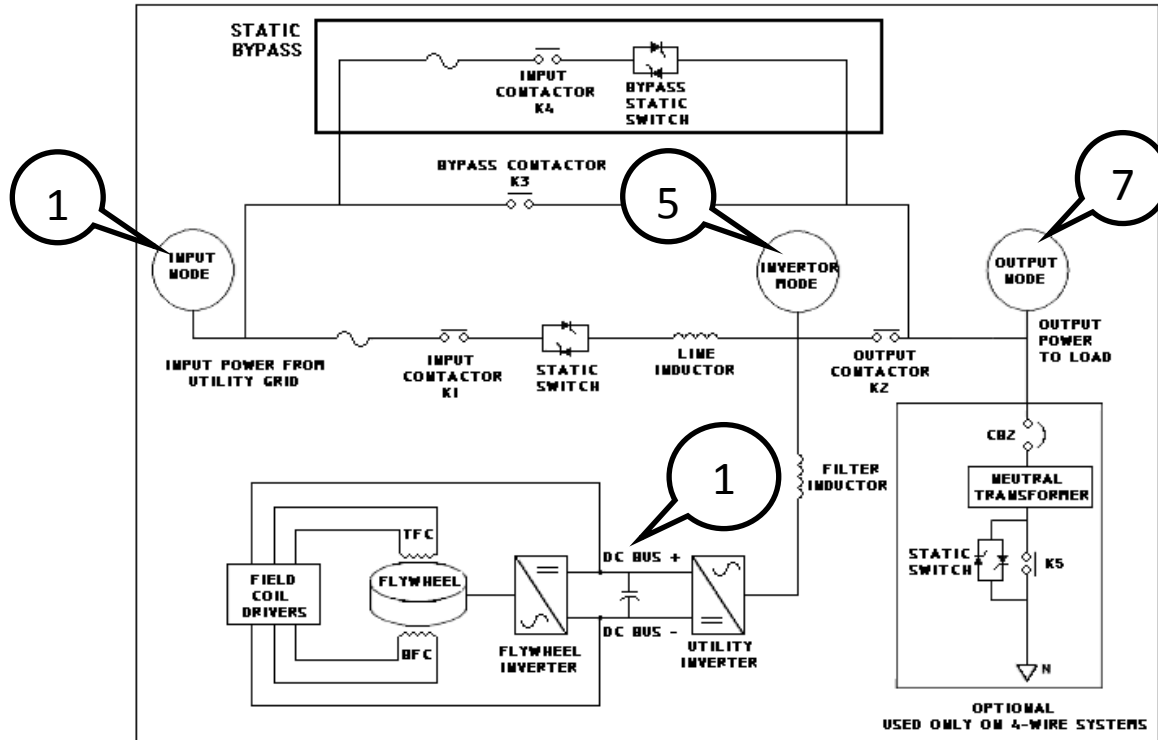
Note: Top Field Coil (TFC) Bottom Field Coil (BFC)

Figure 5: Major Component Line Diagram Overview – 4-Wire System

Component Descriptions

The major UPS components include:

Input Contactor – Designated K1. An electrically operated contactor used to control the flow of electricity into each MMU.

Output Contactor – Designated K2. An electrically operated contactor used to control the flow of electricity from each MMU.

Bypass Breaker – Designated K3. An electrically operated contactor that works in parallel with the static bypass switch that is used to bypass the system.

Static Bypass Switch – The static switch is an assembly made of thyristors (SCRs). It is used to isolate each UPS from the utility grid when the input voltage goes out of tolerance and the UPS needs to support the load with the flywheels.

Flywheel Inverter – The flywheel inverter is an assembly made of IGBTs (Insulated Gate Bipolar Transistors). It is used to control power flow into and out of the flywheel. When the UPS is Online, the flywheel converter motors the flywheel and keeps it a full speed. When the UPS is discharging this converter draws energy from the flywheel to keep the DC bus at a specified voltage.

Utility Inverter – The utility inverter is an assembly made of IGBTs (Insulated Gate Bipolar Transistors). It is used to keep the UPS output at a constant AC voltage for

the load as well as to control the power flow into and out of the DC bus to maintain a constant DC voltage. When the UPS is discharging, the utility converter continues to provide a constant AC voltage for the load by drawing power from the flywheel via the DC bus. The transition from online to discharge is seamless.

Field Coil Driver – The field coil driver is an assembly made of IGBTs (Insulated Gate Bipolar Transistors). These 2 DC-DC converters are used to control current in both the top and bottom field coils located in the flywheel housing. The field coils are used to generate magnetic forces that provide a lifting force on the flywheel thus prolonging bearing life. The flux that generates the magnetic lifting force leaves the rotor through the rotor 'teeth' and induces a voltage on the armature terminals when the rotor is spinning.

Line Inductor – This component provides isolation and filtering between the UPS input and output. It also allows the utility inverter to keep the UPS output voltage constant even when the UPS input voltage varies.

Filter Inductor – This component along with some capacitors filter the PWM (pulse width modulated) sine wave output from the utility inverter to provide a low THD output voltage to the load.

Neutral Transformer – The transformer is used to derive a neutral for the load during discharge when the normal neutral may not be present due to an outage or the opening of a breaker upstream of the UPS. Standard on 50 Hz UPS systems.

3-Wire Systems
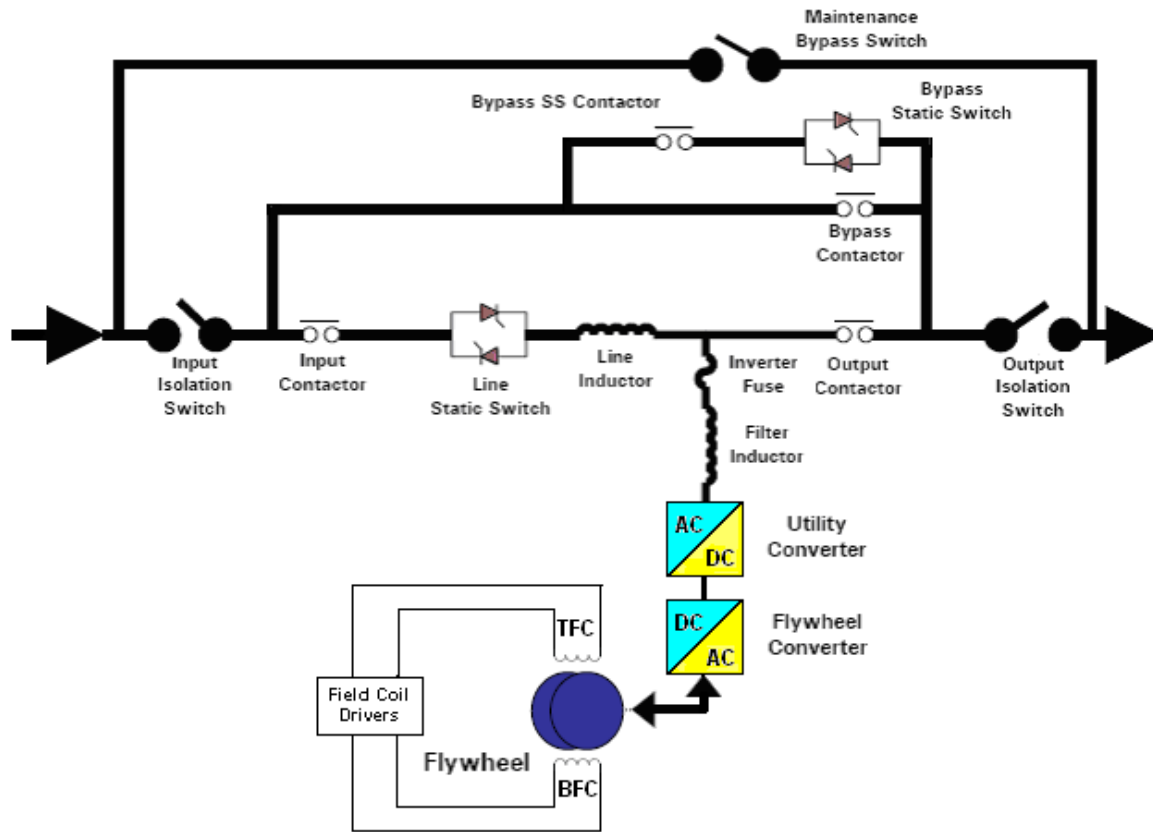
Note: Top Field Coil (TFC) Bottom Field Coil (BFC)

Figure 6: 3-Wire System Diagram – Maintenance Bypass Optional

The term three wire (3-Wire) refers to the number of conductors utilized in the system to conduct electricity. A 3-wire system has three phases of power conductors plus a ground conductor. Although four conductors are actually used, it is referred to as a 3-wire system. Typical 3-Wire Single Module Systems (SMS) configurations are shown in the block diagram above. This diagram is simplified and not intended to replace product schematics.

NOTE: The supply to the UPS must be from a grounded wye source even though the 3-wire UPS does not require a neutral.

Typical 3-Wire System Component Locations

The major 3-wire SMS and MMS system components and the cabinets in which they are located are shown in the following list.

Major Component Locations – 3-Wire Systems		
3-Wire System Component	**SMS Location**	**MMS Location**
Input Isolation Switch	Side Cabinet	Input/Output Cabinet
Bypass Contactor (K4)	Side Cabinet	System Cabinet
Bypass Static Switch	Side Cabinet	System Cabinet
Bypass Static Switch (SS) Contactor	Side Cabinet	System Cabinet
Input Contactor (K1)	Flywheel Cabinet	System Cabinet
Line Static Switch	Flywheel Cabinet	System Cabinet
Line Inductor	Flywheel Cabinet	System Cabinet
Inverter Fuse	Flywheel Cabinet	MMU Cabinet
Filter Inductors	Flywheel Cabinet	MMU Cabinet
Utility Inverter	Flywheel Cabinet	MMU Cabinet
Flywheel Inverter	Flywheel Cabinet	MMU Cabinet
Flywheel	Flywheel Cabinet	MMU Cabinet
Flywheel Field Coil Driver	Flywheel Cabinet	MMU Cabinet
Output Contactor (K2)	Flywheel Cabinet	MMU Cabinet
Output Isolation Switches	Side Cabinet	System Cabinet
Optional Maintenance Bypass Switches	Side Cabinet	Input/Output Cabinet*
Optional Genset Start Breaker	Side Cabinet	Input/Output Cabinet
Optional Universal Maintenance Bypass Control	Not Available**	Input/Output Cabinet*
* *G Series Internal MBP Only. Electrically operated breakers on G series. Internal MBP not available on Z Series (external MBP only on Z Series)*		
** *available only on systems that can parallel using electrically operated breakers*		

Table 2: Table of 3-Wire UPS Component Locations
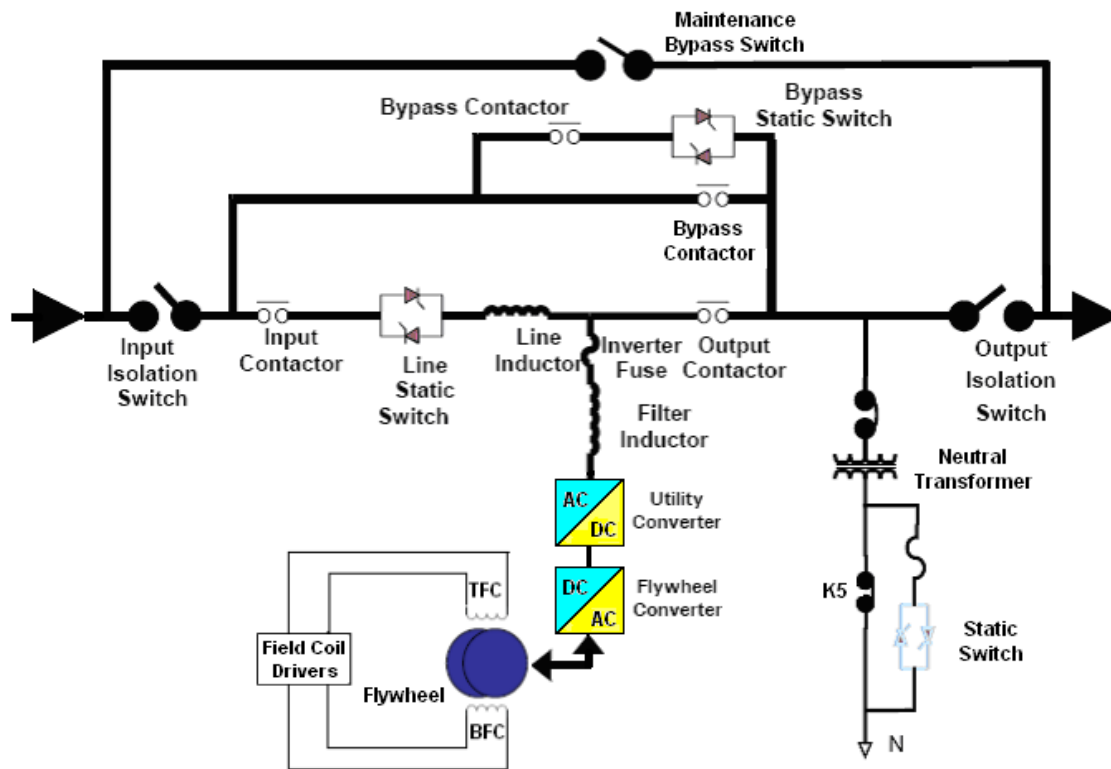
4-Wire Systems

Note: Top Field Coil (TFC) Bottom Field Coil (BFC)

Figure 7: 4-Wire System Diagram – Maintenance Bypass Optional

The term four wire (4-Wire) refers to the number of conductors utilized in the system to conduct electricity and provide a return path. A 4-wire system has three phases of power conductors, a neutral conductor, and a ground conductor. Although five conductors are actually used, it is referred to as a 4-wire system. A 2X neutral is recommended for 4-wire and ground systems.

Typical 4-wire module configurations are shown in the System Diagram. Note the addition of the Neutral transformer and static switch. The transformer is used to derive a neutral for the load during discharge when the normal neutral may not be present due to an outage or the opening of a breaker upstream of the UPS. The 4-Wire System diagram is simplified and not intended to replace product schematics.

Typical 4-Wire System Component Locations

The major 4-wire UPS system components and the cabinets in which they are located are shown in the following list.

Major Component Locations – 4-Wire Systems		
4-Wire System Component	**SMS Location**	**MMS Location**
Input Isolation Switch	Side Cabinet	Input/Output Cabinet
Bypass Contactor (K4)	Side Cabinet	System Cabinet
Bypass Static Switch	Side Cabinet	System Cabinet
Bypass Static Switch (SS) Contactor	Side Cabinet	System Cabinet
Input Contactor (K1)	Flywheel Cabinet	System Cabinet
Line Static Switch	Flywheel Cabinet	System Cabinet
Line Inductor	Flywheel Cabinet	System Cabinet
Inverter Fuse	Flywheel Cabinet	MMU Cabinet
Filter Inductors	Flywheel Cabinet	MMU Cabinet
Utility Inverter	Flywheel Cabinet	MMU Cabinet
Flywheel Inverter	Flywheel Cabinet	MMU Cabinet
Flywheel	Flywheel Cabinet	MMU Cabinet
Flywheel Field Coil Driver	Flywheel Cabinet	MMU Cabinet
Output Contactor (K2)	Flywheel Cabinet	MMU Cabinet
Output Isolation Switches	Side Cabinet	System Cabinet
Ziz-Zag Neutral Breaker	Side Cabinet	System Cabinet
Ziz-Zag Neutral Transformer	Side Cabinet	System Cabinet
Neutral Contactor (K5)	Side Cabinet	System Cabinet
Neutral Fuse	Side Cabinet	System Cabinet
Neutral Static Switch	Side Cabinet	System Cabinet
Optional Maintenance Bypass Switches or Breakers	Side Cabinet	Input/Output Cabinet*
Optional Genset Start Breaker	Side Cabinet	Input/Output Cabinet
Optional Universal Maintenance Bypass Control	Not Available**	Input/Output Cabinet
* G Series Internal MBP Only. Electrically operated breakers on G series. Internal MBP not available on Z Series (external MBP only on Z Series)		
** available only on systems that can parallel using electrically operated breakers		

Table 3: Table of 4-Wire UPS Component Locations

The following table includes the available input connection types, internal maintenance bypass (MBP) types, and grounding connection options for SMS and MMS systems.

Input, Bypass, and Grounding Options			
System	**Option**	**Grounding**	**Component Description**
SMS	Single Input (standard)	3 wire	Bus bar connections
		4-wire	Bus bar connections
SMS	Single Input MBP	3-wire 3-pole	3 manually operated switches
		4-wire 3-pole	3 manually operated switches
G Series MMS	Single Input (standard)	3-wire	Bus bar connections
		4-wire	Bus bar connections
G Series MMS	Single Input MBP*	3-wire 3-pole	3 electrically operated breakers
		4-wire 3-pole	3 electrically operated breakers
G Series MMS	Dual Input	3-wire	Bus bar connections
		4-wire	Bus bar connections
G Series MMS	Dual Input MBP*	3-wire 3-pole	3 electrically operated breakers
		4-wire 3-pole	3 electrically operated breakers
Z Series MMS	Single Input**	3-wire	Bus bar Connection
		4-wire	Bus bar Connection
Z Series MMS	Dual Input**	3-wire	Bus bar Connection
		4-wire	Bus bar Connection
* Breakers are manually controlled by the Maintenance Bypass Controller located in the I/O cabinet			
** Z Series requires an "External" maintenance bypass system			

Table 4: Table of Available Input Connection and Bypass Options

Operation

The UPS functions automatically to supply AC electrical power to the critical load during certain operating conditions. There are several operating modes that allow it to supply power. Most modes have several states occurring within them. The mode and the state are displayed on the cabinet user interface screen.

The UPS continually monitors itself and incoming utility power. It automatically switches among appropriate modes as required, without operator intervention. Detection and switching logic inside the UPS ensures that operating mode changes are automatic and transparent to the critical load.

UPS startup, reset, and shut-down procedures are described in detail in the particular Operations and Maintenance Manual (OMM) and in the Systems Operation, Testing, and Adjusting (SOTA) manual for each UPS.

Operational Considerations

Bringing An MMU Online

To bring an MMU online, the flywheel cabinet key-switch must be cycled to the online position.

IMPORTANT: There must be enough MMUs with keyswitches in the Online position to support the load.

Bringing An MMS Online

To bring an MMs online, the system cabinet key-switch must be cycled to the online position.

IMPORTANT: There must be enough MMUs with keyswitches in the Online position to support the load.

Bringing the PMMS Online

To bring a PMMS online, there must be enough system cabinet keys-witches in the Online position and enough MMUs with keyswitches in the Online position to support the load.

Important Operational Considerations

- The MMU keyswitch is located on each MMU (flywheel) cabinet.

- The System Cabinet keyswitch is located on each system cabinet.

- If the UPS is online and an MMU keyswitch is moved to the bypass position, that MMU will go offline. The remaining online MMUs **MUST** be able to support the load or the MMS transfers to Bypass.

- If the PMMS UPS is online and an MMU keyswitch is moved to the bypass position, that MMU will go Offline. The remaining online MMUs must be able to support the load or the PMMS will transfer to bypass.

- If the PMMS UPS is online and a System Cabinet keyswitch is moved to the Bypass position, that MMS and its MMUs go offline. The remaining online MMS(s) and their MMUs must be able to support the load or the entire PMMS transfers to Bypass.

- If an MMU goes offline due to an internal fault (system displays a "Notice"), the other MMS will not transfer to bypass unless the MMS is overloaded and an overload timer expires (times out).

Operating Modes

The main operating modes are:

- Online Mode

- Discharge Mode

- Bypass Mode

- Automatic Voltage Regulation (AVR) Mode

- Shutdown Mode

- Manual Mode – service technician only

- Calibration Mode – factory initial calibration or service technician only

The UPS continually monitors internal systems and the incoming utility power. The UPS automatically toggles between the modes that are listed above, and without intervention by an operator. The detection logic and the switching logic that is programmed into the UPS ensures operating mode changes are automatic and transparent to the critical load.

The following benefits are provided by the UPS:

- Voltage Regulation

- Power Factor Correction

- Harmonic Cancellation

Voltage Regulation – When online, the UPS uses reactive current circulating from the input source through the line inductor and the inverter, to regulate steady state voltage. The amount of reactive current (current leading or lagging the voltage by 90°) is determined by the deviation of the input voltage from nominal.

If the input voltage is low, the UPS will supply enough leading current (as viewed from the input source) through the line inductor to make up the difference between the actual input voltage and nominal voltage on the output. If the input voltage is high, the UPS will supply lagging current through the line inductor to buck down the input voltage to nominal on the output. The greater the voltage deviation the more reactive current the UPS utility inverter supplies to correct the voltage, but for given voltage differences the amount of reactive current is always the same.

The nominal voltage of the source must be the same as the nominal voltage of the UPS. The impedance of the transformer must be low enough so that the voltage drop of the transformer and distribution between the transformer and the UPS combined with regularly experienced swings in primary voltage to the transformer remain within the voltage tolerance range of the UPS. It may be necessary to adjust taps on the supply transformer to accomplish this. **The supply to the UPS must be from a grounded wye source** even though the UPS does not require a neutral.

Power Factor Correction – The same current interchange for voltage regulation allows improved input power factor, which will be 0.99 with nominal input voltage. If the voltage is significantly below nominal, the input power factor becomes leading to help boost the input voltage. If the input voltage is significantly above nominal the input power factor becomes lagging to help reduce input voltage.

The change of input power factor with high or low voltage is load dependent – it changes more at reduced loads than at the same voltage level and rated load. This

occurs because the amount of reactive current (kVAR) is determined strictly by the voltage difference between input and output while the real current is determined by load kW. Lower kW for the same kVAR gives a lower power factor.

Harmonic Cancellation – High speed Insulated Gate Bipolar Transistor (IGBT) inverter switches provide non-sinusoidal current to non-linear loads, without distorting the output voltage, ensuring that clean, precise power is supplied to all other sensitive loads. The input current harmonics reflected into the input supply by the UPS are low. When operating with primarily linear loads the input current harmonic distortion is less than 3% of full load input current. Under unusual circumstances with large loads having very high harmonic current content, the input current harmonics will still be less than 8%.

Input current harmonics with the full non-linear load test load specified in EC Norm EN 50091 are less than 8%. UL and FCC have no norm to test against. Therefore all products, U.S. as well as international, are specified using the EC norm. Please note this specification does not mean that if the full rated output of the UPS is constituted entirely of highly non-linear load, then the input harmonics will be less than 8%. The UPS greatly attenuates any harmonics from the load from reaching the input but the exact figure cannot be pre-determined for every conceivable amount and type of non-linear load. The load needs these harmonic currents to operate properly, but they are supplied primarily by the utility converter of the UPS.

Please note that when the UPS is in bypass, the upstream source including generator sets must be sized to handle the load directly without any harmonic mitigation by the UPS. This may require a significantly oversized generator if the loads have high harmonic content.

Input harmonic content during recharge is no more than in normal operating mode (Online Standby state).

Online Mode – Input Power Present

Online Mode is the normal operating mode of the UPS. When operating in the Online Mode, the system is ready to protect the load.
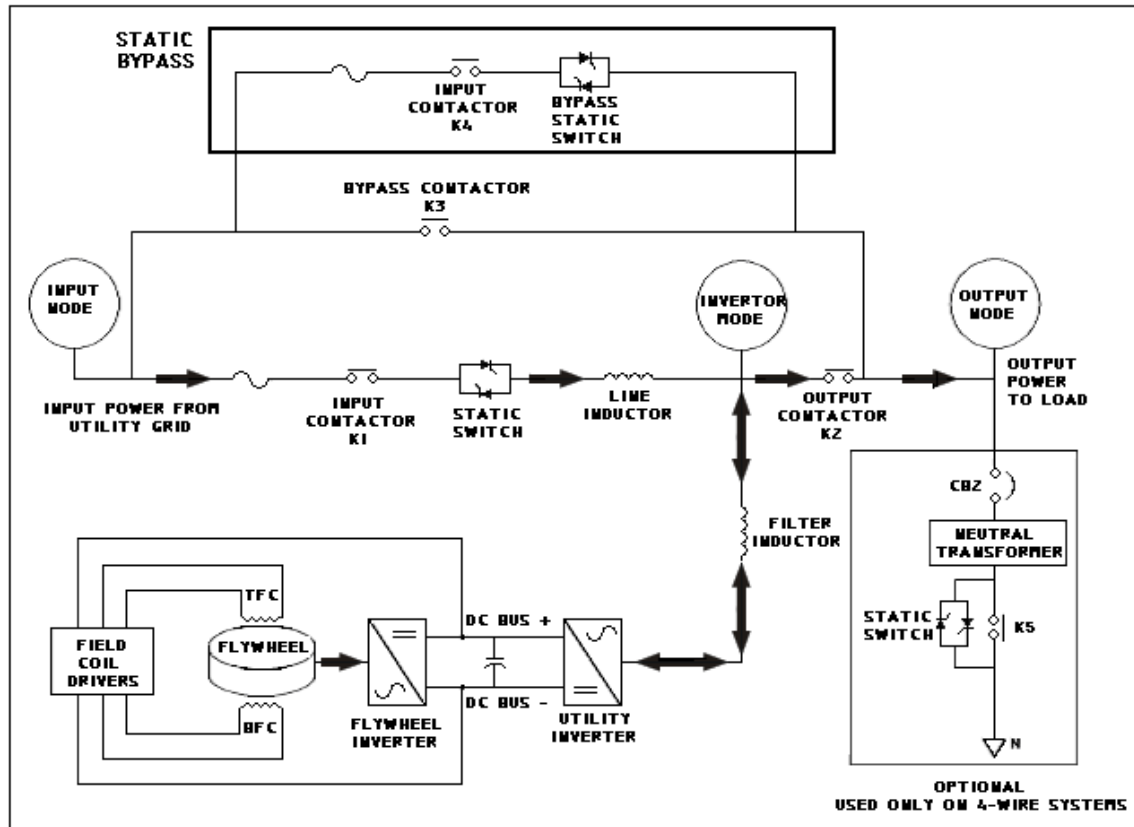
Note: Top Field Coil (TFC) Bottom Field Coil (BFC)

Figure 8: Diagram of Online Mode Power Flow With Input Power Present – All States

Online Mode with input power present has three major states:

- Online Monitoring
- Online Charging
- Online Standby

Online Motoring – The UPS is providing a constant voltage to the load and drawing power from the input to motor the flywheels up to charging speed (4000 RPM). The UPS is now voltage regulating and when the flywheels reach 4000 RPM, the UPS can discharge.

Online Charging – In the Online Charging state, the power flows through the same paths but the charging current is larger because the flywheels are being re-charged after a discharge. Only when the RPM reaches 4000 RPM and the system moves from the Online Motoring to the Online Charging state is the system capable of supporting the load. The energy available is dependent on the RPM at the time the system enters discharge.

Online Standby – When all system flywheels reach their nominal fully charged speed of 7700 RPM, the system is in the Online Standby state. The current used to provide kilowatts for the load flows from the input to the load. The Utility Converter is regulating output voltage by exchanging reactive regulating current with the input through the line inductor.

The UPS is ready to discharge the flywheels to protect the load. A small amount of charging current, about 1 kW, is drawn from the input source to maintain the 7700 RPM standby speed. This is the rated idle speed for the flywheel(s).

Please note that Online Standby state does not imply that the UPS is a standby UPS. The UPS is an online UPS, always working to provide clean power. This "Online Standby" is just the designation of the operating state in which the UPS is fully charged and ready to supply power on its own if the utility should be disrupted.

Online Discharging Mode – Input Power Not Present
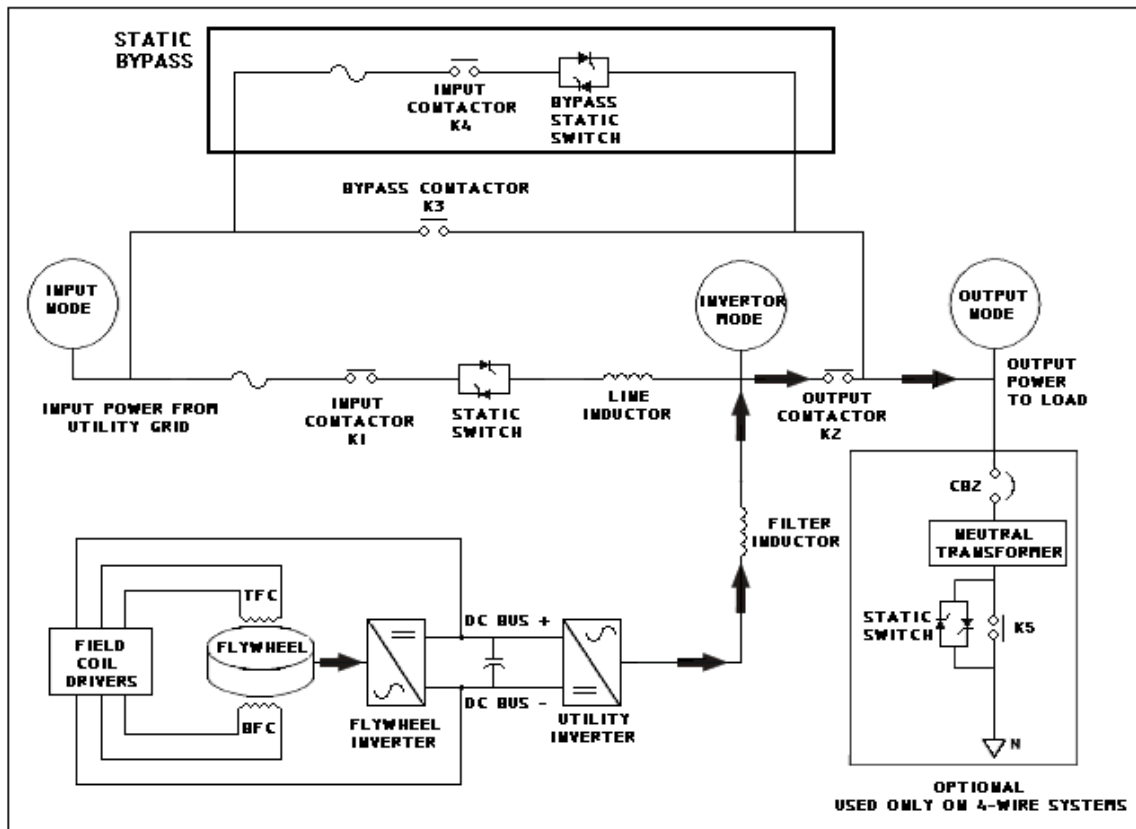
Note: Top Field Coil (TFC) Bottom Field Coil (BFC)

Figure 9: Diagram of Discharge Mode Power Flow

Discharging

The UPS system automatically enters the Discharge state when it is in Online Mode and input power to the UPS is outside of the programmed tolerances. The UPS disconnects from the failed input power source and supplies all of the needed current, including the real current, which supplies kilowatts to the load.

