APPLICATION AND INSTALLATION GUIDE

Uninterruptible Power Supply (UPS)

CATERPILLAR®

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Foreword

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

Engine-specific information and data are 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 engine.

I SERIES 150/300

1 Document Scope

The purpose of this document is to provide an overview of the configuration and operation of the Series 300 UPS and 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 Caterpillar 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 Cat organization and Cat 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 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.

2 Product Overview

2.1 Configurations

The Series 300 UPS is a fully integrated 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.

Depending on kVA rating, the UPS is either a Single Module System (SMS) or a Multi-Module System (MMS). The SMS UPS has one flywheel and all components are contained in the flywheel cabinet or side cabinet, as shown below.

Figure 1: Single Module System Installed

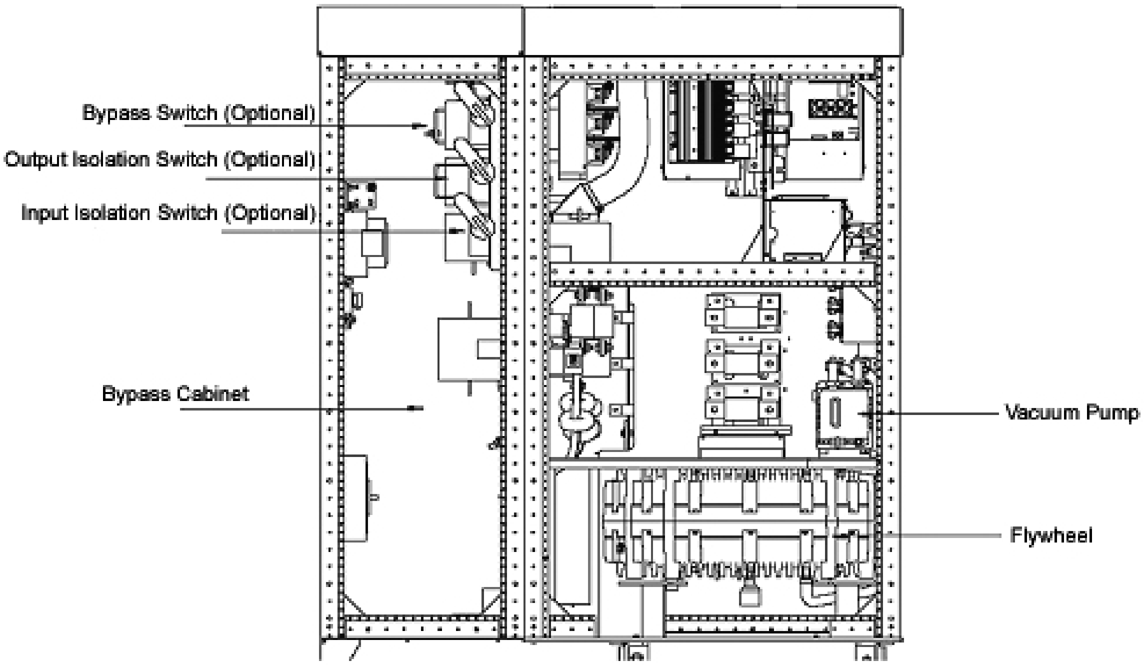


Figure 2: SMS Major Components Diagram

The MMS UPS has various numbers of cabinets depending on kVA rating, as shown in the image below of a Cat UPS 900 or 750 kVA system. Each MMS has an Input/Output (I/O) cabinet positioned on the far left, when viewed from the front. The I/O cabinet contains bus bars on which to land input, output, and bypass cables. Next in line to the right is the system cabinet. The system cabinet contains bus work, MMU isolation switches, and controls which enable multiple MMUs to function as a single UPS. Finally, the three MMU cabinets are shown to the far right. The MMU cabinets contain the flywheel, vacuum pump, line inductor, filter inductor, power electronics, and other items necessary for MMU operation. For a more in-depth overview of the systems refer to the Series 300 Overview document.

Figure 3: Multi-Module System Installed

Model	kVA Rating	kW Rating	I/O Cabinet	System Cabinet	MMU Cabinet
250iE	250	200	1	1	1
250iE N+1	250	200	1	1	2
300E	300	240	1	1	1
300E N+1	300	240	1	1	2
500i	500	400	1	1	2
500i N+1	500	400	1	1	3
600	600	480	1	1	2
600 N+1	600	480	1	1	3
750i	750	600	1	1	3
750i N+1	750	600	1	1	4
900	900	720	1	1	3
900 N+1	900	720	1	1	4

Figure 4: Table of MMS kVA and kW Ratings, and Configuration

Cat UPS 480V 60 Hz					
MODEL	**UPS 150**	**UPS 300**	**UPS 300 Exp**	**UPS 600**	**UPS 900**
RATING	150 kVA (120 kW)	300 kVA (240 kW)	300 kVA (240 kW)	600 kVA (480 kW)	900 kVA (720 kW)

PHYSICAL DATA				
Depth	34.0 in (865 mm)	34.0 in (865 mm)	34.0 in (865 mm)	34.0 in (865 mm)
Width(1)	58.6 in (1) (1488 mm)	127 in (3226 mm)	170 in (4318 mm)	213 in (5410 mm)
Total height	78 in (1980 mm)	96 in (2438 mm)	96 in (2438 mm)	96 in (2438 mm)
Weight(1)	4,585 lb (2080 kg)	7,050 lb (3199 kg)	11,550 lb (5241 kg)	16,050 lb (7282 kg)

Figure 5: SMS & MMS Dimensions and Weights

(1) Dimensions for 3-Wire systems given, 4-Wire systems add 6" (153 mm) to width and 250 lb (113 kg) to weight.

2.1.1 3-Wire Systems

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 UPS 300 module configurations are shown in the following block diagram. This diagram is simplified and not intended to replace product schematics. MMS would be very similar but with additional power electronics, line static switches, inductors and other items common to the flywheel cabinet. However it will only have one bypass static switch and optional maintenance bypass (MBP) switch.

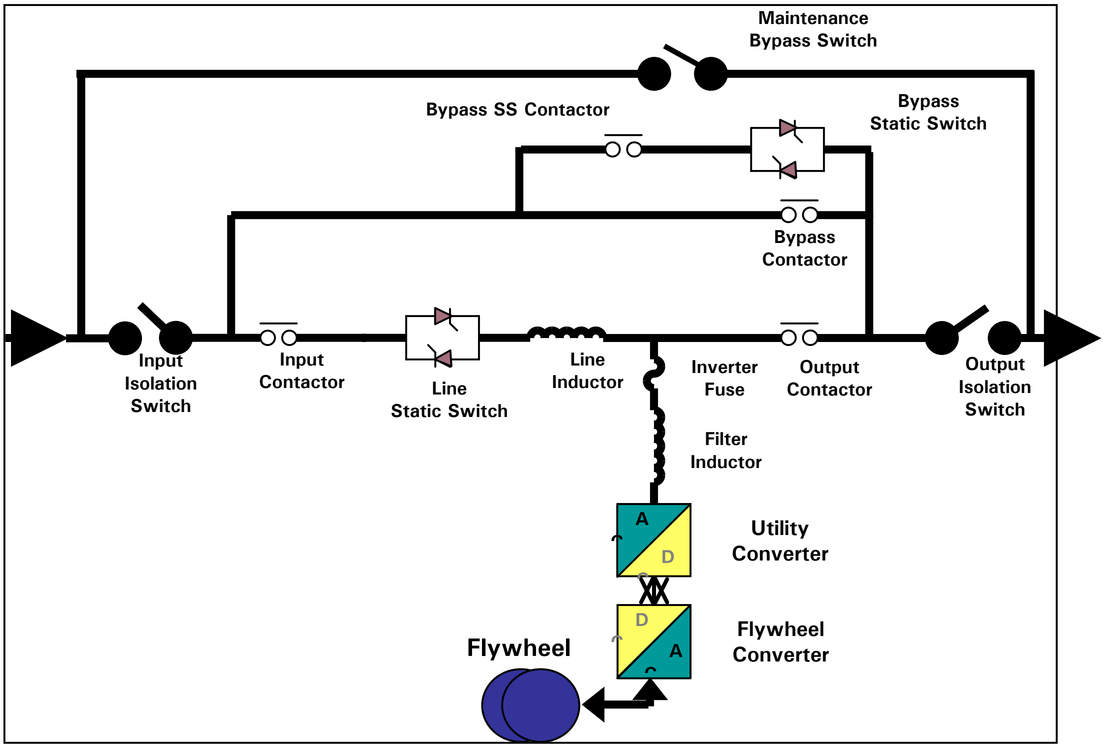


Figure 6: UPS 300 SMS 3-Wire, Maintenance Bypass Optional

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

- Input Isolation Switch – Side Cabinet (MMS – I/O Cabinet)
- Bypass Contactor (K4) – Side Cabinet (MMS – System Cabinet)
- Bypass Static Switch – Side Cabinet (MMS – System Cabinet)
- Bypass Static Switch (SS) Contactor – Side Cabinet (MMS – System Cabinet)
- Input Contactor (K1) – Flywheel Cabinet (MMS – MMU Cabinet)
- Line Static Switch – Flywheel Cabinet (MMS – MMU Cabinet)
- Line Inductor – Flywheel Cabinet (MMS – MMU Cabinet)
- Inverter Fuse – Flywheel Cabinet (MMS – MMU Cabinet)
- Filter Inductors – Flywheel Cabinet (MMS – MMU Cabinet)
- Utility Inverter – Flywheel Cabinet (MMS – MMU Cabinet)
- Flywheel Converter – Flywheel Cabinet (MMS – MMU Cabinet)
- Flywheel – Flywheel Cabinet (MMS – MMU Cabinet)
- Output Contactor (K2) – Flywheel Cabinet (MMS – MMU Cabinet)

- Optional Output Isolation Switch – Side Cabinet (MMS – I/O Cabinet)
- Optional Maintenance Bypass Switch – Side Cabinet (MMS – I/O Cabinet)

Maintenance Bypass Options include:

1. SMS MBP – 3W 3-pole
2. SMS MBP – 4W 4-pole
3. MMS Dual Input No MBP
4. MMS Dual Input 2 Breaker MBP
5. MMS Dual Input 3 Breaker MBP
6. MMS Single Input 3 Breaker MBP

The supply to the UPS must be from a grounded wye source even though the Series 300 UPS does not require a neutral.

2.1.2 4-Wire Systems

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 following block 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. This diagram is simplified and not intended to replace product schematics.

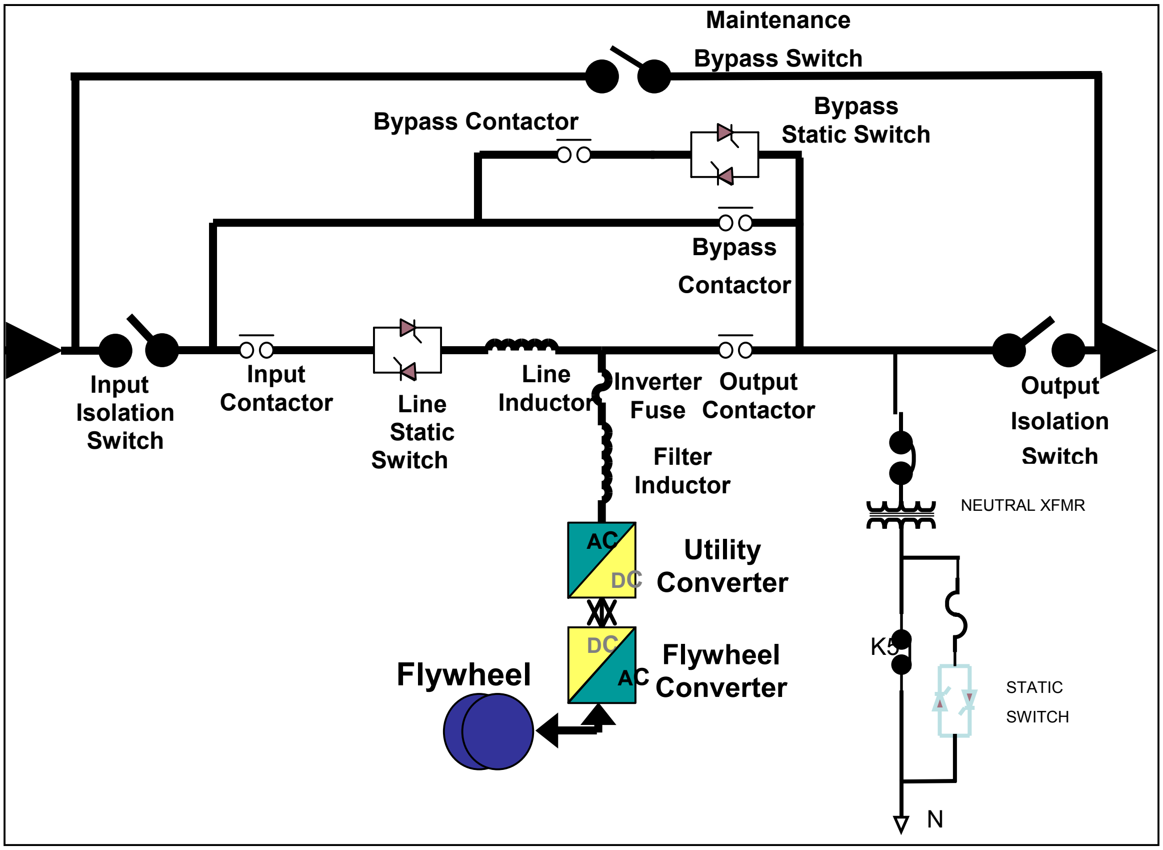


Figure 7: 4-Wire System Diagram, Maintenance Bypass Optional

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

Input Isolation Switch – Side Cabinet

- Bypass Contactor (K4) – Side Cabinet (MMS – System Cabinet)
- Bypass Static Switch – Side Cabinet (MMS – System Cabinet)
- Bypass Static Switch (SS) Contactor – Side Cabinet (MMS – System Cabinet)
- Input Contactor (K1) – Flywheel Cabinet (MMS – Individual MMU Cabinets)
- Line Static Switch – Flywheel Cabinet (MMS – Individual MMU Cabinets)
- Line Inductor – Flywheel Cabinet (MMS – Individual MMU Cabinets)
- Inverter Fuse – Flywheel Cabinet (MMS – Individual MMU Cabinets)
- Filter Inductors – Flywheel Cabinet (MMS – Individual MMU Cabinets)

- Utility Inverter – Flywheel Cabinet (MMS – Individual MMU Cabinets)
- Flywheel Converter – Flywheel Cabinet (MMS – Individual MMU Cabinets)
- Flywheel – Flywheel Cabinet (MMS – Individual MMU Cabinets)
- Output Contactor (K2) – Flywheel Cabinet (MMS – Individual MMU Cabinets)
- Ziz-Zag Neutral Breaker– Side Cabinet (MMS – System Cabinet)
- Ziz-Zag Neutral Transformer– Side Cabinet (MMS – System Cabinet)
- Neutral Contactor (K5) – Side Cabinet (MMS – System Cabinet)
- Neutral Fuse– Side Cabinet (MMS – System Cabinet)
- Neutral Static Switch – Side Cabinet (MMS – System Cabinet)
- Optional Output Isolation Switch – Side Cabinet (MMS – I/O Cabinet)
- Optional Maintenance Bypass Switch – Side Cabinet (MMS – I/O Cabinet)

Maintenance Bypass Options include:

1. SMS MBP-4W 4-pole
2. MMS Dual Input No MBP, 3-pole device
3. MMS Dual Input 2 Breaker MBP, 3-pole device
4. MMS Dual Input 3 Breaker MBP, 3-pole device
5. MMS Single Input 3 Breaker MBP, 3-pole device

Become familiar with these components, their designations, and their system locations. The system records and displays messages that refer to these components and their operating states.

2.1.3 Operation

The UPS automatically supplies AC electrical power to the critical load during certain 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. 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.

2.1.4 Overview Operating Modes

The main operating modes are:

- Online Mode
- Bypass Mode
- Automatic Voltage Regulation (AVR) Mode
- Shutdown Mode

The operator can command the system to enter the online or bypass modes via the User Interface. When an operator presses the EPO button on the front of the cabinet, the system enters the Shutdown mode. The operator cannot directly place the system into the AVR mode. AVR is a special operating mode to which the system transitions only under certain conditions. If the system is in the Online Mode, it may automatically transition to the Bypass, Shutdown, or AVR modes depending on internal and external UPS system conditions.

2.1.5 Online Mode with 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. When online, output voltage is being regulated in steady state to within +/-2% of its nominal set point. Online Mode has three major states. The first two occur when input power is present and are the following:

Online Charging – The system enters this state when the flywheel reaches 4000 RPM. The system is charging in this state. The system can sustain discharge in this state.

Online Standby – When the speed of the flywheel reaches full charge speed, 7700 RPM, the system is in the Online Standby state.

The following diagram shows the current flows in these Online Mode states:

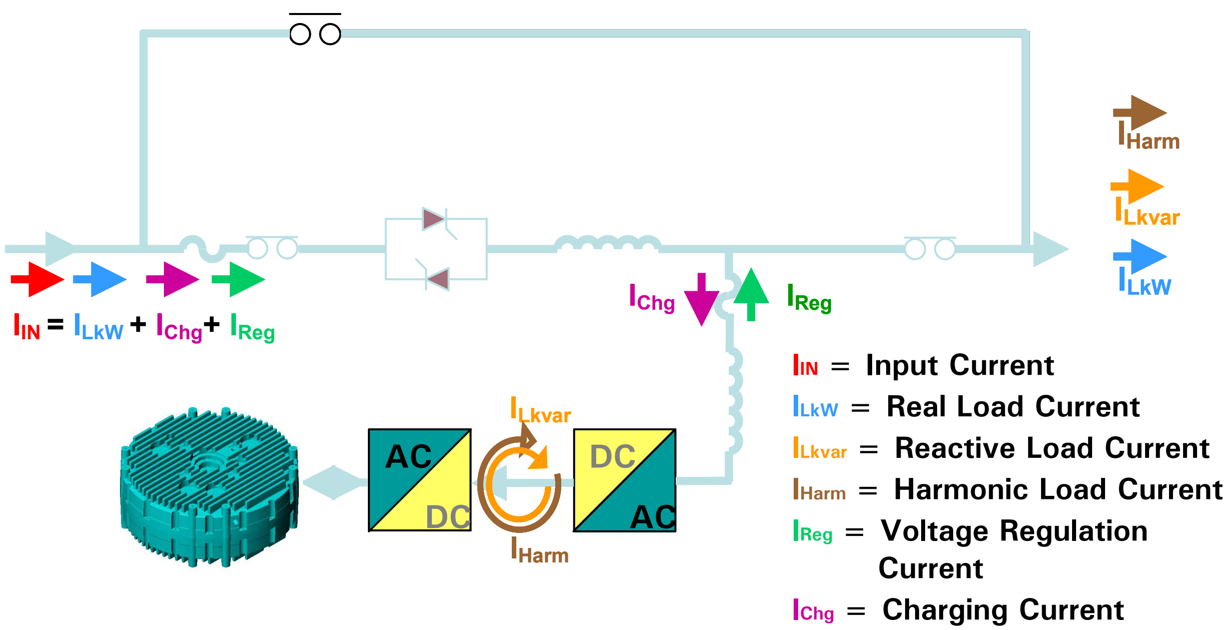


Figure 8: Online Mode with Input Power Present

In the online standby state, the current I_{Lkw} to provide kilowatts for the load flows from the input to the load. No energy is taken from the flywheel. The Utility Converter regulates output voltage by exchanging reactive regulating current, I_{Reg}, with the input through the line inductor. A small amount of charging current, I_{Chg}, flows into the flywheels to maintain them at full speed. The reactive and harmonic currents, I_{Lkva} and I_{Harm}, are provided to the load by the utility converter, not by the input power source to the UPS. 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.

In 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 is the system capable of supporting the load. The energy available is dependent on the RPM at the time it enters discharge.

2.1.6 Online Discharging Mode

The UPS system automatically enters this state when it is in Online Mode and input power to the UPS is disrupted. The UPS disconnects from the failed input power source and supplies all of the current, including the real current, I_{Lkw}, which supplies kilowatts to the load. A discharge is triggered by the input voltage or frequency deviating outside of the tolerance limits set for the UPS. These limits are adjustable. There are separate tolerance limits for fast input voltage deviation detection and RMS voltage deviation detection. A discharge will also be triggered if the DC bus voltage of the UPS drops below a preset limit, indicating that power is not being delivered to the UPS from the input source.

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 flywheels gradually slow down as they deliver power, but the output voltage of the UPS remains the same. When input power returns, 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. The ramp rate is adjustable in kW per second.

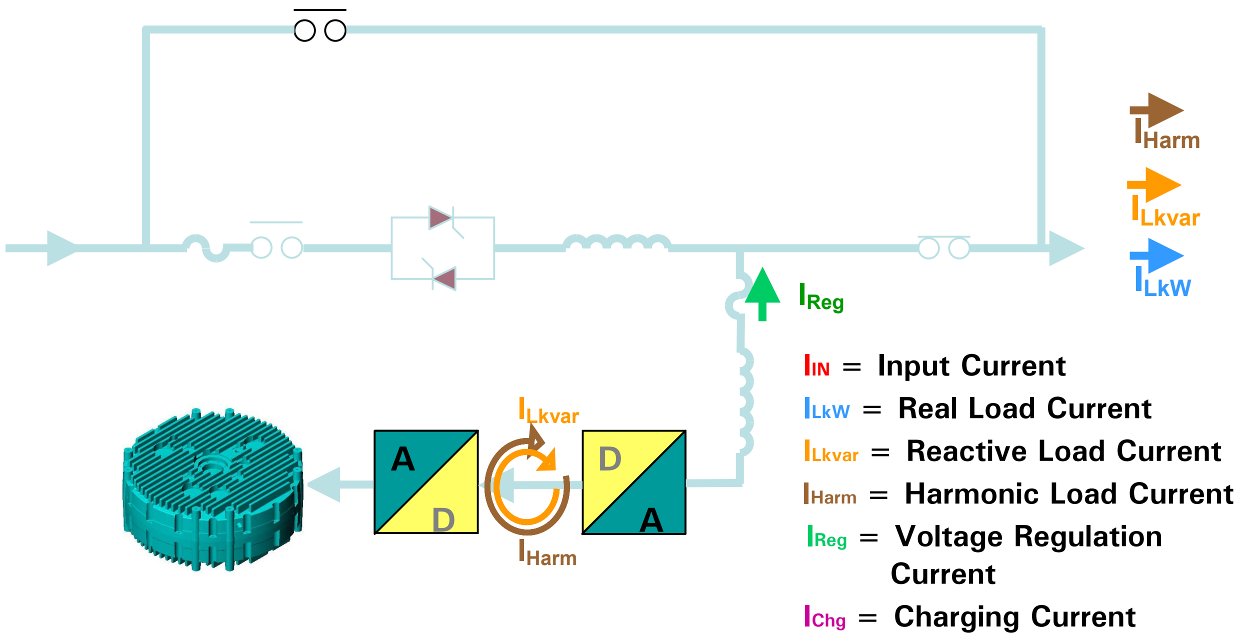


Figure 9: Online Discharging Mode

2.1.7 Automatic Voltage Regulation (AVR) Mode

The UPS will enter AVR mode if the UPS is operating from input power and there is insufficient flywheel energy available to support the load. In this mode the UPS is regulating and conditioning output power as it does in Online Mode, but it will not be able to support the load if the input source fails. The system will enter AVR mode automatically if the UPS has transferred to bypass during an exhaustive discharge (i.e. the input power was present but the UPS ran out of flywheel energy before walk-in was completed). As soon as the UPS restarts, the load will be transferred from bypass but it will not discharge until the flywheels' RPM exceed 4000 RPM. At that point, the unit returns to Online Charging mode.

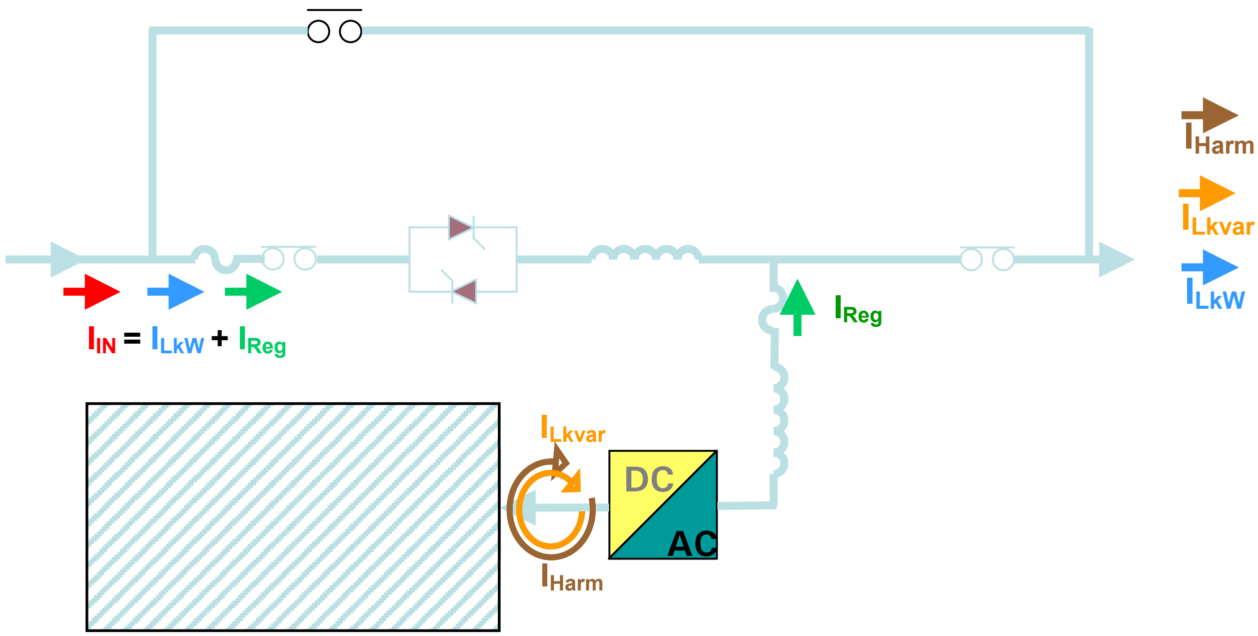


Figure 10: AVR Mode, Flywheel Energy Not Available

2.1.8 Bypass Mode

Bypass Mode directly connects the incoming utility power to the load through the Static Bypass, bypassing the UPS system. The next figure shows system power flow when in bypass mode. The load is **not protected** when the system is in Bypass Mode and will be affected by a disruption of the incoming power.

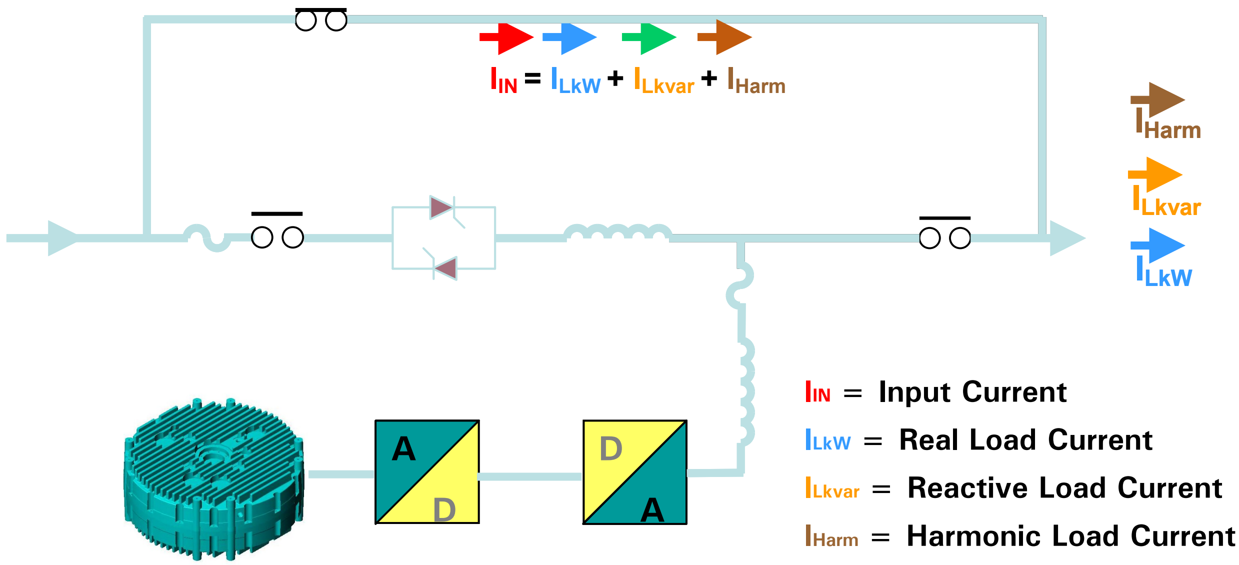


Figure 11: Bypass Mode

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

- System start-up
- Operator command via User Interface or monitoring software
- Output overload
- Failure to recover from a fault

Repeated errors causing the system to switch between Bypass and Online Modes can lock the system in Bypass Mode. When the system is locked in Bypass Mode, the operator must intervene to bring the system back online. This is done either via the user interface or the monitoring software.

2.1.8.1 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
- During error recovery

2.1.8.2 Bypassed-Auto Start

This is the default state at start-up. The system cannot immediately protect the load after the system is started. During normal operation, the system will enter Automatic Voltage Regulation (“AVR”) mode.

2.1.9 Shutdown Mode – EPO

When the system is in the Shutdown mode such as 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 any 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 (if installed).
- There are internal or external conditions that could lead to system failure.

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 system cabinet and each MMU cabinet, for MMS, that needs to be moved to the “I” position. The SMS reset switch is in the flywheel cabinet.

3 Input

3.1 Input Currents and kW

The Series 300 is a line-interactive UPS. That means that the input current, kW and power factor vary not only with changes in the amount of load on the UPS but also as a function of input voltage. The more the input voltage varies from nominal the more reactive current is required to regulate the output voltage. This regulating current is the I_{Reg} current shown in following figure.