Discharging Sequence

During a discharge the UPS turns off the static disconnect switch as soon as it starts discharging and then opens the input contactor (K1). The static bypass switch is also off during discharge. The power to support the load is supplied by the flywheels through the flywheel converters and the utility converters.

The flywheel inverters regulate the voltage on the DC Bus, and the Utility Inverter converts the DC Bus voltage to 3-phase AC voltage, which is supplied to the load. The flywheels gradually slow down as they deliver power, but the output voltage of the UPS remains the same.

When input power returns to within the tolerances from the generator set or utility, the UPS resynchronizes to the input voltage, closes K1 and turns on the static disconnect switch. It then walks the load back onto the input source using a linear current ramp selected for the input source. This walkin ramp rate is adjustable in kW per second.

Running out of flywheel energy – The default action when running out of flywheel energy prior to the standby generator set or utility power becoming available is to transfer to internal bypass if the bypass is available. One can optionally elect to have the system shutdown, turning off power to the load.

Overload While in Discharge Mode

In normal operation, the Cat UPS System has up to 10 times overload capability for up to 10 milliseconds. The system will immediately transfer to bypass whenever the overload is 200% or greater and utility is within specified tolerances. This assures maximum fault clearing capacity. Overload capability is shown in the table below for SMS and MMS systems

While on flywheel power (when utility power is not available), the overload rating is 120% for 10 seconds. Larger loads will cause the system to transfer to bypass if bypass is available and synchronized. The likelihood and profile of motor starting currents should be considered before adding them to critical load on the UPS output.

Overload Capability – SMS and MMS	
Time	UPS Rating Overload
Continuous	Up to 105%
10 minutes	125%
2 minutes	150%
30 seconds	200%
10 milliseconds	> 200%

Table 5: Table of UPS Overload Capability

Return of Utility Power – On return of the utility power the default setting is automatic restart of the UPS System and powering of the protected load. The generator set is shut down after a cool-down period. Manual restart is also an option, when operator intervention is desired before re-starting

Discharging Modes

Discharge

The flywheels will go into discharge while in normal online operation when:

- **RMS Voltage is High or Low** – If the RMS voltage goes above or below the level specified by the user in the operating parameters, the UPS will discharge. A message will appear in the Event log file.

- **Fast Voltage Transient Occurs** – The UPS continually monitors the voltage that originates from the utility. If the voltage specified by the user exceeds a certain range or drops below a certain range, the flywheels will discharge in order to correct the voltage. A message is sent to the Event log file.

- **Frequency is High or Low** – The UPS is constantly monitoring the frequency of the utility power. If the UPS determines the frequency is out of the range specified by the user, the flywheels will discharge in order to correct the frequency and a message will appear in the Event log file.

- **DC Bus Voltage High or Low** – The utility inverter keeps AC voltage at the normal operating voltage, usually 400 or 480 VAC. The utility inverter keeps DC voltage at 750 DCV. If an input disturbance occurs, the DC bus will either go up or down, and the phase load will be changed by the utility inverter, causing the UPS to discharge. If the DC bus voltage of the UPS drops below a preset limit, this would indicate power is not being delivered to the UPS from the input source.

Phase Match – The UPS is still in Discharge Mode delivering power to the load. The UPS has qualified the input voltage. Additionally, the UPS will match the output (frequency and phase) to the input source.

Walk In – Once a phase match is achieved, the UPS connects to the source. Then, the UPS transfers the load from the flywheel to the source at a programmed rate. The Uninterruptible Power Supply initiates the on-line state (motoring state) upon completion of the "walk in" state.

Self-Discharge Mode (Service Mode)

This state helps brake the flywheel down to zero (0) RPM at a fast rate to prepare the system to be moved or to secure it for maintenance. The Online-Self Discharge mode should only be entered once in a 24 hour time period to avoid overheating flywheel field coils. The system will not go into this state automatically.

Exhaustive Discharge Configurations (Auto Load and Start)

Auto Load and Start is a software configurable operating parameter that determines UPS behavior when power is first applied to the input following an exhaustive discharge of stored electrical energy.

NOTE: Auto Load and Start configurations can only be changed by qualified service personnel.

Configurable Startup Settings:
Manual Load on Manual Start – The UPS remains in Shutdown Mode when power is first applied to the input. The load will not be automatically powered. Manual operation is required to power the load and bring the UPS online.

Auto Load On Manual Start – UPS automatically goes into Bypass mode when power is first applied to the input. Manual operation is required to bring the UPS online.

Auto Load On Auto Start – UPS automatically goes into Bypass Mode, then goes to On-line Mode when power is first applied to the input. Manual operation is not required to bring the UPS online.

The table below shows the available configurable manual and auto start settings.

Startup Configurations		
Auto Load and Start Settings	Startup Type	System Operation
0	Manual Load on Manual Start	The UPS remains in Shutdown Mode when power is first applied to the input. The load will not be automatically powered. Manual operation is required to power the load and bring the UPS online.
1 (Default)	Auto Load On Manual Start	UPS automatically goes into Bypass mode when power is first applied to the input. Manual operation is required to bring the UPS online.
2	Auto Load On Auto Start	UPS automatically goes into Bypass Mode, then goes to On-line Mode when power is first applied to the input. Manual operation is not required to bring the UPS online.

Table 6: Table of Configurable Startup Setting

Bypass Modes
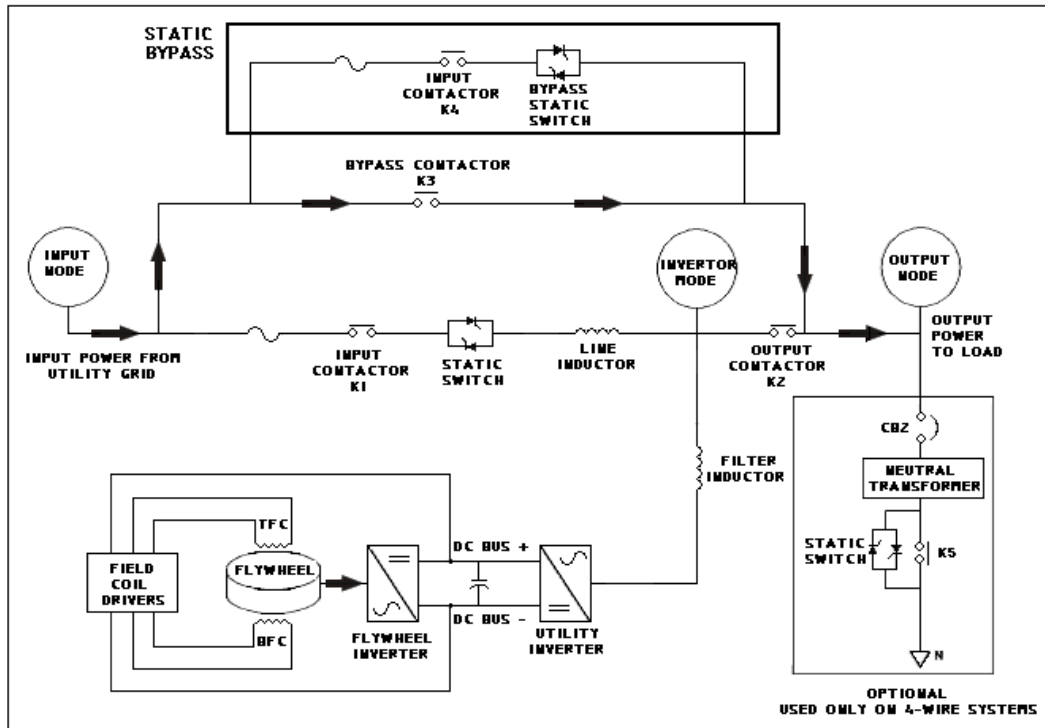
Note: Top Field Coil (TFC) Bottom Field Coil (BFC)

Figure 10: Bypass Mode Power Flow

Bypass Mode directly connects the incoming utility power to the critical load through the Static Bypass, bypassing the UPS system. The bypass circuit provides a path for power directly from an alternate AC source.

The load is **not protected** when the system is in Bypass Mode and will be affected by a disruption of the incoming power.

The system enters Bypass Mode for any of the following reasons:

- System start-up

- Operator command via User Interface or monitoring software

- Output overload or malfunction

- Failure to recover from a fault

Repeated errors that cause the system to move between the Bypass Mode and Online Mode can lock the system into the bypass mode. When the system is locked in the Bypass Mode, the user must change the mode of the system via the keyswitch or the UPS software.

The system bypass circuit consists of the following components:

- Static Bypass Switch

- Output contactor

- Bypass Circuit Breaker

The UPS output contactor isolates the UPS module outputs. The System bypass circuit breaker works in parallel with the static bypass switch. The static bypass switch is a solid-state device that can instantaneously connect the alternate AC source to the load such as a generator set.

Bypassed – Offline

This is the state the system enters when the system has been locked into bypass because of a fault condition. Power is going through the UPS internal bypass circuit. The system can only leave this state when commanded by the monitoring software or key-switch.

When an MMU is offline, there is no power flow through the MMU. Its contactors are open, and its line static switch and utility inverter are off. If any other MMUs are online (MMS system only), the bypass breaker is open.

Bypassed – Verify Signals

When the system is in this state, it verifies that the correct system telemetry is present. This state is used when you are starting the system or during error recoveryÆ (repeated errors that cause the system to move between the Bypass Mode and Online Mode)

Bypassed – Auto Start

This is the default state at startup. The system cannot immediately protect the load after the system is started. During normal operation, the system will enter Automatic Voltage Regulation ("AVR") mode. A flywheel assembly preheat period may be required.

Automatic Voltage Regulation (AVR) Modes

The UPS will enter the AVR mode automatically if the UPS is operating from input power and there is insufficient flywheel energy available to support the load. This may occur during a manual startup or restart such as after an exhaustive discharge (i.e. the input power was present but the UPS ran out of flywheel energy before walk-in was completed).

The system remains in the Automatic Voltage Regulation Mode until the system is charged and until the system is able to sustain discharge. This means there are enough flywheels rotating above 4000 RPM to support the load connected to the UPS output.

While in AVR mode output voltage is regulated to the nominal set-point. The power factor and harmonic benefits of the UPS are also present in this mode.

The load is **not protected** when the system is in AVR mode.

The system enters the Automatic Voltage Regulation mode for any of the following reasons:

- System Start-up (manual or auto)
- Flywheel Errors -there are not enough flywheels available to support the load connected to the UPS output

AVR Motoring – When the UPS is transitioning from Bypass to Online, it transfers from Bypass to AVR mode and then begins to motor (or preheat as required) the flywheels. During the AVR Auto Start state, the flywheel must achieve a rate of 45 RPM before changing to the AVR Charging state.

The system remains in the AVR Mode until there are enough flywheels above 4000 RPM to support the load connected to the UPS output.

AVR Charging – The system enters this state when the system starts to charge the flywheel. Normally, the system enters the On-line Charging state when the flywheel reaches 4000 RPM. When the speed of the flywheel reaches 7700 RPM, the system enters the On-line Standby state.

Under normal operation the system enters the AVR Charging state whenever the flywheel falls below 4000 RPM.

AVR – Verify Signals – When the system is in this state, the system verifies that the correct system telemetry is present. This state is used when you are starting the system or during the recovery of flywheel errors.

Shutdown Mode – EPO

When the system is in the Shutdown mode such as from an Emergency Power Off (EPO) command, K1, K2, K3, and K4 are open. There is no power flow through the system when the system is shut down and no power is supplied to the load. All contactors are open, and both static switches and utility inverters are OFF.

Shutdown mode can be entered for either of the following reasons:

- An EPO has occurred. EPO occurs when you press either the EPO button on the front of the controls cabinet or a remote EPO button (optional).

- There are internal or external conditions that could lead to system failure.

The Emergency Power Off (EPO) button is located on the front of the Flywheel cabinet of an SMS system and on the front of the System cabinet in an MMS system. Pressing the EPO button transitions the UPS to the Shutdown mode.

Operator intervention is required to put the system back online if it is shut down. If an EPO has occurred, there is a reset switch located behind the door on the flywheel cabinet of an SMS system or behind the door of the System cabinet in an MMS system.

WARNING: High voltage may be present internally in the UPS for no less that five (5) minutes after an EPO has occurred. A qualified electrical professional should restart the system after an EPO event. The cause of the event must be corrected first.

Manual Mode

Only factory trained service technicians may use the manual mode. When the system is in the manual mode, a technician can conduct diagnostic tests of the subsystems, calibrate telemetry, or enter flywheel preheating mode for example.

Calibration Mode

Calibration Mode is used in the factory during the initial calibration and in the field as needed by a qualified service technician.

- Calibration Point – The system uses this state to calibrate a telemetry channel. A flywheel preheat mode may be required.

- Energizing – This state is used during Rotor Position Sensor (RPS) calibration. This state energizes the flywheel.

- Auto Adjusting – This state adjusts the commutation of the flywheel to maximize charging.

Flywheel Preheat Mode

The UPS uses the Preheat cycle in order to warm the rotor/stator assembly. It is necessary to verify if preheat is necessary with the start of the flywheel. The various factors that determine if preheating is required include:

- armature temperature

- ambient room temperature

- the length of time of the flywheel in the room at this ambient temperature

- the length of time since the energizing of the flywheel to full speed

The armature temperature of the flywheel must be at least 30 °C (86 °F) before the start of rotation. If the temperature of the flywheel is below 30 °C (86 °F), a preheat cycle of the flywheel will be automatically initiated:

- when you enter the On Line state

- prior to calibration of the Rotor Position sensor

If the temperature is greater than 30 °C (86 °F), a preheat cycle will not normally be performed.

In a normal preheat cycle, the armature temperature determines the length of the preheat cycle. If the temperature is below 30 °C (86 °F), the system will calculate a required cycle time of preheat from 6 minutes (minimum) to 42 minutes (maximum). The preheat is accomplished by sending 3-phase AC voltage to the armature at 85 amperes.

After the preheat, a time period of thermal equalization is determined. This period of time allows the heat that is generated in the armature to be radiated into the rotor. Thermal equalization allows temperatures to equalize. The minimum and maximum times for equalization are 6 minutes and 15 minutes. The time for the equalization of the temperatures will be equal to the preheat time. The time period for thermal equalization will not be greater than 15 minutes.

Once the preheat cycle is complete, the UPS will automatically continue with start-up or the calibration of the Rotor Position Sensor.

42 Minute Preheat Mode

A 42 minute preheat cycle for the flywheels will be initiated if the power to the Flywheel cabinets has been turned off for more than 48 hours. In some cases, the preheat length will not be needed.

If the preheat cycle is completed, the length of the preheat will overheat the armature. This overheating will result in a delay in order to obtain nominal rotor speed. A trained technician can call technical support in order to receive a password for bypassing the 42 minute preheat mode.

The technical support representative will ask three questions in order to determine if the preheat time can be shortened and an override password be provided:

- the temperature in the room of the flywheel

- the length of time of the flywheel in the room in this temperature

- the length of time since the energizing of the flywheel (full speed)

You must have a computer that is connected via a direct serial connection. You must perform the keystroke "Ctrl-^" in order to issue this command into the UPS.

Operational Considerations

Utility Sources

In general, utility sources should be sized by professional engineers who are aware of all the load characteristics, conditions, codes, and equipment limitations that affect proper source selection sizing. However, the following are guidelines that affect source capacity, wire sizing, and supply breaker sizing for the UPS alone. Other loads attached to the source must also be taken into account when sizing the utility source.

Source Capacity

The utility source should have sufficient free capacity to supply the currents including recharge at the default rate at 85% of operating voltage. The source **must** have sufficient free capacity to supply the currents including minimum recharge at 90% of nominal voltage to be able to operate over the default input voltage window for which voltage regulation is specified. If sufficient capacity is not available to supply full load and minimum recharge current over an input voltage window of nominal +/-10%, the unit will **not** be able to maintain its specified voltage regulation.

Limiting Input Current

If the input current of the UPS must be set at a lower value than is necessary for the UPS to provide maximum performance, it reduces performance in the following order:

- The recharging current will be reduced. However, it cannot be reduced below the minimum value of 20 kW per flywheel.

- If the recharge rate has been reduced to the minimum value, then voltage regulation will be reduced, which means that the output voltage will vary by more than the amount in the product specifications for a +/-10% input voltage variation. However, the UPS will continue to keep the load up unless the input voltage deviation is large enough and the regulation is reduced so drastically that the UPS cannot maintain the output voltage within the required output voltage window discussed in the sections below on output.

Supply Breaker Sizing

Below is a table that lists each UPS power, current ratings, and breaker size. The sizes are general suggestions which cannot take into account all situations and applications. The breaker trip rating should be adjustable. Different breakers may have characteristics including trip tolerance bands or de-rating requirements. Also, dual input MMS may require two different sizes of breakers on each of the input feeds due to the additional load of the recharge current on the system feed.

UPS Capability and Breaker Sizing						
UPS System	Voltage/ Frequency (volts)	KVA/kW	Nominal Current (amps)	Maximum Continuous Current (amps)	Maximum Non-Continous Current (amps)	Typical Breaker Size (amps)
60 Hz						
SMS 300	480	300/240	299	400	420	500
300G/300Z	480	300/240	302	400	420	500
600G/600Z	480	600/480	599	800	840	1000
900Z	480	900/720	898	1200	1260	1600
1200Z	480	1200/960	1198	1600	1680	2000
50 Hz						
SMS 250	380-400-415	250/225	355-337-325	400	420	500
250iG/ 250iZ	380-400-415	250/225	355-340-325	400	420	500
500iG/ 500iZ	380-400-415	500/450	709-674-650	800	840	1000
750iZ	380-400-415	750/675	1064 -1011-975	1200	1260	1600
1000iZ	380-400-415	1000/ 900	1419-1348-1299	1600	1680	2000

Table 7: Table of Suggested Supply Breaker Size

In bypass, the supply breaker will see the customer load. Very often these loads have a constant kW characteristic. Therefore they will draw more current at low input voltage than at nominal voltage. For example, a 300 kVA 3-wire, 480 volt unit operating at rated capacity supplies 361 amps to the load. If that load transfers to bypass at 10% low voltage, the bypass current to this load will be 400 amps, not the 361 amps that it draws at nominal voltage. You cannot assume that because the UPS breaker is rated 400 amps that any 500 amp breaker installed under any or all conditions can provide the same current carrying capability.

Wire Sizing

Wiring must follow all applicable codes, of all jurisdictions having authority (national, state and local). The type of wire being used, the installation conditions of the wire, the temperature rating of the devices to which the wire will be attached, and physical conditions at the specific installation site all affect wire sizing and wire cannot be sized until all of this information is available. At the amperages associated with these products the wire must be sized **after all** applicable de-ratings for the rating of the breaker supplying it. When choosing a wire size it is important to determine that the attachments at both ends of the wire run can accommodate the number and size wire being chosen. The UPS manual and the connect drawing provide this information.

Wire Terminations

The system connection points are bus bars in the Input/Output cabinet, and can accommodate up to eight cables per phase and neutral. The bus bars are drilled for 1 or 2 hole NEMA lugs with ½″ hardware. A ground bus is provided to accommodate multiple 1-hole or 2-hole lugs. Lugs are not supplied. The input output cabinet accommodates top and/or bottom cable entry via removable 12-gauge steel conduit-access plates.

Diesel Generator Set Power Sources

The UPS is designed to work with diesel generator sets. Consult the factory before using with natural gas generator sets.

General Requirements

Generator sets should have electronic isochronous governors. Consult the factory before using with older style mechanical isochronous governors. All voltage regulators should be of the 3-phase sensing type.

Generator Set Sizing

Sizing for the generator set source to be applied with a UPS product begins by determining the input power required to support the UPS. The input power requirement is comprised of a calculation which includes the UPS Output power, the recharge and the efficiency of the UPS. The best practice to ensure the generator set is sized to accommodate the maximum load the UPS could generate is to size the system based on the full rated capability of the product. However, this calculation could be altered to provide a calculation based on actual load on the UPS.

To calculate the input power requirement you need to add the output kw to the total recharge of the flywheels and divide by the efficiency of the UPS at the given load percentage. This can be divided by the input power factor to determine the kVA requirement for the UPS.

$$\frac{\text{Output KW + Recharge}}{\text{Efficency}} = \text{Input kW}$$

$$\text{Input kW / Input PF} = \text{Input kVA}$$

For example; in a 600 kVA UPS the output kW is 480 kW. The recharge for each of the 2 flywheels is 75kW each, making the total recharge 150kW. The Efficiency at the full rated load is 97%.

This would make the input kW 650kW.

$$\frac{480 + 150}{.97} = 650\text{kW}$$

If we were to assume the voltage is near nominal and the unit is operating at full load the the input power factor should remain near 0.9pf. This would make the input kVA requirement 722kVA.

650kW / 0.9 = 722kVA

There are several steps which can be taken to reduce the input requirements of the UPS from limiting the input amperage to managing the recharge of the flywheels. There are two ways with which the recharge of the flywheel can be managed. First the recharge can be reduced to as low as 25 kW per flywheel. Reducing the recharge will extend the recharge from 120 seconds to 3.5 minutes.

Recharge can also be delayed for each cabinet independently with a maximum delay of 15 minutes. The delay is preset into each flywheel cabinet and can be extended across multiple MMS systems if necessary. The last flywheel must begin charging prior to the 15 minute window has been reached.

Combining the use of the reduced recharge along with the delayed motoring can reduce the recharge demand for a 1200kVA UPS from 300kW to 25kW, which may provide significant advantage in sizing of the generator set. Any calculations used in determining the sizing of the system should be passed on to the startup technician to be set on site. Both of the recharge changes can be set by a trained service technician.

NOTE: It is possible to have separate charging parameters when operating on Utility and Generator set by providing a contact closure to the UPS to identify the generator is supplying the input power. See the On Generator Set Parameters in Table 8 below for the parameters which can be altered and their values.

On Generator Signal

One of the programmable input contacts of the UPS (See OMM manual) can be programmed to advise the UPS that it is operating on generator set power. The default input contact settings assign the "On Generator" function to input contact 1 of the UPS. This UPS input should be wired to an auxiliary contact in the ATS switch that indicates when the ATS is in the "emergency" (on generator) position. The UPS can be programmed by a service technician to have different values for many of its operating parameters when the On Generator input is activated.

In addition, a programmable output contact can be programmed to activate the ATS once the flywheel reaches a certain percentage of energy remaining. The diagram below addresses this and the contact connection talked about above.

Automatic Transfer Switch

Utility

Start Out   Start In   ATS Command Contact

On Genset Contact

AC

24VDC

Quality → Critical Load

Event Scenario
- On Utility – with 3 good phases
- Phase outage occurs
- UPS detects outage – ATS may not
- ATS Command Contact changes
- ATS TEST START INPUT is Activated
- ATS starts genset start cycle
- UPS on alternative "genset parameters"
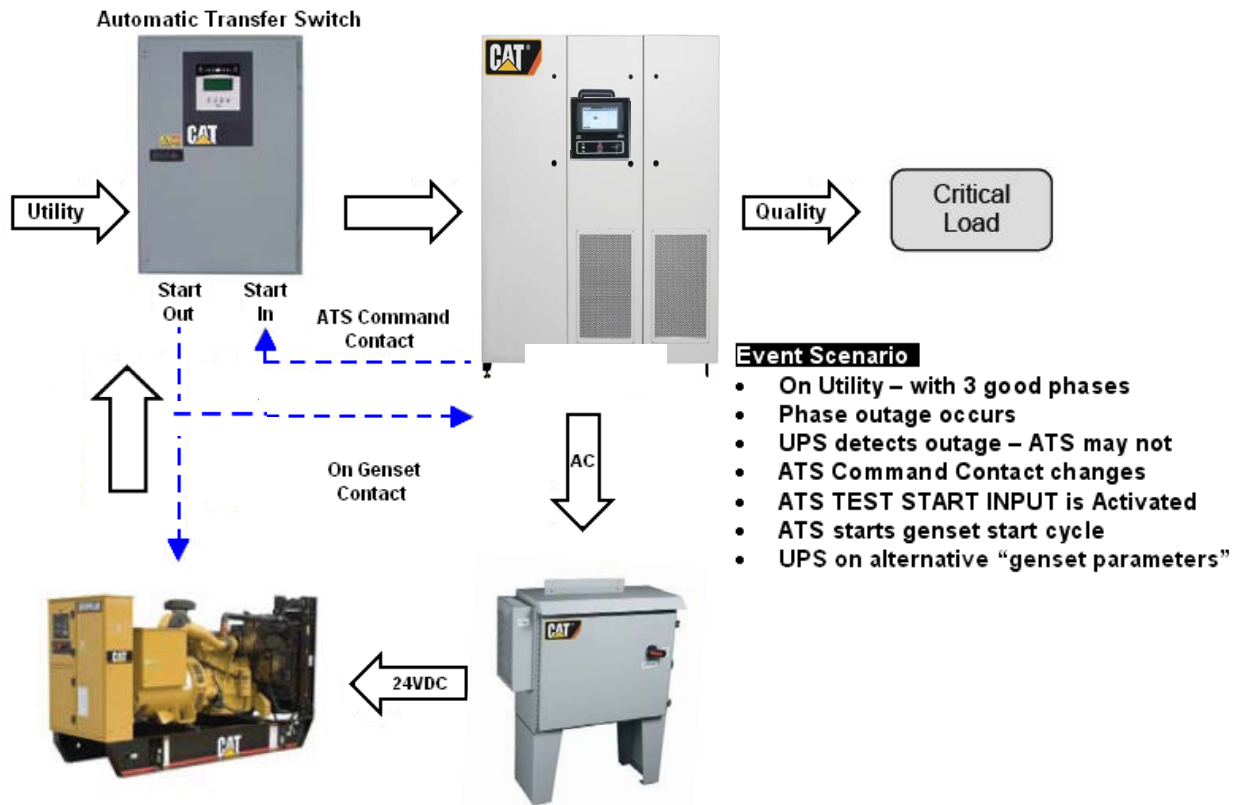
Figure 11: Suggested UPS Communication Links

Continuous Power Sequence

Utility Outage

Transfer Switch Signals Generator Set (adjustable)

Generator Set starts and output stabilizes

UPS Syncs with Generator Set

UPS walks in Generator Set (adjustable)

Generator Set Powers Load

On Generator Set, UPS recharges

t = 0.0   t = 1.0 – 2.0   t = 7.5   t = 9.0   t = 12.0
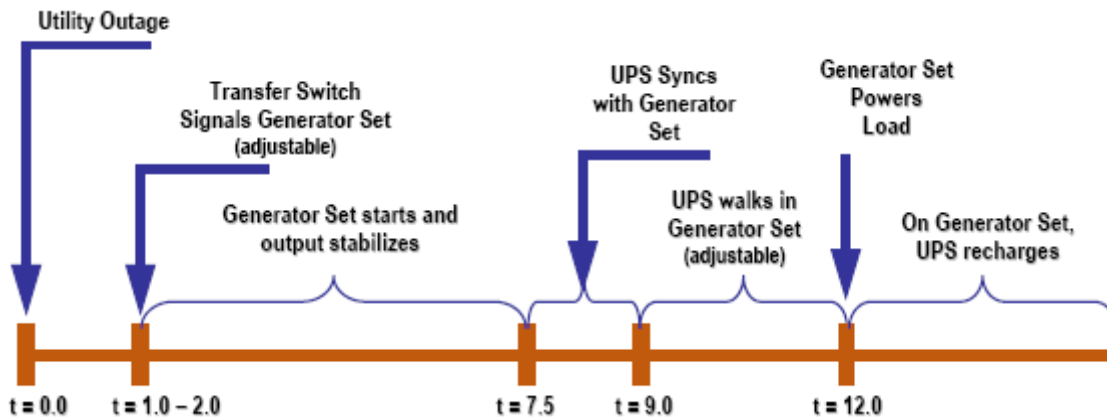
Figure 12: Continuous Power Sequence

A typical continuous power sequence for a utility power outage with UPS ride-through to generator set power is shown above. The UPS supplies power to the load during the time needed to start the generator set and to allow the UPS to ramp up its input current (walk-in) on generator set power. During the transition to running fully on generator power, the UPS flywheel is only supplying about half of the required power on average during the 2.5 seconds of walk-in. The UPS still has at least 1.5 seconds of energy left at rated UPS power at the end of the transfer to the generator set. The UPS 250iG or 250iZ and larger (except the 1000iZ and 1200Z) can be equipped with an additional MMU to provide extra time, the N+1 configuration.

On Generator Set Parameters

The following is a list of SMS and MMS programmable operating and default parameters that are most likely to be set when commissioning a newly installed UPS. The high and low limits are only software limits, not the functional limits.