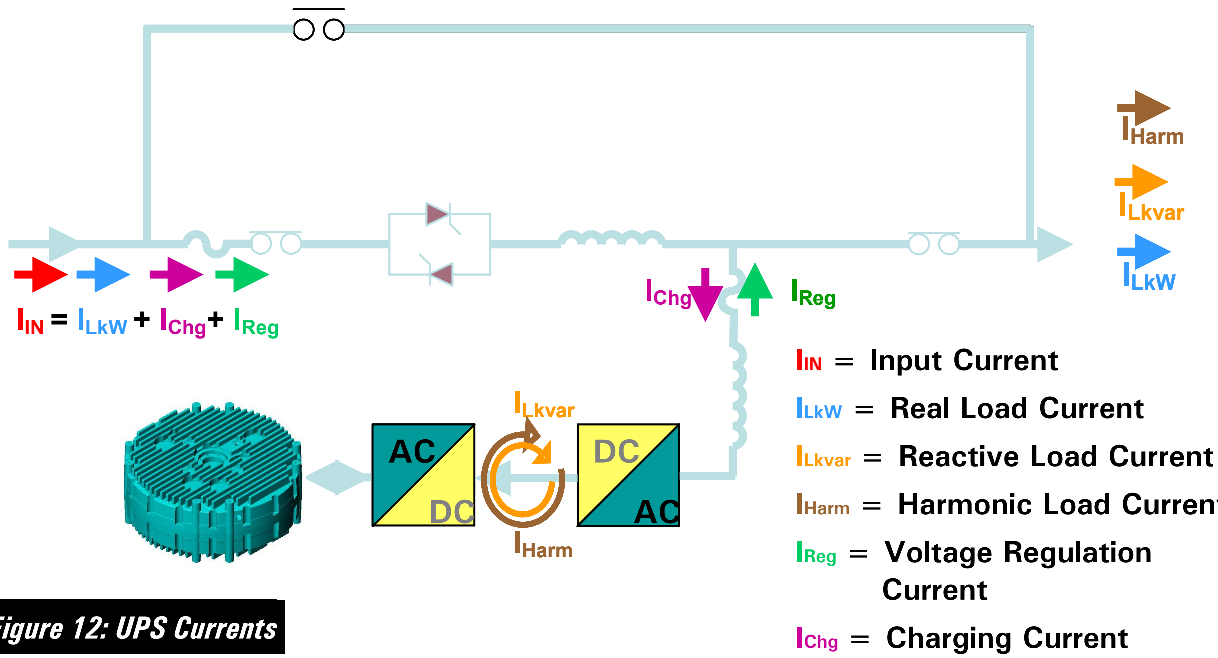


Figure 12: UPS Currents

UPS modules are constant power (kW) Loads. That means as input voltage falls for a given load on the UPS, the real input current to the UPS I_{LkW} rises because the UPS must deliver the same kW to its load. Actually, the UPS input kW actually rises as input voltage deviates from nominal because the utility converter in the UPS has to work harder to produce the additional voltage regulating current I_{Reg} which reduces UPS efficiency.

Calculating input currents is not easy to do. Real, reactive and harmonic currents must all be treated as vectors pointing in different directions. Except in very unusual cases, load harmonic currents do not significantly affect the amount of UPS input current.

Input voltage tolerance limits are programmable in the field by service personnel. The maximum settings are +10%/-15%. Factory default settings are at +10%/-10%, which is the input voltage range for maintaining specified output voltage regulation **at full load.** At lesser load levels, regulation is maintained over a wider input voltage range but the UPS will discharge and disconnect from the input source if the input voltage deviates beyond the input voltage tolerance window that has been programmed, even if the UPS could have maintained regulation over a wider voltage range.

3.1.1 Input Current Limits

The RMS input current to the UPS is limited by the firmware. The factory default setting is the maximum setting. Lower limits are field-programmable. However, reducing the input current limit will reduce some or all of the following: maximum load the UPS can support, amount of voltage regulation the UPS can provide, available recharge current available (which lengthens the recharge time). When the UPS reaches input current limit during operation, it will first reduce any recharge current until the recharge current reaches the minimum allowable value. If further restriction is required, the UPS will then start to reduce the amount of voltage regulation that it provides, and finally, if the current limit has been set so low that the UPS cannot support the load, the UPS will go to bypass. **Depending on load power factor, and input voltage at a particular moment in time, the load may actually draw higher current (but not kW) from the source than the UPS.**

The factory default (Maximum) input current limits are the following:

Product	Factory Setting for Maximum Current (amps)
CSUPS 150 kVA	240
CSUPS 300 kVA	440
CSUPS 300E kVA	440
CSUPS 600 kVA	880
CSUPS 900 kVA	1320
CSUPS 120i kVA	290
CSUPS 250i kVA	440
CSUPS 250iE kVA	440
CSUPS 500i kVA	880
CSUPS 750i kVA	1320

Figure 13: Input Current Limits, Factory Default Setting

3.1.2 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.

3.1.3 Input Power Factor

Input harmonic currents to the UPS are normally low. Therefore input power factor is determined by displacement power factor, the cosine of the angle between input voltage and current. 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 input power factor however, will not always be the same for a given voltage difference (except at nominal where the difference is zero) because the power factor depends on the reactive current and the real current (kW). Therefore, power factors swing over a wider range at light loads than they do at heavy loads even though the amount of reactive current stays the same.

$$\text{P.F.} = \frac{\text{kW}}{(\text{amps} \times 1.73 \times \text{nominal volts} \times \text{voltage }\%)}$$

Please note that **you cannot determine the correct input voltage of the UPS for the purposes of this calculation by reading the UPS input voltage with the UPS online**. See the section on voltage regulation for details.

3.1.4 Input Current Harmonics

The input current harmonics reflected into the input supply by the UPS are low. With a linear load input current harmonic content is less than 3%. 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 and are shown as I_{Harm} on the current path diagrams. 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).

3.1.5 Utility Sources

In general, utility sources should be sized by professional engineers who are aware of all of 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.

3.1.6 Voltage

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 Series 300 UPS does not require a neutral. See the section on grounding for more detail.

3.1.7 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.

3.1.8 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.

3.2 Supply Breaker Sizing

Below is a table that lists each UPS power and current ratings.

Product	Voltage/ Freq	Power Level (kVA/kW)	Nominal Current (amps)	Maximum Continuous Current (amps)	Maximum Current Including Non-Continuous (amps)
Cat UPS 150 kVA	480/60	150/120	151	200	240
Cat UPS 300 kVA	480/60	300/240	297	400	440
Cat UPS 300E kVA	480/60	300/240	297	400	440
Cat UPS 600 kVA	480/60	600/480	595	800	880
Cat UPS 900 kVA	480/60	900/720	892	1200	1320
Cat UPS 120i kVA	400/50	120/120	180	230	290
Cat UPS 250i kVA	400/50	250/200	299	400	440
Cat UPS 250iE kVA	400/50	250/200	299	400	440
Cat UPS 500i kVA	400/50	500/400	599	800	880
Cat UPS 750i kVA	400/50	750/600	899	1200	1320

Figure 14: Cat UPS Current Specifications

In the following table, Table 15, are listed suggested recommended breaker sizes. The sizes are general suggestions which cannot take into account all situations and applications. 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.

Product	Voltage/Freq	Typical Breaker Sizes (amps)
CSUPS 150 kVA	480/60	300
CSUPS 300 kVA	480/60	500
CSUPS 300E kVA	480/60	500
CSUPS 600 kVA	480/60	1000
CSUPS 900 kVA	480/60	1600
CSUPS 120i kVA	400/50	350
CSUPS 250i kVA	400/50	500
CSUPS 250iE kVA	400/50	500
CSUPS 500i kVA	400/50	1000
CSUPS 750i kVA	400/50	1600

Figure 15: Cat UPS Suggested 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 297 amps to the load. If that load transfers to bypass at 10% low voltage, the bypass current to this load will be 1600 amps, not the 1445 amps that it draws at nominal voltage. You cannot assume that because the UPS breaker is rated 1600 amps that any 1600 amp breaker installed under any conditions can provide the same current carrying capability.

3.2.1 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 for the Series 300 UPS.

3.2.2 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.

3.3 Diesel Generator Set Power Sources

The Cat series 300 is designed to work with diesel generator sets. **Consult the factory before using with natural gas generator sets.**

3.3.1 General Requirements

Generator sets used with Cat UPS 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.

3.3.2 Sizing

The general rule is that the generator should have **1 kW of available capacity for every kVA of rated UPS capacity**. Note that this is based on rated UPS capacity, not the actual load on the UPS. For example, a 750 kW generator set is the minimum generator set size that should be used with a 750 kVA UPS when no other loads will be supplied by that generator set. This sizing provides sufficient generator capacity to supply the load, UPS losses and UPS recharging power.

When encountering situations in which the maximum capacity that a group of UPS modules must support will **always** be significantly less than the total rated capacity of the modules, use the input current and power. With the maximum number of UPS operating, calculate the input current and kW for each of the UPS modules, including recharge, with the entire critical power system operating at design capacity. Add the currents and kW that each UPS will draw in redundant operation.

When operating on generator set, it is not realistic to assume the input voltage will always remain at nominal. It is also not realistic in most circumstances to assume that the generator set voltage will vary over a +10%/-15% voltage window. Under normal conditions it is assumed that the input voltage when operating on generator set will stay within the range of 95% – 105% of nominal. Add the maximum currents and kW of the UPS modules that you derive using these limits to determine the generator set capacity. Note that when operating on generator set it is possible to supply a contact closure to the UPS to limit the charging power to any value between the minimum and maximum values. Charging power cannot be set to zero or any value lower than the minimum. See the On Generator signal section below for more information on this feature. It is usually acceptable to reduce charging to the minimum level when operating on generator set provided the system is constrained to remain on generator set power and not retransfer in less than 7 minutes.

3.3.3 On Generator Signal

One of the programmable input contacts of the UPS (See OMM manual for information about these contacts) 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. The factory settings are chosen to be appropriate for most generator sets sized using the general rule stated above.

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.

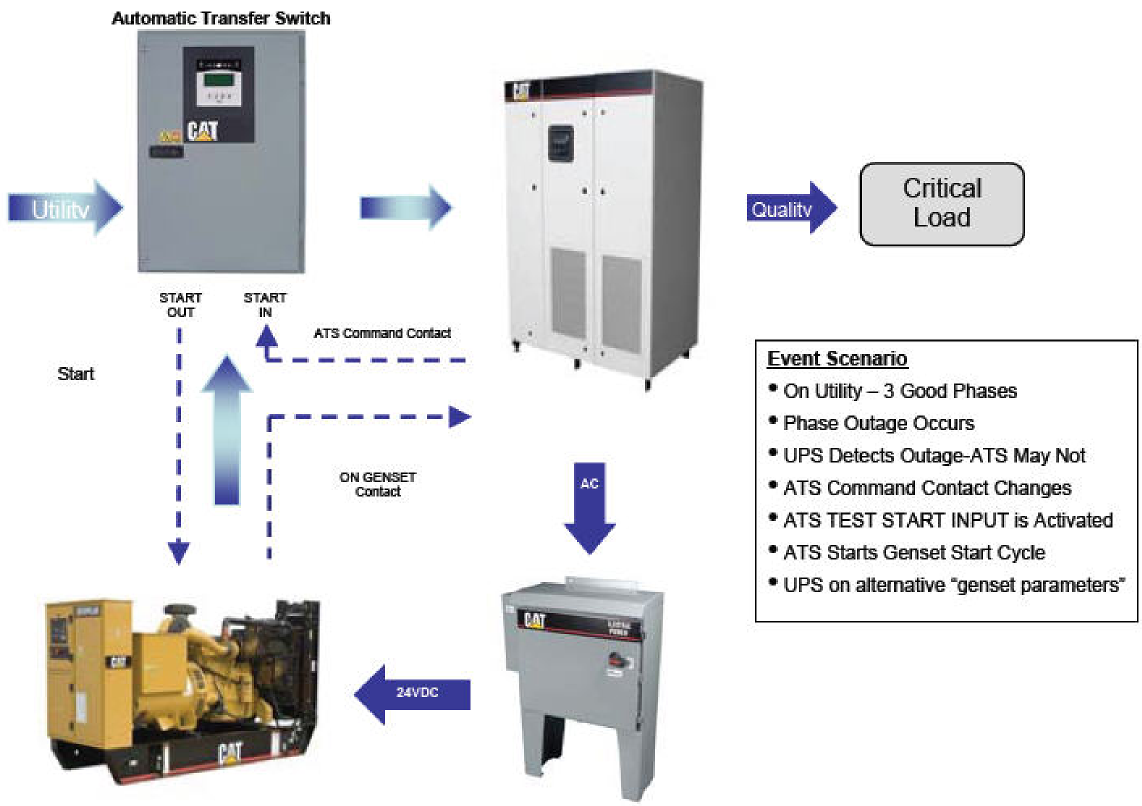


Figure 16: Suggested CPS Communication Links

3.3.4 Continuous Power Sequence

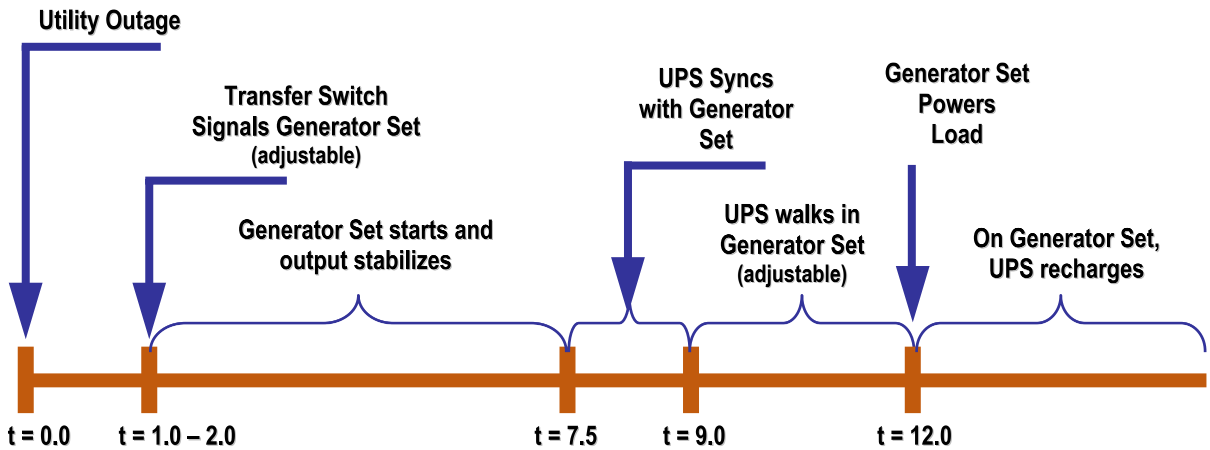


Figure 17: Continuous Power Sequence

A typical continuous power sequence for a power outage and UPS ride-through to generator set power is shown above for a UPS 300 series. The UPS supplies power to the load during the time needed to start the generator set and allow the UPS to ramp up its input current (walk-in) on generator set power. Since the UPS flywheel is only supplying about half 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 generator set. UPS 250iE and larger can be equipped with an additional MMU to provide extra time, the N+1 configuration.

3.3.5 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 gen 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. See the On Generator Signal section above for more information about alternate operating parameters that can be put into effect when operating from a generator set (or other alternate power source).

4 UPS 300 on Generator Set - Setpoints

Operating and Default Parameter								
v 1.3	**UPS Operating Parameters Name**	**Lower Limit**	**Upper Limit**	**60 Hz Default**	**50 Hz Default**	**Modify from GUI**	**Password Level**	**Definitions**
42	Frequency Slew Rate	0.05	3	1	1	No	Service	This controls the speed in which the UPS output voltage will be brought in-phase (phase match) with the input to begin the process of ending a discharge.
50	Min DC Bus Charg. Curr.	0	150	100	100	Yes	Service	Sets the minimum DC bus current that all of the CSHVs will be allowed to use for motoring the flywheels.
61	GS Max Input Current	10	1720	1600	1720	Yes	Service	Sets the **Maximum Input current** while the On Generator signal from a **remote input** is high (closed). This could be used with **GS Max. Mtr In Current** to prevent a generator overload when the generator rating smaller than the UPS. A successful installation involving an undersized generator requires the transient response of the generator to be very good.
62	GS Max Charging In Curr.	10	1720	1600	1720	Yes	Service	Sets the **Max. Mtring In Curr.** while the On Generator signal from a **remote input** is high.
63	GS Max DC Bus Charg Curr	0	1000	200	200	Yes	Service	Sets the **Max. DC Bus Charg. Curr.** while the On Generator signal from a **remote input** is high.
64	GS Transient VAC Tol.	0	50	25	25	Yes	Service	Sets the **Transient VAC Tolerance** while the On Generator signal from a **remote input** is high (closed).
65	GS Walk-in Rate	40	1000	350	350	Yes	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.
66	GS Over Frequency Trip	50	66	62	51.5	No	Service	Sets the **Over Frequency Trip** while the On Generator signal from a **remote input** is high.
67	GS Under Frequency Trip	45	60	58	48.5	No	Service	Sets the **Under Frequency Trip** while the On Generator signal from a **remote input** is high.
68	GS Discharge Volt Match	0	1	1	1	No	Service	When the UPS is ready to start a walk-in from a discharge and the On Generator signal from a **remote input** is high, it will match the input and output voltages before closing the main static switch. If this parameter is set to 0 it will not. Instead it will maintain the **Nominal Voltage** setpoint throughout the walk-in.

5 Output

5.1 Rating

The output ratings of the 300 Series UPS units are as follows:

Cat UPS 480V 60 Hz					
MODEL	UPS 150	UPS 300	UPS 300 Exp	UPS 600	UPS 900
RATING	150 kVA (120 kW)	300 kVA (240 kW)	300 kVA (240 kW)	600 kVA (480 kW)	900 kVA (720 kW)
OUTPUT					
Frequency	Input synchronized (normal operation), +/-0.2% free running				
Current – nominal amps	181	361	361	722	1084
Voltage – nominal	480 VAC 3-phase, 3-wire plus ground (4-wire with optional 4-wire input)*				
Voltage regulation					
Steady state	+/-2% for +/-10% input and balanced or unbalanced loads				
Flywheel mode	+/-2% for steady-state balanced or unbalanced loads				
Transient	+/-5% for 100% load step				
Voltage distortion	<3% linear loads and <5% for 100% non-linear loads				

Figure 18: Output Ratings 480-VAC Systems

Cat UPS 380V/400V/415V 50 Hz					
MODEL	UPS 120i	UPS 250i	UPS 250i Exp	UPS 500i	UPS 750i
RATING	120 kVA (120 kW)	250 kVA (200 kW)	250 kVA (200 kW)	500 kVA (400 kW)	750 kVA (600 kW)
OUTPUT					
Frequency	Input synchronized (normal operation) nominal +/-0.2% free running				
Current	183/173/167	380/361/348	380/361/348	761/723/696	1140/1084/1044
Voltage – nominal	Same as input				
Voltage regulation					
Steady state	+/-2% for +/-10% input and balanced or unbalanced loads				
Flywheel mode	+/-2% for steady state balanced or unbalanced loads				
Transient	+/-5% for 100% load step				
Voltage distortion	<3% linear loads and <5% for 100% non-linear loads				

Figure 19: Output Ratings 400-VAC Systems

The ratings of the UPS vary as you move away from these rating points. In many cases that only means the UPS will not be able to meet all of its specifications, voltage regulation, in particular if you try to operate at rated load (either kVA or kW) with loads with significantly different power factor.

5.1.1 Overloads in Bypass

The following capabilities are during normal operation with a static bypass. Configuration design should not be designed with intentional overload scenarios without factory notification accompanied with proper documentation and explanation of the loads.

Up to 125%	10 minutes
Up to 150%	2 minutes
Up to 200%	30 seconds

Note: If three overloads are seen in one hour, the UPS will lock itself into bypass.

6 Bypass

The bypass circuit powers the critical load for one of the following reasons:

- When maintenance is required
- When the Cat UPS cannot maintain voltage to the load due to sustained overload or malfunction

The bypass circuit also provides a path for power directly from an alternate AC (bypass) source.
The UPS control system constantly monitors the availability of the system bypass circuit to perform a transfer. The UPS output contactor isolates the Cat UPS module outputs. The system bypass circuit breaker works in parallel with the optional static bypass switch.
The static bypass switch is a solid-state device that can instantaneously connect the alternate AC source to the load.

7 Efficiency and Heat Rejection

7.1 Nominal Values

The nominal heat rejection values have been obtained through testing with the values rounded up for a conservative number.

Nominal Heat Rejection	
Model	**BTU**
120i	14,000
150	18,300
250	25,000
300	25,300
500	50,900
600	50,600
750	76,400
900	75,900

Figure 20: Nominal Heat Rejection Table, BTU

7.2 Worst Case Values

The worst case heat rejection values were obtained with testing and by making certain assumptions. These numbers are considered very conservative. The number presented would represent multiple full discharge and charge cycles until overheat. So in fact, this is worst case and should be used for design considerations, although it is unlikely to occur in real-world applications.

Worst Case Heat Rejection	
Model	**BTU**
120i	19,000
150	23,300
250	48,200
300	52,200
500	96,400
600	104,500
750	144,600
900	156,700

Figure 21: Worst Case Heat Rejection Table, BTU

8 Installation

8.1 Anchoring

The UPS must be anchored to a concrete slab that is fully cured. The slab should be poured with a minimum of 3000 psi concrete. Existing slabs should be free from cracks and seams in the vicinity of the installation. Refer to the figures in the section for Anchoring in order to determine the requirements for the positioning of the slab.

The following tools and equipment are required for MMU and SMS:

1. Transport system forklift or pallet jack 3.0 ton capacity (forks less than 24" wide)
2. 1/2" drive socket wrench
3. 3/4" socket, ½" drive
4. 36" extension bar, 1/2" drive
5. 15/16" open end wrench
6. Anchor bolts (4 ea.)

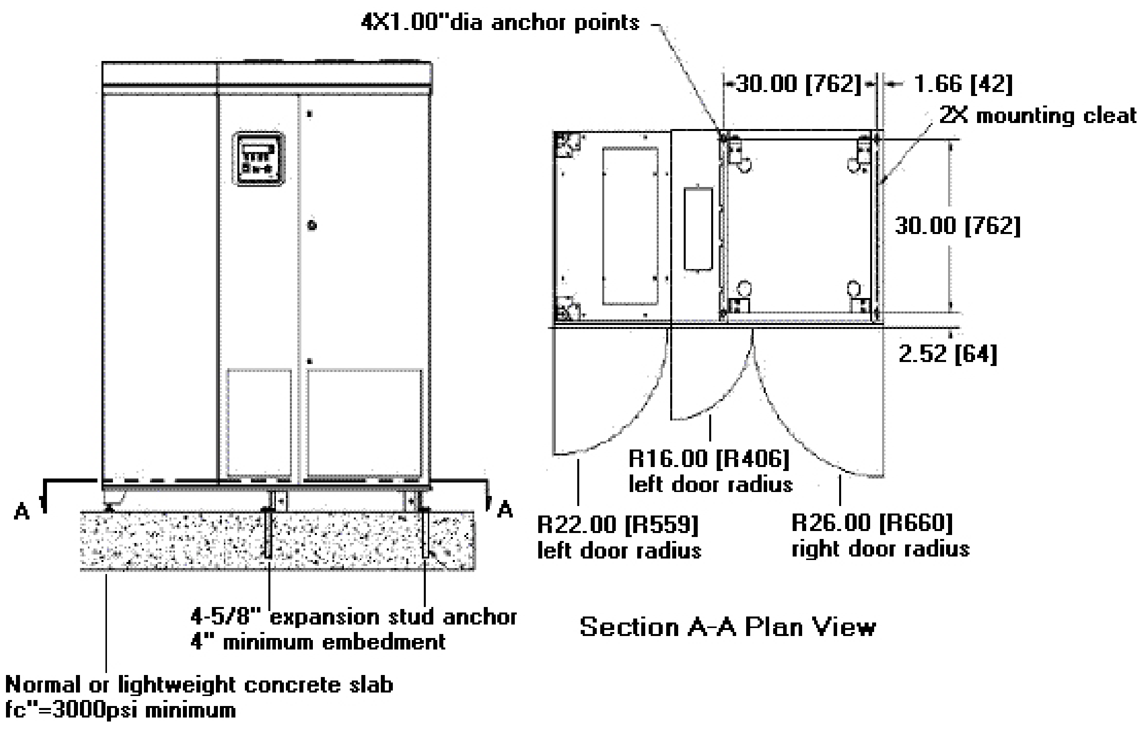


Figure 22: Anchoring Specifications

Install the anchors in accordance with the manufacturer's specifications. The anchors must meet the following specifications:

1. 5/8 X 6 inch length (min.) expansion stud with 4 inch minimum embedment anchor bolts must be used for the proper interface to the frame.
2. The shear load capacity per anchor must be 7650.9 N (1720 lb.).
3. The tensile load capacity per anchor is 3113.8 N (700 lb.).

When the thickness of the slab or the strength of the concrete is unknown consult "Section 1923 of the Uniform Building Code" or contact Caterpillar Inc. Customer Service.

CAUTION

The flywheel is shipped with bearing retainers installed to relieve the bearing of transient forces that may be encountered during shipping and handling. Do not attempt to remove the retainers or operate the unit until it is properly bolted to its floor anchors. The bearing retainers are to be removed only by Caterpillar Inc. certified personnel during the final inspection and before initial pre-startup.

8.2 Ventilation

Operation in a small, enclosed space, such as a Power Module, is possible if a minimum unobstructed airflow of 1800 CFM per MMU (power stage) plus 900 CFM per System Cabinet and 900 CFM per Input/Output cabinet is provided. The maximum tolerable backpressure is estimated to be 0.05" of H_2O. All units (single and multi module) are designed for installation in locations with 8 ft. (2438 mm) minimum ceiling height. The standard requirement for ceiling distance from the top of the cabinet is 24 inches. If this is not possible 18 inches is allowable if at least 6 inches of clearance is available on the rear and sides of the system. If the proper clearances are not given, it is possible for the system to run hot and may cause premature failures.

9 Grounding

9.1 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.

Cat UPS has been designed to work with all of these standard grounding configurations.
The standard configuration for Cat UPS Series 300 480V systems is 3-wire solidly grounded and the standard for 380-415V systems is 4-wire solidly grounded. Impedance grounding can be easily accommodated, although it requires an SER.

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, Cat UPS requires an upstream isolation transformer for the UPS and bypass before it can be connected to these power systems.

9.1.1 3-Wire Wye

Figure 23 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.

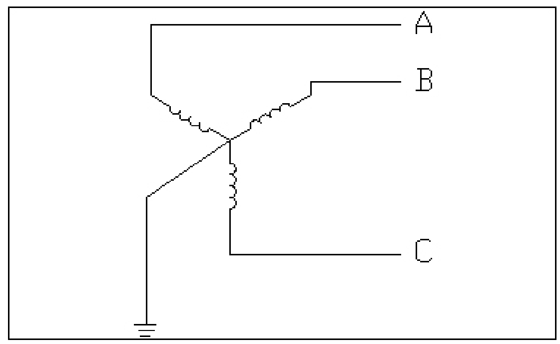


Figure 23: 3-Wire Wye Connected With Solid Ground

9.1.2 4-Wire Wye

Figure 24 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.

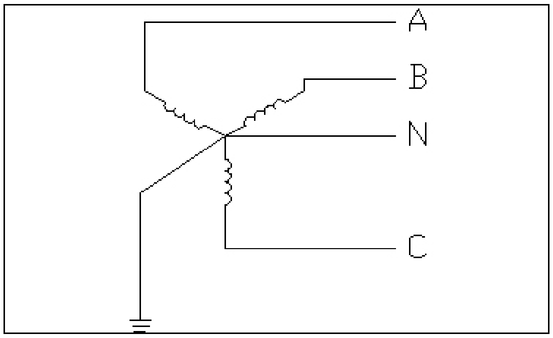


Figure 24: 4-Wire Wye Connected with Solid Ground

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.

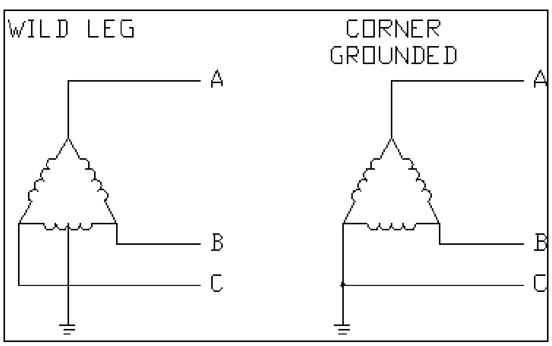


Figure 25: Incompatible Grounding Configurations

9.1.3 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).

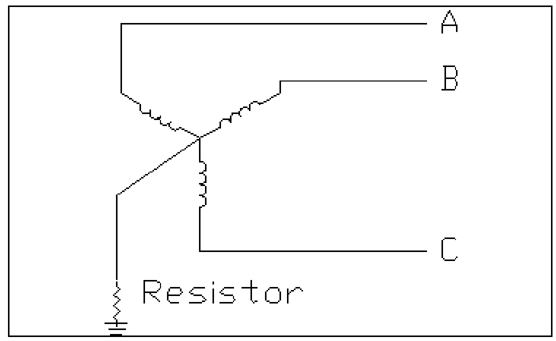


Figure 26: Impedance Grounded System

9.2 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. Figure 27 shows a typical North American power system with conversion from 480V 3-wire to 208/120V 4-wire.

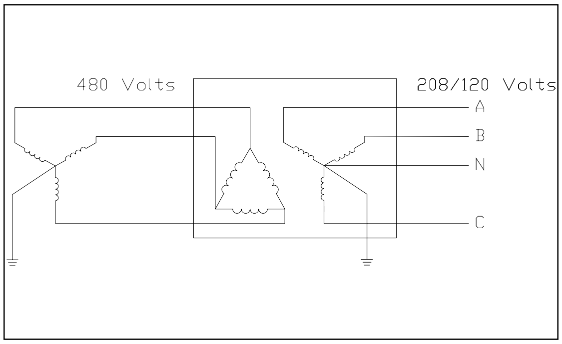


Figure 27: North American Power System

9.3 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 Figure 24, without intermediate transformation between the service entrance transformer and the loads.

Please remember that 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.

9.4 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 bad source paralleling configurations are shown in Figure 28.

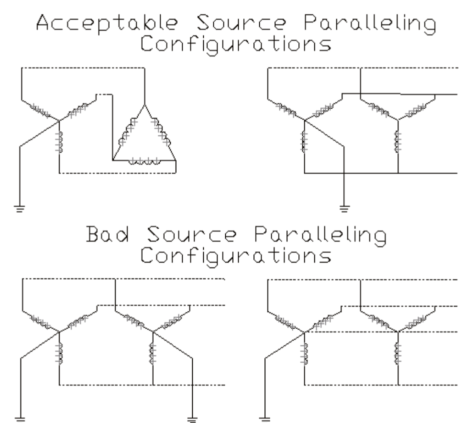


Figure 28: Good and Bad Source Paralleling

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 another story. 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 Figure 29.

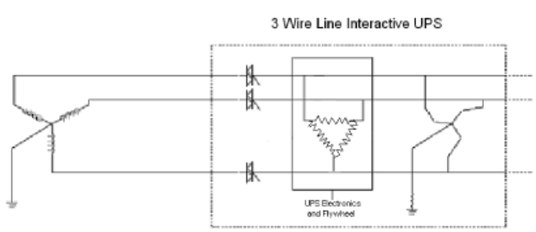


Figure 29: CAT 3-Wire UPS

The resistor 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.