NOTE: Not all parameters will be set to their default limits when the UPS is received. They should all be checked. Parameter

Parameter	Limits		Default		Units	Password Level	Definition
	Low	High	60Hz	50Hz			
Transient VAC Tolerance	1	50	15		%	Service	Sets the percent deviation from the prevailing input voltage in which the system will disqualify the input voltage and enter into discharge. Lowering this parameter causes the system to enter into discharge on small events and improves the output transient performance. Increasing this parameter decreases the likelihood that the system will enter discharge on utility noise events. COMMENT: If the UPS does not have the on generator signal wired, it may be appropriate to set this to 25%. It is not as important with the APC1P board used in current UPS models.
Genset Transient Tolerance	1	50	25	25	%	Service	Sets the Transient VAC Tolerance while the On Generator signal from a Remote Input is high (closed)
Genset Walk-in Rate	10	8000	85		kW/sec	Service	Sets the Walk-in Rate while the On Generator signal from a remote Input is high. If this walk-in rate is set too high, the generator voltage can sag or slow down in frequency, causing the input voltage to be disqualified and the UPS to go back into discharge before the walk-in is complete. COMMENT: This setting should be load bank tested. The UPS input voltage and frequency should be observed during the walk-in to know how much the engine slows down as the load is applied during the walk-in. This is a good indication of engine performance to should be discussed with the generator representative.
Maximum Motor Current	10	400	200		Apeak	Service	Sets the peak current that will be applied to the armature while motoring. This ultimately controls the amount of power that will be drawn from the source to motor the flywheel.

Genset Maximum Motor Current	10	400	200		Apeak	Service	Sets the Maximum Motor Current while the On Generator signal from a Remote Input is high (closed). This parameter should not be set to 0 and be greater than the Min. motoring current. COMMENT: This is the best way to reduce the amount of power drawn by the UPS during recharge. 200 = ~75 kW of recharge power per flywheel;100 = ~30 kW of recharge power per flywheel. Setting this value to 90 or 80 is OK but flywheel field coil temperatures should be monitored during motoring.
MMU Maximum Input Current	10	400	400		Arms	Service	Sets the Maximum Input Current per MMU when the UPS is not motoring. If the input voltage (-10%) and load conditions (100% load, 0.8pf) exist such that the input current hits this number, the UPS will reduce the amount of voltage correction until the conditions change. COMMENT: These parameters are not very useful now that there are system input current and power limits.
Genset MMU Maximum Input Current	10	420	420		Arms	Service	Sets the Maximum Input Current while the On Generator signal from a remote input is high (closed). A successful installation involving an undersized generator requires the transient response of the generator to be very good. COMMENT: These parameters are not very useful now that there are system input current and power limits.
Genset Maximum Motoring Input Current	10	420	420		Arms	Service	Sets the Maximum Motoring Input Current while the On Generator signal from a Remote Input is high (closed). COMMENT: These parameters are not very useful now that there are system input current and power limits.

(P)MMS Maximum Input Current *	100	10000	3400		Arms	User	Sets the maximum input current that the PMMS (or MMS) will draw from the source. This parameter is also settable on an MMS. COMMENT: Can be used to set a system (PMMS or MMS) Input Current Limit. This may be useful if the input breaker is undersized.
Genset (P)MMS Maximum Input Current *	100	10000	3400		Arms	User	Sets the maximum input current that the PMMS (or MMS) will draw from the source when the on generator remote input is active. This parameter is also settable on an MMS. COMMENT: Same as (P)MMS Max Input Current
(P)MMS Maximum Input Power *	100	7000	2800		kW	User	Sets the maximum input power that the PMMS (or MMS) will draw from the source. This parameter is also settable on an MMS and should be at least 100 kW larger than the largest UPS load. COMMENT: Same as Genset (P)MMS Maximum Input Power
Genset (P)MMS Maximum Input Power *	100	7000	2800		kW	User	Sets the maximum input power that the PMMS (or MMS) will draw from the source when the on generator remote input is active. This parameter is also settable on an MMS and should be at least 100 kW larger than the largest UPS load. COMMENT: Can be used to set a system (PMMS or MMS) input power limit. This may be useful to prevent overloading a generator. This number should be at least 100 kW larger than the largest UPS load.

Genset Motoring Delay	0	600	0		seconds	Service	Sets the amount of time the controller will wait before it will start motoring the flywheel. This delay is only active when the On Genset signal is high. (MMS)This parameter has to be set in each MMU and can be a different value in each MMU. If the flywheel is waiting to motor and below 4000 RPM it will be discharge disabled. COMMENT: Can be used if the generator is undersized. If the flywheel is waiting to motor and below 4000 RPM it will be in discharge disabled. Even a 10s delay can be useful if the engine is closely matched because the flywheel's field coil currents are high at the end of discharge and represent a load to the engine. A 10s delay will allow the field coil currents to be reduced to their motoring levels before the motoring ramp begins.
Input Under Volt Trip	1	15			%	Service	Sets the percent deviation below the Nominal Voltage setpoint in which the system will disqualify the input voltage and enter into discharge. COMMENT: This setting can be lowered (UV) to 15%. Some generators have a droop function that lowers the voltage as the frequency drops in response to a step load. The generator droop function is not very useful with the generator connected to a UPS because it doesn't reduce the torque required by the engine
Fast in Under Volt Fault	1	15			%	Service	Sets the % level for the fast input undervoltage (input voltage D) transfer to bypass. This is only active when the UPS is in AVR mode. COMMENT: This setting can be lowered (UV) to 20%. Some generators have a droop function that lowers the voltage as the frequency drops in response to a step load. The generator droop function is not very useful when the generator is connected to a UPS because it doesn't reduce the torque required by the engine. Since the UPS keeps constant voltage on the load bank.

Under Frequency Trip	45	60	58	48.5	Hz	Service	Sets the minimum frequency in which the system will disqualify the input voltage and enter into discharge. A step load on a generator may cause the generator to slow down below this level. This is the minimum frequency to which the load will be exposed to while the UPS is Online. This also sets the minimum frequency for UPS start up and Bypass Range Checking. COMMENT: Especially with computer loads, this setting can be set 1-2 Hz lower.
Frequency Slew Rate	0.05	3	1		Hz/Sec	Service	This controls the speed in which the UPS output voltage will be brought in-phase (phase match) with the input before it can begin the walk-in. COMMENT: Especially with computer loads, this setting can be set 1-2 Hz/Sec higher. Raising the slew rate should be done cautiously if there are motor or drive loads on the UPS output.
Phase Match Tolerance	0.1	3			degrees	Engineer	Sets the maximum allowed phase error (degree) to transition from phase-match to walk-in during discharge. COMMENT: Especially with computer loads, this setting can be set 1-2 degrees wider.
* MMS and (P)MMS only							

Table 8: On Generator Set Programmable Parameters

ATS Notes and Connections
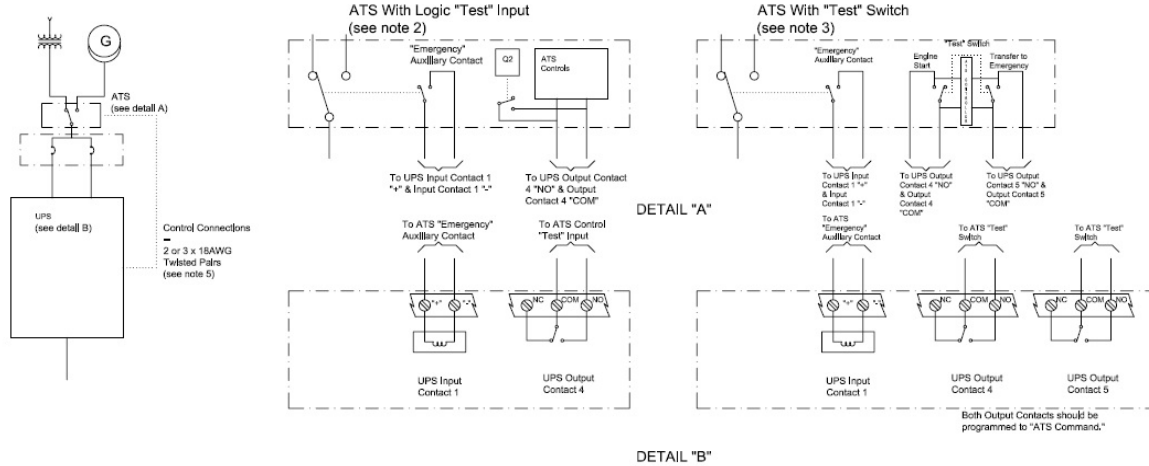
Notes:

1. It is highly recommended that the ATS be interfaced to the UPS to avoid energy depletion due to multiple short outages.
2. "Test" input to ATS Control may be denoted as option Q2 (typ. Caterpillar). Other designations may also apply. "Emergency" Auxiliary contact may be denoted as option A3 (typ. Caterpillar). Other designations may also apply. Consult ATS manual or manufacturer for connection details.
3. "Test" switch may be denoted as option 6A (typ. Caterpillar). Other designations may also apply. "Emergency" Auxiliary contact may be denoted as option A3 (typ. Caterpillar). Other designations may also apply. Consult ATS manual or, manufacturer for connection details.
4. Consult UPS Operations and Maintenance Manual for specific connections locations and contact programming instructions.
5. If ATS controls utilize a "Test" input (refer to note 2), 2 18AWG twisted pairs are required. If the ATS utilizes a DPDT switch, 3 18AWG twisted pairs are required.
6. The ATS input voltage tolerances should be set to the same as or tighter than the input tolerance setting of the UPS.
7. The UPS input contact should be programmed to 'On GENERATOR SET.'
8. The UPS output contacts should be programmed to 'ATS Command.'
9. The 'ATS Command Level' parameter should be set to a value that will allow enough time for the generator to start and be connected to the input of the UPS before the flywheel(s) run out of energy. A typical setting is 85%. Full load testing is recommended to insure sufficient generator start times. Setting the value too high may cause the relay to energize during a transfer from generator to utility.
10. The 'ATS Stop Delay' parameter is defaulted to 0 seconds but a delay can be added if desired.
11. The ATS Command relay will be energized when the following 4 conditions are met:
    1. UPS in discharge
    2. UPS in discharge for more than 1 second
    3. UPS not in walk-in
    4. System (flywheel) % energy < ATS Command Level
12. The ATS Command relay will de-energize when the following 3 conditions are met:
    1. UPS in stand-by (flywheel(s) at full speed)
    2. System (flywheel) % energy > ATS

Figure 13: ATS Interconnect – SMS, G Series, Z Series

Additional Concepts

Transient voltage Surge Suppressors

Although the UPS will protect the load from line surges, and complies with standards for surge withstand, extreme voltage surges may damage the UPS equipment. Therefore, it is recommended that all installations have appropriately sized Transient Voltage Suppression Systems (TVSS) at building electrical service entrance.

Systems without a Redundant MMU

In a system without a redundant MMU, all the Multiple Module Units will supply the full rated load. If the Multiple Module Units malfunction, there will be a transfer of the load to the bypass line without an interruption of power. Any Multiple Module Units can be taken off the critical load manually for maintenance without disturbing the critical load bus.

Selective Tripping

Each MMU has a self-diagnostic capability. If a failure of a Multiple Module Unit occurs, the faulty Multiple Module Unit will be removed from the critical bus. Selective tripping does not rely on information that is shared among Multiple Module Units.

Load Sharing

In an MMS system with multiple MMUs in parallel operation, all of the inverter units automatically share the load at all times. The output current of individual Multiple Module Units will be no more than 5% unbalanced. The parallel load sharing function is programmed within each MMU. In (N + 1) systems, the redundant MMU only shares the reactive current.

Manual Load Transfers

A manual load transfer between the UPS output and the alternate bypass AC source can be initiated from the UPS control panel. Manually initiated transfers will make the connection to the alternate bypass AC source before breaking the connection (closed transition). These transfers utilize the UPS output and the system bypass circuit breakers.

Automatic Load Transfers

An automatic load transfer between the inverter outputs and the alternate bypass AC source is initiated if an overload condition is sustained for a time period that is in excess of the system output capability. An automatic load transfer may also be initiated due to a malfunction that would affect the output voltage.

Transfers that are caused by overloads initiate an automatic retransfer of the load back to the system only after the load has returned to a level within the rating of the UPS. The system logic of the UPS allows the load to be retransferred up to three times. The retransfers are adjustable within ten minute periods in order to prevent cyclical transfers which are caused by overloads. **The system will be locked out in bypass mode on the fourth transfer and must be reset.**

Momentary Overloads

The static bypass switch will connect the bypass AC source to the load and close the system bypass circuit breaker in one of the following cases:

- Load current inrush

- Branch load circuit fault is in excess of the system rating. The transfer of the load to bypass mode will be uninterrupted.

Protection and Back-feed Prevention

The critical output bus is protected from the flow of excess current by fuses. Each phase of the bypass circuit is protected by the bypass circuit breakers. Monitors for blown fuses indicate when a blown fuse will prevent the path for the static bypass switch from being available for automatic transfers.

The static bypass switch will not feed the UPS power back to the bypass distribution system while the UPS system is operating on flywheel mode during a bypass source power outage. The static bypass switch is provided with redundant bypass power outage sensing circuits. The static bypass switch is provided with disconnects that are for redundant bypass power outage sensing.

The back-feed prevention system operates even if two component failures exist simultaneously. If a shorted SCR is detected, the static bypass switch is isolated. An alarm message will be annunciated at the control panel for the System Cabinet. The load shall remain on conditioned power and protected power after detection of a shorted SCR and after isolation of the static bypass switch.

Power Sources

The only connections that are needed for operation of the system include:

- Three-phase connections from the supply

- Neutral input connection for four-wire systems only

- Three-phase connections to the Load

There are several voltage sources that are developed internally for the system.

- **Input 230 VAC Source** – This source is derived from a multi-tap control power transformer (T1). The primary terminals are connected to the input node. This source is used in order to provide power to the following components: the bypass contactor (K3 - SMS only), the input contactor (K1), cooling fan 2, and cooling fan 5.

- **Output 230 VAC Source** – This source is derived from a multi-tap control power transformer (T2). The primary terminals are connected to the output node. This source is used to provide power to the following components: the vacuum pump, the output contactor K2, cooling fan 1, cooling fan 3, cooling fan 4, and cooling fan 6.

- **190 VAC Source** – This source is derived from multi-tap control power transformers (T1, T2, and T3). T3 is only in the System Cabinet of Multiple Module Systems. This source is rectified to 268 VDC on the power distribution board. This source is used to supply power to the dual 24 VDC power supplies.

- **24 VDC Source** – This source is derived from dual 24 VDC power supplies. The source is used by most of the system's circuit boards.

- **±400 VDC Bus** – This power source is initially obtained by rectifying and magnifying the voltage that is present at the filter node. This source is used to drive the field coils in the flywheel. This source is used by the flywheel converter.

Automatic Transfer Switches

Most microprocessor-based Automatic Transfer Switches (ATS) have the required features to allow proper integration with the UPS.

The minimum required features are the following:

1. Three-phase voltage sensing on the normal and emergency inputs.
2. Programmable under and over voltage tolerance settings with minimum window less than nominal +/- 10%.
3. Programmable under- and over-frequency settings with minimum window less than nominal +/- 1% and maximum greater than +/- 5%.
4. Programmable generator set start delay with minimum setting of 1 second or less. Note if the switch also has a transfer delay (a delay between the point in time at which generator set input meets frequency and voltage requirements and the time of transfer to the generator set), it is important that this delay be adjustable to zero.
5. External transfer-test input activated by a potential-free contact closure that will cause the transfer switch to start the engine and transfer to it. This is used in conjunction with the programmable contacts of the UPS to avoid multiple, short but rapidly repeating outages from exhausting the flywheel even though no single outage is long enough to cause the transfer switch to start the engine and transfer.
6. Switch position contacts. An auxiliary contact on the switch that is available to give the UPS an "On Generator" signal when the transfer switch is in the emergency position.

Grounding

Proper grounding is necessary for optimum performance, reliability, and safety. Improper grounding will result in uncontrolled electrical circuit paths and in unreliable electrical circuit paths. Uncontrolled electrical circuit paths can cause electrical activity that may be unsafe and degrade the electronics and communications.

A safety ground wire must be installed from building ground to the ground point in the UPS module cabinet. The grounding conductor must comply with local codes and requirements.

Grounding Configurations

There are three commonly used grounding methods around the world for 3-phase power systems. These are the following:

1. 3-wire wye solidly grounded
2. 4-wire wye solidly grounded – 3-phases plus neutral
3. Impedance grounded – 3-phases, no neutral and a resistor between the neutral point of the source and ground.

The SMS and MMS UPS systems have been designed to work with these standard grounding configurations. The standard configuration for the 480V UPS is 3-wire solidly grounded and the standard for 380-415V systems is 4-wire solidly grounded. Impedance grounding can be provided by request at increased cost.

There are other non-standard grounding methods such as "wild leg" grounded delta, corner grounded delta and ungrounded delta. These are obsolete methods but can still be found, mostly in older industrial areas. As with most other UPS systems, The SMS and MMS Series UPS requires an upstream isolation transformer for the UPS and bypass before it can be connected to these more obsolete power systems.

3-Wire Wye

The figure below shows a 3-wire, wye connected, solidly grounded power system. The neutral point of the 3-phase system is connected directly to ground and neutral conductors are not run from the source.
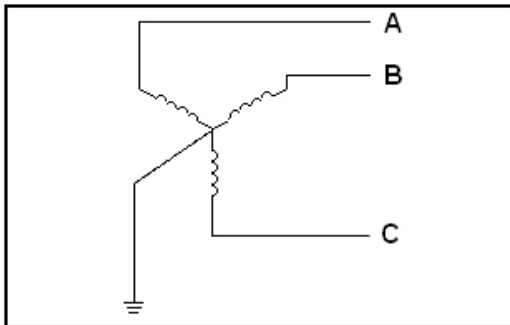
Figure 14: 3-Wire Wye Connected w/ Solid Ground

4-Wire Wye

The figure below shows a 4-wire, wye connected, solidly grounded system. It is the same as the previous configuration except that a neutral is run form the source so that loads can be connected line to neutral as well as line-to-line. A 480V 4-wire system is often shown as 480/277V or 277/480V because the line-to-line voltage is 480V and the line to neutral voltage is 277V. Similarly, in a 400V, 4-wire, wye-connected system is often shown as 400/230V or 230/400V and a 208V 4-wire system is shown as 208/120V or 120/208V.
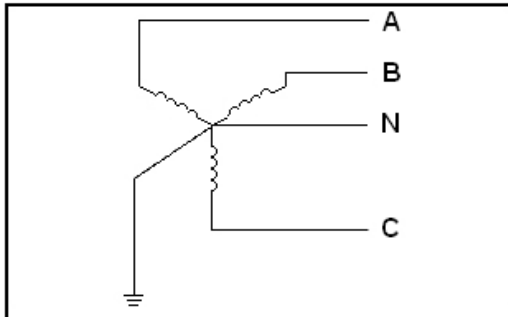
Figure 15: 4-Wire Wye Connected w/ Solid Ground

Wild Leg or Corner Grounded Systems

Three phase systems designated 480/240V, 460/230V or 440/220V are "wild leg" systems. They are not wye connected and cannot be used with a Cat UPS without an upstream isolation transformer. Wild leg and corner grounded systems are shown in the figure below.
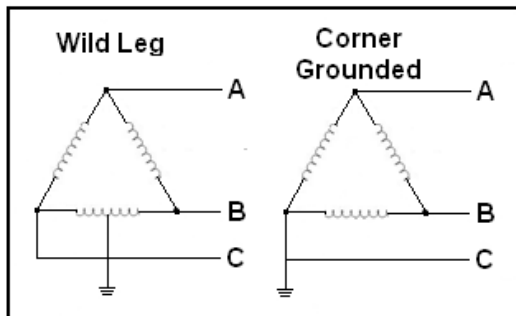
Figure 16: Incompatible Grounding Configurations

Impedance Grounded

Impedance grounded systems have a resistor between the neutral point of the source and ground. The idea is to limit the current of a ground fault to a low value, typically less than 10 amps, so that a ground fault can be indicated and located, but the system can continue to operate.

Neutrals are prohibited in impedance grounded systems in North America.
They are permitted in some European countries (IT-AN systems). The figure below
illustrates an impedance grounded source (sometimes called high impedance
grounded).
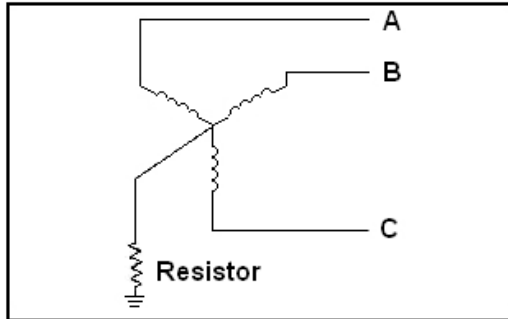
Figure 17: Impedance Grounded System

North America

In North America, 480-volt systems are predominantly 3-wire solidly grounded. The
loads are actually at 208/120V 3-phase, 4-wire and a transformer or power
distribution unit (PDU) containing a transformer is normally installed down stream of
the UPS to convert from 480V to 208V. In most cases, the only loads that operate
at 277V, the line to neutral voltage for 480V systems, are fluorescent lighting. In
most cases this voltage is derived using a 480V to 277V transformer because the
loads are small compared to the other loads and it is cheaper to install lighting
transformers than to run neutrals throughout the power system. The following figure
shows a typical North American power system with conversion from 480V 3-wire to
208/120V 4-wire.
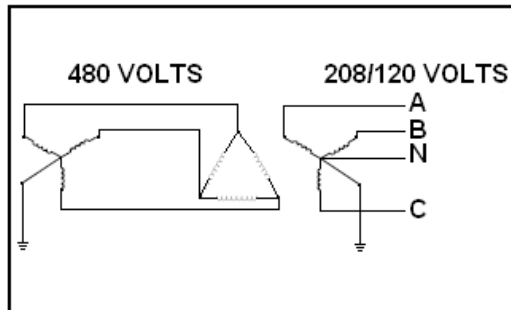
Figure 18: North American Power System – Typical

Europe and Other 400V (also 380V and 415V) Areas

In the parts of the world using 400V systems, the loads actually run on 400V 3-phase or 230V single phase power. Therefore, transformers are typically not used between the UPS and the loads. Therefore, 4-wire electric distribution is almost universally used at this voltage level. 400V Power Systems look like the figure below, without intermediate transformation between the service entrance transformer and the loads.
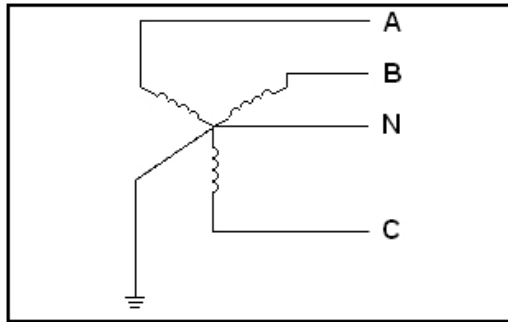
Figure 19: Europe and Other 400V Systems Grounding

IMPORTANT: Because of the bypass, UPS systems with 4-wire outputs must always have 4-wire inputs unless the UPS output and all bypasses flow through an isolation transformer supplied as part of the UPS. Most UPS systems do not have a transformer between the bypass and the load. Line interactive and standby UPS also need a neutral in 4-wire systems because the load is actually supplied by the input source of the UPS most of the time.

Line Interactive vs. Double Conversion and Standby UPS

It is well known in the power industry that, except in certain special highly controlled situations, two non-identical wye transformer windings cannot be connected in parallel if their neutrals are connected, either directly or through ground. Large circulating currents will result from small differences in the transformers. Acceptable and non-acceptable source paralleling configurations are shown below.
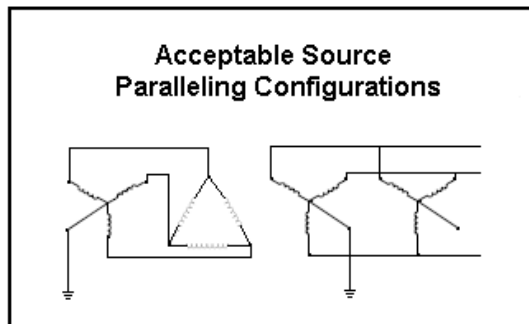
Figure 20: Acceptable Source Paralleling Configurations
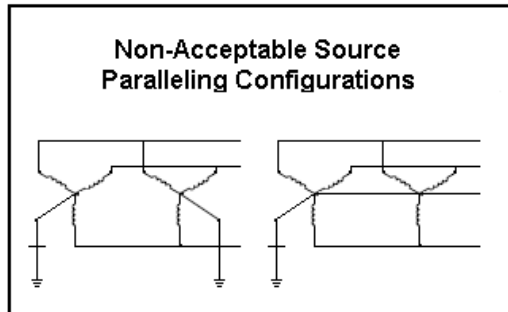
Figure 21: Non-Acceptable Source Paralleling Configurations

A double conversion UPS has no AC power connection between the inverter and the input source when the inverter is running. The DC bus separates them. That means the UPS can have a wye output, and its neutral can be either grounded (3-wire systems) or connected to the incoming neutral (4-wire systems).

In a standby UPS we can also connect the output neutral to the incoming neutral because the inverter is running at low current when connected to the incoming power. This limits circulating currents to a very low level. Whenever the inverter is operating at high current, the UPS is disconnected from the incoming source and no circulating currents can flow.

A line interactive UPS is different. The inverter operates at high current levels when connected to the utility. It normally supplies all of the reactive current for the load and whatever reactive current is needed to regulate voltage. The result is that the output of the inverter can only be connected to neutral when the UPS is disconnected from the input supply. It also means that in a 3-wire system the output of the UPS cannot be solidly grounded because this is just like connecting the neutrals together. The Cat UPS solves these issues using an innovative design. The Configuration for 3-wire systems is shown in the figure below.
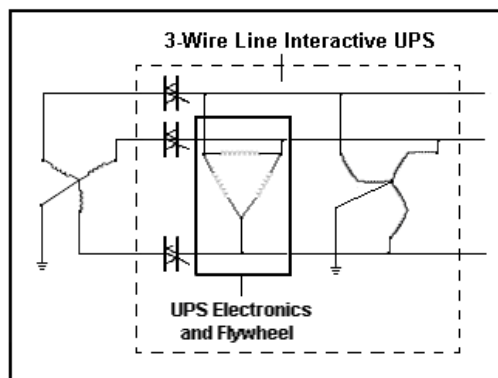
Figure 22: 3-Wire Line Interactive UPS Grounding

A built in resistor in the grounding circuit eliminates circulating currents during normal operation and keeps the output ground referenced during discharge. This configuration is solidly grounded during normal operation and impedance grounded

during discharge. If we detect a low impedance ground fault condition during discharge, the UPS will shut down without being subjected to high fault currents. The grounding transformer is very small because the resistor limits current through the transformer to less than 10 amps under fault conditions. This solution keeps our efficiency high, eliminates high current stress on the UPS from ground faults, and requires no additional footprint and very little additional weight.
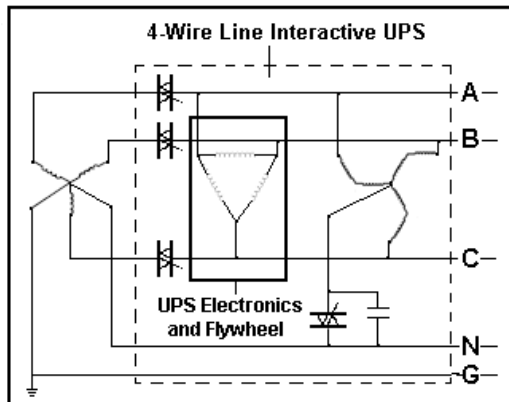
Figure 23: 4-Wire Line Interactive UPS Grounding

The figure above shows the configuration for 4-wire systems. The neutral is supplied from the source to the load, as in all 4-wire UPS. The difference is that when we disconnect from the utility we must connect the neutral of the UPS Inverter to the Utility neutral to provide a complete circuit for single-phase loads. This is the essentially the same thing as 4-wire switching which is used extensively in Europe between generators and utility. The Neutral is 2X rated. This requires a much larger grounding transformer than for the 3-wire system but it is still small compared to normal transformers because it only has to handle the neutral current for short periods. This will not increase the footprint of Multi-Module systems and requires only a slightly wider bypass cabinet for a 4Wire SMS bypass cabinet.

Product Overview

Single Module Systems

Bypass Cabinet   Flywheel Cabinet

Note: 4-wire bypass cabinet shown

Figure 24: Single Module System SMS

Depending on kVA rating, the UPS is either a Single Module System (SMS) with one single flywheel or a Multiple Module System (MMS) with multiple flywheels. The UPS 250/300 SMS single flywheel systems are distinguished from the MMS systems by a combined system (power electronics) and flywheel cabinet that is bolted to a bypass cabinet. This flywheel cabinet also houses the flywheel vacuum pump and touch screen interface on the cabinet door. There are 6 cooling fans on top the flywheel cabinet with one being redundant. One fan or multiple fan failures will signal an alarm but will not cause the UPS to go to bypass if temperatures are within limits.

The SMS bypass cabinet contains the input and output power connections. These may be solid bus bars or optional maintenance bypass (MBP) switches. The width of the bypass cabinet can be two different sizes, a three-wire system bypass cabinet and a wider four-wire system bypass cabinet that contains a neutral transformer. See the current UPS price list for configurable options.

The optional single input MBP Disconnect Switches are available at 60 or 50 Hz, in 3 or 4-wire configurations, and consist of the following manually operated switches: Bypass, Output, and Input. Electrically operated breakers are not available. They are located on the right side of the SMS Bypass cabinet at the top. See the illustration below for the location of the switches in the cabinet.

There are different configurations of switches that depend on options, on the cabinet and utility connections. The 60 Hz 3 breaker Maintenance Bypass (MBP) in 3 or 4-wire will use 3 pole switches. The 50 Hz MBP will use 4 pole switches. See the table of available SMS Maintenance Bypass Configurations below.

Unlike the MMS systems, the SMS systems are single input only and cannot add expansion flywheel modules for increased kVA capability or for increasing ride through time as an N + 1 system. These terms will be addressed later. If a dual input system is required a MMS UPS must be configured. Also, the SMS systems **cannot** be paralleled with another SMS, or MMS UPS.

SMS System Configuration and Capability

Below is a table of available 60 and 50 Hz configurations.