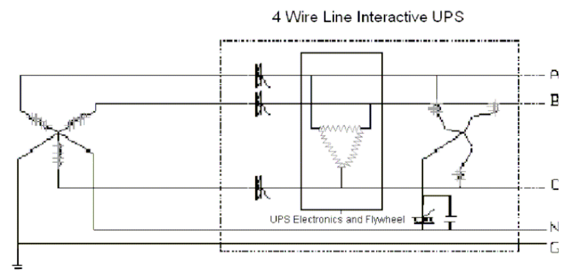


Figure 30: CAT 4-Wire UPS

Figure 30 shows our optional 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 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 UPS 250i or a UPS 300 4-wire.

10 Options

10.1 4-Wire input & output – 480 volt 60 Hz

While the majority of 480 VAC UPS applications will require 3-wire power, some single-phase loads (usually lighting) may be directly connected to the UPS and require a neutral connection. These applications require the optional 4-wire input & output feature. For the 150 and 300 kVA single module systems, this 4-wire is available with top cable access only.

10.2 Maintenance Bypass

The maintenance bypass option allows partial system isolation without load interruption in order to perform maintenance on the UPS system. No cabinet expansion is required for this option. There is no power protection while in maintenance bypass mode. This option is available in the following configurations:

SMS Options

- None
- Single input, 3-Wire, 3 device bypass
- Single input, 4-Wire, 3 device bypass

MMS Options

- Single input, 3 device bypass – not available on 750i and 900 models
- Dual input, no MBP
- Dual input, 2 device bypass
- Dual input, 3 device bypass

Note: *Dual input systems require inputs to come from a common (synchronized) source*

10.3 Dual input – no maintenance bypass

This option provides for 2 inputs that are derived from a common source when no maintenance bypass is required or a separate standalone maintenance bypass will be used. Inputs for the UPS and internal bypass are separated. This option is not available on 150 and 300 SMS.

10.4 External Source Sync

This option provides a means for a MMS UPS to synchronize to an external source whenever the flywheel is supplying the load. This option may be required for isolated redundant configurations to help the UPS module outputs synchronize. This is a factory option only. Not available on SMS.

10.5 Modems

The UPS comes with specific modems for certain geographical locations, frequency, and voltage ratings. Some locations around the world have very unique modem requirements. Thus, when possible select the optional factory installed modem in 115 and 230 VAC version. The voltage rating typically relates to 60 Hz and 50 Hz requirements common in North America and EU countries. If the location has unique modem requirements, an external modem option is available.

10.6 Ethernet

Ethernet is a common type of network that allows interconnection between the UPS and other devices. It can give the user the following capabilities:

- E-mail (e-mail requires Ethernet connection to a local area network (LAN) with SMTP e-mail server)
- SNMP
- Modbus
- Connection to UPSView over a LAN (network monitoring requires static IP address to be assigned to each UPS)

10.7 Modbus

Modbus Protocol is a messaging structure developed by Modicon in 1979. It is used to establish master-slave/client-server communication between intelligent devices. It is a de facto standard, truly open and the most widely used network protocol in the industrial manufacturing environment. It has been implemented by hundreds of vendors on thousands of different devices to transfer discrete/analog I/O and register data between control devices.

10.7.1 Modbus TCP

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.

10.7.2 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. For example, port COM1 in a PC can be used for a mouse, port COM2 for a modem, etc. This is an example of point-to-point communication: 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.

10.8 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 a 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.

10.9 GENSTART Starting Module

The GENSTART option provides a redundant source of starting power for generator sets. The GENSTART increases the reliability of the standby power system by ensuring that the generator has power available to start, removing the common cause of generator set starting failures, dead starting batteries. The GENSTART can parallel power from the starting batteries to provide one reliable DC power source to the starting motor. The GENSTART receives 3-phase 380/400/415/480 VAC power from a reliable power source such as a UPS. The GENSTART converts the AC voltage into 24 VDC for the starter motor. Unlike batteries, the GENSTART 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. The GENSTART can be wall-mounted (standard) or floor-mounted with the optional floor mounting kit. In either installation, the module should be securely fastened, as detailed in the GENSTART manual, to a support rated to accept the loads of the GENSTART option, approximately 350 lbs.

The GENSTART Starting Module (GSM) is sized just like a battery, by Cold Cranking Amps. The GSM will reliably produce 1725 CCA.

This number was arrived at by repetitive testing under conditions dictated by the ASME specification. 1725 CCA was the lowest number recorded, so to be conservative that is the rating. The GSM is a much stiffer source than a battery and hence the starting voltage will not drop as much as a battery alone.

If a generator set requires two starters, it is recommended that two GSM be used, one per starter. Alternatively, using one GSM to start multiple small generator sets has not been tested. However, total current still must remain at or below the 1725 CCA rating and thus seems reasonable. This should not be a common issue since smaller generator sets use 12VDC and the GSM output is 24VDC.

The input of the GENSTART is rated at 32 amps, which leads to a 40-amp breaker. Two 40-amp breakers, to support two GENSTART modules, can be installed in the UPS as an option.

Summary Specifications	
Nominal Voltage (Voltage Regulation)	24 VDC (+10%/-30%) at 0 - 1000 amperes DC
Cold Cranking Amperes	1725 amperes DC
Output Current Rating	1000 amperes DC
Input Voltage	380 - 480 VAC, 3-Phase
Output Voltage	24 VDC

Figure 31: GENSTART Starting Module (GSM) Specifications

10.10 Internal GSM Breakers

Two 40-amp beakers are available to support two GENSTART modules. This allows power to be taken off the output of the UPS and avoid the installation of a wall mounted panel. However, if the customer has UPS power easily available, it can be taken from an existing panel.

10.11 Dry Contacts

Dry contacts are provided on the SIO (Systems Input Output) board in the bottom left of the MMU or System cabinet. These contacts are used to communicate with various kinds of monitoring systems or building software. In addition, remote EPO buttons connect on the SIO board.

The 6 inputs and 6 output contacts are also an opportunity to improve the monitoring or understanding of a power system. The I/O contacts can be used to bring in operational status of other equipment, such as the generator set, ATS, HVAC, etc.

All contacts can be configured using UPSView in order to indicate if certain conditions exist. The contacts are located on the System I/O board. 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 used to configure that contact.

The SIO board is shown in the figure below. The SIO is generally located on the left of the MMU and System cabinet. Refer to the manuals for further details.

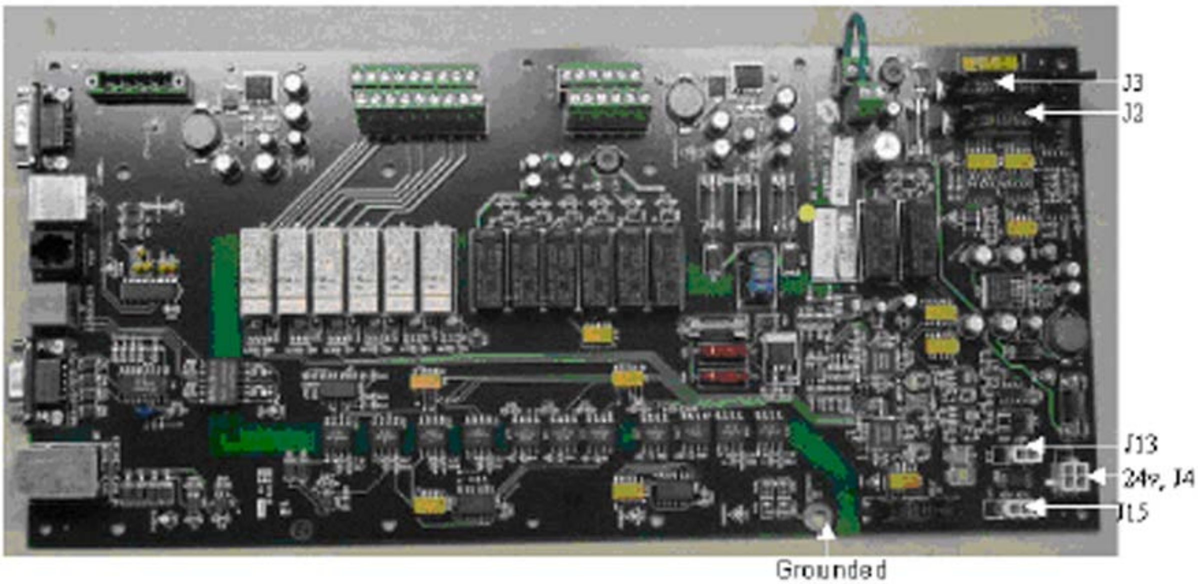


Figure 32: SIO (System Input Output) Board Detail

The connector's designators and functions are listed below. The connector J number label is printed on the board.

(1) "J6" "Remote Output Contacts"
(2) "J14" "Remote Input Contacts"
(3) "J7" "Remote EPO Contacts"
(4) "J4" "24 VDC Power In"
(5) "J1" "RS-232/RS-485"
(6) "J12" "Device Net"
(7) "J8" "CS ViewNET/CAN A"
(8) "J9" "Ethernet"
(9) "J10" "Modem
(9a) "J10a'
(10)"J11" "Chasis"
(11) "J15" "Rem EMO"
(12) "J2"
(13) "J3"
(14) "J13" "Rem EPO"

Figure 33: SIO Connector Designator and Function

The tables below are details of the input, output, and remote EPO terminals.

I/O Terminal Connection Detail			
Input Terminals 24VDC provided		**Output Terminals** Form C:	
CC In – J14		**CC Out – J6**	
1	COM	1	Output 1 – N.O.
2	COM	2	Output 1 – COM
3	COM	3	Output 1 – N.C.
4	COM	4	Output 2 – N.O.
5	COM	5	Output 2 – COM
6	COM	6	Output 2 – N.C.
7	Input 1	7	Output 3 – N.O.
8	Input 2	8	Output 3 – COM
9	Input 3	9	Output 3 – N.C.
10	Input 4	10	Output 4 – N.O.
11	Input 5	11	Output 4 – COM
12	Input 6	12	Output 4 – N.C.
		13	Output 5 – N.O.
		14	Output 5 – COM
EPO Input Terminals		15	Output 5 – N.C.
J14		16	Output 6 – N.O.
1	COM	17	Output 6 – COM
2	COM	18	Output 6 – N.C.
3	N.O.		
4	N.C. Jumper must exist		
All of the above terminal blocks are located on the SIO board.			

10.12 UPSView

UPSView is an optional data monitoring software package that tracks more than 40 operating parameters in real time and displays the data on a computer display. UPSView is compatible with Windows 98, NT 4.0, 2000, and XP. For MMS, Detail and Summary View options are available in UPSView. Refer to the UPSView manual for detail of the software features and operations.

The image below shows how the text comments and tiles are color coded to show normal (green), notice (yellow), and alarm (red) messages.

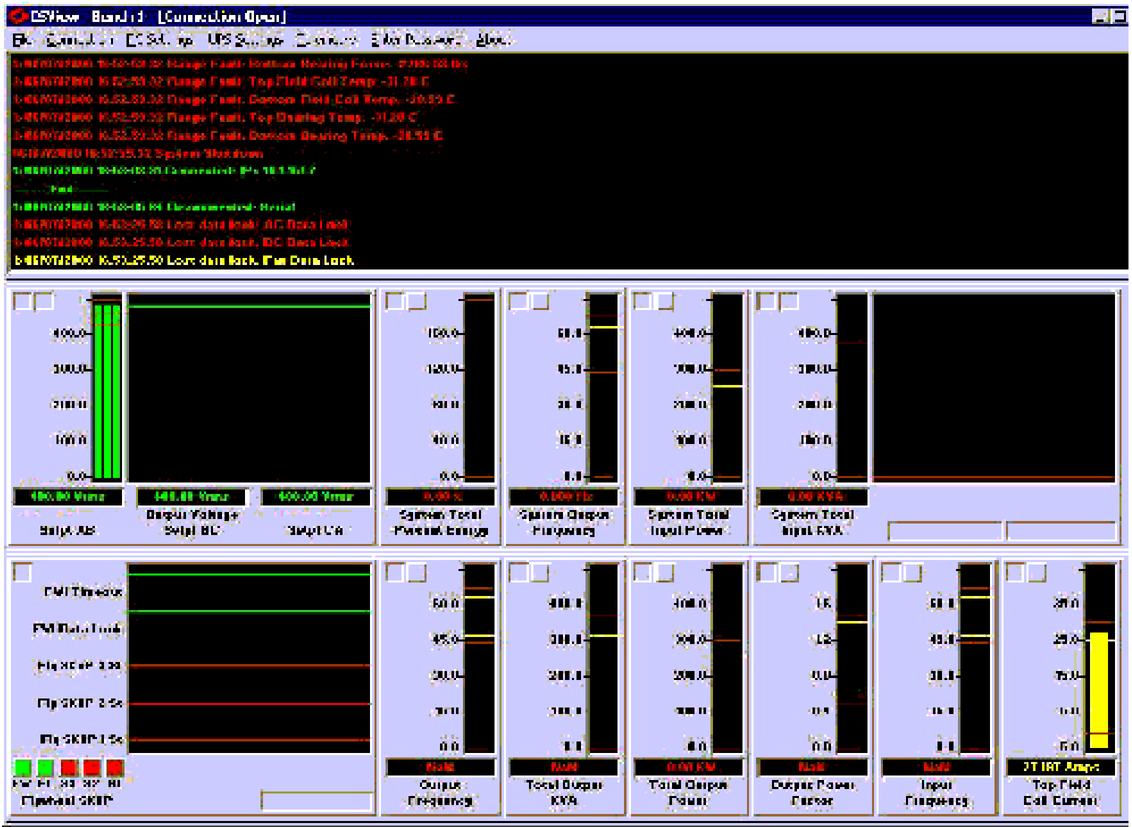


Figure 34: UPSView Screen Image

10.13 Remote Status Panel

The Remote Status Panel allows the user to monitor various functions through the use of eight status lights. The panel is designed for flush mounting or surface mounting in a panel box. Use 18 AWG or larger wire. The wire will consist of 3 conductors. The wire consists of a data conductor, a ground conductor, and a power conductor. There are 14 terminal screw connections on the back of the status panel. Refer to the manuals for detail information on connections.