SMS Configurations and Capability		
	60 Hz	**50 Hz**
System	SMS 300	SMS 250i
KVA Rating	300	250
Power Factor	0.8	0.9
Maximum kVA	300	225
kW Rating	240	225
N + 1 MMU Option	No	No
# of Flywheels	1	1
Maintenance Bypass Option	Manual Internal Switches	Manual Internal Switches
Paralleling Support	No	No

Table 9: Table of SMS Configurations and Capability

Ride Through Times – SMS

The tables below approximate ride through times vs. load being carried by the UPS at 60 and 50 Hz for the SMS systems.

SMS 60 Hz Ride Through Time		
% rated	**kW**	**Ride Through Time**
100	240	13 seconds
75	180	17 seconds
50	120	25 seconds
25	60	50 seconds

Table 10: Table of ride through times SMS 300

SMS 50 Hz Ride Through Time		
% rated	**kW**	**Ride Through Time**
100	200	17 seconds
75	150	22 seconds
50	100	32 seconds
25	50	61 seconds

Table 11: Table of ride through times SMS 250

Single Module System Component Diagram

The following figure shows a simplified line diagram and major components of the SMS system. The diagram includes the optional maintenance bypass. The 4-wire neutral transformer shown is optional on the 60 Hz product.
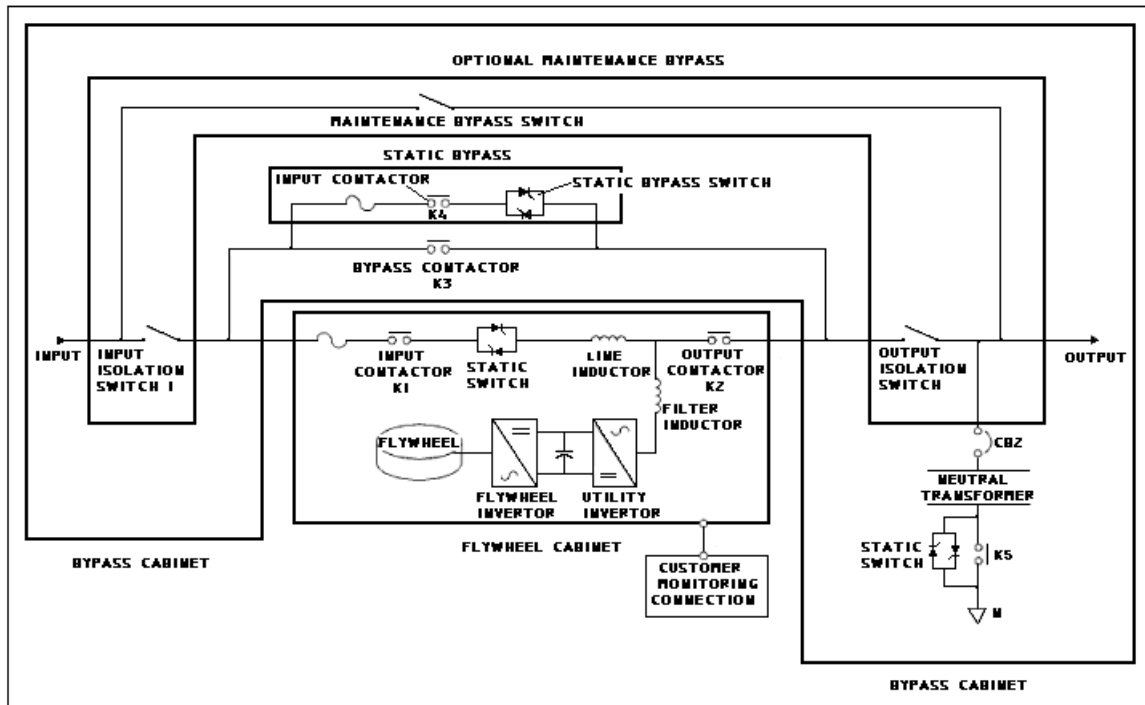
Note: 4-wire neutral transformer optional on 60 Hz UPS
Note: optional maintenance bypass shown

Figure 25: SMS One Line Diagram – Single Input 4-Wire

The following frontal views of the SMS shows major standard and optional component locations. See the SMS Installation Drawings for more views.
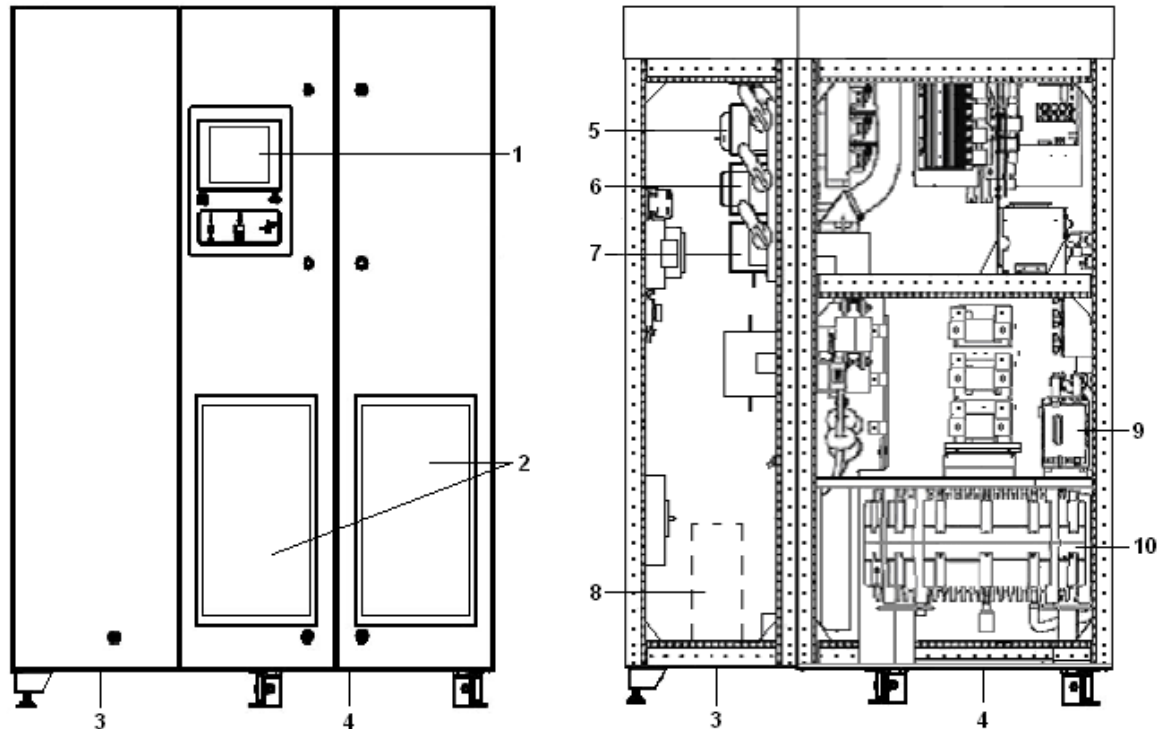
1. Touchscreen Interface
2. Air Filters
3. Bypass Cabinet
4. Flywheel Cabinet
5. Bypass Switch (optional)
6. Output isolation switch (optional)
7. Input isolation switch (optional)
8. Neutral transformer – 4-wire (optional at 60 Hz)
9. Vacuum pump
10. Flywheel

Figure 26: SMS Major Components Diagram – (front view)

SMS Maintenance Bypass Configurations

The table below shows available 3 and 4-wire configurations with optional Maintenance Bypass (MBP) switches. The switches are manually operated.

WARNING: Input power to the bypass switches is still available and must be considered when servicing.

Maintenance Bypass Configurations		
Series	**Utility**	**MBP Switch**
SMS	3-wire	3-pole
SMS	3-wire	not present
SMS	4-wire	3-pole
SMS	4-wire	4-pole (optional)
SMS	4-wire	not present

Table 12: Table of Available SMS Maintenance Bypass Configurations

The following views of the SMS bypass cabinet show the major standard and optional component locations.
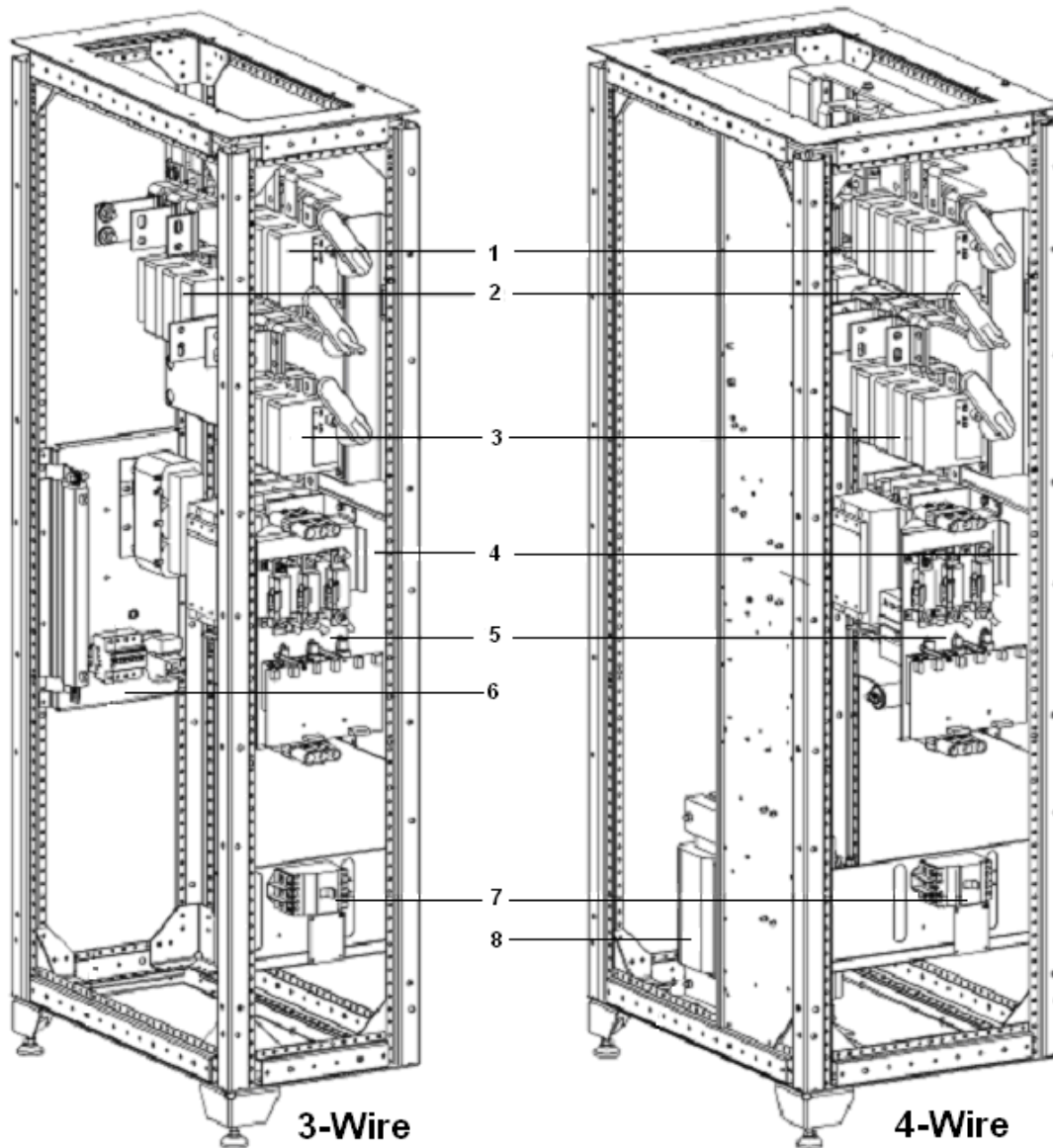
1. Bypass Switch-manually operated (optional)
2. Output Switch-manually operated (optional)
3. Input Switch-manually operated (optional)
4. Right Panel
5. Static Bypass Panel
6. Rear Panel (3-wire only)
7. GSM Circuit Breaker (optional)
8. Zig-Zag Transformer (neutral transformer, 4-wire only)

Figure 27: Right View of Bypass Cabinet (shields removed)

3-Wire   4-Wire
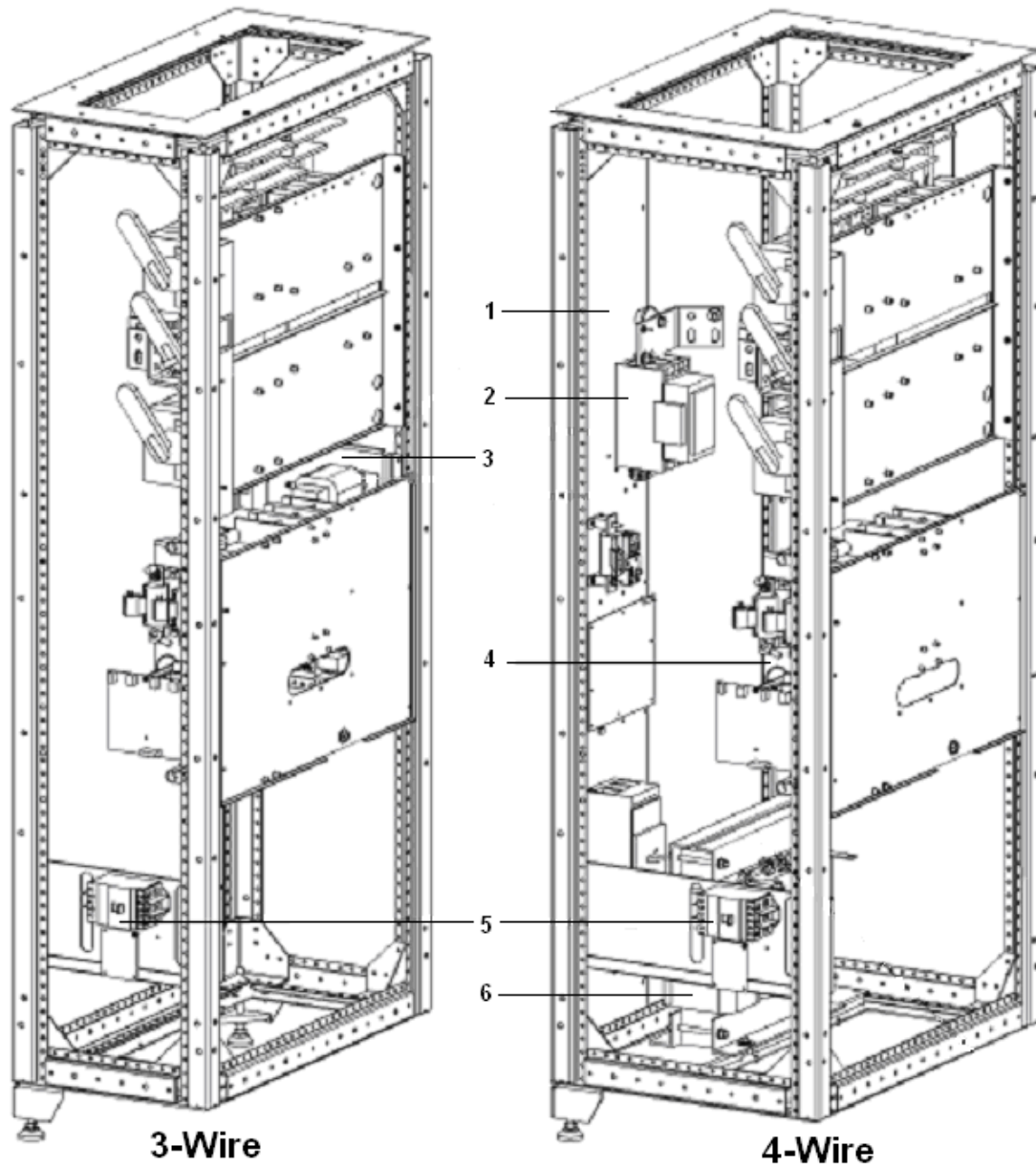
1. Left panel (4-wire only)
2. Contactor "K5"
3. Rear panel 3-wire only
4. Static bypass Panel
5. GSM Circuit Breaker (optional)
6. Zig-Zag Transformer Panel (neutral transformer, 4-wire only)

Figure 28: Left View of Bypass Cabinet (shields removed)

Multi-Module Systems
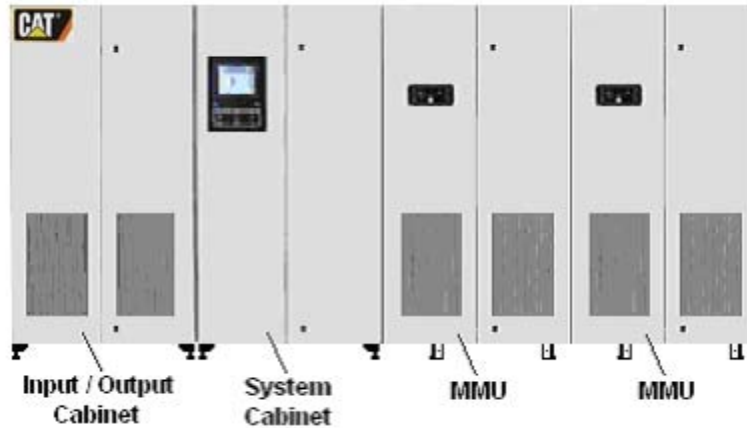
Note: MMS shown with 2 MMUs (flywheel cabinets)

Figure 29: Multi-Module System MMS

Multi-Module Systems

The Multiple or Multi-Module System (MMS) UPS have various numbers of cabinets depending on the kVA rating and optional redundant MMUs. Each MMS has an Input/Output (I/O) Cabinet, a System Cabinet, and one or more MMU cabinets. In certain locations, the Z Series UPS systems may be installed without an I/O cabinet when connected to switchgear. The I/O cabinet is standard on all systems for use in the United States and Canada. It is required for UL and CSA Certifications.

Below are tables of UPS capability, cabinet quantities per UPS system, and factory configurable bypass options.

	G Series Cabinet Quantities							
	G Series 60 Hz				G Series 50 Hz			
	300kVA	300kVA N+1	600kVA	600kVA N+1	250kVA	250kVA N+1	500kVA	500kVA N+1
Input/Output Cabinet	1	1	1	1	1	1	1	1
System Cabinet	1	1	1	1	1	1	1	1
MMU Cabinet	1	2	2	3	1	2	2	3

Table 13: G Series Cabinet Quantity and Capability

1200Z Series Cabinet Quantities							
	300kVA	300kVA N+1	600kVA	600kVA N+1	900kVA	900kVA N+1	1200kVA
Input/Output Cabinet	1	1	1	1	1	1	1
System Cabinet	1	1	1	1	1	1	1
MMU Cabinet	1	2	2	3	3	4	4

Table 14: Table of Z Series UPS and Cabinet Quantity – 60 Hz

1000iZ Series Cabinet Quantities*							
	250kVA	250kVA N+1	500kVA	500kVA N+1	750kVA	750kVA N+1	1000kVA
Input/Output Cabinet	1	1	1	1	1	1	1
System Cabinet	1	1	1	1	1	1	1
MMU Cabinet	1	2	2	3	3	4	4

Table 15: Table of iZ Series UPS and Cabinet Quantity – 50 Hz

Available MMS Configurations and Capability – 60 Hz									
System	kVA Rating	Power Factor	kW Rating	# of MMUs	Redundant N+1 MMU Option	Maximum kVA Expansion	Maximum # of Flywheels per System	Maintenance Bypass Option	Paralleling Support
G Series									
300G	300	0.8	240	1	Yes	600	3	Internal Electrically Operated	Yes - with G Series ONLY
600G	600	0.8	480	2	Yes	600	3	Internal Electrically Operated	Yes - with G Series ONLY
Z Series									
300Z	300	0.8	240	1	Yes	1200	4	External Only	Yes - with Z Series ONLY
600Z	600	0.8	480	2	Yes	1200	4	External Only	Yes - with Z Series ONLY
900Z	900	0.8	720	3	Yes	1200	4	External Only	Yes - with Z Series ONLY
1200Z	1200	0.8	960	4	No	1200	4	External Only	Yes - with Z Series ONLY

Table 16: Table of 60 Hz G Series and Z Series MMS Configurations and Capability

					Available MMS Configurations and Capability – 50 Hz					
System	kVA Rating	Power Factor	kW Rating	# of MMUs	Redundant N + 1 MMU Option	Maximum kVA Expansion	Maximum # of Flywheels per System	Maintenance Bypass Option	Paralleling Support
G Series									
250iG	250	0.9	225	1	Yes	500	3	Internal Electrically Operated	Yes - with G Series Only
500iG	500	0.9	450	2	Yes	500	3	Internal Electrically Operated	Yes - with G Series Only
Z Series									
250iZ	250	0.9	225	1	Yes	1000	4	External Only	Yes - with Z Series Only
500iZ	500	0.9	450	2	Yes	1000	4	External Only	Yes - with Z Series Only
750iZ	750	0.9	675	3	Yes	1000	4	External Only	Yes - with Z Series Only
1000iZ	1000	0.9	900	4	No	1000	4	External Only	Yes - with Z Series Only

Table 17: 50 Hz G Series and Z Series MMS Configurations and Capability

The following figures show the UPS Multi-Module System cabinet capabilities and cabinet quantities. Systems are shown without cable wireways. See particular UPS Installation Drawings for more views.

Figure 30: 300G/300Z, 250iG/250iZ Multi-Module System Cabinets

Figure 31: MMS Configuration – 300G N+1/300Z N+1, 250iG N+1/250iZ N+1, 600G/600Z, 500iG/500iZ Multi-Module System Cabinets
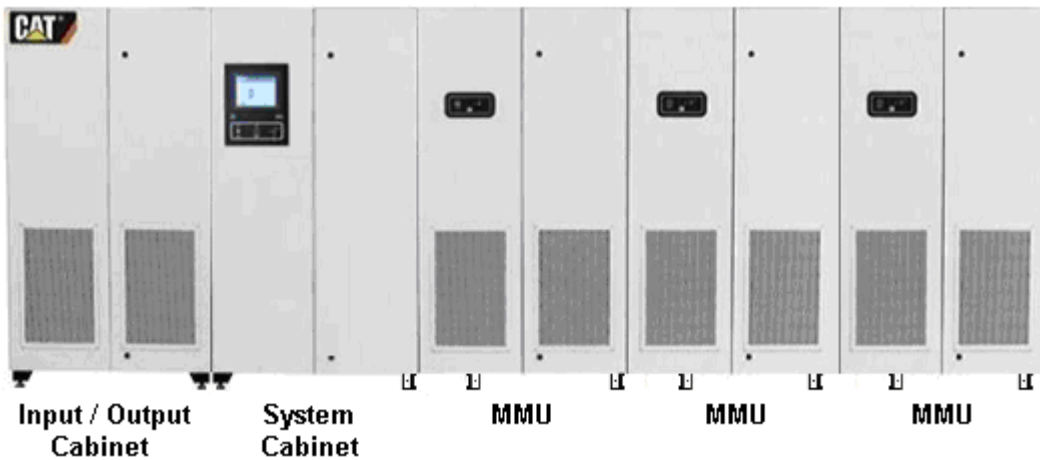
Figure 32: MMS Configuration – 600G N+1/600Z N+1, 500iG N+1/500iZ N+1, 900Z, 750iZ
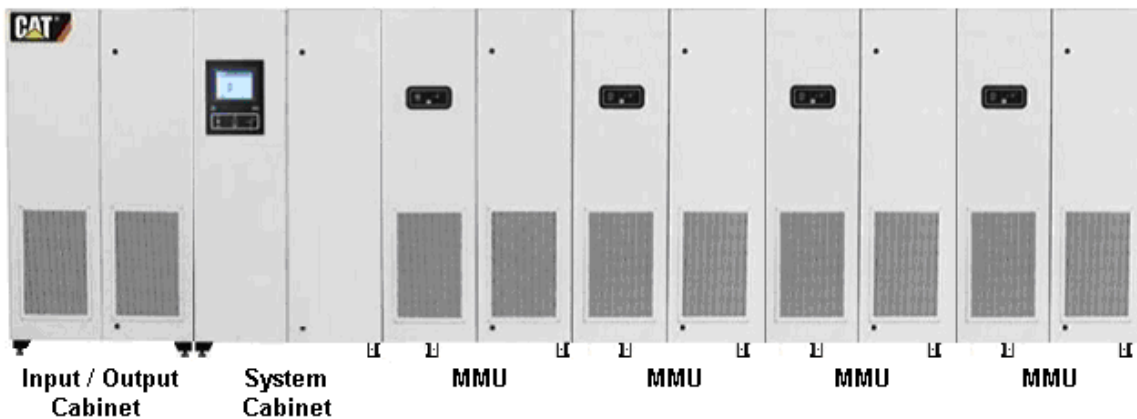
Figure 33: MMS Configuration – 900Z N+1/750iZ N+1, 1000iZ, 1200Z
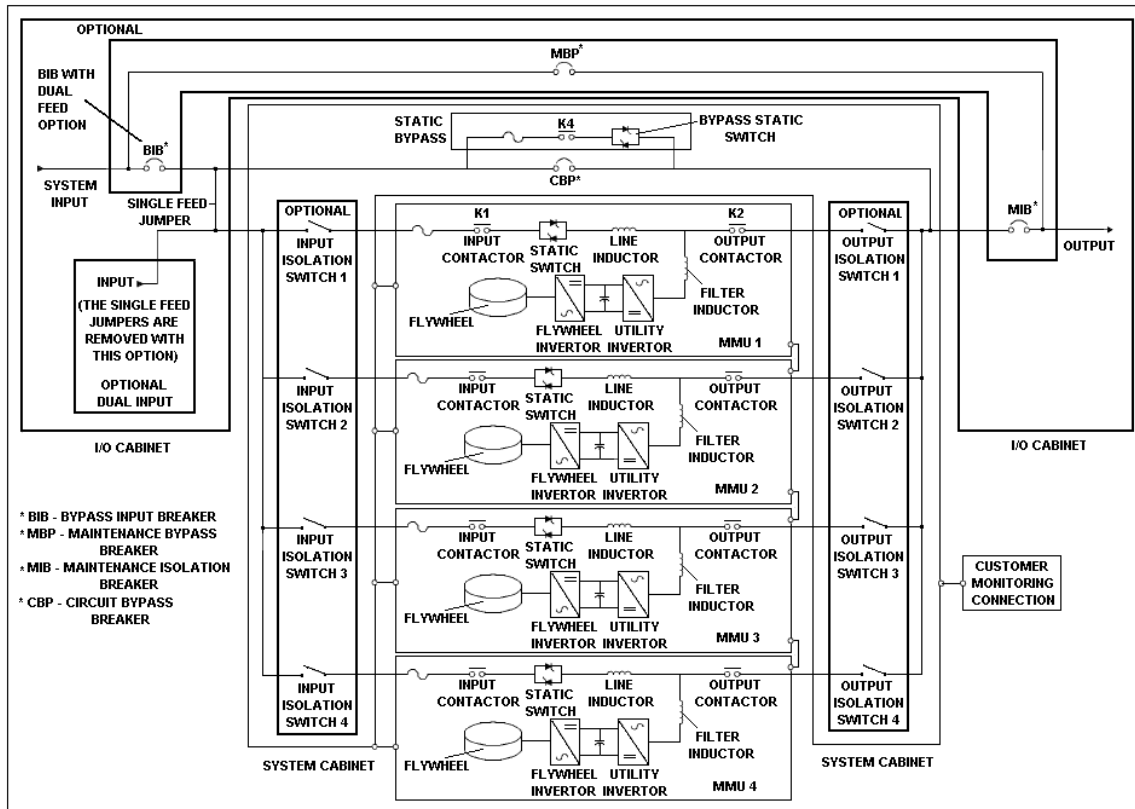
Note: optional maintenance bypass shown

Figure 34: MMS One Line Diagram – G Series N+1 Dual Input 3-wire

Input/Output Cabinet

The Input/Output (I/O) cabinet is the connection point for incoming and outgoing power connections. It is positioned to the far left when viewed from the front. The I/O cabinet provides the primary connection points for AC connections to the UPS. It contains bus bars on which to land input, output, and bypass cables. The bus bars in the G series are rated for 800 amps and the bus bars in the Z series are rated for 1600 amps. It also contains cabinet air filters in the doors for both the I/O cabinet and the Systems cabinet that will be placed next to it.

The I/O cabinet can be factory configured for either single or dual input in 3 or 4-wire configurations. The dual input option provides for 2 inputs that are derived from a common source when no maintenance bypass is required or a separate "stand alone" maintenance bypass will be used. Inputs for the UPS and internal bypass are therefore separated. When the system is in maintenance bypass, the 3-phase power is also output via the I/O cabinet.

NOTE: Dual input systems require inputs to come from a common (synchronized) source.

IMPORTANT: The I/O cabinet is standard on all systems which require UL or CSA certification.
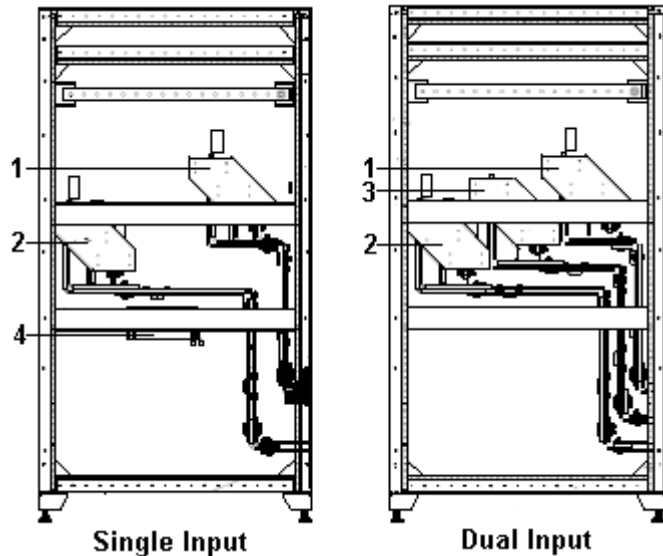
1. Single Input Bus
2. Output Bus
3. Dual Input (Bypass) Bus - optional
4. 4-wire connection - optional @ 60Hz

Figure 35: Input/Output Cabinet (typical) – front view

G Series Input/Output Cabinet

The G Series I/O cabinet standard consist includes a single input. Dual busbar input, and 3 electrically operated breaker maintenance bypass are optional. The 3 breaker MBP can be factory configured for either single or dual input systems.