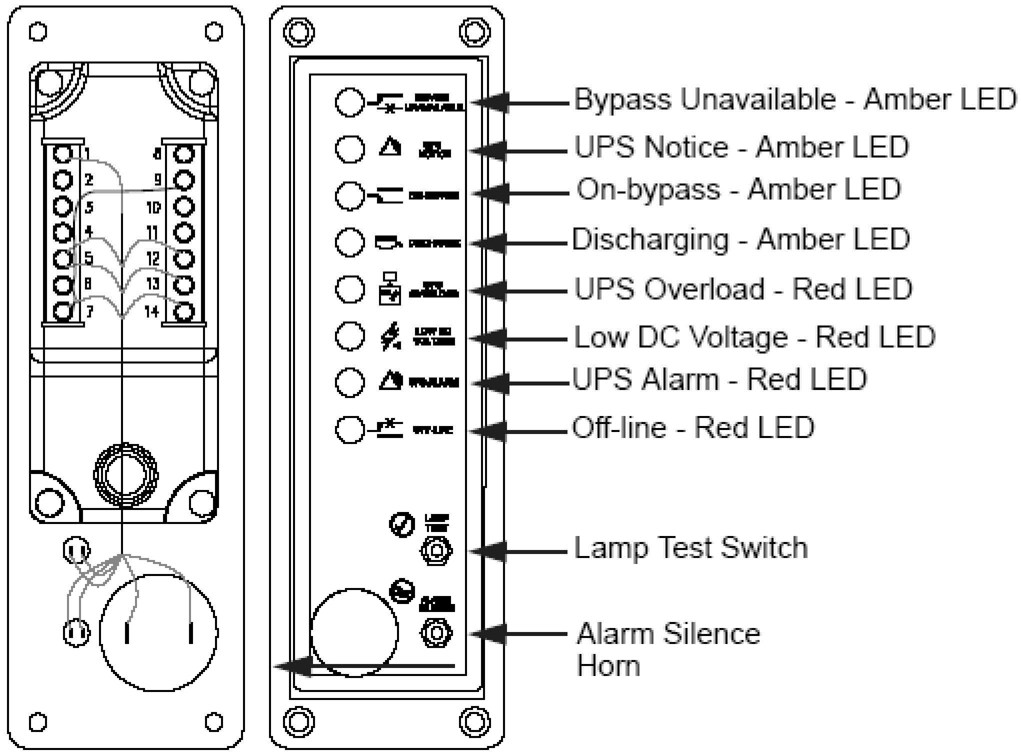


Figure 35: Remote Status Panel Detail

11 Top Recurring Issues

11.1 Forklift Capacity

The SMS and MMU cabinet weight 4500 to 4800 lb (2040 to 2194 kg). Therefore, a forklift or pallet jack with enough capacity must be on site to handle the unpacking and installation of the system. In addition, the forks width must be less than 24 inches to fit within the mounting cleats on the bottom of the system.

11.2 Unpacking

The Unpacking instructions are located on the outside of the system during shipping. It is important that all boxes or components that are packaged with a particular MMU or SMS stay with that system. It would be helpful discuss unpacking with the person on site to prevent loss of items.

11.3 Anchor Specifications

The UPS must be anchored to a concrete slab that is fully cured. The slab should be poured with a minimum of 3000 psi concrete. Existing slabs should be free from cracks and seams in the vicinity of the installation. Refer to the figures in the section for Anchoring in order to determine the requirements for the positioning of the slab.

The following tools and equipment are required for MMU and SMS:

1. Transport system forklift or pallet jack 3.0 ton capacity (forks less than 24" wide)
2. 1/2" drive socket wrench
3. 3/4" socket, 1/2" drive
4. 36" extension bar, 1/2" drive
5. 15/16" open end wrench
6. Anchor bolts (4 ea.)

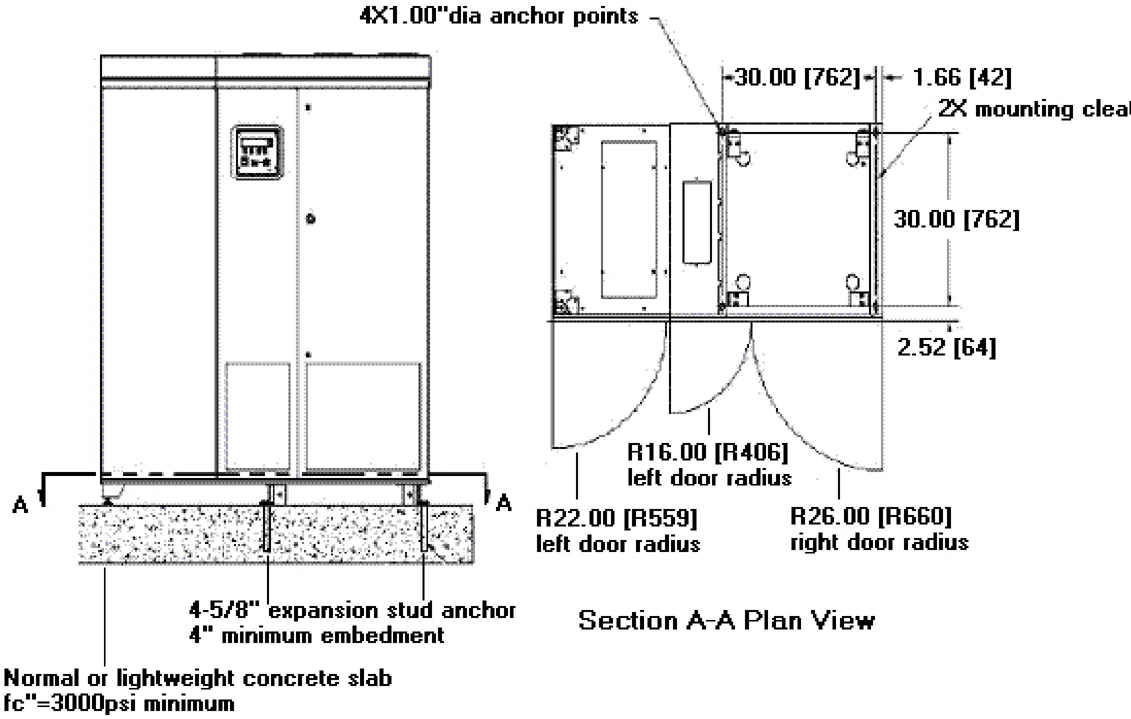


Figure 36: System Anchor Specifications

Install the anchors in accordance with the manufacturer's specifications. The anchors must meet the following specifications:

1. 5/8 X 6 inch length (min.) expansion stud with 4 inch minimum embedment anchor bolts must be used for the proper interface to the frame.
2. The maximum shear load capacity per anchor must be 7650.9 N (1720 lb.).
3. The maximum tensile load capacity per anchor is 3113.8 N (700 lb.).

When the thickness of the slab or the strength of the concrete is unknown consult "Section 1923 of the Uniform Building Code" or contact Caterpillar Inc. Customer Service.

CAUTION

The flywheel is shipped with bearing retainers installed to relieve the bearing of transient forces that may be encountered during shipping and handling. Do not attempt to remove the retainers or operate the unit until it is properly bolted to its floor anchors. The bearing retainers are to be removed only by Caterpillar Inc. certified personnel during the final inspection and before initial pre-startup.

11.4 System Anchoring

The anchoring of the system requires the following steps.

1. **Locate** position for drilling holes.
2. **Drill** core holes for anchor bolts.
3. **Lift** the system off of the ground using a forklift or pallet jack.
4. **Remove** the mounting cleats.
5. **Bolt** the mounting cleats to the floor.
6. **Slide** the system onto the mounting cleats.
7. **Bolt** the system to the mounting cleats.

Zone 4 Seismic qualified Flywheel. Compliance with this standard is based on calculations. *A Seismic Anchoring Kit is available*.

Below is a check list that should be used for each installation.

STEP	TASK	INITIAL AND DATE
1.	All packing materials and restraints have been removed from each cabinet.	
2.	Each cabinet in the UPS system has been placed in the proper position.	
3.	The Input/Output and System cabinets have been adjusted to a height of 78".	
4.	The MMU cabinet(s) have been properly anchored.	
5.	A ground bond is installed between all cabinets.	
6.	All switchboards, conduits, and cables are properly routed to the UPS system.	
7.	All power cables are properly sized and terminated.	
8.	A ground conductor is properly installed in the I/O cabinet.	
9.	The area around the installed UPS system is clean and dust free.	
10.	The UPS system has been installed on a level, sealed concrete pad or a sealed concrete floor.	
11.	Adequate workspace exists around the UPS system.	
12.	Adequate lighting is provided around the UPS system.	
13.	A 120 V service outlet is located within 25 feet of the UPS system.	
14.	The GenSTART system is mounted in its installed location (OPTIONAL).	
15.	The GenSTART cabling has been routed and terminated (OPTIONAL)	
16.	The Remote Status Panel is mounted in its installed location (OPTION-AL).	
17.	THe control wiring for the Remote Status Panel is terminated properly (OPTIONAL).	
18.	The Remote Emergency Power Off (REPO) button is mounted in its installed location and its wiring is terminated properly (OPTIONAL).	
19.	The Input and Output Dry contacts are wired appropriately.	

Make a copy of the Installation Checklist before filling it out, and retain the original.

Figure 37: Installation Check List

11.5 900 Dual Input

The 750 and 900-kVA Cat UPS are dual input only. One input powers the UPS and the other the Bypass & Maintenance Bypass. The system input feed powers the load and provides the power to charge the flywheels. Thus, the system input requires a larger upstream breaker than that of the bypass feed.

11.6 900 & 750 kVA Breaker Options

MMS have a 2 breaker MBP option. However, it is almost never advised to select the two breaker option. After review of the One-Line, it will be obvious that under some configuration, it might not be possible to get from the maintenance bypass to online status without additional hardware upstream.

11.7 External Source Synch

The External source synch option is only available on MMS units. This option is to synch the output of the UPS to a secondary source during discharge so that it is in phase when the transfer is made.

11.8 SMS & Dual Entry

The SMS 150 to 300 kVA Cat UPS are single input only. If you need to have dual input, an upgrade to a 300E will be required. Alternatives such as static switches may be engineered into the configuration if desire. However, the cost may be equivalent.

11.9 GENSTART Sizing

The GENSTART module is a very capable piece of equipment. However, even though we would like to have only one unit per generator set, it may not be possible. All things considered including starter current rating, ambient temperature, and generator set size more than one unit may be required for reliable operation in all climates. The GENSTART is will provide 1725 cold cracking amps. It therefore should be sized similar to a battery, by the CCA rating.

11.10 Fan Airflow CFM

The SMS and MMU cabinets have six fans on top of the cabinet. These fans are redundant in that you can have one fan fail and still perform within specifications, allowing time for replacement of the failed fan. The System and I/O cabinets have 3 fans each with one being redundant.

12 Series 300 Modbus Register Map

12.1 General

- UPS Series 300 supports Modbus/TCP, Class 0 and Modbus/RTU.
- All registers are read-only, accessed with MODBUS FC3 (read multiple registers).
- There are 5 register groups: System, MMU, Event, Status and Summary.
- Register pairs, shown as (x)(x+1) represent a 32 bit floating point value. The lower numbered register contains bits 15-0 of the value, the higher numbered Register contains bits 31-16 of the floating point value.
- Registers shown as (x) are 16 bit unsigned quantities.
- References to a register number X is equivalent to Modbus Register 40000+X.

12.2 System Group

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

Register	Group	Description	Units
(1)	System	Firmware Rev, Lower	(see Note 1)
(2)	System	Firmware Rev, Upper	
(3)	System	FPGA Rev, Lower	(see Note 2)
(4)	System	FPGA Rev, Upper	
(5)	System	Notice Active	0 or 1
(6)	System	Alarm Active	0 or 1
(7)	System	System Mode	(integer)
(8)	System	System State	(integer)
(9)	System	System Year	4 digit year
(10)	System	System Month	1 to 12
(11)	System	System Date	1 to 31
(12)	System	System Hour	0 to 23
(13)	System	System Minute	0 to 59
(14)	System	System Second	0 to 59
(15)(16)	System	Output Frequency	Hertz
(17)(18)	System	Input Frequency	Hertz
(19)(20)	System	Output Power Factor	0.0 to 1.0
(21)(22)	System	Input Power Factor	0.0 to 1.0
(23)	System	Firmware Rev, Lower	(see Note 1)

Register	Group	Description	Units
(24)	System	Firmware Rev, Upper	
(25)	System	FPGA Rev, Lower	(see Note 2)
(26)	System	FPGA Rev, Upper	
(27)	System	Notice Active	0 or 1
(28)	System	Alarm Active	0 or 1
(29)	System	System Mode	(integer)
(30)	System	System State	(integer)
(31)	System	System Year	4 digit year
(32)	System	System Month	1 to 12
(33)	System	System Date	1 to 31
(34)	System	System Hour	0 to 23
(35)	System	System Minute	0 to 59
(36)	System	System Second	0 to 59
(37)(38)	System	Output Frequency	Hertz
(39)(40)	System	Input Frequency	Hertz
(41)(42)	System	Output Power Factor	0.0 to 1.0
(43)(44)	System	Input Power Factor	0.0 to 1.0
(45)(46)	System	Percent Energy	Percent
(47)(48)	System	Percent Load	Percent
(49)(50)	System	Output Power	Kilowatts
(51)(52)	System	Output KVA	KVA
(53)(54)	System	Input Power	Kilowatts
(55)(56)	System	Input KVA	KVA
(57)(58)	System	Input Line Volt AB	Vac
(59)(60)	System	Input Line Volt BC	Vac
(61)(62)	System	Input Line Volt CA	Vac
(63)(64)	System	Bypass Line Volt AB	Vac
(65)(66)	System	Bypass Line Volt BC	Vac
(67)(68)	System	Bypass Line Volt CA	Vac
(69)(70)	System	Output Line Volt AB	Vac
(71)(72)	System	Output Line Volt BA	Vac
(73)(74)	System	Output Line Volt CA	Vac
(75)(76)	System	Input Current Phase A	Amps
(77)(78)	System	Input Current Phase B	Amps
(79)(80)	System	Input Current Phase C	Amps
(81)(82)	System	Output Current Phase A	Amps
(83)(84)	System	Output Current Phase B	Amps
(85)(86)	System	Output Current Phase C	Amps

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, the 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]

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.

12.3 MMU Detail Group

Register	Group	Description	Units
(100)(101)	MMU detail	Input Volts AB	VAC
(102)(103)	MMU detail	Input Volts BC	VAC
(104)(105)	MMU detail	Input Volts CA	VAC
(106)(107)	MMU detail	Filter Volts AB	VAC
(108)(109)	MMU detail	Filter Volts BC	VAC
(110)(111)	MMU detail	Filter Volts CA	VAC
(112)(113)	MMU detail	Output Volts AB	VAC
(114)(115)	MMU detail	Output Volts BC	VAC
(116)(117)	MMU detail	Output Volts CA	VAC

Register	Group	Description	Units
(118)(119)	MMU detail	Inverter Current A	Amps
(120)(121)	MMU detail	Inverter Current B	Amps
(122)(123)	MMU detail	Inverter Current C	Amps
(124)(125)	MMU detail	Input Current A	Amps
(126)(127)	MMU detail	Input Current B	Amps
(128)(129)	MMU detail	Input Current C	Amps
(130)(131)	MMU detail	Output Current A	Amps
(132)(133)	MMU detail	Output Current B	Amps
(134)(135)	MMU detail	Output Current C	Amps
(136)(137)	MMU detail	Target Output Volts AB	VAC
(138)(139)	MMU detail	Target Output Volts BC	VAC
(140)(141)	MMU detail	Target Output Volts CA	VAC
(142)(143)	MMU detail	DC Offset Correction AB	VAC
(144)(145)	MMU detail	DC Offset Correction BC	VAC
(146)(147)	MMU detail	DC Offset Correction CA	VAC
(148)(149)	MMU detail	Output Voltage Setpoint AB	VAC
(150)(151)	MMU detail	Output Voltage Setpoint BC	VAC
(152)(153)	MMU detail	Output Voltage Setpoint CA	VAC
(154)(155)	MMU detail	Input Volts AN	VAC
(156)(157)	MMU detail	Input Volts BN	VAC
(158)(159)	MMU detail	Input Volts CN	VAC
(160)(161)	MMU detail	Output Frequency	Hertz
(162)(163)	MMU detail	Output MMU Power	kW
(164)(165)	MMU detail	Output MMU kVA	kVA
(166)(167)	MMU detail	Output Power Factor	0.0 to 1.0
(168)(169)	MMU detail	Input Frequency	Hertz
(170)(171)	MMU detail	Input MMU Power	kW
(172)(173)	MMU detail	Input MMU kVA	kVA
(174)(175)	MMU detail	Input Power Factor	0.0 to 1.0
(176)(177)	MMU detail	Cabinet Temperature	°C
(178)(179)	MMU detail	Air Inlet Temperature	°C
(180)(181)	MMU detail	Static Switch Temperature	°C
(182)(183)	MMU detail	Generator Set Start IGBT Temperature	°C
(184)(185)	MMU detail	Positive DC Bus Voltage	VDC
(186)(187)	MMU detail	Negative DC Bus Voltage	VDC
(188)(189)	MMU detail	Tachometer	RPM
(190)(191)	MMU detail	Percent Energy	%

Register	Group	Description	Units
(192)(193)	MMU detail	Vacuum Gauge	milliTorr
(194)(195)	MMU detail	Top Field Coil Current	Amps
(196)(197)	MMU detail	Bottom Field Coil Current	Amps
(198)(199)	MMU detail	Bottom Bearing Force	Pounds
(200)(201)	MMU detail	Lateral Vibration	G's
(202)(203)	MMU detail	Axial Vibration	G's
(204)(205)	MMU detail	Top Field Coil Temperature	°C
(206)(207)	MMU detail	Bottom Field Coil Temperature	°C
(208)(209)	MMU detail	Armature Temperature	°C
(210)(211)	MMU detail	Top Field Coil IGBT Temperature	°C
(212)(213)	MMU detail	Bottom Field Coil IGBT Temperature	°C
(214)(215)	MMU detail	Top Bearing Temperature	°C
(216)(217)	MMU detail	Bottom Bearing Temperature	°C
(218)(219)	MMU detail	RPS Advance setpoint	0 to 255
(220)	MMU detail	MMU Mode	Integer
(221)	MMU detail	MMU State	Integer

12.4 Event Log Group

The Event Log Group provides a way to read the event log from the UPS Series 300.