On the G series only, when the MBP option is factory configured, an integrated manually operated push button controller is installed in the I/O cabinet. See Universal Maintenance Bypass Controller (UMBC). This controller manually operates the electrically operated bypass breakers. Manual operation of the maintenance bypass is requires because the UMBC does not communicate with the Bypass Input Switch.

The MPB option includes:

- A bypass input switch (BIBS) that isolates the UPS input.

- A maintenance isolation switch (MIB), electrically operated that isolates the UPS output.

- A maintenance bypass switch (MBP), electrically operated that connects the UPS input and output bus.

The I/O cabinet bus work and MBP are limited to an 800A maximum in the G Series.
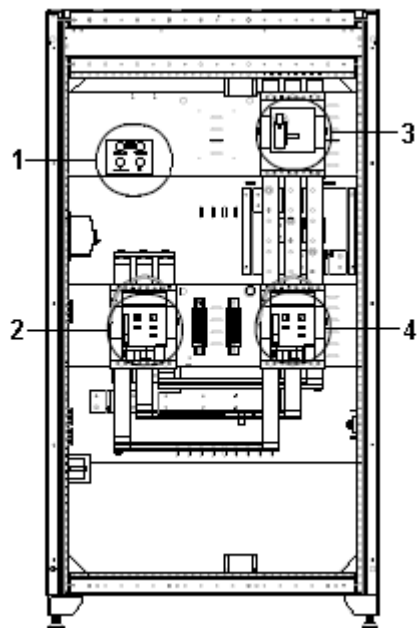
1. UMBC controller
2. MIS (Maintenance Isolation Switch) – from I/O to MMUs
3. MBP (Maintenance Bypass switch)
4. BYP (Bypass Input switch)

Figure 36: G Series I/O Cabinet w/ Bypass Option

System Cabinet

Next in line to the right of the I/O cabinet is the System Cabinet. The System Cabinet contains the external user touchscreen interface, the UPS controlling electronics, internal bus work, MMU (flywheel) input and output isolation switches, bypass circuit breaker, static bypass switch, optional 4-wire neutral transformer, and controls which enable multiple MMUs to function as a single UPS.

There are 3 cooling fan on top of the system cabinet with one being redundant. One fan or multiple fan failures will signal an alarm but will not cause the UPS to go to bypass if temperatures are within limits.

The user touchscreen interface panel and its operation is the same as used in the SMS system.
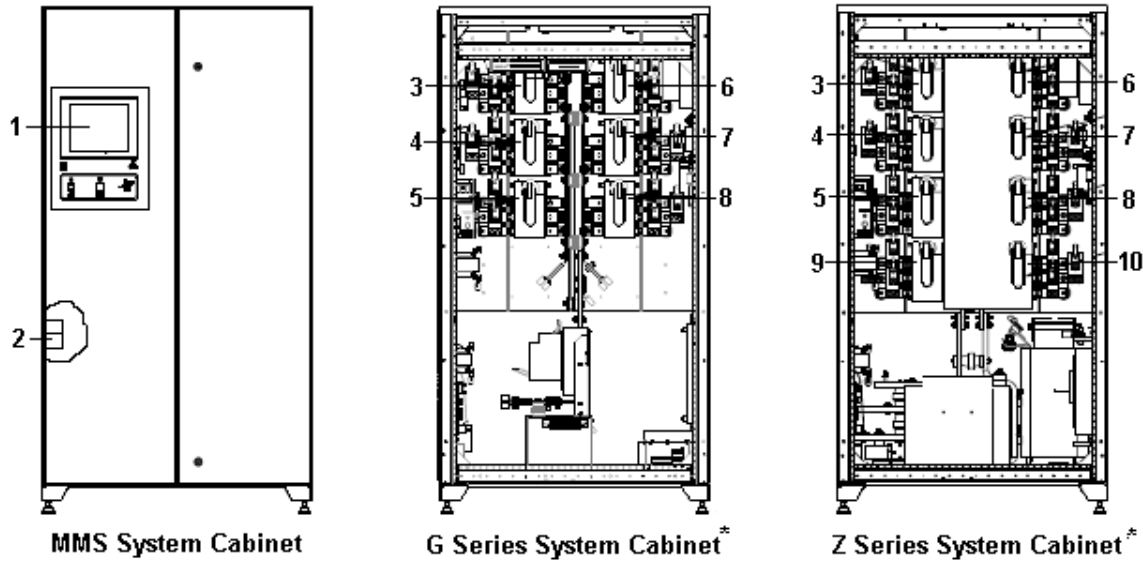
*typical cabinets, doors removed
1. User touchscreen interface
2. EPO reset (behind left door)
3. MMU 1 input isolation switch
4. MMU 2 input isolation switch
5. MMU 3 input isolation switch (optional on G Series)
6. MMU 1 output isolation switch
7. MMU 2 output isolation switch
8. MMU 3 output isolation switch (optional on G Series)
9. MMU 4 input isolation switch – Z Series only
10. MMU 4 output isolation switch – Z Series only

Figure 37: G and Z Series System Cabinets

NOTE: G series system cabinets ship with two input and two output switches for one and two MMU systems standard. G series system cabinets ship with three input and three output switches for three MMU systems (example: N + 1). If a G Series N + 1 expansion module is purchased later, the module will ship with additional input and output isolation switches. G Series systems have 3 MMU maximum, therefore no more than 3 switch set will ever be needed.

NOTE: All Z series system cabinets ship with four input and four output switches standard. Z Series systems have a 4 MMU maximum, therefore no more than 4 switch sets will ever be needed.

MMU Cabinet - front   MMU Cabinet - internal view*
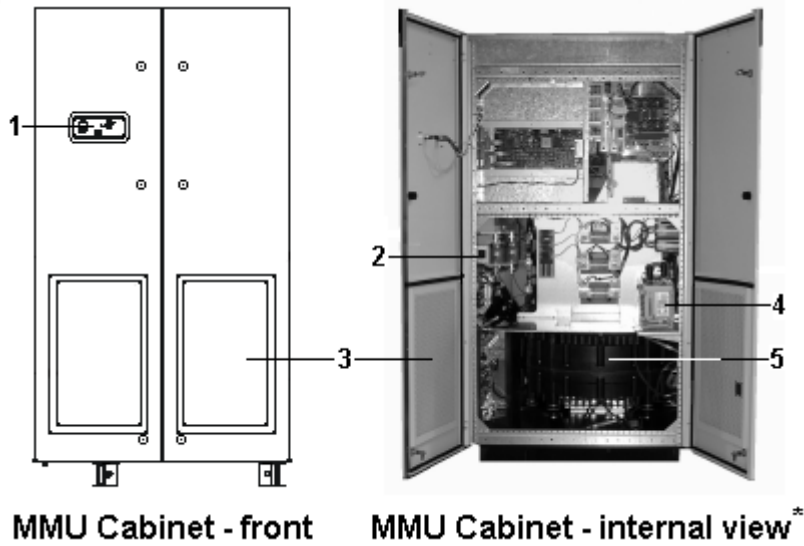
*some shields removed

1. MMU user interface panel
2. Emergency Power Off reset
3. Filters
4. Vacuum pump
5. Flywheel

Figure 38: MMU Series System Cabinets

MMU Cabinet

Finally, the MMU cabinet(s) are located to the far right. The MMU cabinets contain the User Interface Panel with keyswitch, the flywheel, vacuum pump, line inductor, filter inductor, power electronics, and other items necessary for MMU operation. There are 6 cooling fans on top of each MMU cabinet with one being redundant. One fan or multiple fan failures will signal an alarm but will not cause the UPS to go to bypass if temperatures are within limits.

NOTE: There is a limit of 3 flywheel cabinets in the G Series. These would be 600 N + 1 or 500N + 1 configurations.

NOTE: There is a limit of 4 flywheel cabinets per UPS in the Z Series. This includes redundant N + 1 configurations. The 1000iZ and 1200Z systems do NOT have N + 1 capability since they cannot have more than 4 MMUs.

User Interface Panel

The User Interface Panel provides the primary means for the operator to interface with an "individual" MMU.

The MMU keyswitch is used to control the operation of the individual MMU(s). The keyswitch is used to reset and/or restart an MMU after an error, or after any Emergency Shutdown mode is activated. The keyswitch is used to lock the MMU(s) into Bypass or Online position when the key is turned to that position and then removed from the keyswitch.

NOTE: This function only prevents manual operator intervention. The system will still switch to Bypass automatically if necessary.
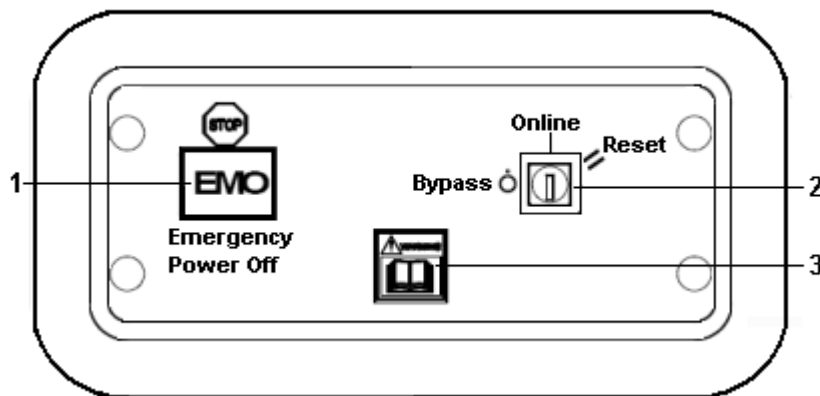
1. Emergency Module Off button
2. 3-Position Keyswitch – Bypass, Online, Reset
3. Warning Label

Figure 39: User Interface Panel

Keyswitch

The keyswitch has the following positions:

- **Bypass** – This position is used to transfer the MMU(s) to Bypass during certain maintenance procedures. This position may offer no protection from problems with the incoming power. If the capacity of the system is available the remaining MMU(s) may protect the load.

- **Online** – The keyswitch will be in this position during the normal operation of the MMU(s). This position provides protection for problems with incoming power.

- **Reset** – This position is used to reset the MMU(s) after any shutdown condition. The reset position is a spring loaded position that returns the key to the online position when released.

NOTE: If the system is being started for the first time or after a failure, the system pre-start procedure should only be performed by a qualified technician.

Emergency Module Off (EMO) Button

This button is labeled "EMO". The EMO button is used to place the MMU(s) in the shutdown mode.

NOTE: When the EMO button is used, the appropriate MMU(s) is disconnected and could cause the system to go to Bypass if the remaining MMU(s) do not have sufficient capacity to support the load. Power is not supplied to the load from that particular MMU(s). However, voltage is still present on the input terminals. The critical load will lose protected power.

Paralleling Complete MMS Systems

For increased capacity and/or system redundancy, a G Series UPS may be paralleled **ONLY** with another G Series. The Z Series UPS may **ONLY** be paralleled with another Z Series. This is due to differences in bus design and current carrying capability.

It is acceptable to parallel systems with different capacities as long as equivalent electrical systems from the input to the output bus are used. This provides an equivalent electrical circuit when the system is in internal bypass mode.

A 600Z may be paralleled with a 1200Z or a 250iG may be paralleled with a 500iG. Equivalent electrical systems require:

- All cables feeding to and from the UP to the bus work must be equal size (ampacity).

- The cables must be sized for the capacity of the largest UPS being used.

- All protection and isolation devices (breakers) must be sized for the largest UPS being used.

- Cable lengths must be the same. The total equivalent cable length from the Parallel Input Bus to Parallel Output Bus must be the same. The input and output lengths can be different as long as the total length is the same.

System Network Interface

Paralleling requires the System Cabinet of each UPS being paralleled to have an optional System Network Interface (SNI) board installed to allow communication between UPS systems. This board assembly is installed on the System Cabinet left component panel on top of the System Cabinet Controller board. Two separate and redundant serial cables connect the SNI board to the optional System Network Hub (SNH) to complete the communication link required for paralleling. Both the SNI and SNH may be added later in the field after initial UPS installation.
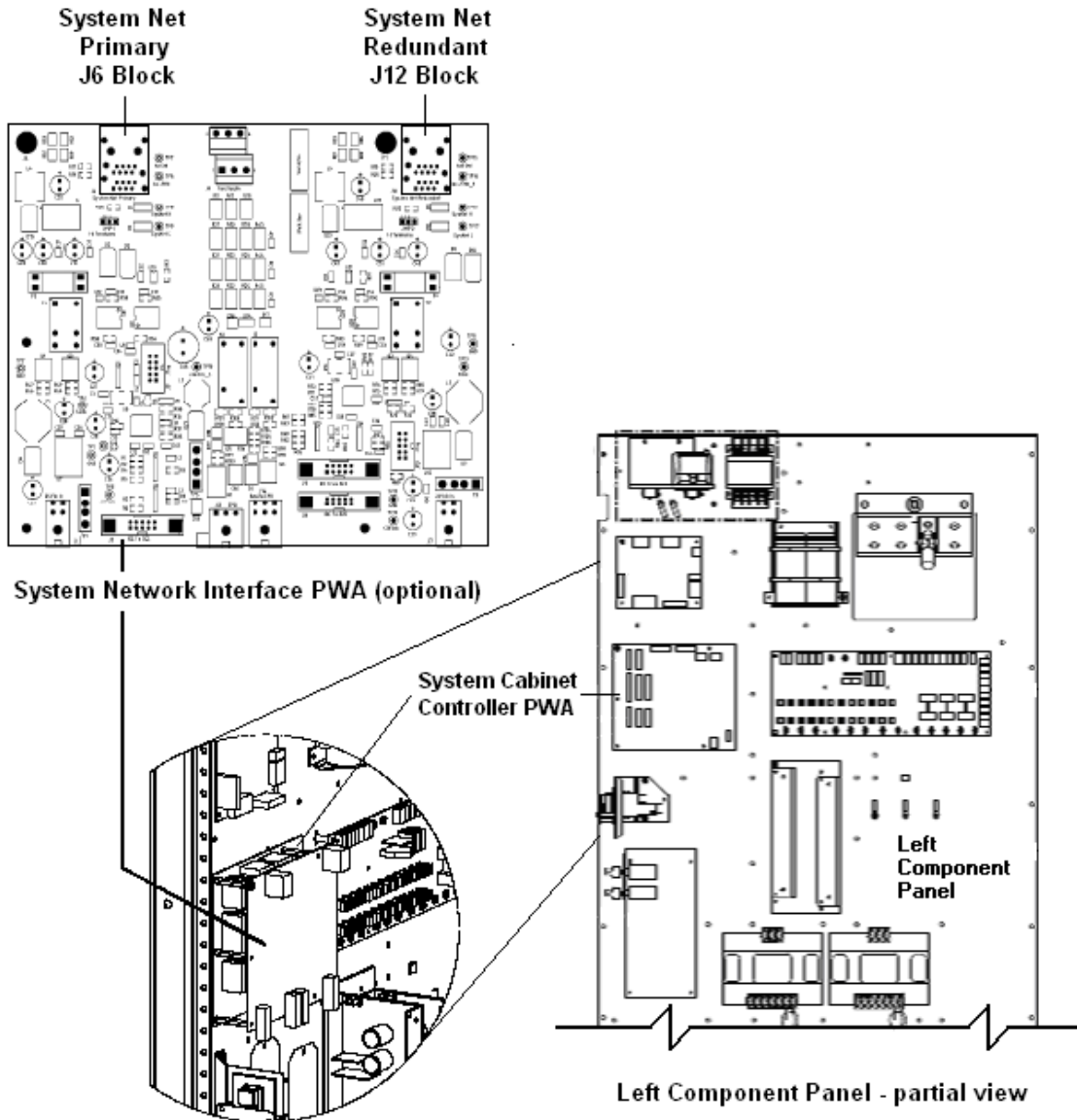
Figure 40: System Network Interface PWA

SysNet

When paralleled, the UPS systems communicate with each other on a redundant network called "SysNet". The SysNet network is connected in a star configuration with a System Network Hub.

System Network Hub

The optional field installable System Network Hub (SNH) allows up to a maximum of 7 G or Z series UPS systems to be configured in parallel for a paralleled multi-module system (PMMS). The SNH provides communications from each UPS through 2 separate and redundant serial RJ45 connections into 2 hubs (primary and redundant secondary) in the same control box.

No local power supply is needed. Independent, diode coupled power is supplied through the serial cables from the UPS modules. The SNH includes a wall mount enclosure but can be mounted inside a cabinet. Each UPS system to be paralleled must have an optional SNI PWA installed.

Figure 41: System Network Hub with Redundant PWA's

Universal Maintenance Bypass Controller
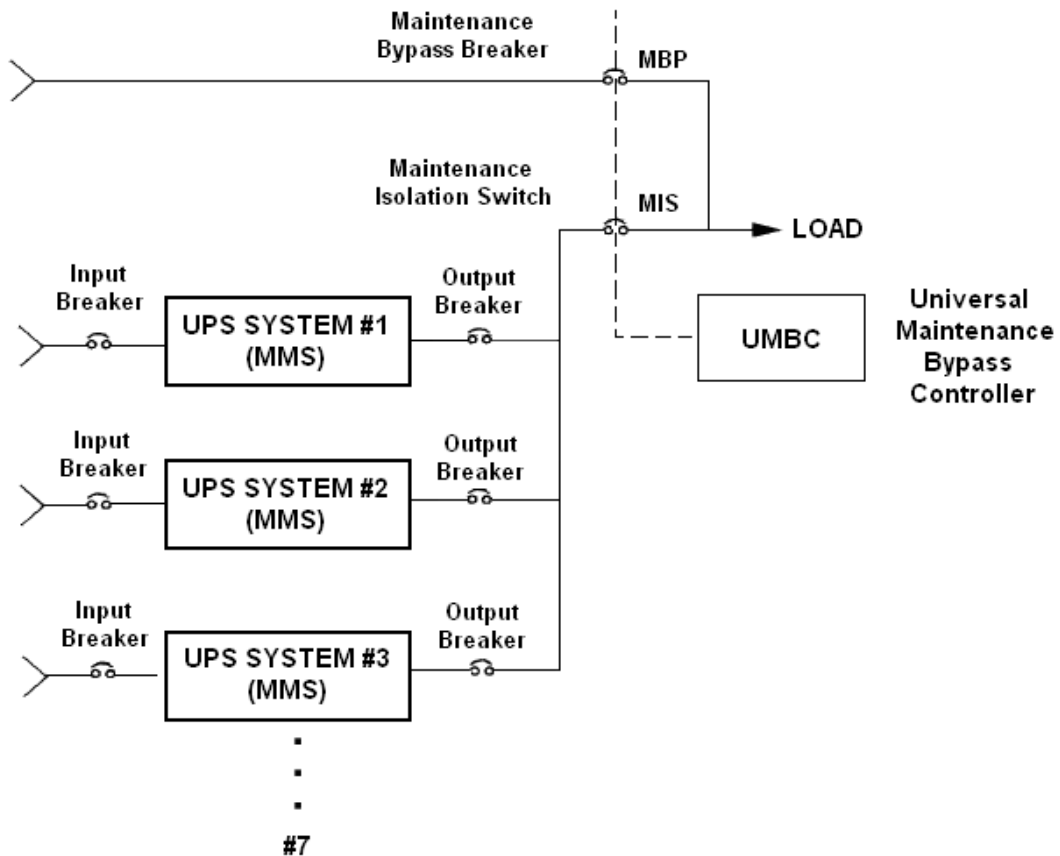
Note: MBP – Maintenance Bypass Breaker
Note: MIS – Maintenance Isolation Switch

Figure 42: UMBC Maintenance Bypass Control One-line Diagram

Universal Maintenance Bypass Controller

The Universal Maintenance Bypass Controller (UMBC) is available to manually control electrically operated circuit breakers in an external wrap around maintenance bypass circuit that completely isolates the UPS. It communicates with each UPS being paralleled as well as controls the circuit breakers (MBP and MIS) in a UPS maintenance bypass circuit.

The MBP and MIS work as a transfer pair to transfer the system to and from maintenance bypass.

The MBP (Maintenance Bypass Breaker) is a motor operated, stored energy breaker and is controlled by the UMBC to transfer the system to and from maintenance bypass. The MIS (Maintenance Isolation Switch) is the other breaker that makes up the maintenance bypass breaker pair. It is located between the common output of the UPS and the load bus. See the figure above.

The UMBC interlocks and ensures all paralleled UPS systems will be in bypass before going to maintenance bypass. If appropriate conditions are met, the UMBC performs transfers to and from maintenance bypass with a closed transition method providing an overlap. The UMBC can also prohibit closed transitions if a 'dead bus' is detected and can recover from failed transfer attempts.

Since the MBP directly connects the incoming utility power to the load while bypassing the UPS, the load is not protected when the system is in bypass and will be affected by a disruption of the incoming power. The UMBC will prevent unwanted back-feeding to the utility. The system records and displays messages that refer to the maintenance bypass components and their operating states.

NOTE: Two optional UMBC models are available:

- for 1-3 UPS systems
- for 4-7 UPS systems

UMBC Cabinet

The UMBC cabinet may be wall mounted, mounted on the side of a cabinet, or pan mounted inside a cabinet as the manual control can separate from the circuitry.

NOTE: The UMBC option does not include the circuit breakers. The option only provides interlock and control signals to support an orderly transition to a Maintenance Bypass.
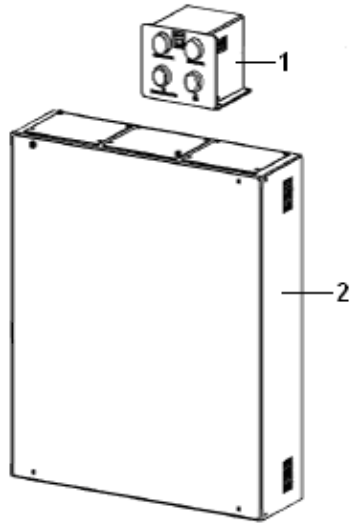
1. Removable UMBC Control box
2. UMBC cabinet containing electronics

Figure 43: UMBC Cabinet

The Pushbutton Control Box Includes:

Two lighted pushbuttons

- To UPS

- To Bypass

Two Indicator Lights

- Bypass Fail

- Break Transfer
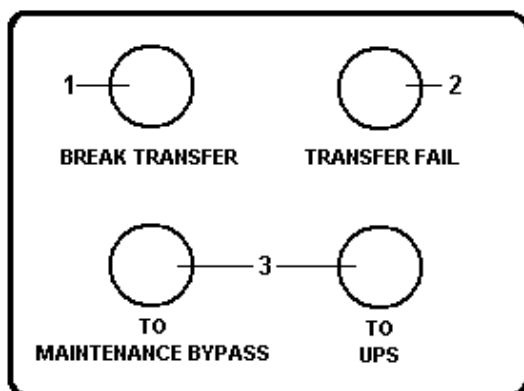
1. Amber Light
2. Red Light
3. Push Button

Figure 44: UMBC Controls and Indicator Lights

Operating the UMBC

Conditions

"Transfer Fail" light Conditions

- If any breaker (MIS or MBP fails to close during one of these transfers, the other breaker will not open and the "Transfer Fail" light illuminates.

- If a breaker fails to open during one of these transfers, the other breaker will be opened and the "Transfer Fail" light illuminates.

If the "Transfer Fail" light is lit, the last button pressed will be blinking. This indicates the sequence that failed.

IMPORTANT: To clear the "Transfer Fail" light, the non-blinking button must be pressed.

No breaker closes unless voltage is present and within tolerance at its line terminals.

"Break Transfer" light conditions

NOTE: There is also a UL listed timer that will not allow the MBP and MIS to be closed at the same time for more than 4 seconds. This timer will trip the MIS breaker.

- If the source of the closed breaker is invalid (which could include a dead bus), the "Break Transfer" light is illuminated.

- If the "Break Transfer" light is illuminated, and the illuminated button is pushed, the closed breaker will be tripped BEFORE the open breaker is closed (break-before-make).

- If there is no voltage on the output because MBP (BKR304) is closed and its source has been removed (for example: an upstream breaker trip) the "Break Transfer" light will be lit.

- If there is no voltage on the output because MIS (BKR303) is closed but its source has been removed (for example: an upstream breaker trip) the "Break Transfer" light will be lit.

Transferring from UPS to Maintenance Bypass

"To Maintenance Bypass Button" Illuminated – MIS (Breaker Closed and MBP Breaker Open

When the **MIS b**reaker is closed, the "To Maintenance Bypass" button is illuminated.

- Press the "To Maintenance Bypass" button to close the MBP breaker and open the MIS breaker (closed transition). Hold the button down until the "To UPS" button lights.

NOTE: If the **MBP** breaker is closed, the "To UPS" button is illuminated.

Transferring from Maintenance Bypass to UPS

"To UPS" Button Illuminated – MIS Breaker Open and MBP Breaker Closed

When the **MBP** breaker is closed, the "To UPS" button is illuminated.

- Press the "To UPS" button to close the MIS breaker and open the MBP (closed transition). Hold the button down until the "To Maintenance Bypass Button" lights

NOTE: If the **MIS** breaker is closed, the "To Maintenance Bypass" button is illuminated.

Touch Screen User Interface
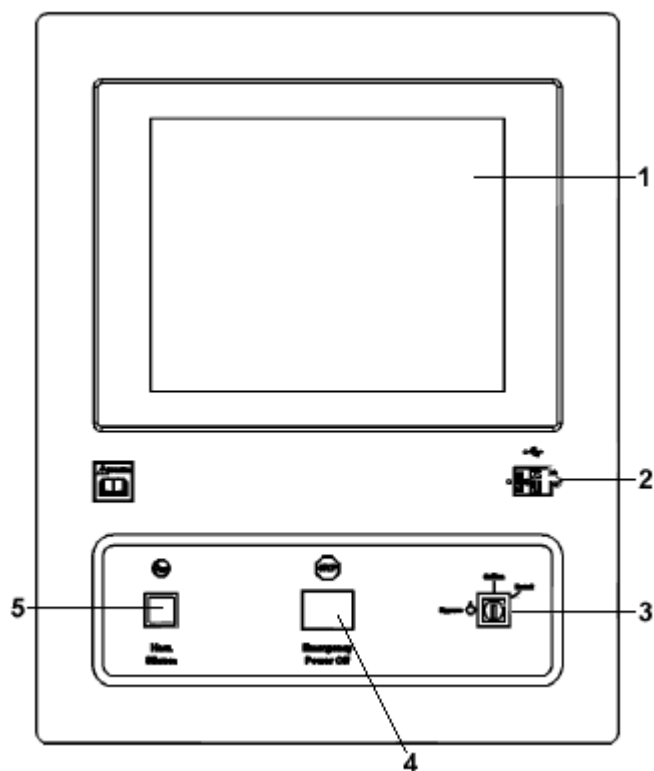
1   Touchscreen
2. USB Interface
3. Multi-Position System Cabinet Keyswitch
    - Bypass / Online / Reset
4. EPO Emergency Power Off Button
5. Horn Silence Button

Figure 45: Touchscreen Panel and Manual Controls

The user Touch Screen Interface is located on the left door of both the SMS Flywheel cabinet and the MMS System Cabinet. The display is the same for both systems. The Interface Panel allows the operator to monitor the operation of the UPS in real-time.

Navigating the System Cabinet Touchscreen Display

The access level you have been assigned can limit or expand the amount of freedom you have to manage the UPS system. The following paragraphs explain access levels.

NOTE: Use your finger, a pencil eraser, or a similar small, soft object to touch the keypad. Avoid touching the screen with your fingernails or a sharp object.

There are three levels of access for the touchscreen display. They are:

- Guest

- Operator

- Administrator

Guest – This is the default access level. All read-only screens are available at Guest level. No login is needed for Guest access at the UPS.

IMPORTANT: Remote access via a web browser **DOES** require a login, even for Guest. No Guest *password* is required.

Operator – Operators have the same privileges as Guests with the following additions: Email Setup, Caution Configuration and Remote Access Control screens. No Operator accounts are set when the UPS ships from Caterpillar.

Administrator – Administrator users can perform all of the Guest and Operator functions and can add and remove user accounts and configure the display. Operator and Administrator level accounts may be added. Once an Administrator level account has been added, the default account is disabled. If accounts are deleted, an Administrator level account must be the last one on the system. Once the last entered Administrator level account is deleted, the default account is re-enabled.

IMPORTANT: You must log off after deleting operators before the system actually delete them. After doing so, you must log back in to delete an administrator and return the system to default administrator and password.

The following illustration shows the order and access of the various screens used to control and manage the UPS.

```
Back    Log On         Notice and Alarms      Language           Navigation              Home page

         Guest***           Event Log***        English***       Home***              System Diagram***
         Operator**         Export Events***     French***        MMU Diagram***        System Detail***
         Administrator*     Email Events***      German***        Event Log***          System Overview***
                                                 Italian***       System Detail***
                                                 Portuguese***    MMU Detail ***
                                                 Spanish***       Plotting***
                                                 Russian***       Trace Select***
                                                 Japanese***      Service Notification***
                                                 Chinese***       Cautions***
                                                                  Email Setup**
                                                                  Remote Access**
                                                                  Accounts*
                                                                  Configuration*
```
*

      Available to Administrator Only
**   Available to Operator and Administrator
*** Available to All Levels

Figure 46: Access and Selections for Touchscreen Interface Display

The System Cabinet Touchscreen User Interface Panel **DOES NOT** allow the operator to:

- Stop the system in an emergency

- Place the system into bypass

- Reset the system

- Silence the horn

These operations must be performed manually from the manual control panel directly below the touchscreen on the System Cabinet door.

System Cabinet Keyswitch – Used to control the operation of the system. The keyswitch is used under the following conditions:

- Reset or restart the system after an error, or any Emergency Shutdown mode is activated.

- Lock the system into the Bypass, or Online position when the key is turned to that position and is removed from the keyswitch.

NOTE: This function only prevents manual operator intervention. The system will still switch to Bypass automatically if necessary.

The keyswitch has the following positions:

- **Bypass** – This position is used to transfer the system to bypass during certain maintenance procedures. This position offers no protection from problems with the incoming power.

- **Online** – The keyswitch will be in this position during the normal operation of the system. This position provides protection for problems with incoming power.

- **Reset** – This position is used to reset the system after any shutdown condition. The reset position is a spring loaded momentary position that returns the key to the online position when released.

Emergency Power Off (EPO) Button – This button is red and is labeled "EPO." The EPO button is used to place the system in the shutdown mode.

NOTE: When the EPO button is used, the entire system is secured. Power is not supplied to the load. However, voltage is still present on the input terminals. The critical load will lose protected power.

Horn Silence Button – Pressing the Horn Silence Button silences the audible alarm.

Display Contrast Adjustment

Once power is applied to the system, the touchscreen should be active. If the Home screen is not displayed or there is no text visible, touch the screen. There is a backlight time-out feature that turns the screen backlight off to save power. Touching the screen re-illuminates the display backlight. After touching the screen and the screen is still dark, contact a service technician.

Events

The User Interface allows the display of ALL Events, Alarm and Notice, or Alarms Only.

Notice Messages

System errors that are not critical will generate Notice Messages. When this condition exists, the system will not shift to the Bypass mode. However, a service technician may be required to fix the problem.

A Notice Message causes the "NOTICE" banner to display on the touchscreen. The system also emits an audible alarm. These messages are displayed in the Event Log. The Event Log may be accessed from the touchscreen display or using UPSView software.

UPSView is software used for configuring, commissioning, data monitoring, and used as a diagnostic troubleshooting tool. UPSView allows downloading the history of events for the UPS from a local or a remote location. The software can be used to analyze Alarm or Notice conditions.

UPSView can be monitored locally via a serial port or connected remotely through a dialup modem, RS232 port, or Ethernet networks. Event notification through e-mail or paging can be configured. See External Communications.

Examples of the events that generate Notice Messages are fan failures or abnormal thermal conditions:

Alarm Messages

System errors that are critical will generate Alarm Messages. Alarm messages indicate that the system is in Bypass mode and action is required. An Alarm message will cause the "Alarm" message to be displayed. The system will also emit an audible alarm. These messages are printed to the "Event Log".

Examples of the events that generate Alarm Messages are:

- Multiple Fan Failures

- Extreme Thermal Conditions

- Overload Conditions

Exporting Events to a USB Device

To export to a USB device locally, simply connect the USB device with a folder titled "Display_logs" to the USB port on the front of the System Cabinet below the touchscreen display and touch the "Export Events" button on the Event Log screen. The system writes information to the USB device which may then be distributed as appropriate.

IMPORTANT: Do not remove the USB device until all information has been transferred. The system displays a message when the transfer is complete.

UPSView Software

UPSView is compatible with Windows 95, 98, NT 4.0, 2000, XP, and Windows 7.

Real-time Monitoring

UPSView software allows local or remote monitoring of numerous operating parameters in real-time display. This software is used to commission, configure, monitor, as well as trouble-shoot the UPS systems.

The UPSView Software is the same for both SMS and MMS systems. It is the Firmware loaded on each system that will be different for an SMS and MMS.

UPSView gives the user access to a wide range of data, including:

- Input/output currents

- Input/output voltages

- System temperatures

- System component states

- System event logs, displayed in graphical and text format

UPSView capabilities include:

- Remote notification capabilities
- Historical plots
- Event logging
- Expandable windows
- System diagnostic aids

Diagnostic Capabilities

UPSView can be used to remotely or locally download the UPS event history log and analyze "Alarm" or "Notice" conditions. The software also allows the user to cancel paging notification events remotely.

The following typical input measurements are monitored and displayed by UPSView:

- Three-phase line voltage
- Three-phase current
- Total power (kW)
- Total kVA
- Input power factor

The following typical output measurements are monitored and displayed by UPSView:

- Three-phase line voltage
- Three-phase current
- Total power (kW)
- Total kVA
- Output power factor

Internal system measurements monitored and displayed by UPSView:

- Cabinet air temperature
- Air inlet temperature
- Static Switch temperature
- Positive DC bus voltage
- Negative DC bus voltage
- Flywheel tachometer (RPM)
- Percent energy available
- Vacuum level

- Top field coil current
- Bottom Field coil current
- Lateral bearing vibration
- Axial bearing vibration
- Top field coil temperature
- Bottom field coil temperature
- Armature temperature
- Top field coil Insulated Gate Bipolar Transistor (IGBT) temperature
- Bottom field coil Insulated Gate Bipolar Transistor (IGBT) temperature
- Top bearing temperature
- Bottom bearing temperature
- Motor timing advance setting

Internal System Component States Monitored and displayed by UPSView:

- Input contactor state
- Output contactor state
- Bypass contactor state
- Flywheel converter status
- Utility converter status
- Input relay states
- Output relay states
- Fan status
- Fuse status
- Genstart Module status

Remote Communication, Monitoring, and Notification

Customer Interfaces

The customer interfaces are accessible through the System Input/Output (SIO) board or Printed Wiring Assembly (PWA) located on the left component panel. The SIO Board provides an isolation barrier between the controller and communication ports.

NOTE: Route any interface cables as far away from power cables as possible in order to minimize EMI electromagnetic interference.

The figure below of the left component panel shows the location of the communication interface components and other components.

Modem and Network Hub power supply receptacles

Fan Motor PWA

System Cabinet Controller PWA

EPO Reset Switch

MMU Communication selection switches: RS232 or Modem

AC Voltage Interface PWA

System Input/Output Communications PWA

System Input/Output Daughter Board PWA

Power Distribution PWA

Left Component Panel

Æ
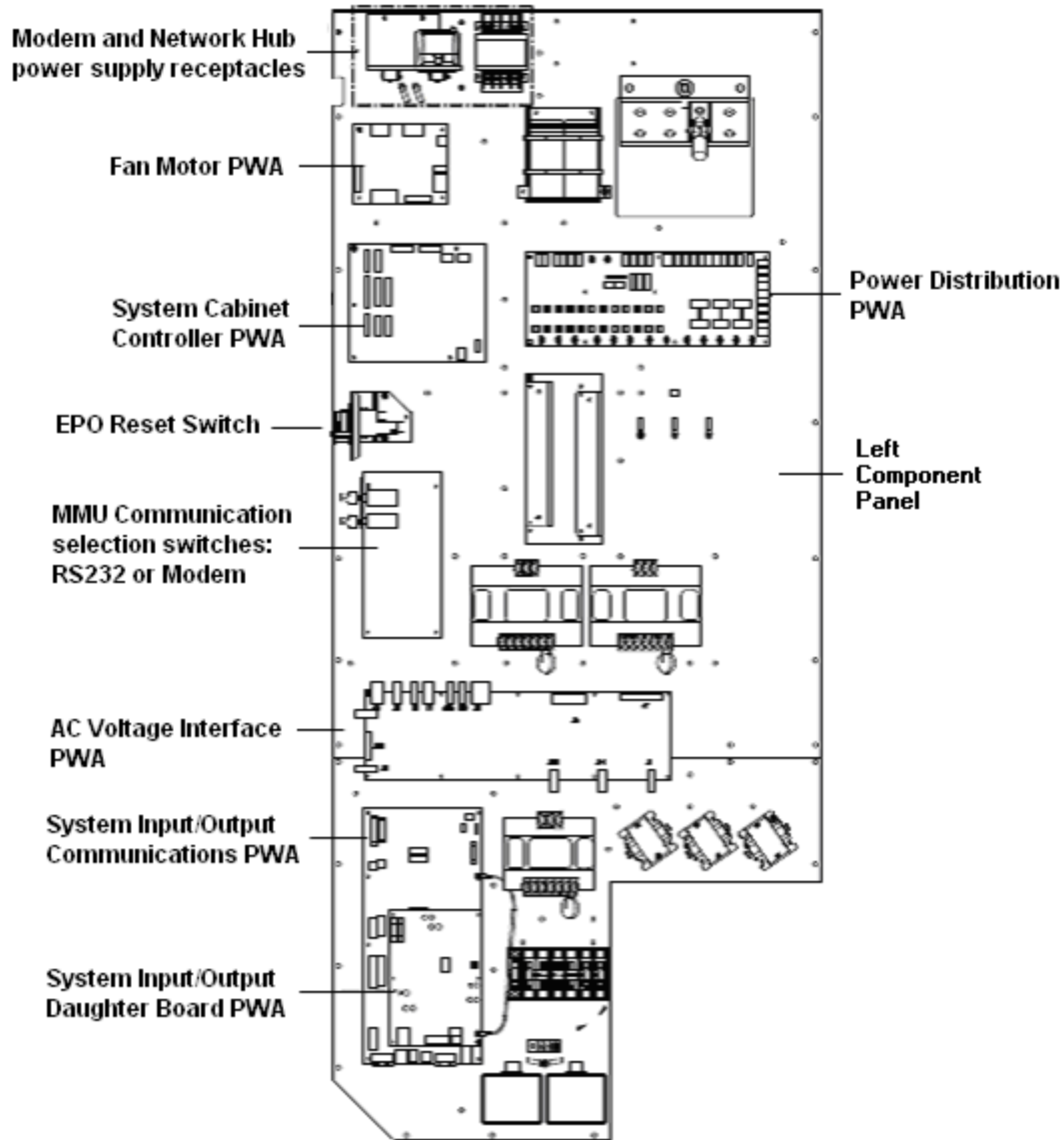
*   Typical panel located in SMS flywheel cabinet or MMS System cabinet
Note: PWA = printed wiring assembly

Figure 47: Interface Board Locations on Left Component Panel*
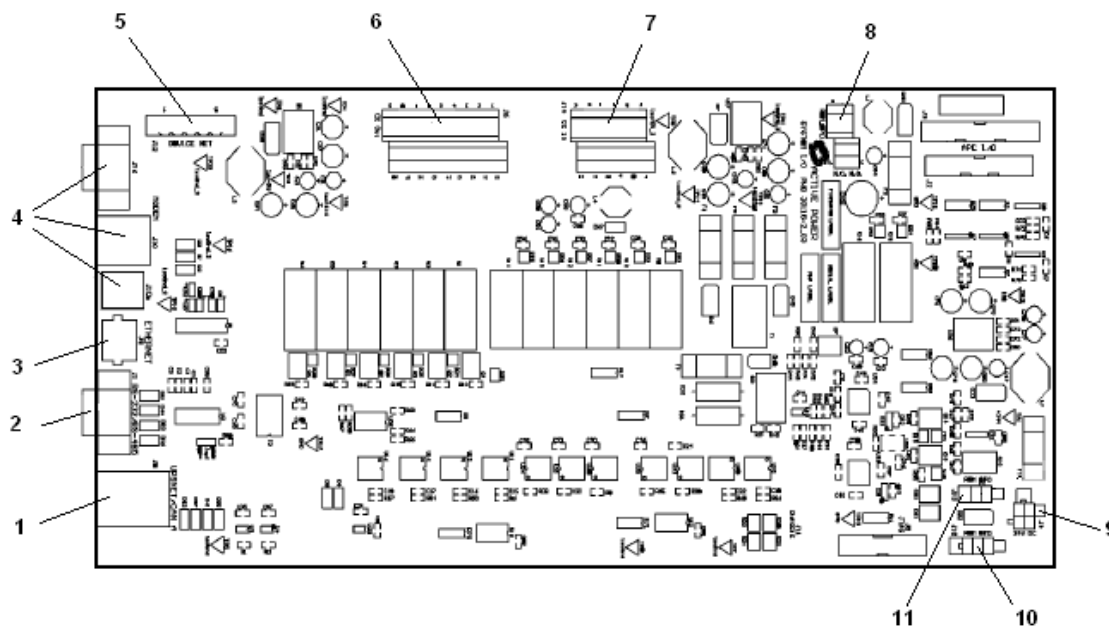
Note: Connector functions are listed below. Connection J Numbers are printed on the Printed Wiring Assembly (PWA)

1. UPSnet/ Can A (primary) J8
2. Ethernet/Modbus TCP J9
3. RS-232/RS-485 J1
4. Modem J10 J10a J16
5. Device Net J12
6. Remote Output Contacts J6
7. Remote Input Contacts J14
8. Remote EPO Contacts J7
9. 24VDC Power In J4
10. Remote EMO Trip J15
11. Remote EPO Trip J13

Figure 48: System Input/Output PWA

Connection Methods for Communications

There are three methods of connecting to the system with UPSView:

- RS-232 or RS-485 – through a direct cable connection

- Modem – through a dedicated phone line

- Ethernet Network – allows multiple users of the UPS View Software that are connected to a local area network (LAN) to monitor the operation of the UPS simultaneously

External Communications

External communications can be done via one of the following methods: RS-232/RS-485 port, Modem, Ethernet, Modbus, SNMP, Dry Contacts, Remote Emergency Power Off, and Remote Status Panel.

Remote Notification – The UPS has two ways to remotely notify users of errors in the system.

- Page out (on a modem)

- Send e-mail (to configured recipients)

NOTE: For additional connection information, refer to UPS Operations and Maintenance Manual (OMM).

Direct Connection Through RS-232 or RS-485 Cable

A computer connected locally by cable to the RS-232 or RS-485 serial port allows system monitoring with UPSView monitoring software.

The cable is connected to the serial port on the SIO board. The SIO board is located on the left component panel in an SMS Flywheel Cabinet or in the MMS System cabinet.

In an MMS System, one of the MMU in the system serves as the processor for the external communications. A rotary switch on the Parallel Cabinet Interface Board in the System Cabinet allows you to select the MMU that will be used for external communications.

NOTE: On the SIO Board, there is a jumper ("JMP1") that is preset for RS-232 communications. If you need RS-485 communications, the jumper must be reset.

Paging Notification Through a Modem

Numeric or Alpha-Numeric paging notification to multiple phones on a paging list can be accomplished using the standard Modem through the UPSView software. The modem must be enabled and a dedicated analog phone line to the modem is required.

The modem can be configured to operate in "escalation" mode if no return call is made in a certain amount of time. The system uses an automatic redial and rotation sequence after set delays for up to 200 call attempts.

Dialing continues until the UPS is contacted by personnel that are using UPSView via the Internet or a phone line in order to ensure that the issue is addressed. Users may individually enable or disable paging for alarm events or notice events separately.

Modem Specifications

- Numeric paging – System will leave UPS code number, call back number and notice or alarm code to indicate severity of problem

- Alphanumeric paging – System will provide description of product, cause of alarm, serial number, location and callback number

  - o Connects with all major modem protocols

  - o Carrier Loss Redial enables the modem to automatically redial the last number called if a loss of carrier is detected

  - o Remote Configuration allows modem settings to be configured from a remote location

  - o Dial Security including Dialback secures your network by verifying authorized callers and modems prior to passing a remote originated call or initiating dialback based on device configuration

Modem Standards And Protocols Supported

- ITU V.90 at up to 56 Kbps technology

- TU-T V.34 at 33.6 Kbps or 28.8 Kbps

- V.32terbo at 19.2 Kbps (21.6 Kbps between Courier modems with ASL)

- ITU-T V.32bis at 14.4 Kbps

- HST at 16.8 Kbps

- Backward compatible with most ITU-T and Bell standards

Connection via Ethernet Network

By using the Ethernet Option, multiple users of the UPS View Software that are connected to a local area network (LAN) can monitor the operation of the Cat UPS simultaneously and in Real Time.

Ethernet is a common type of network that allows interconnection between the UPS and other devices. The UPS standard Ethernet capability allows remote monitoring over a Local Area Network (LAN) by multiple users of the UPSView software simultaneously.

A computer running UPSView must have network access to enable monitoring via the network. Network monitoring requires an IP address that is assigned to the UPS.

Ethernet can give the UPSView user the following capabilities:

- E-mail (requires Ethernet connection to a local area network (LAN) with Simple Mail Transfer Protocol (SMTP) e-mail server)

- SNMP (Simple Network Management Protocol)

- Modbus **Á**

- Connection to UPSView over a LAN (network monitoring requires static IP address to be assigned to each UPS)**Á**

NOTE: Each MMU must be configured to be monitored over Ethernet.

Emailing and Exporting Events

Email accounts may be set up to which the system will send alarms and notices to those on the receipts list. The email system can be set up to where the emailed event log is delivered never, monthly, weekly or daily. You can also set the email system up to send service and caution notifications.

The E-mail messages contain the following information:

- UPS model and serial number

- UPS physical location

- The triggering event

To email an event log, simply select the field and use the virtual keyboard to enter the destination email address in the "To" address line and touch the "Email Events" button.

E-mail requires the Remote Notification option and a connection to a Local Area Network with an Simple Mail Transfer Protocol (SMTP) e-mail server.

NOTE: See the UPS OMM Manual for detailed information on setting up Email addresses for exporting events.

Dual Communication – For multi-path communications capability, both the Ethernet and Modem can be applied to c@ˇÆæ{ ^ÆÊÚÙÆ•c^{ ÊÆ

Remote Access

Remote Access is available to allow a remote service engineer to change operating parameters in an SMS/MMS. The service engineer must connect to an MMU over the modem with UPSView and must be logged in with a service password. Until the service engineer is connected via modem and logged in, remote access cannot be granted.

Once these prerequisites are met, the Display on the Remote Access screen will show a password entry field and a send button. The user must enter the access code and send it to the MMU to grant the remote service engineer permissions to make changes.

Modbus

Modbus Protocol is a messaging structure used to establish master-slave/ client-server communication between intelligent devices.

Modbus allows monitoring of the system via an Ethernet TCP interface or an RS-485 (RTU) serial connection.

NOTE: Modbus must be enabled and requires a System Input/Output Daughter Board (SIOD). This board is now standard but was an option on earlier UPS versions.

Look at the "Show Configuration" page on the LCD display or type "CTRL-N" from UPSView in order to verify that Modbus is enabled.

A Modbus Register List is included later in this guide.

Modbus TCP utilizes Ethernet communications protocol for the Modbus protocol. TCP/IP is the common transport protocol of the Internet and is actually a set of layered protocols, providing a reliable data transport mechanism between machines. Thus Modbus TCP is the Modbus protocol via Ethernet communications protocols.

Modbus RS-485

Modbus RS-485 is another way to communicate the Modbus protocol. RS-485 is a data transfer technique similar to RS-232 but with the following distinctions. The RS-232 signals are represented by voltage levels with respect to ground. There is a wire for each signal, together with the ground signal (reference for voltage levels).

This interface is useful for point-to-point communication at slow speeds. One port, one device. Due to the way the signals are connected, a common ground is required. This implies limited cable length of about 30 to 60 meters maximum. (Main problems are interference and resistance of the cable.) Shortly, RS-232 was designed for communication of local devices, and supports one transmitter and one receiver.

RS-485 uses a different principle: Each signal uses one twisted pair (TP) line – two wires twisted around each other. This technique is referred to as 'Balanced data transmission', or 'Differential voltage transmission'. For RS-485 the cable can be up to 1200 meters (4000 feet) long, and commonly available circuits work at 2.5 MB/s transfer rate.

RS-485 is used for multipoint communications: more devices may be connected to a single signal cable. Most RS-485 systems use Master/Slave architecture, where each slave unit has its unique address and responds only to packets addressed to this unit. These packets are generated by Master (e.g. PC), which periodically polls all connected slave units.

The following RS485 connections are supported:

- Half Duplex (2 wire)
- Full Duplex (4-wire)

NOTE: Each MMU must have a unique ID number when Modbus RTU is used.

Modbus Register Map

General

- The SMS, G and Z Series UPS supports Modbus/TCP, Class 0 and Modbus/RTU.

- Most registers are read-only, accessed with MODBUS Function Codes: 3 (read multiple registers) or 23 (read/write multiple registers).

- The few read/write registers will be noted as such in the document below as **R/W**. They can be read the same way as the read only registers and can be written with MODBUS Function Codes:
  6 (write single register), 16 (write multiple registers), or 23 (read/write multiple registers).

- **SMS** represents Single Module Systems, while **(P)MMS** represents (Parallelled) Multi Module Systems.

- There are 5 register groups: System, MMU, Event, Status and Summary.

- Register pairs, shown as (x)(x + 1) represent a 32 bit floating point or unsigned integer value. The lower numbered register contains bits 15-0 of the value (the least significant 16-bits), the higher numbered register contains bits 31-16 of the value (the most significant 16-bits). Format = Float32 or Unsigned32. **To insure a proper 32-bit read, the pair of registers need to be read at the same time. Reading them with two different read requests could have non-coherent data.**

- **Writes of 32-bit data are assumed to be in ascending register order.** It is safest to write the full 32-bits in a single write request which will guarantee this, but if done in two write requests, then the order needs to be taken into account as some processing will not be done until the highest register is written.

- Registers with BCD (Binary Coded Decimal) format can be displayed in hexadecimal. For example if the "System Date" register returns 35 decimal (23 hex), then the day of the month is the 23rd.

- Registers shown as (x) are 16 bit unsigned quantities. (Format = Unsigned16)

- References to a register number X is equivalent to Modbus Register 40000 + X.

System Group

The system group pertains to those signals that are common to all MMUs of a system.

Register	Group	Description	Format	Units
(1)	System	Firmware Rev, Lower	Unsigned16	**See note 1**
(2)	System	Firmware Rev, Upper	Unsigned16	
(3)	System	FPGA Rev, Lower	Unsigned16	**See Note 2**
(4)	System	FPGA Rev, Upper	Unsigned16	
(5)	System	Notice Active	Unsigned16	
(6)	System	Alarm Active	Unsigned16	
(7)	System	System Mode	Unsigned16	
(8)	System	System State		
(9)	System	System Year	BCD	4 digit year
(10)	System	System Month	BCD	1 to 12
(11)	System	System Date	BCD	1 to 31
(12)	System	System Hour	BCD	0 to 23
(13)	System	System Minute	BCD	0 to 59
(14)	System	System Second	BCD	0 to 59
(15)(16)	System	Output Frequency	Float32	Hertz
(17)(18)	System	Input Frequency	Float32	Hertz
(19)(20)	System	Output Power Factor	Float32	0.0 to 1.0
(21)(22)	System	Input Power Factor	Float32	0.0 to 1.0
(23)(24)	System	Percent Energy	Float32	Percent
(25)(26)	System	Percent Load	Float32	Percent
(27)(28)	System	Output Power	Float32	Kilowatts
(29)(30)	System	Output KVA	Float32	KVA
(31)(32)	System	Input Power	Float32	Kilowatts
(33)(34)	System	Input KVA	Float32	KVA
(35)(36)	System	Input Line Volt AB	Float32	Vac
(37)(38)	System	Input Line Volt BC	Float32	Vac
(39)(40)	System	Input Line Volt CA	Float32	Vac
(41)(42)	System	Bypass Line Volt AB	Float32	Vac
(43)(44)	System	Bypass Line Volt BC	Float32	Vac
(45)(46)	System	Bypass Line Volt CA	Float32	Vac
(47)(48)	System	Output Line Volt AB	Float32	Vac
(49)(50)	System	Output Line Volt BC	Float32	Vac
(51)(52)	System	Output Line Volt CA	Float32	Vac
(53)(54)	System	Input Current Phase A	Float32	Amps
(55)(56)	System	Input Current Phase B	Float32	Amps
(57)(58)	System	Input Current Phase C	Float32	Amps
(59)(60)	System	Output Current Phase A	Float32	Amps
(61)(62)	System	Output Current Phase B	Float32	Amps
(63)(64)	System	Output Current Phase C	Float32	Amps
FPGA = field programmable gate array				

Table 18: Table of Common Modbus System Registers

Note 1:

Firmware Revisions are shown as: M.mmXY (example: 1.02)

Where:

- M represents the major rev, mm represents the minor rev, X represents the Beta letter and Y represents the Developer Letter. **For production code Beta and developer letters will be null.**

- The Lower 16 bits of the Firmware Rev contain the Beta Letter (upper byte) and Developer Letter (lower byte).

- The Upper 16 bits contain the Major Rev (upper byte) and the minor Rev (lower byte).

Example: if Register 1 contains 0x7068, and Register 2 contains 0x005a.

The firmware revision would be shown as 0.90ph, indicating major/minor rev level of .90, beta version p, developer 'h'.

Note 2:

The FPGA rev is shown as X.YZ, where X and Y are numeric and represent major and minor revs. Z is a Beta letter. Example (1.30)

The FPGA rev information can be decoded as follows.

Major.Minor = (float) Register 3 / 100.

The Beta letter is ASC((Register 4 & 255) + 0x60). This is deprecated and will always be null (zero) from version 5.0 and beyond.

The Product Family code is contained in the upper 8 bits of Register 4. The product code will always be 0 (zero) for UPS Series 300.

Example: If register 3 contains 0x00A0 and Register 4 contains 0x0008, the FPGA revision would be shown as 1.6h and would indicate a valid Series 300 UPS FPGA.

MMU Detail Group

Register	Group	Description	Format	Units
(100)(101)	MMU detail	Input Volts AB	Float32	VAC
(102)(103)	MMU detail	Input Volts BC	Float32	VAC
(104)(105)	MMU detail	Input Volts CA	Float32	VAC
(106)(107)	MMU detail	Filter Volts AB	Float32	VAC
(108)(109)	MMU detail	Filter Volts BC	Float32	VAC
(110)(111)	MMU detail	Filter Volts CA	Float32	VAC
(112)(113)	MMU detail	Output Volts AB	Float32	VAC
(114)(115)	MMU detail	Output Volts BC	Float32	VAC
(116)(117)	MMU detail	Output Volts CA	Float32	VAC
(118)(119)	MMU detail	Inverter Current A	Float32	Amps
(120)(121)	MMU detail	Inverter Current B	Float32	Amps
(122)(123)	MMU detail	Inverter Current C	Float32	Amps
(124)(125)	MMU detail	Input Current A	Float32	Amps
(126)(127)	MMU detail	Input Current B	Float32	Amps
(128)(129)	MMU detail	Input Current C	Float32	Amps
(130)(131)	MMU detail	Output Current A	Float32	Amps
(132)(133)	MMU detail	Output Current B	Float32	Amps
(134)(135)	MMU detail	Output Current C	Float32	Amps
(136)(137)	MMU detail	Target Output Volts AB	Float32	VAC
(138)(139)	MMU detail	Target Output Volts BC	Float32	VAC
(140)(141)	MMU detail	Target Output Volts CA	Float32	VAC
(142)(143)	MMU detail	DC Offset Correction AB	Float32	VAC
(144)(145)	MMU detail	DC Offset Correction BC	Float32	VAC
(146)(147)	MMU detail	DC Offset Correction CA	Float32	VAC
(148)(149)	MMU detail	Output Voltage Setpoint AB	Float32	VAC
(150)(151)	MMU detail	Output Voltage Setpoint BC	Float32	VAC
(152)(153)	MMU detail	Output Voltage Setpoint CA	Float32	VAC
(154)(155)	MMU detail	Input Volts AN	Float32	VAC
(156)(157)	MMU detail	Input Volts BN	Float32	VAC
(158)(159)	MMU detail	Input Volts CN	Float32	VAC
(160)(161)	MMU detail	Output Frequency	Float32	Hertz
(162)(163)	MMU detail	Output MMU Power	Float32	kW
(164)(165)	MMU detail	Output MMU KVA	Float32	KVA
(166)(167)	MMU detail	Output Power Factor	Float32	0.0 to 1.0
(168)(169)	MMU detail	Input Frequency	Float32	Hertz
(170)(171)	MMU detail	Input MMU Power	Float32	kW
(172)(173)	MMU detail	Input MMU KVA	Float32	KVA
(174)(175)	MMU detail	Input Power Factor	Float32	0.0 to 1.0
(176)(177)	MMU detail	Cabinet Temperature	Float32	ºC
(178)(179)	MMU detail	Air Inlet Temperature	Float32	ºC
(180)(181)	MMU detail	Static Switch Temperature	Float32	ºC
(182)(183)	MMU detail	Genset Start IGBT Temperature	Float32	ºC

(184)(185)	MMU detail	Positive DC Bus Voltage	Float32	VDC
(186)(187)	MMU detail	Negative DC Bus Voltage	Float32	VDC
(188)(189)	MMU detail	Tachometer	Float32	RPM
(190)(191)	MMU detail	Percent Energy	Float32	%
(192)(193)	MMU detail	Vacuum Gauge	Float32	milliTorr
(194)(195)	MMU detail	Top Field Coil Current	Float32	Amps
(196)(197)	MMU detail	Bottom Field Coil Current	Float32	Amps
(198)(199)	MMU detail	Bottom Bearing Force	Float32	Pounds
(200)(201)	MMU detail	Lateral Vibration	Float32	G's
(202)(203)	MMU detail	Axial Vibration	Float32	G's
(204)(205)	MMU detail	Top Field Coil Temperature	Float32	ºC
(206)(207)	MMU detail	Bottom Field Coil Temperature	Float32	ºC
(208)(209)	MMU detail	Armature Temperature	Float32	ºC
(210)(211)	MMU detail	Top Field Coil IGBT Temperature	Float32	ºC
(212)(213)	MMU detail	Bottom Field Coil IGBT Temperature	Float32	ºC
(214)(215)	MMU detail	Top Bearing Temperature	Float32	ºC
(216)(217)	MMU detail	Bottom Bearing Temperature	Float32	ºC
(218)(218)	MMU detail	RPS Advance Setpoint	Float32	0 to 255
(220)	MMU detail	MMU Mode	Unsigned16	**See Note 6**
(221)	MMU detail	MMU State	Unsigned16	**See Note 7**