The UPS Series 300 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 be up to 80 characters in length, plus a trailing null. For messages less than 80 characters long, the trailing bytes are zeroed. Attempts to read a message index greater than the number of indicated messages (in registers 250, 251 or 252) will result in a null string (all message bytes being zeroed).

To Retrieve the event log:

- Read the number of All messages, alarm and/or warning messages (regs. 250,251, and/or 252)

- If there are more than zero messages, set the Command register for the desired message level. (See below.) 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.
- Pseudo-coded routines for reading the entire event log, and for periodically checking for new event messages, are shown below.

12.5 Commands Values for Registers 253, 254, and 255

Value	Meaning	Description
0	Reset	Sets the internal index to the oldest message stored in the event log. This command should be issued at least once when reading the event log.
1	Advance	Advances the internal index to the next message of the appropriate event type. If there are no more messages of the appropriate type available, a NULL string will be placed in the ASCII string registers.

```
Pseudo-code:
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 all ascii bytes
      Read_many(256, 41)
      Num_All_msgs =
      Num_All_msgs -1
      Write(253, 1)                   -- Advance the "All Messages"
                                      Command -Register
Periodic_update:                      -- 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_         -- if there are new events
  Num_Alarm_msgs)
  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 all ascii bytes
  Read_many(256, 41)
```

Note: The UPS Series 300 accumulates events in 2 sectors in flash memory. Each sector can hold 2038 events. When a sector is filled (number of all events = 2038), the most-recent 1440 events are copied to the other (erased) sector before adding new messages to the event log. Therefore, it is possible for the values in registers 250, 251 and 252 to suddenly decrease (from 2036 to 1442, for instance). This must be taken into account when designing code which examines these registers.

Register	Group	Read/ Write	Description
(250)	Event	R	Number of All Messages
(251)	Event	R	Number of Warning and Alarm Messages
(252)	Event	R	Number of Alarm Messages Only
(253)	Event	R/W	"All Messages" Command Register
(254)	Event	R/W	"Warning and Alarm Messages" Command Register
(255)	Event	R/W	"Alarm Messages Only" Command Register
(256)	Event	R	Bytes 0 and 1 of the ASCII message string
(257)	Event	R	Bytes 2 and 3 of the ASCII message string
(258)	Event	R	Bytes 4 and 5 of the ASCII message string
(259)	Event	R	Bytes 6 and 7 of the ASCII message string
(260)	Event	R	Bytes 8 and 9 of the ASCII message string
(261)	Event	R	Bytes 10 and 11 of the ASCII message string
(262)	Event	R	Bytes 12 and 13 of the ASCII message string
(263)	Event	R	Bytes 14 and 15 of the ASCII message string
(264)	Event	R	Bytes 16 and 17 of the ASCII message string
(265)	Event	R	Bytes 18 and 19 of the ASCII message string
(266)	Event	R	Bytes 20 and 21 of the ASCII message string
(267)	Event	R	Bytes 22 and 23 of the ASCII message string
(268)	Event	R	Bytes 24 and 25 of the ASCII message string
(269)	Event	R	Bytes 26 and 27 of the ASCII message string
(270)	Event	R	Bytes 28 and 29 of the ASCII message string
(271)	Event	R	Bytes 30 and 31 of the ASCII message string
(272)	Event	R	Bytes 32 and 33 of the ASCII message string
(273)	Event	R	Bytes 34 and 35 of the ASCII message string
(274)	Event	R	Bytes 36 and 37 of the ASCII message string

Register	Group	Read/ Write	Description
(275)	Event	R	Bytes 38 and 39 of the ASCII message string
(276)	Event	R	Bytes 40 and 41 of the ASCII message string
(277)	Event	R	Bytes 42 and 43 of the ASCII message string
(278)	Event	R	Bytes 44 and 45 of the ASCII message string
(279)	Event	R	Bytes 46 and 47 of the ASCII message string
(280)	Event	R	Bytes 48 and 49 of the ASCII message string
(281)	Event	R	Bytes 50 and 51 of the ASCII message string
(282)	Event	R	Bytes 52 and 53 of the ASCII message string
(283)	Event	R	Bytes 54 and 55 of the ASCII message string
(284)	Event	R	Bytes 56 and 57 of the ASCII message string
(285)	Event	R	Bytes 58 and 59 of the ASCII message string
(286)	Event	R	Bytes 60 and 61 of the ASCII message string
(287)	Event	R	Bytes 62 and 63 of the ASCII message string
(288)	Event	R	Bytes 64 and 65 of the ASCII message string
(289)	Event	R	Bytes 66 and 67 of the ASCII message string
(290)	Event	R	Bytes 68 and 69 of the ASCII message string
(291)	Event	R	Bytes 70 and 71 of the ASCII message string
(292)	Event	R	Bytes 72 and 73 of the ASCII message string
(293)	Event	R	Bytes 74 and 75 of the ASCII message string
(294)	Event	R	Bytes 76 and 77 of the ASCII message string
(295)	Event	R	Bytes 78 and 79 of the ASCII message string
(296)	Event	R	Bytes 80 and 81 of the ASCII message string

12.6 Status Group

The Status Group are status registers for the system and MMU.

Each bit has a particular meaning for a particular FPGA revision.

Register	Group	Description
(350)	Status	System Status Register 1
(351)	Status	System Status Register 2
(352)	Status	System Status Register 3
(353)	Status	MMU Status Register A
(354)	Status	MMU Status Register B
(355)	Status	MMU Status Register C
(356)	Status	MMU Status Register D
(357)	Status	MMU Status Register E

Note: The three system status registers are only available on systems with a Systems Cabinet (i.e. systems that can support more than 1 MMU).

12.6.1 Bit definitions for System Status Register 1

(Bit 15 is the most significant bit).

B15: SYS_CAB_USER_DATA_LOCK_BIT, communication with user interface board ok

B14: SYS_CAB_IO_DATA_LOCK_BIT, communication with i/o interface board ok

B13: SYS_CAB_FAN_DATA_LOCK_BIT, communication with fan interface board ok

B12: SYS_CAB_AC_DATA_LOCK_BIT, communication with AC interface board ok

B11: SYS_CAB_T3_FUSE_BIT, pwr supply xfrmr fuse okay

B10: SYS_CAB_T2_FUSE_BIT, pwr supply xfrmr fuse okay

B9: SYS_CAB_T1_FUSE_BIT, pwr supply xfrmr fuse okay

B8: SYS_CAB_SPARE_0, spare bit

B7: SYS_CAB_PS_2_OK_BIT, 24 V power supply 2 okay

B6: SYS_CAB_PS_1_OK_BIT, 24 V power supply 1 okay

B5: SYS_CAB_FAN_6_OK_BIT, spare bit

B4: SYS_CAB_FAN_5_OK_BIT, spare bit

B3: SYS_CAB_FAN_4_OK_BIT, spare bit

B2: SYS_CAB_FAN_3_OK_BIT, System Cabinet fan 3 is okay

B1: SYS_CAB_FAN_2_OK_BIT, System Cabinet fan 2 is okay

B0: SYS_CAB_FAN_1_OK_BIT, System Cabinet fan 1 is okay

12.6.2 Bit definitions for System Status Register 2

B15: SYS_CAB_SS_FUSE_OK_BIT, Bypass Static Switch fuse is okay

B14: SYS_CAB_SPARE_BIT, spare bit

B13: SYS_CAB_SPARE_BIT, spare bit

B12: SYS_CAB_SPARE_BIT, spare bit

B11: SYS_CAB_SPARE_BIT, spare bit

B10: SYS_CAB_SPARE_BIT, spare bit

B9: SYS_CAB_SPARE_BIT, spare bit

B8: SYS_CAB_SPARE_8

B7: SYS_CAB_SPARE_7

B6: SYS_CAB_IN_6_CONTACT_BIT, System Cabinet remote input contact

B5: SYS_CAB_IN_5_CONTACT_BIT, System Cabinet remote input contact

B4: SYS_CAB_IN_4_CONTACT_BIT, System Cabinet remote input contact

B3: SYS_CAB_IN_3_CONTACT_BIT, System Cabinet remote input contact

B2: SYS_CAB_IN_2_CONTACT_BIT, System Cabinet remote input contact

B1: SYS_CAB_IN_1_CONTACT_BIT, System Cabinet remote input contact

B0: SYS_CAB_SPARE_BIT

12.6.3 Bit definitions for System Status Register 3

B15: SYS_CAB_BYPASS_ROTATION_CW, bypass input phase rotation is clockwise

B14: SYS_CAB_BYPASS_ROTATION_CCW, bypass input phase rotation is counter-clockwise

B13: SYS_CAB_FREQUENCY_LOCK

B12 – B9: Spare bits

B8: SYS_CAB_K3_STATUS_ERR, K3 status bit doesn’t match K3 command bit

B7: SYS_CAB_COMMUNICATION_ERR, error with one of the satellite sys. Cab. boards

B6: SYS_CAB_K3_CB_CURRENT_TRIP, bypass CB tripped because of current overload

B5: SYS_CAB_FAN_SPARE_5

B4: SYS_CAB_FAN_SPARE_4

B3: SYS_CAB_FAN_SPARE_3

B2: SYS_CAB_FAN_SPARE_2

B1: SYS_CAB_ZIGZAG_OL_RELAY_TRIP, zigzag xfrmr overload relay has tripped

B0: SYS_CAB_ZIGZAG_BREAKER_TRIP, zigzag breaker relay has tripped

12.6.4 Bit definitions for MMU Status Register A

B15: K3_STATUS_BIT	- Bypass contactor status bit (1 = closed)
B14: K2_STATUS_BIT	- MMU output contactor status bit (1 = closed)
B13: K1_STATUS_BIT	- MMU input contactor status bit (1 = closed)
B12: USER_DATA_LOCK	- MMU user interface board communications okay
B11: IO_DATA_LOCK	- MMU input/output interface board communications okay

B10: FAN_DATA_LOCK	- MMU fan interface board communications okay
B9: DC_DATA_LOCK	- MMU DC interface board communications okay
B8: AC_DATA_LOCK	- MMU AC interface board communications okay
B7: GS_DATA_LOCK (Optional)	- MMU Generator Set Start interface board communications okay
B6: UNLOADING_TO	- Unloading controller had a timeout reaching setpoint
B5: LOW_SPEED_SHUTDOWN	- Discharge ending because of flywheel speed
B4: FLY_MASTER_ENABLE	- Flywheel Master Controller enabled
B3: EXT_SYNC_BIT	- Synchronize output to external input source cmd bit
B2: K4_STATUS_BIT	- Bypass static switch contactor status bit
B1: S_BYP_SW_FUSE_OK_BIT	- Bypass static switch fuse status bit
B0: MASTER_ENABLE	- The MMU master controller is enabled

12.6.5 Bit definitions for MMU Status Register B

B13: DISCHARGING_BIT	- MMU is discharging
B12: SPARE_BIT	
B11: SPARE_BIT	
B10: MMU_T2_FUSE_BIT	- MMU power supply xfrmr 2 fuse okay
B9: MMU_T1_FUSE_BIT	- MMU power supply xfrmr 1 fuse okay
B8: PS_3_BIT	- MMU 24V DC power supply 3 okay
B7: PS_2_BIT	- MMU 24V DC power supply 2 okay
B6: PS_1_BIT	- MMU 24V DC power supply 1 okay
B5: FAN_5_BIT	- MMU Fan 6 okay
B4: FAN_4_BIT	- MMU Fan 5 okay
B3: FAN_3_BIT	- MMU Fan 4 okay
B2: FAN_2_BIT	- MMU Fan 3 okay
B1: FAN_1_BIT	- MMU Fan 2 okay
B0: FAN_0_BIT	- MMU Fan 1 okay

12.6.6 Bit definitions for MMU Status Register C

B14:	- MMU input has counter-clockwise

AC_COUNTER_CLOCKWISE_BIT	phase rotation
B13: AC_CLOCKWISE_BIT	- MMU input has clockwise phase rotation
B12: STATIC_SW_FULLY_ON_BIT	- MMU Input static switch is turned on
B11: STATIC_SWITCH_TIMEOUT	- Timeout controlling MMU input static switch
B10: OVERSPEED_ERR	- Flywheel overspeed shutdown
B9: RPS_ERR	- Rotor Position Sensor Error
B8: SKIIP_3_ERR	- Flywheel SKIIP 3 error
B7: SKIIP_2_ERR	- Flywheel SKIIP 2 error
B6: SKIIP_1_ERR	- Flywheel SKIIP 1 error
B5: SKIIP_C_ERR	- Utility Inverter Phase C SKIIP error
B4: SKIIP_B_ERR	- Utility Inverter Phase B SKIIP error
B3: SKIIP_A_ERR	- Utility Inverter Phase A SKIIP error
B2: FWI_DATALOCK_ERR_BIT	- Flywheel Interface Board communications error
B1: LOW_DC_BUS_ERR	- A DC Bus had a low voltage error
B0: HI_DC_BUS_ERR	- A DC Bus had a high voltage error

12.6.7 Bit definitions for MMU Status Register D

B15: BYPASS_AVAILABLE_BIT	- Bypass input is qualified for bypass transfers
B14: EXT_SYNC_CMD_BIT	- Discharge sync. to ext. downstream source
B13: BYPASS_SSW_OKAY_BIT	- Bypass static switch is present and operating
B12: BYPASS_SYNC_BIT	- Output is synchronized to the bypass source
B11: AHC_ENABLE_BIT	- Active harmonic correction enable bit
B10: FLYWHEEL_SYS_ENABLE_BIT	- The flywheel master controller enable bit
B9: REDUNDANT_MMU_BIT	- The system has at least 1 MMU more than the load requires
B8: AVR_ENABLE_BIT	- Automatic Voltage Regulation is enabled
B7: NEUTRAL_CONNECTED_BIT	- System has a neutral connection