Table 19: Table of Common MMU Detail Registers

Event Log Group

Register	Group	Read/Write	Description	Format
(250)	Event	R	Number of All Messages	Unsigned16
(251)	Event	R	Number of Warning and Alarm Messages	Unsigned16
(252)	Event	R	Number of Alarm Messages Only	Unsigned16
(253)	Event	R/W	"All Messages" Command Register (always reads zero)	Unsigned16
(254)	Event	R/W	"Warning and Alarm Messages" Command Register (always reads zero)	Unsigned16
(255)	Event	R/W	"Alarm Messages Only" Command Register (always reads zero)	Unsigned16
(256)	Event	R	Bytes 0 and 1 of the ASCII message string	Unsigned16
(257)	Event	R	Bytes 2 and 3 of the ASCII message string	Unsigned16
(258)	Event	R	Bytes 4 and 5 of the ASCII message string	Unsigned16
(259)	Event	R	Bytes 6 and 7 of the ASCII message string	Unsigned16
(260)	Event	R	Bytes 8 and 9 of the ASCII message string	Unsigned16
(261)	Event	R	Bytes 10 and 11 of the ASCII message string	Unsigned16
(262)	Event	R	Bytes 12 and 13 of the ASCII message string	Unsigned16
(263)	Event	R	Bytes 14 and 15 of the ASCII message string	Unsigned16
(264)	Event	R	Bytes 16 and 17 of the ASCII message string	Unsigned16
(265)	Event	R	Bytes 18 and 19 of the ASCII message string	Unsigned16
(266)	Event	R	Bytes 20 and 21 of the ASCII message string	Unsigned16
(267)	Event	R	Bytes 22 and 23 of the ASCII message string	Unsigned16
(268)	Event	R	Bytes 24 and 25 of the ASCII message string	Unsigned16
(269)	Event	R	Bytes 26 and 27 of the ASCII message string	Unsigned16
(270)	Event	R	Bytes 28 and 29 of the ASCII message string	Unsigned16
(271)	Event	R	Bytes 30 and 31 of the ASCII message string	Unsigned16
(272)	Event	R	Bytes 32 and 33 of the ASCII message string	Unsigned16
(273)	Event	R	Bytes 34 and 35 of the ASCII message string	Unsigned16
(274)	Event	R	Bytes 36 and 37 of the ASCII message string	Unsigned16
(275)	Event	R	Bytes 38 and 39 of the ASCII message string	Unsigned16
(276)	Event	R	Bytes 40 and 41 of the ASCII message string	Unsigned16
(277)	Event	R	Bytes 42 and 43 of the ASCII message string	Unsigned16
(278)	Event	R	Bytes 44 and 45 of the ASCII message string	Unsigned16
(279)	Event	R	Bytes 46 and 47 of the ASCII message string	Unsigned16
(280)	Event	R	Bytes 48 and 49 of the ASCII message string	Unsigned16
(281)	Event	R	Bytes 50 and 51 of the ASCII message string	Unsigned16
(282)	Event	R	Bytes 52 and 53 of the ASCII message string	Unsigned16
(283)	Event	R	Bytes 54 and 55 of the ASCII message string	Unsigned16
(284)	Event	R	Bytes 56 and 57 of the ASCII message string	Unsigned16
(285)	Event	R	Bytes 58 and 59 of the ASCII message string	Unsigned16
(286)	Event	R	Bytes 60 and 61 of the ASCII message string	Unsigned16
(287)	Event	R	Bytes 62 and 63 of the ASCII message string	Unsigned16
(288)	Event	R	Bytes 64 and 65 of the ASCII message string	Unsigned16
(289)	Event	R	Bytes 66 and 67 of the ASCII message string	Unsigned16
(290)	Event	R	Bytes 68 and 69 of the ASCII message string	Unsigned16

(291)	Event	R	Bytes 70 and 71 of the ASCII message string	Unsigned16
(292)	Event	R	Bytes 72 and 73 of the ASCII message string	Unsigned16
(293)	Event	R	Bytes 74 and 75 of the ASCII message string	Unsigned16
(294)	Event	R	Bytes 76 and 77 of the ASCII message string	Unsigned16
(295)	Event	R	Bytes 78 and 79 of the ASCII message string	Unsigned16
(296)	Event	R	Bytes 80 and 81 of the ASCII message string	Unsigned16

Table 20: Table of Event Log Registers

Event ID Registers

Register	Group	Read/ Write	Description	Format
(300)(301)	Event	R	Beginning Event ID	Unsigned32
(302)(303)	Event	R	Ending Event ID	Unsigned32
(304)(305)	Event	R/W	Current Event ID	Unsigned32
(306)(307)	Event	R	Proprietary Binary Event Data	Unsigned32
(308)(309)	Event	R	Proprietary Binary Event Data	Unsigned32
(310)(311)	Event	R	Proprietary Binary Event Data	Unsigned32
(312)(313)	Event	R	Proprietary Binary Event Data	Unsigned32
(314)(315)	Event	R	Proprietary Binary Event Data	Unsigned32
(316)(317)	Event	R	Proprietary Binary Event Data	Unsigned32
(318)(319)	Event	R	Proprietary Binary Event Data	Unsigned32
(320)(321)	Event	R	Proprietary Binary Event Data	Unsigned32

Table 21: Table of Event ID Registers

Event Log

The Event Log Group provides a way to read the event log from the UPS. The UPS stores events in its internal memory according to severity.

- **Status Events** are normally occurring events deemed important enough to store in event memory, but not associated with an error condition.

- **Notice Events** indicate a possible failure or abnormal condition and should be investigated. Examples are: 1 fan failure, temperature slightly high.

- **Alarm Events** require immediate attention. Examples are: Extreme over-temperature, several fan failures at once.

The Message itself is sent as ASCII text in registers 256-296 and can include up to the first 80 characters of the event message, plus a trailing null. For messages less than 80 characters long, the trailing bytes are zeroed.

Attempts to read a message that is not in the range of allowable messages (i.e. an invalid ID is entered in registers 304-305 or trying to increment beyond the end of the event log with registers 253-255) will result in a null string (all message bytes being zeroed).

The ASCII string will be the result from the last event command request, i.e. the last write to one of the command registers (253-255) or the current event ID (304-305).

Event Log Storage Info: The SMS and MMS UPS systems accumulate events in a circular buffer. This buffer will hold up to 4096 events.

This means that once the buffer is full, register 250 will always return the same number of events, and registers 251 and 252 may not change when a new warning or alarm message is put into the buffer if one of the same type was removed from the buffer.

IMPORTANT: Traversing thru the event log with the reset and increment style (registers 253-255) is a deprecated method of filling the event log string (registers 256-296) and is provided for backward compatibility purposes.

There are new registers for using 32-bit event ID's (registers 300-305) and an event severity register (number 297) to try and allow more flexibility with using the event log. To see the old method, look after the event ID method below.

To retrieve the event log using event ID's:

- Read the beginning event ID, registers 300-301, and ending event ID, registers 302-303.

- If they are not the same, then there are events in the event log.

- To get the entire event log: start at the beginning event ID, write the event ID to the current event ID registers 304-305, read the event out of the event log string registers, increment the event ID by one and repeat. Keep doing this until you reach the ending event ID.

- Since the event ID range is known, it is possible to just grab part of the event log, such as the last 20 events by just subtracting the number of events desired from the ending event ID and incrementing through to the end.

- To check for new events, just look to see if the ending event ID has changed. On an event log erase, the ID's will all reset and start over at zero.

- For a given unit in a SMS or (P)MMS, as long as the event log is not erased or there is no other catastrophic problem, the event ID should be the same even if the unit restarts. So, if communication is lost with a unit, one can know what part of the event log, if any, is missing once communications are restored by comparing the last event ID obtained from the ending event ID registers.

Also, using the event severity register 297, one can perform his/her own parsing for warnings and/or alarms as well.

Pseudo-code for using Event ID:

Read_All_Event_Messages: -- read all event messages stored in the—event log

Begin_ID = Read_many(300, 2)

End_ID = Read_many(302, 2)

If (Begin_ID != End_ID)   -- there are events

Current_ID = Begin_ID

Write_many(304, 2, Current_ID)

Message_text = Read_many(256, 41)   -- read all ascii bytes

Severity = Read_many(297, 1)

While (Current_ID != End_ID) AND (Severity != Invalid Event)

Current_ID = Current_ID + 1

Write_many(304, 2, Current_ID)

Message_text = Read_many(256, 41)   -- read all ascii bytes

Severity = Read_many(297, 1)

End_ID = Read_many(302, 2)   -- see if there are new events

Periodic_update: – most recent messages since last poll and see if any were alarms

End_ID = Read_many(302, 2)   -- Read the latest event ID

If (End_ID != Current_ID)   -- if there are new events (assumes current id was equal to end id previously)

Severity = Status Event   -- initialize it to a valid value

While (Current_ID != End_ID) AND (Severity != Invalid Event)

Current_ID = Current_ID + 1

Write_many(304, 2, Current_ID)   -- look at the next message

Severity = Read_many(297, 1)

If (Severity == Alarm)

Message_text = Read_many(256, 41)   -- read all ascii bytes

To retrieve the event log using registers 250-255 (old way of doing things and not as easy to use):

- One can read the number of a messages, alarm messages, and/ or alarm and warning messages (registers 250,251, and/or 252) to use as a loop counter for getting all of a certain type of events, or one can just issue the reset command for the desired type of events in registers 253-255 and keep advancing through them until it gets to an empty ASCII string (or an invalid event severity in register 297).

- If there are more than zero messages, set the Command register for the desired message level (registers 253-255). A "Reset" command should be issued first. Subsequent "Advance" commands should be issued to progress through all the events.

- If another message is available, the ASCII string area will contain the ASCII characters for the message. The end of the message will be padded with NULL characters. If no other messages are available, the ASCII string area will contain zeros.

- This method requires traversing through the entire event log to get events for the first time, or after a the system processor restarts which can be annoying.

- After getting all of the events, then one has to periodically try to advance to the next event to see if a new one is available since the number of messages is not guaranteed to always change like it did in the old days. Of course, one could now just look at the ending event ID to see if it has changed, but the event ID method is now the recommended method anyway.

- On a system processor restart or an event log erase, a "Reset" command will need to be issued to get the event log registers working again with this method, which of course means traversing through the entire event log again.

- The three different command registers for advancing and resetting to the beginning of the log are not independent. In other words, if you reset for alarm events it will move to the first alarm event. If you then increment an all messages event it will move one event from the first alarm. In other words, one cannot mix and match their use correctly. If one starts traversing through the events for one type of message, then he/she should continue using that type until it reaches the end. With the addition of register 297 (event severity), one could use that to do one's own parsing of warning, alarm, and all messages.

- Pseudo-coded routines for reading the entire event log, and for periodically checking for new event messages, are shown below.

NOTE: This is for the old way of traversing the event log, and the methods shown below may not work for all cases any more (for example, the new ways of keeping event counts will make the periodic update code not work correctly). One may need to look at Event ID's or the severity register when trying to maintain a copy of the event log.

Read_All_Event_Messages: – read all event messages stored in the—event log

Num_All_msgs = Read_single(250)

If (Num_All_Msgs > 0)

Write(253, 0)   -- Reset the "All Messages" Command Register

While (Num_All_msgs > 0)

Message_text = Read_many(256, 41)   -- read all ascii bytes

Num_All_msgs = Num_All_msgs −1

Write(253, 1)   -- Advance the "All Messages" Command -Register

Periodic_update: –
(old, no longer works correctly):   -- Read the most recent "Alarm" messages since last poll

Num_Alarm_msgs = Read(252)   -- Read the number of Alarm Messages stored in the event log

If (Num_Alarm_msgs != last_ Num_Alarm_msgs)   -- if there are new events

Write(255, 1)   -- Advance the "Alarms Only" index to the next message

Message_text = Read_many(256, 41)   -- read all ascii bytes

while(Message_text != NULL)   -- read all non-null messages

Write(255, 1)   -- Advance the "Alarms Only" index to the next message

Message_text = Read_many(256, 41)   -- read all ascii bytes

Periodic_update: – (new, that will work):   -- Read the most recent "Alarm" messages since last poll

Write(255, 1)   -- Advance the "Alarms Only" index to the next message, to see if there is one

Severity = Read_many(297, 1)

While (Severity != Invalid Event)   -- there was an alarm event, read all non-null messages.

Message_text = Read_many(256, 41)   -- read all ascii bytes

Write(255, 1)   -- Advance the "Alarms Only" index to the next message

Severity = Read_many(297, 1)

Status Group

The Status Group contains Status Registers for the system and MMU. Each bit has a particular meaning for a particular FPGA revision.

Register	Group	Format	Description
(350)	Status	Unsigned16	System Status Register 1
(351)	Status	Unsigned16	System Status Register 2
(352)	Status	Unsigned16	System Status Register 3
(353)	Status	Unsigned16	MMU Status Register 1
(354)	Status	Unsigned16	MMU Status Register 2
(355)	Status	Unsigned16	MMU Status Register 3
NOTE: The System Status Registers are only available on systems with a Systems Cabinet (i.e. systems that can support more than 1 MMU).			

Table 22: Table of Common Status Group Registers

Status Register Bit Definitions

Bit Definitions for System Status Register 1

Bit	Definition	Description
15	SYS_CAB_USER_DATA_LOCK_BIT	communication with user interface board ok
14	SYS_CAB_IO_DATA_LOCK_BIT	communication with i/o interface board ok
13	SYS_CAB_FAN_DATA_LOCK_BIT	communication with fan interface board ok
12	SYS_CAB_AC_DATA_LOCK_BIT	communication with AC interface board ok
11	SYS_CAB_T3_FUSE_BIT	power supply transformer fuse okay
10	SYS_CAB_T2_FUSE_BIT	power supply transformer fuse okay
9	SYS_CAB_T1_FUSE_BIT	power supply transformer fuse okay
8	SYS_CAB_SPARE_0	Spare bit
7	SYS_CAB_PS_2_OK_BIT	24 V power supply 2 okay
6	SYS_CAB_PS_1_OK_BIT,	24 V power supply 1 okay
5	SYS_CAB_FAN_6_OK_BIT	Spare bit
4	SYS_CAB_FAN_5_OK_BIT	Spare bit
3	SYS_CAB_FAN_4_OK_BIT	Spare bit
2	SYS_CAB_FAN_3_OK_BIT	System cabinet fan 3 is okay
1	SYS_CAB_FAN_2_OK_BIT	System cabinet fan 2 is okay
0	SYS_CAB_FAN_1_OK_BIT	System cabinet fan 1 is okay
NOTE: Bit 15 is the most significant bit		

Table 23: Table of Status Register 1 Bit Definitions

Bit Definitions for System Status Register 2

Bit	Definition	Description
15	SYS_CAB_SS_FUSE_OK_BIT	Bypass Static Switch fuse is okay
14	SYS_CAB_SPARE_BIT	Spare bit
13	SYS_CAB_SPARE_BIT	Spare bit
12	SYS_CAB_SPARE_BIT	Spare bit
11	SYS_CAB_SPARE_BIT	Spare bit
10	SYS_CAB_SPARE_BIT	Spare bit
9	SYS_CAB_SPARE_BIT	Spare bit
8	SYS_CAB_SPARE_8	
7	SYS_CAB_SPARE_7	
6	SYS_CAB_IN_6_CONTACT_BIT	System Cabinet remote input contact
5	SYS_CAB_IN_5_CONTACT_BIT	System Cabinet remote input contact
4	SYS_CAB_IN_4_CONTACT_BIT	System Cabinet remote input contact
3	SYS_CAB_IN_3_CONTACT_BIT	System Cabinet remote input contact
2	SYS_CAB_IN_2_CONTACT_BIT	System Cabinet remote input contact
1	SYS_CAB_IN_1_CONTACT_BIT	System Cabinet remote input contact
0	Reserved for future use	

Table 24: Table of System Status Register 2 Bit Definitions

Bit Definitions for System Status Register 3

Bit	Definition	Description
15	SYS_CAB_BYPASS_ROTATION_CW	bypass input phase rotation is clockwise
14	SYS_CAB_BYPASS_ROTATION_CCW	bypass input phase rotation is counter-clockwise
13	SYS_CAB_FREQUENCY_LOCK	
12		Spare bits
11		Spare bits
10		Spare bits
9		Spare bits
8	SYS_CAB_K3_STATUS_ERR, K3	status bit doesn't match K3 command bit
7	SYS_CAB_COMMUNICATION_ERR	Error with one of the satellite sys. Cab. boards
6	SYS_CAB_K3_CB_CURRENT_TRIP	Bypass CB tripped because of current overload
5	SYS_CAB_FAN_SPARE_5	
4	SYS_CAB_FAN_SPARE_4	
3	SYS_CAB_FAN_SPARE_3	
2	SYS_CAB_FAN_SPARE_2	
1	SYS_CAB_ZIGZAG_OL_RELAY_TRIP	zigzag transformer overload relay has tripped
0	SYS_CAB_ZIGZAG_BREAKER_TRIP	zigzag breaker relay has tripped

Table 25: Table of System Status Register 3 Bit Definitions

MMU Status Register Bit Definitions

Bit Definitions for MMU Status Register A

Bit	Definition	Description
15	K3_STATUS_BIT	Bypass contactor status bit (1 = closed)
14	K2_STATUS_BIT	MMU output contactor status bit (1 = closed)
13	K1_STATUS_BIT	MMU input contactor status bit (1 = closed)
12	USER_DATA_LOCK	MMU user interface board communications okay
11	IO_DATA_LOCK	MMU input/output interface board comm. okay
10	FAN_DATA_LOCK	MMU fan interface board communications okay
9	DC_DATA_LOCK	MMU DC interface board communications okay
8	AC_DATA_LOCK	MMU AC interface board communications okay
7	GS_DATA_LOCK (Optional)	MMU Genset Start interface board communications okay
6	UNLOADING_TO	Unloading controller had a timeout reaching setpoint
5	LOW_SPEED_SHUTDOWN	Discharge ending because of flywheel speed
4	FLY_MASTER_ENABLE	Flywheel Master Controller enabled
3	EXT_SYNC_BIT	Synchronize output to external input source command bit
2	K4_STATUS_BIT	Bypass static switch contactor status Bit
1	S_BYP_SW_FUSE_OK_BIT	Bypass static switch fuse status bit
0	MASTER_ENABLE	The MMU master controller is enabled

Table 26: Table of MMU Status Register 1 Bit Definitions

Bit Definitions for MMU Status Register B

Bit	Definition	Description
13	DISCHARGE_STAT	Discharge Status
12	Spare Bit	
11	Spare Bit	
10	MMU_T2_FUSE_BIT	MMU power supply transformer 2 fuse is okay
9	MMU_T1_FUSE_BIT	MMU power supply transformer 1 fuse is okay
8	PS_3_BIT	MMU 24V DC power supply 3 is okay
7	PS_2_BIT	MMU 24V DC power supply 2 is okay
6	PS_1_BIT	MMU 24V DC power supply 1 is okay
5	MMU_FAN_5_OK	MMU Fan 6 is okay
4	MMU_FAN_4_OK	MMU Fan 5 is okay
3	MMU_FAN_3_OK	MMU Fan 4 is okay
2	MMU_FAN_2_OK	MMU Fan 3 is okay
1	MMU_FAN_1_OK	MMU Fan 2 is okay
0	MMU_FAN_0_OK	MMU Fan 1 is okay

Table 27: Table of MMU Status Register 2 Bit Definitions

Bit Definitions for MMU Status Register C

Bit	Definition	Description
14	AC_COUNTER_CLOCKWISE_BIT	MMU input has counter clockwise phase rotation
13	AC_CLOCKWISE_BIT	MMU input has clockwise phase rotation
12	SSW_RAMP_DONE_BIT	MMU Input static switch startup ramp is finished
11	STATIC_SWITCH_TIMEOUT	Timeout controlling MMU input static switch
10	OVERSPEED_ERR	Flywheel overspeed shutdown
9	RPS_ERR	Rotor Position Sensor Error
8	SKIIP_3_ERR	Flywheel SKIIP 3 error
7	SKIIP_3_ERR	Flywheel SKIIP 2 error
6	SKIIP_3_ERR	Flywheel SKIIP 1 error
5	SKIIP_C_ERR	Utility Inverter Phase C IGBT error
4	SKIIP_B_ERR	Utility Inverter Phase B IGBT error
3	SKIIP_A_ERR	Utility Inverter Phase A IGBT error
2	FWI_DATALOCK_ERR_BIT	Flywheel Interface Board comm. error
1	LOW_DC_BUS_ERR	A DC Bus had a low voltage error
0	HI_DC_BUS_ERR	A DC Bus had a high voltage error

Table 28: Table of MMU Status Register 3 Bit Definitions

Bit Definitions for MMU Status Register D

Bit	Definition	Description
15	BYPASS_AVAILABLE_BIT	Bypass input is qualified for bypass transfers
14	EXT_SYNC_CMD_BIT	Discharge sync. To ext. downstream source
13	BYPASS_SSW_OKAY_BIT	Bypass static switch is present and operating
12	BYPASS_SYNC_BIT	Output is synchronized to the bypass source
11	AHC_ENABLE_BIT	Active harmonic correction enable bit
10	FLYWHEEL_SYS_ENABLE_BIT	The flywheel master controller enable bit
9	REDUNDANT_MMU_BIT	System has at least 1 MMU more than load requires
8	AVR_ENABLE_BIT	Automatic Voltage Regulator is enabled
7	NEUTRAL_CONNECTED_BIT	System has a neutral connection
6	K4_CONTROL_BIT	Bypass static switch contactor close command
5	START_SWEEP_ENABLE_BIT	Rotor spin sweep is enabled
4	K3_CONTROL_BIT	Bypass contactor open request
3	K2_CONTROL_BIT	Output contactor close request
2	K1_CONTROL_BIT	Input contactor close request
1	UNLOADING_ENABLE_BIT	Rotor unloading controller is enabled
0	STATIC_SWITCH_ENABLE_BIT	MMU input static switch is enabled

Table 29: Table of MMU Status Register 4 Bit Definitions

Bit Definitions for MMU Status Register E

Bit	Definition	Description
15	DISCHARGE_ENABLE_BIT	MMU discharge is enabled
14	FLYWHL_INV_ENABLE_BIT	MMU flywheel inverter is enabled
13	FIELD_ENABLE_BIT	MMU field coil controller is enabled
12	UTIL_INV_ENABLE_BIT	MMU Output Utility Inverter is enabled
11	SYSTEM_ENABLE_BIT	MMU master controller enable command
10	ALARM_ACTIVE	MMU has an active alar event
9	NOTICE_ACTIVE	MMU has an active notice event

Table 30: Table of MMU Status Register 5 Bit Definitions

Summary Group

The summary group contains some information about each UPS unit connected via the CAN bus. Register values for MMUs that are not present on the CAN bus are returned as zeros (0). There are registers or nodes for seven MMUs connected to each other via the CAN bus.

Register	Group	Format	Description
(375)	Summary	Unsigned16	Detected number of MMU's
(376)	Summary	Unsigned16	Expected number of MMU's

Table 31: Table of MMU Summary Group Registers

MMU Node 1

Register	Group	Format	Description
(380)	Summary	Unsigned16	MMU Mode, Unit 1
(381)	Summary	Unsigned16	MMU State, Unit 1
(382)(383)	Summary	Float32	Tachometer, Unit 1
(384)(385)	Summary	Float32	Percent Usable Energy, Unit 1
(386)(387)	Summary	Float32	Cabinet Temperature, Unit 1
(388)(389)	Summary	Float32	Vacuum Gauge, Unit 1
(390)(391)	Summary	Float32	MMU Output Power, Unit 1
(392)(393)	Summary	Float32	MMU Output KVA, Unit 1
(394)(395)	Summary	Float32	MMU Input Power, Unit 1
(396)(397)	Summary	Float32	MMU Input KVA, Unit 1
(398)(399)	Summary	Float32	MMU Spare telemetry channel, Unit 1
(400)(401)	Summary	Float32	MMU Spare telemetry channel, Unit 1
(402)(403)	Summary	Float32	MMU Input Current Phase A, Unit 1
(404)(405)	Summary	Float32	MMU Input Current Phase B, Unit 1
(406)(407)	Summary	Float32	MMU Input Current Phase C, Unit 1
(408)(409)	Summary	Float32	MMU Output Current Phase A, Unit 1
(410)(411)	Summary	Float32	MMU Output Current Phase B, Unit 1
(412)(413)	Summary	Float32	MMU Output Current Phase C, Unit 1

Table 32: Table of MMU Summary Group Node 1 Registers

MMU Node 2

Register	Group	Format	Description
(424)	Summary	Unsigned16	MMU Mode, Unit 2
(425)	Summary	Unsigned16	MMU State, Unit 2
(426)(427)	Summary	Float32	Tachometer, Unit 2
(428)(429)	Summary	Float32	Percent Usable Energy, Unit 2
(430)(431)	Summary	Float32	Cabinet Temperature, Unit 2
(432)(433)	Summary	Float32	Vacuum Gauge, Unit 2
(434)(435)	Summary	Float32	MMU Output Power, Unit 2
(436)(437)	Summary	Float32	MMU Output KVA, Unit 2
(438)(439)	Summary	Float32	MMU Input Power, Unit 2
(440)(441)	Summary	Float32	MMU Input KVA, Unit 2
(442)(443)	Summary	Float32	MMU Spare telemetry channel, Unit 2
(444)(445)	Summary	Float32	MMU Spare telemetry channel, Unit 2
(446)(447)	Summary	Float32	MMU Input Current Phase A, Unit 2
(448)(449)	Summary	Float32	MMU Input Current Phase B, Unit 2
(450)(451)	Summary	Float32	MMU Input Current Phase C, Unit 2
(452)(453)	Summary	Float32	MMU Output Current Phase A, Unit 2
(454)(455)	Summary	Float32	MMU Output Current Phase B, Unit 2
(456)(457)	Summary	Float32	MMU Output Current Phase C, Unit 2

Table 33: Table of MMU Summary Group Node 2 Registers

MMU Node 3

Register	Group	Format	Description
(468)	Summary	Unsigned16	MMU Mode, Unit 3
(469)	Summary	Unsigned16	MMU State, Unit 3
(470)(471)	Summary	Float32	Tachometer, Unit 3
(472)(473)	Summary	Float32	Percent Usable Energy, Unit 3
(474)(475)	Summary	Float32	Cabinet Temperature, Unit 3
(476)(477)	Summary	Float32	Vacuum Gauge, Unit 3
(478)(479)	Summary	Float32	MMU Output Power, Unit 3
(480)(481)	Summary	Float32	MMU Output KVA, Unit 3
(482)(483)	Summary	Float32	MMU Input Power, Unit 3
(484)(485)	Summary	Float32	MMU Input KVA, Unit 3
(486)(487)	Summary	Float32	MMU Spare telemetry channel, Unit 3
(488)(489)	Summary	Float32	MMU Spare telemetry channel, Unit 3
(490)(491)	Summary	Float32	MMU Input Current Phase A, Unit 3
(492)(493)	Summary	Float32	MMU Input Current Phase B, Unit 3
(494)(495)	Summary	Float32	MMU Input Current Phase C, Unit 3
(496)(497)	Summary	Float32	MMU Output Current Phase A, Unit 3
(498)(499)	Summary	Float32	MMU Output Current Phase B, Unit 3
(500)(501)	Summary	Float32	MMU Output Current Phase C, Unit 3

Table 34: Table of MMU Summary Group Node 3 Registers

MMU Node 4

Register	Group	Format	Description
(512)	Summary	Unsigned16	MMU Mode, Unit 4
(513)	Summary	Unsigned16	MMU State, Unit 4
(514)(515)	Summary	Float32	Tachometer, Unit 4
(516)(517)	Summary	Float32	Percent Usable Energy, Unit 4
(518)(519)	Summary	Float32	Cabinet Temperature, Unit 4
(520)(521)	Summary	Float32	Vacuum Gauge, Unit 4
(522)(523)	Summary	Float32	MMU Output Power, Unit 4
(524)(525)	Summary	Float32	MMU Output KVA, Unit 4
(526)(527)	Summary	Float32	MMU Input Power, Unit 4
(528)(529)	Summary	Float32	MMU Input KVA, Unit 4
(530)(531)	Summary	Float32	MMU Spare telemetry channel, Unit 4
(532)(533)	Summary	Float32	MMU Spare telemetry channel, Unit 4
(534)(535)	Summary	Float32	MMU Input Current Phase A, Unit 4
(536)(537)	Summary	Float32	MMU Input Current Phase B, Unit 4
(538)(539)	Summary	Float32	MMU Input Current Phase C, Unit 4
(540)(541)	Summary	Float32	MMU Output Current Phase A, Unit 4
(542)(543)	Summary	Float32	MMU Output Current Phase B, Unit 4
(544)(545)	Summary	Float32	MMU Output Current Phase C, Unit 4

Table 35: Table of MMU Summary Group Node 4 Registers

SNMP

Simple **N**etwork **M**anagement **P**rotocol (**SNMP**) is a widely used protocol for monitoring the health and welfare of network equipment (e.g. routers), computer equipment and even industrial devices.

SNMP requires an information structure file called an MIB file. Management Information Bases (MIBs) are a collection of definitions which define the properties of the managed object within the device to be managed. Every managed device keeps or transmits a set of values for each of the definitions written in the MIB. You can think of a MIB as an information structure of the device. See the OMM manual for your UPS for SNMP setup.

Dry Contacts

Contact Function Lists

Customer interface connections are provided by 6 input and 6 output form "C" dry contacts located on the System Input/Output (SIO) Daughter board. The SIO PWA board is located on the left component panel in the Flywheel or Systems cabinet.

In addition, remote EPO buttons connect to Terminal Block J7 on the SIO Daughter board.

All contacts can be configured using UPSview software in order to communicate with various kinds of monitoring systems or building software if certain conditions

exist. The Input/Output (I/O) contacts can be used to bring in the operational status of equipment, such as the generator set, ATS, HVAC, etc.

Each input is intended to interface to a single-pole single-throw switch. The switch connects the pair of contacts or the switch disconnects the pair of contacts. The contacts that are user programmable have an operating parameter (function value) used to configure that contact. See the available Function Lists below.

IMPORTANT: All remote INPUT contacts must be programmed so that NO TWO are programmed alike.

Dry Contact Specifications

Maximum Voltage: 42.4 V rms or 60 VDC

Maximum Current: 3 Amps

Power Source Class: SELV/Class 2 circuit

User Programmable Remote Input Contacts

Each of the six user programmable remote input contacts has an operating parameter used to configure that contact.

The following lists of functions can be assigned to the remote input contacts by entering the parameter in the operating parameter for the associated remote input.

Contact	Function	Description
1	1	On Generator
2	2	Remote Switch to the PS to Bypass
3	3	Remote Switch to the UPS to On-Line mode
4	4	Building Alarm 1
5	5	Building Alarm 2
6	6	Building Alarm 3

Table 36: Table of Default Input Contact Function Assignments

Number	System Logic	Input Type	Available Function Assignments for Input Contacts
0			None
1	OR		On Generator (closed = generator) [1]
2	IND	M*	Remote switch UPS to Bypass
3	IND	M*	Remote switch UPS Online [2]
4	OR		Building Alarm 1 (Yellow) [3]
5	OR		Building Alarm 2 (Yellow) [3]
6	OR		Building Alarm 3 (Yellow) [3]
7	OR		Building Alarm 4 (Yellow) [3]
8	OR		Fire Alarm (Yellow) [3]
9	OR	M*	Remote Alarm Silence [4]
10	IND		Gen-Set Start Breaker Open [5]
11	OR		Room Temperature Abnormal [6]
12	OR		External Synch. Enable
13	OR		User Defined Msg Notice 1 (Yellow) [7]
14	OR		User Defined Msg Notice 2 (Yellow) [7]
15	OR		User Defined Msg Alarm 1 (Red)
16	OR		User Defined Msg Alarm 2 (Red)
17	IND		GSO Group A open
18	IND		GSO Group B open
19	IND		GSO Group C open
20	IND		GSO Group D open
21	OR		User Defined Msg 1 (Green)
22	OR		User Defined Msg 2 (Green)
23	OR	M*	Remote Spindown
24	OR		Online Inhibit
25	IND	M*	Remote Braking
26	NA		Syncronized Walk-in Enable
27	NA		OK to Walk-in
28	IND	M*	Transfer Inhibit

1   When the input contactor is set to the On Generator mode, various limits can be set for the "Transient Voltage Detection" operating parameter. The "Maximum Input Current" operating parameter and the "Walk-in Rate" operating parameter.
2   Used to remotely command the UPS to go to the on-line mode.
3   This feature is used to detect an external alarm, and log such an event in the UPS history file.
4   Used to silence the alarm from a remote location.
5   A "breaker open" message is printed when the input is activated. A "breaker closed" message is printed when the input is deactivated.
6   A message is printed when the input is activated. A different message is printed when input is deactivated.
7   This message is defined by the user.

*   Denotes momentary contact. All other inputs are maintained.

Table 37: Table of Programmable Input Contact Function Assignments

System Logic Notes:

- **IMPORTANT: All remote inputs and outputs must be programmed the same in all MMSs and PMMSs.**

- On PMMSs, **each** MMS input that is to be used must be wired with isolated dry contacts.

OR

- On Paralleled Multi-Module Systems (PMMS), the contacts from all MMS's are OR'ed together (MMS1 **OR** MMS2 **OR** MMS3 ect.) so that all MMSs will respond if any remote input changes.

- The remote outputs will respond as the OR of all MMSs.

- On a PMMS with Centralized Bypass, the OR inputs can be wired only to the Centralized Bypass Control Cabinet (CBCC)

IND

- On PMMSs, the contacts from any MMSs are treated independently so that only the MMS with the remote input change will respond.

- The remote outputs will respond as the OR of all MMSs.

- On a PMMS with Centralized Bypass, the IND inputs must be wired to the MMSsand NOT the CBCC.

NA

- Not available with PMMS

User Programmable Remote Output Contacts

Each of the six user programmable remote output Form C type contacts has an operating parameter that is used to configure that contact

The following is a list of the default output function assignments.

Contact	Function	Description
1	101	Online (normal)
2	102	On Bypass
3	103	Flywheel Discharging
4	50	Flywheel Percent Energy
5	118	Notice Condition or An Alarm Condition is Active
6	119	Alarm Condition is Active

Table 38: Table of Default Output Contact Function Assignments

The following list of functions can be assigned to the remote output contacts by entering the parameter in the menu for the operating parameter for the associated remote output.

Number	Logic	Available Functions Assignments for Output Contacts
0		**None**
1-100	OR	Flywheel Percent Energy – the flywheel has the programmed percentage of usable energy available and the system is online.
101	OR	On-line
102	IND	Bypass
103	IND	Discharging
104	IND	Notice
105	IND	Alarm
106	IND	Overload – the system goes to Bypass because of an overload condition
107	IND	Cabinet Temperature Abnormal
108	IND	External Alarm (Building & Fire)
109		Not used
110	IND	Overload to Bypass
111		Not used
112	IND	Fan problem
113		Not used
114		Not used
115		Not used
116	OR	ATS Command
117	IND	Motoring
118	IND	Notice (LED)
119	IND	Alarm (LED)
120		Output KW level
121	NA	Ready to Walk-in
122	OR	Any MMS Overload Notice
123	OR	Any MMS Overload Alarm
124	IND	Bypass Available

Table 39: Table of Programmable Output Contact Function Assignments

System Logic Notes:

- **IMPORTANT: All remote inputs and outputs must be programmed the same in all MMSs and PMMSs.**

- On PMMSs, **each** MMS input that is to be used must be wired with isolated dry contacts.

OR

- On Paralleled Multi-Module Systems (PMMS), the contacts from all MMS's are OR'ed together (MMS1 **OR** MMS2 **OR** MMS3 ect.) so that all MMSs will respond if any remote input changes.

- The remote outputs will respond as the OR of all MMSs.

- On a PMMS with Centralized Bypass, the OR inputs can be wired only to the Centralized Bypass Control Cabinet (CBCC)

IND

- On PMMSs, the contacts from any MMSs are treated independently so that only the MMS with the remote input change will respond.

- The remote outputs will respond as the OR of all MMSs.

- On a PMMS with Centralized Bypass, the IND inputs must be wired to the MMSs and NOT the CBCC.

NA

- Not available with PMMS System Logic Notes:

Input/Output Contact Customer Connections

Customer interface connection points for programmable input/output contacts are on numbered terminal blocks located on the SIO Daughter Board PWA which is attached to the SIO Communication PWA.

Input Contacts

The input contacts terminal block is numbered J14 on the SIO Daughter Board PWA. Each contacts is rated 3amps.

Input Contacts Terminals			
1	Common 1	7	Input 1
2	Common 2	8	Input 2
3	Common 3	9	Input 3
4	Common 4	10	Input 4
5	Common 5	11	Input 5
6	Common 6	12	Input 6

Table 40: Table of Input Contacts Customer Connections at Block J14

Output Contacts

The output contacts terminal block is numbered J6 on the SIO Daughter Board PWA. Each contact is rated 3amps.

Output Contacts Terminals			
1	Output 1-N.O.	10	Output 4-N.O.
2	Output 1-COM	11	Output 4-COM
3	Output 1-N.C.	12	Output 4-N.C.
4	Output 2-N.O.	13	Output 5-N.O.
5	Output 2-COM	14	Output 5-COM
6	Output 2-N.C.	15	Output 5-N.C.
7	Output 3-N.O.	16	Output 6-N.O.
8	Output 3-COM	17	Output 6-COM
9	Output 3-N.C.	18	Output 6-N.C.

Table 41: Table of Input Contacts Customer Connections at BlockJ6

Figure 49: Remote Emergency Power Off Button

Remote Emergency Power Off Button – Optional

The optional Remote Emergency Power Off (REPO) button is used to initiate an emergency shutdown of the system causing the UPS to drop the load. It is the equivalent to the local EPO button but is mounted external to the UPS. Only one REPO button is needed per UPS.

When activated there is no power flow through the system when the system is shut down and no power is supplied to the load. All contactors are open, and the static switches and utility inverters are OFF.

Operator intervention is required to put the system back online if it is shut down using REPO.

NOTE: The REPO will not actuate by any internal maintenance bypass. High voltage may still be present on the UPS input terminals or any customer supplied breaker.
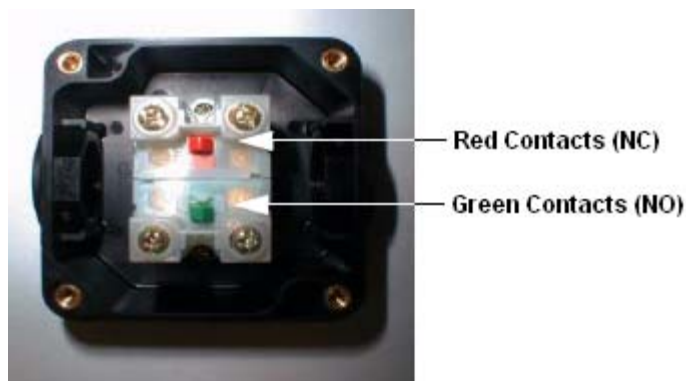
Figure 50: Remote EPO Button Contacts

Remote EPO Connection

The SIO board has the ability to work with either Normally Open or Normally Closed REPO Systems.

Connections are made to Terminal Block J7 on the SIO daughter board. The SIO board is located on the Left Component panel in the lower left hand corner of the panel.

Terminal J7 has two sets of contacts that operate independently of each other.

- Normally open (terminals 1 and 3)
- Normally closed (terminals 2 and 4)

To use the **Green** normally open contacts in the REPO button, route wires from terminals 3 and 4 in the REPO button to the Remote EPO contacts J7 Terminals 1 and 3.

To use the **Red** normally closed contacts in the REPO button, remove the jumper wire and route wires from terminals 1 and 2 in the REPO button REPO contacts J7 Terminals 2 and 4.

The REPO Button circuit is considered a control circuit (ELV circuit) and the wiring must be routed separately from the Class 2 (SELV) wiring. Wiring should be in conduit with 18AWG minimum. The maximum distance from the UPS is 152m or 500ft.

NOTE: The system is shipped with a jumper connected across the normally closed contacts (terminals 2 and 4). If the normally closed contacts are used remove the jumper. If no REPO is added, the normally open contacts (terminals 1 and 3) are used. Do **NOT** remove the jumper if no REPO is added.

The Remote Status Panel connection points from the System Input/Output Daughter (SIOD) board Terminal Block J5 are listed below.

Panel Connections		SIOD J5 Connections
Terminal	Description	Terminal
1	+24VDC	1 (Power)
2	Serial Data In	5 (Data)
3	Spare	
4	Spare	
5	Spare	
6	Jumper to 7	
7	Ground	3 (Ground)
8	Spare	
9	Jumper to 6	
10	Spare	
11	Spare	
12	Lamp Test	
13	Horn Silence	
14	Horn Output	

Table 42: Remote Status Panel Connections
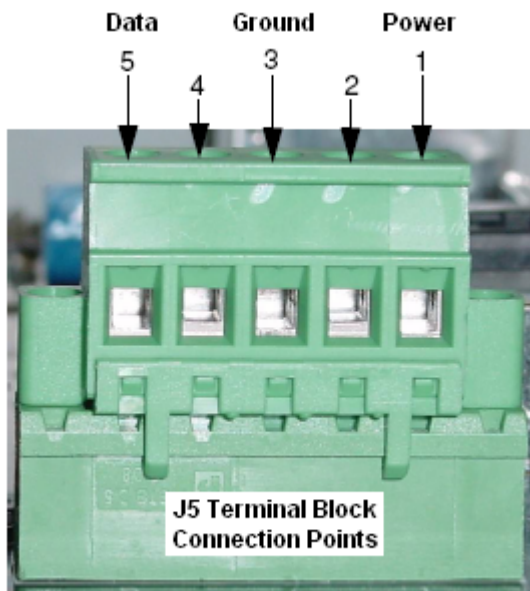
Note: J5 Terminal Block connector located on SIO Daughter board

Figure 52: Remote Status Panel to J5 Connections

Genset Start Module

Figure 53: Genset Start Module

The Genset Start Module option provides a more reliable redundant source of starting power for a generator set. This option removes the most common cause of generator set starting failures, dead starting batteries. The Genset Start Module or Modules can parallel with the normal generator set starting batteries using a supplied blocking diode to provide a DC power source to the starting motor(s).

Each module can provide up to 1725 cold cranking amps to the package starting motor(s). The Module receives 3-phase 380/400/415/480 VAC power from ANY reliable power source, such as a UPS. The AC voltage is converted into 24 VDC for the starter motor(s). Two Genset Start Modules can be connected and operated from one UPS system if needed.

The Genset Start Module will indicate its functional status by the Customer Status Contact output. The Customer Status Contact output is a normally open or normally closed contact that is energized to indicate the module is in normal operating status. Specifically, the contact is energized whenever AC power is applied to the module, the input breaker is closed, the thermal switches are closed, and all internal fuses are good. In this state, the normally open contacts are closed and the normally closed contacts are open. See the Genset Start Module OMM manual for connections and setup.

The module enclosure should be installed as close to the engine starting motor(s) as possible and can be floor (standard) or wall mounted. The legs are removable.

The Genset Start Module must be electrically isolated from the UPS before servicing. A separate external over-current protection device (breaker) is required for each module. This provides UPS protection from any Genset Start Module failure and isolation protection when servicing the module while the UPS is operating. The input

of the Genset Start Module is rated at 32 amps, which leads to a 40-amp breaker. The breaker(s) can be factory optioned or supplied by others and mounted in an existing panel. If factory supplied the breaker(s) will be mounted in the SMS side cabinet or in the I/O cabinet in MMS systems.

Genset Start Module Specifications	
Nominal Voltage (Voltage Regulation)	24VDC (+10% / -30%) @ 0 – 1000A DC
Cold Cranking Amperes	1725A DC
Output Current Rating	1000A DC
Input Voltage	380-480 VAC, 3-PH
Output voltage	24 VDC

Table 43: Table of Genset Start Module Specifications

External Source Synchronization

This factory option provides a means for the UPS to synchronize the discharge of the flywheel to an external source. This may be a genset or another UPS. This option ensures synchronous transfer to redundant systems during discharge.

In order for this option to work, an in tolerance (+/-10VAC) 3-phase AC voltage source signal must be provided to the ESS terminal block and to a dry contact on the remote input that is programmed to ESS enable. In a Paralleled Multi Module System (PMMS), the ESS wiring must be connected to every MMS and the dry contact programmed to ESS enabled.

When the UPS is in discharge and the ESS enable is active, the UPS synchronizes its output with the signals provided by the redundant source. When a valid source returns to the UPS input, it will synchronize its output to the input (phase match) source and transfer the load from the flywheels to the input source (walk-in).

The ESS will be located in the outside bottom left panel in the flywheel cabinet (SMS) or system cabinet (MMS).

Installation

Installation Considerations

Inspect Upon Receipt

Inspect tilt and shock indicators. A 30 degree tilt is the acceptable maximum. The shock indicator should be clear (not showing red). IMPORTANT: If the tilt indicator has registered a tilt of over 30 degrees or if the shock indicator is red and indicating it has registered an unacceptable shock, you must suspect hidden damage. Photograph the tilt and shock indicators in place on the cabinet for assistance in processing a damage claim.

Site Considerations

The UPS should be installed on a structurally sound, near level floor, and in a reasonably clean and dust free environment away from direct sunlight or any heat source.

Adequate ventilation, including air conditioning, must be provided to limit heat accumulation in hot weather. Service clearance for the UPS must be considered as well as clearance above the UPS for ventilation. The UPS should not be operated in a sealed room or container without specific climate control that meets the minimum system specifications

If you plan to use UPSView monitoring software, you may need to plan for the installation of the RS-232 or 485 cable from the system to the chosen local computer connection. For remote monitoring, a modem or Ethernet and phone line or local network connection are required to interface to with UPSView. Wiring for the remote Remote Status panel and Remote EPO may also be required. Electrical connections can enter through the top or bottom of the system cabinet.

It is best to use the shortest cable runs possible and to provide allowances for any future additions. Cabling runs should be as short as possible and along with switchgear should be sized for the highest loads expected considering any future expansion. This helps to reduce future costs at time of upgrade.

Be certain that the floor at the final equipment location and along the route (inside the facility) to the installation site, can support the weight of the UPS **and any material handling equipment.**

Service and Ventilation Clearances

A clearance of 914 mm (36 inch) is required from the front of the unit for service. See your particular UPS Operations and Maintenance Manual (OMM) and Installation Drawings for dimensions. The sides and rear of the system can be placed near walls. Leave 50.8 mm (2 inch) clearance between the wall and cabinet. When possible, clearance behind the unit will facilitate easier cable runs.

All units, SMS and MMS, require a minimum clearance of 457 mm (18 inch) between the top of the unit and the ceiling (note: this does not include the wireway, just the cabinet itself).

Ambient Temperatures

If the following conditions cannot be met then conditioning of the air must be provided. Operating ambient temperature range for cold start shall be at least 0° C to 40° C (32° F to 104° F). Ambient storage temperature range shall be at least -25° C to 70° C (-13° F to 158° F). Relative humidity limits shall be 5% to 95%, non-condensing. Operating elevation limit shall be at least 3000 feet without de-rating. For operation above 3000 feet the ambient operating temperature shall be reduced by no more than 1.2°C for each 1000 feet up to an elevation of 7000 feet.

Operating temperature range is 0° C to 40° C (32° F to 104° F). Relative humidity must be less than 95% without condensation. Proper ventilation is necessary to ensure that the environmental conditioning system can accommodate the BTU load, even during utility outages.

High Altitude Operation

De-rate the ambient operating temperature by 1.2° C for each 1,000 feet of altitude above the rated maximum of 3,000 feet.

Ventilation and Heat Rejection

The cooling airflow at the site should be enough to remove the heat rejected from the UPS during extended full load operation. This ventilation must be capable of working during utility outages. Nominal heat rejection values shown on the UPS Spec Sheets have been obtained through full load testing with the values rounded up to provide a more conservative number. These values do not provide for multiple full load discharges and flywheel re-charging that would not normally occur.

Seismic Requirements

The unit is equipped with a zone 4 seismic qualified flywheel. Compliance with the zone 4 standard is based on calculations.

NOTE: the seismic option is required to provide mounting hardware for the I/O cabinet and the system cabinet where seismic qualifications are required.

Flooring or Slab Installation

The floor should be a minimum of 20.7 MPa (3000 psi) fully cured concrete or suitable material that can meet floor loading of 15.56 kN/m^2 (325 lbs per square foot) and can meet the load requirements of the anchor bolts. The floor should be level within 3 degrees. Any concrete slab should be flat to within 1/8th of an inch in a 10 foot long stretch. Existing slabs should be free from cracks and seams in the vicinity of the installation.

Anchor bolt positioning into a slab must be at least 304.8 mm (12 inches) from the outside edge of the slab or pad. See your particular UPS Operations and

Maintenance Manual (OMM) and Mechanical Drawings for complete installation directions and anchor bolt positioning dimensions.

NOTE: The flywheel is shipped with bearing retainers installed to relieve the bearing of transient forces that may be encountered during shipping and handling. NEVER move the unit with the bearing retainers removed. Do not attempt to operate the unit until it is properly bolted to its floor anchors and the bearing retainers have been removed.

Anchoring and Cabinet Leveling

Once it has been determined the floor meets the requirements for loading of the system and proper UPS to wall spacing or edge of slab spacing has been maintained, the UPS cabinets can be installed. It is suggested to start with the farthest right MMU cabinet first.

NOTE: In certain locations, the Z Series UPS systems may be installed without an input/output cabinet when connected to switchgear.

The MMS Input/Output cabinet, System cabinet, and SMS Bypass cabinet have adjustable leveling feet use to match the height of the MMU(s) or flywheel cabinet of an SMS. The leveling feet must be installed after the shipping skids are removed and before placement.

NOTE: If the input/output cabinet is to be installed, the input/output cabinet and the system cabinet must be leveled and bolted together before installing the shipping split bus bars.

Providing the proper installation height of all cabinets is required to allow proper installation of the cable wire-way above the UPS. The wire-way assembly provides the means for routing the AC input and output power cables and the control cables between the MMUs and the system cabinet. The UPS OMM manual has complete wire-way installation directions.
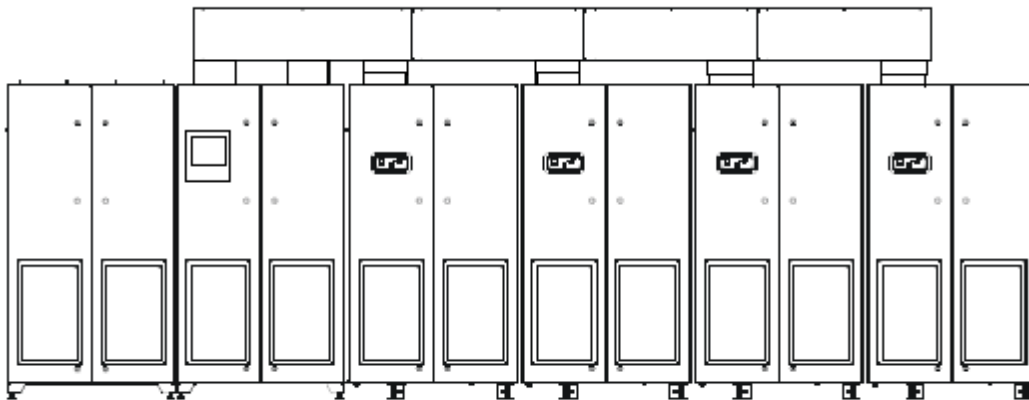
Figure 54: UPS w/ Wire-Way Installed – MMS System Shown

Any cabinet with a flywheel must be anchored to reduce any transmitted vibration. Special anchor cleats are provided.
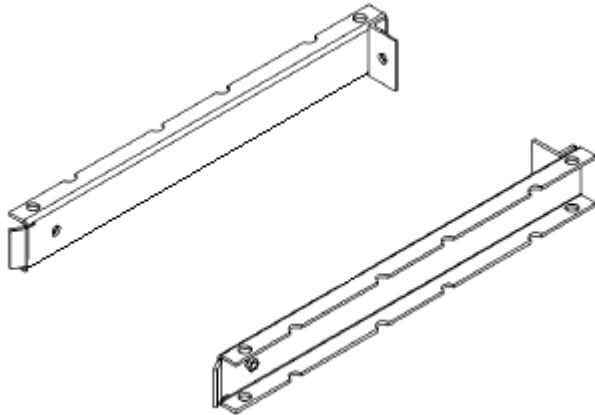
Figure 55: MMU Anchoring Cleats

The anchors must meet the following specifications:

- Anchor bolts must be 5/8 x 6 inch long (min.), Hilti Kwik Bolt II stud expansion with 4 inch minimum

- Stud expansion anchor bolts must be used in order to secure the machine properly. A stud expansion anchor bolt is recommended. There must be 101.60 mm (4 inch) of minimum embedment in the concrete. The stud expansion anchor bolts must be 15.88 mm (0.625 inch) wide. The stud expansion anchor bolts must have a minimum length of 152.40 mm (6 inch).

- The maximum shear load per the anchor must be 7650.9 N (1720 lb.).

- The maximum tensile load per the anchor is 3113.8 N (700 lb.).
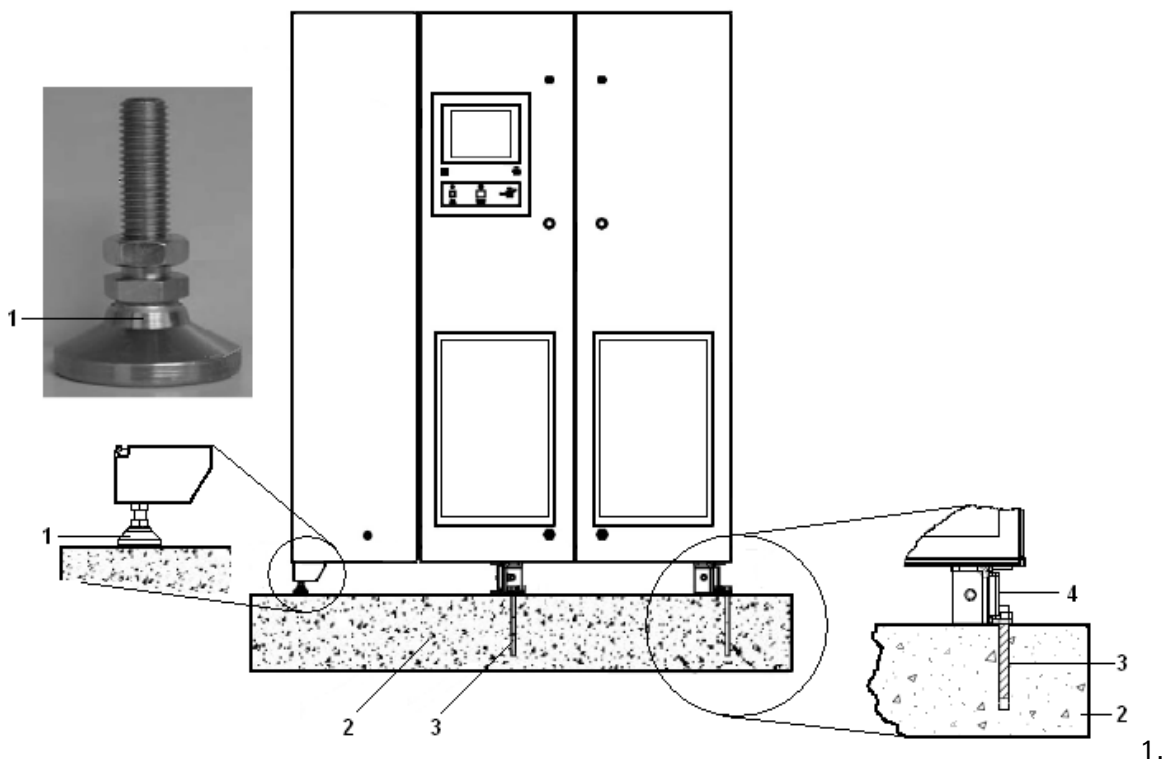
Adjustable leveling foot
2. Concrete slab
3. Anchor bolt
4. Anchor cleat

Figure 56: Anchoring and Leveling – SMS System Shown

Installation Checklist and Commissioning

An Installation Checklist is the final step in ensuring your UPS system is properly installed before startup. The checklist is available on-line and should be completed prior to commissioning. This checklist ensures you have completely installed all hardware, cables, and other equipment. Completing all items on the checklist will help provide a smooth installation and properly operating system. It is suggested a copy be made. The checklist may be requested in the future for maintenance or repair purposes.

Maintenance

Maintenance

Routine maintenance procedures are only to be carried out by qualified personnel.

WARNING: Risk of electric shock or energy hazard. Parts inside this UPS are energized by the flywheel even when the UPS is powered down.

Air Filters – Clean (All Cabinets)

The air filter should be inspected periodically and normally cleaned after 90 days of operation. Filters should be cleaned more frequently if you observe excessive dust build up, filter deflection due to blocked airflow, or high temperature warnings. Replace damaged filters.

Cable and Bus Connections – Check

Check the tightness and torque of the major power conductors once every three (3) to five (5) years. This period may vary due to local environmental conditions.

Flywheel Housings and Cabinets- Clean

The accumulation of dust on the surface of the flywheel housing and inside the cabinets can reduce heat transfer and reduce cooling. General cleanliness should be monitored and dust or contaminant buildup on system components should be removed. Routine cleaning of air filters should minimize dust buildup on these surfaces.

If the flywheel housing fins show heavy deposits of dust, the system should be de-energized and the deposits wiped off with a clean damp rag. Inspection and cleaning can be done at the same time the air filters are cleaned.

Vacuum Pump Oil – Change or Add

Vacuum pump oil can be viewed through the sight glass on the pump. The sight glass should be kept clean using a clean lint free cloth.

The Vacuum pump oil should be changed once per year or as necessary if oil appears contaminated (yellowish or brown). If storage is anticipated, or if vacuum pump shutdown is anticipated for more than 30 days, the vacuum pump oil reservoir should be drained and filled with new oil.

An oil level that is higher than the level/fill line may indicate condensation of vapor. This situation requires the oil to be changed.

A low level indicates that oil should be added to the pump.

Warning: Do not over fill the pump.

Bearing – Replacement

The bearings must be replaced periodically. The recommended interval is estimated at four (4) years. Upgrade kits are available for systems in the field with older bearings. The bearings are contained in removable cartridges. These are replaced at

the same time as the bearings. The cartridges must be accurately positioned for proper operation.

Your system notifies you with a message displayed on the control panel that the bearing change is due, or if bearing temperatures are high. Only trained personnel should perform the replacement.

MMU Controller Board Battery – Replace

The MMU controller board located on the left component panel uses a coin style NEDA/ANSI 5004LC 3.0V lithium battery with an estimated life of 5 years. When replacing the battery, replace with the same number and type as installed.

WARNINGS:

- **Do not replace battery when MMU Controller Board is energized.**

- **Do not dispose of the battery in a fire. The battery may explode.**

Applicable Standards

North American Standards

60 Hz units configured for North American voltages shall comply with the following standards:

- UL1778

- FCC Rules and Regulations 47, Part 15, Subpart J, Class A

- NEMA PE 1 – 1983

- NFPA 70 – National Electric Code

- ASI C62.41, Category A & B

- OSHA

- CSA C22.2 No. 107.1 Commercial and Industrial Power Supplies

- Industry Canada ICE-003

- Year 2000 compliance

- UL1004 Electric Motors

International Standards

50 Hz or 60 Hz units configured for international voltages shall comply with the following standards:

- EEE 587-1980/ANSI C62.41 1980, Category A & B Recommended practice on surge voltages in low power circuits

- 73/23/EEC Low Voltage Directive

- 89/336/EEC, EMC Directive

- EN50091-1-1

- Applicable parts of EN60950, as referenced in EN50091-1-1
    - EN50091-2
    - 89.336/EEC
- Applicable parts, as referenced in EN50091-2 of the following:
    - 801-2, level 3 (6KV air, 8KV contact). ESD standard
    - IEC 801-3, level 2. EMI standard
    - IEC 801-4, level 2. Transients
    - IEC 1000-2-2

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