B6: K4_CONTROL_BIT	- Bypass static switch contactor close cmd
B5: START_SWEEP_ENABLE_BIT	- Rotor spin-up sweep is enabled
B4: K3_CONTROL_BIT	- Bypass contactor open request
B3: K2_CONTROL_BIT	- Output contactor close request
B2: K1_CONTROL_BIT	- Input contactor close request
B1: UNLOADING_ENABLE_BIT	- Rotor unloading controller is enabled
B0: STATIC_SWITCH_ENABLE_BIT	- MMU input static switch is enabled

12.6.8 Bit definitions for MMU Status Register E

B15: DISCHARGE_ENABLE_BIT	- MMU discharge is enabled
B14: FLYWHL_INV_ENABLE_BIT	- MMU flywheel inverter is enabled
B13: FIELD_ENABLE_BIT	- MMU field coil controller is enabled
B12: UTIL_INV_ENABLE_BIT	- MMU Output Utility Inverter is enabled
B11: SYSTEM_ENABLE_BIT	- MMU master controller enable command
B10: ALARM_ACTIVE	- MMU has an active alarm event
B9: NOTICE_ACTIVE	- MMU has an active notice event

12.7 Summary Group

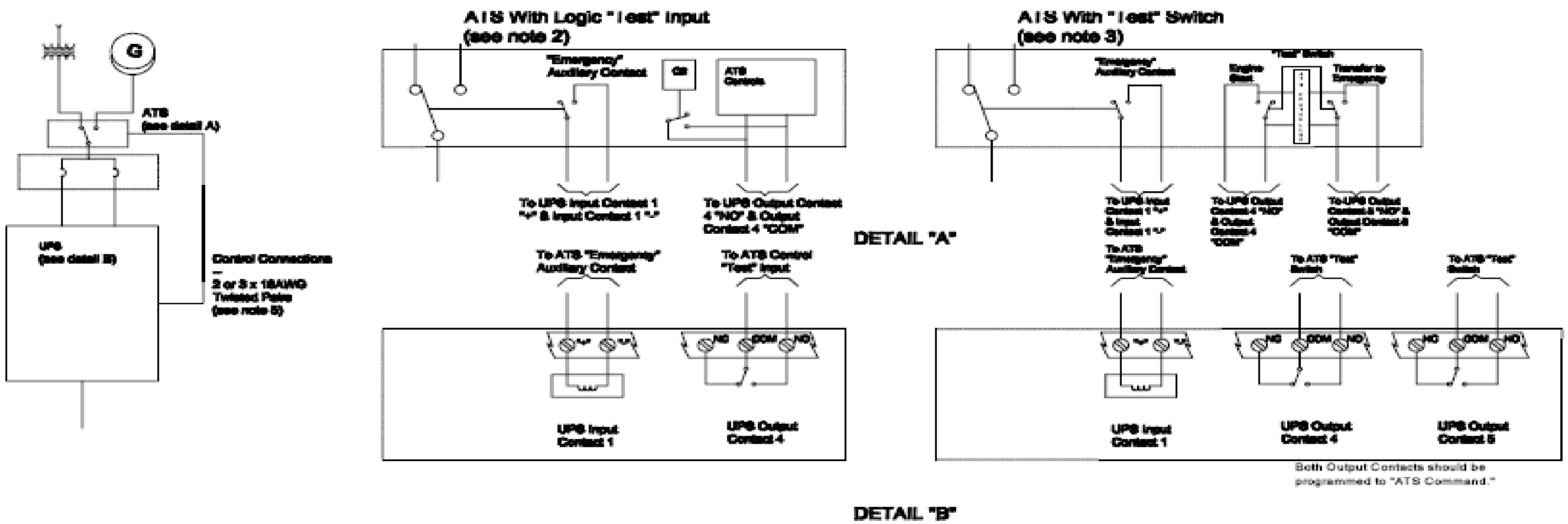
The summary group contains some information about each UPS Series 300 unit connected via the CAN bus. Register values for CS2s that are not present on the CAN bus are returned as zeros (0). There are registers for four UPS Series 300 units connected to each other via the CAN bus. Reading registers from a unit that is not connected to the bus will return zeros.

Register	Group	Description
(375)	Summary	Detected number of MMU's
(376)	Summary	Expected number of MMU's
(380)	Summary	MMU Mode, Unit 1
(381)	Summary	MMU State, Unit 1
(382)(383)	Summary	Tachometer, Unit 1
(384)(385)	Summary	Percent Usable Energy, Unit 1
(386)(387)	Summary	Cabinet Temperature, Unit 1
(388)(389)	Summary	Vacuum Gauge, Unit 1

Register	Group	Description
(390)(391)	Summary	MMU Output Power, Unit 1
(392)(393)	Summary	MMU Output kVA, Unit 1
(394)(395)	Summary	MMU Input Power, Unit 1
(396)(397)	Summary	MMU Input kVA, Unit 1
(398)(399)	Summary	MMU Spare telemetry channel, Unit 1
(400)(401)	Summary	MMU Spare telemetry channel, Unit 1
(402)(403)	Summary	MMU Input Current Phase A, Unit 1
(404)(405)	Summary	MMU Input Current Phase B, Unit 1
(406)(407)	Summary	MMU Input Current Phase C, Unit 1
(408)(409)	Summary	MMU Output Current Phase A, Unit 1
(410)(411)	Summary	MMU Output Current Phase B, Unit 1
(412)(413)	Summary	MMU Output Current Phase C, Unit 1
(424)	Summary	MMU Mode, Unit 2
(425)	Summary	MMU State, Unit 2
(426)(427)	Summary	Tachometer, Unit 2
(428)(429)	Summary	Percent Usable Energy, Unit 2
(430)(431)	Summary	Cabinet Temperature, Unit 2
(432)(433)	Summary	Vacuum Gauge, Unit 2
(434)(435)	Summary	MMU Output Power, Unit 2
(436)(437)	Summary	MMU Output kVA, Unit 2
(438)(439)	Summary	MMU Input Power, Unit 2
(440)(441)	Summary	MMU Input kVA, Unit 2
(442)(443)	Summary	MMU Spare telemetry channel, Unit 2
(444)(445)	Summary	MMU Spare telemetry channel, Unit 2
(446)(447)	Summary	MMU Input Current Phase A, Unit 2
(448)(449)	Summary	MMU Input Current Phase B, Unit 2
(450)(451)	Summary	MMU Input Current Phase C, Unit 2
(452)(453)	Summary	MMU Output Current Phase A, Unit 2
(454)(455)	Summary	MMU Output Current Phase B, Unit 2
(456)(457)	Summary	MMU Output Current Phase C, Unit 2
(468)	Summary	MMU Mode, Unit 3
(469)	Summary	MMU State, Unit 3
(470)(471)	Summary	Tachometer, Unit 3
(472)(473)	Summary	Percent Usable Energy, Unit 3
(474)(475)	Summary	Cabinet Temperature, Unit 3
(476)(477)	Summary	Vacuum Gauge, Unit 3
(478)(479)	Summary	MMU Output Power, Unit 3

Register	Group	Description
(480)(481)	Summary	MMU Output kVA, Unit 3
(482)(483)	Summary	MMU Input Power, Unit 3
(484)(485)	Summary	MMU Input kVA, Unit 3
(486)(487)	Summary	MMU Spare telemetry channel, Unit 3
(488)(489)	Summary	MMU Spare telemetry channel, Unit 3
(490)(491)	Summary	MMU Input Current Phase A, Unit 3
(492)(493)	Summary	MMU Input Current Phase B, Unit 3
(494)(495)	Summary	MMU Input Current Phase C, Unit 3
(496)(497)	Summary	MMU Output Current Phase A, Unit 3
(498)(499)	Summary	MMU Output Current Phase B, Unit 3
(500)(501)	Summary	MMU Output Current Phase C, Unit 3
(512)	Summary	MMU Mode, Unit 4
(513)	Summary	MMU State, Unit 4
(514)(515)	Summary	Tachometer, Unit 4
(516)(517)	Summary	Percent Usable Energy, Unit 4
(518)(519)	Summary	Cabinet Temperature, Unit 4
(520)(521)	Summary	Vacuum Gauge, Unit 4
(522)(523)	Summary	MMU Output Power, Unit 4
(524)(525)	Summary	MMU Output kVA, Unit 4
(526)(527)	Summary	MMU Input Power, Unit 4
(528)(529)	Summary	MMU Input kVA, Unit 4
(530)(531)	Summary	MMU Spare telemetry channel, Unit 4
(532)(533)	Summary	MMU Spare telemetry channel, Unit 4
(534)(535)	Summary	MMU Input Current Phase A, Unit 4
(536)(537)	Summary	MMU Input Current Phase B, Unit 4
(538)(539)	Summary	MMU Input Current Phase C, Unit 4
(540)(541)	Summary	MMU Output Current Phase A, Unit 4
(542)(543)	Summary	MMU Output Current Phase B, Unit 4
(544)(545)	Summary	MMU Output Current Phase C, Unit 4

13 ATS Notes and Connections



Notes: Apply to 300 and 1200 Series

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 Command Level
    3. ATS stop Delay timer has expired

Figure 38: ATS Interconnect

14 Application Notes

14.1 Cat UPS Single-Module Systems

14.1.1 General

Feeder sizing – Size the input feeder for maximum input current rather than nominal. This higher value includes current for maximum voltage regulation at low line and simultaneous recharging of the flywheel. Nominal input current is the input current at full load, nominal input voltage and fully charged flywheel.

Dual input is not available on the single module systems

Always size the output feeder the same as the UPS input feeder, unless external over current protection is present on the output. The table below gives output current ratings as well as input to allow output feeder sizing if an external output breaker is used.

Please note that nominal input current is less than rated output current on the 300-kVA systems. This is not a mistake. Nominal input current is measured at nominal input voltage and rated output. The UPS 300 rated output is specified as 300 kVA, 0.8-power factor.
The input power factor is between 0.99 and 1.0 at rated load and nominal input voltage. The power factor improvement under these nominal conditions more than offsets efficiency losses of the UPS and results in the nominal input current being lower than the rated output current. However, since over-current protection is supplied by the customers upstream protection device supply, the UPS input and output feeders must be the same size.

Currents used for conductor sizing

480 VAC

	UPS 150	UPS 300
Power Factor	0.8	0.8
Maximum Input Current	200 A	440 A
Nominal Input Current	151 A	297 A
Nominal Output Current	181 A	361 A

380 VAC

	UPS 120i	UPS 250i
Power Factor	1.0	0.8
Maximum Input Current	230 A	440 A
Nominal Input Current	189 A	315 A
Nominal Output Current 380 VAC	183 A	380 A

400 VAC

	UPS 120i	UPS 250i
Power Factor	1.0	0.8
Maximum Input Current	230 A	440 A
Nominal Input Current	180 A	299 A
Nominal Output Current 400 VAC	173 A	361 A

415 VAC

	UPS 120i	UPS 250i
Power Factor	1.0	0.8
Maximum Input Current	230 A	440 A
Nominal Input Current	173 A	288 A
Nominal Output Current 415 VAC	167 A	348 A

Neutral – The standard system configuration for 480V systems is 3-wire and ground. The standard configuration for 380V, 400V, and 415V is 4-wire and ground, capable of supporting a double sized neutral. If single-phase loads are to be supported directly from the UPS output without an intermediate transformer, then the 4-wire and ground system is required. A 2x neutral is recommended for 4-wire and ground systems.

ATS – Over voltage sensing of the utility and generator (normal and emergency) three-phase voltage is required. Some ATS models do not support this feature, it is available optionally with other models and many models (particularly those using microprocessor control) come with this feature standard. When retrofitting a system into an existing power system with an existing ATS, a Cat UPS System sales representative.

Wire Terminations – The system connection points are bus bars in the left-hand side of the cabinet, and can accommodate two lugs per phase if the optional maintenance bypass is not included and 1 lug per phase if it is included. The neutral accommodates two lugs in either case. The bus bars are drilled for 1- or 2-hole NEMA lugs with ½" hardware. (This will accommodate lugs for cable sizes up to one 500 MCM per phase and 2 500 MCM for the neutral of 4 wire systems.) A ground bus is provided to accommodate multiple 1-hole or 2 hole lugs. **Lugs are not supplied**. Top and/or bottom cable entry is accommodated on the 3 wire and 4 wire systems.

External Maintenance bypass – The system is available with a 3-device maintenance bypass circuit installed in the UPS cabinet. Some engineers and users may require this function to be accommodated within their existing switchgear instead. The power source for an external bypass must be sized to accommodate full system load and be from the same source as the UPS (matching phase and rotation). Some external bypass schemes may require a signal from the UPS system to indicate the UPS is on bypass. This signal is one of the standard output contacts available on the UPS.

Heat rejection – Cooling should be sized for maximum heat rejection shown on the data sheets. This will ensure adequate cooling for continuous operation under worst-case conditions. Although HVAC is sized for worst case, actual losses and heat rejection usually are at or near nominal values.

480 VAC

	UPS 150	**UPS 300**
Maximum Heat Rejection	5.6 kW	15.3 kW
	19,000 btu/hr	52,200 btu/hr

380/400/415 VAC

	UPS 120i	**UPS 250i**
Maximum Heat Rejection	5.6 kW	14.1 kW
	19,000 btu/hr	48,200 btu/hr

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.

Ducting ventilation & Ceiling Height – Operation in a small, enclosed space, such as an outdoor enclosure, is possible if a minimum unobstructed airflow of 1800 CFM is provided. The maximum tolerable backpressure is estimated at 0.05" of H_2O. All units are designed for installation in locations with 8 ft. (2438 mm) minimum ceiling height.

Anchoring – The anchoring structure for the system must be designed to withstand a shearing force of 7650.9 N (1,720 lbf) and lifting force of 3113.8 N (700 lbf) per anchor. 5/8-inch anchors must be used. Minimum distance of the anchors from the edge of slabs or housekeeping pads will vary with the anchor used. See the specification data for the selected anchor for this information. Use the seismic kit for installations that must meet seismic requirements. This kit will allow the UPS to be anchored in accordance with seismic zone 4 and California OSPHD requirements.

Dry contact relays – The UPS provides 6 input (relay coil) and 6 output (form C normally open or normally closed) dry contacts with 6 user selectable functions on input and 6 on output.

Available input functions are as follows:

1 On Generator (allows activation of alternate settings for transient voltage detection, maximum input current and walk-in rate operating parameters)

2 Remote switch UPS to Bypass

3 Remote switch UPS on-line (inhibited if a Notice or Alarm is active)

4 Building Alarm 1 – Triggers External Alarm output contact

5 Building Alarm 2 – Triggers External Alarm output contact

6 Building Alarm 3 – Triggers External Alarm output contact

7 Building Alarm 4 – Triggers External Alarm output contact

8 Fire Alarm – Triggers External Alarm output contact

9 Remote Alarm Silence – Silences the buzzer if a Notice or Alarm is Active

10 Generator Set Start Breaker Open (i.e., if a circuit breaker is required by code, an auxiliary contact of the breaker initiates display of breaker open/closed status.)

11 Room Temperature Abnormal – Indicates excessively high ambient temperature

12 Synchronize to the External Source

13 User Defined Input 1 Notice Message

14 User Defined Input 2 Notice Message

15 User Defined Input 1 Alarm Message

16 User Defined Input 2 Alarm Message

17 Generator Start Output Monitoring Group 1 – used with GENSTART Option

18 Generator Start Output Monitoring Group 2 – used with GENSTART Option

19 Generator Start Output Monitoring Group 3 – used with GENSTART Option

20 Generator Start Output Monitoring Group 4 – used with GENSTART Option

The 4 building alarms, generator set start breaker open, and room temperature abnormal indications are logged as Notices. User Defined Inputs 1 and 2 are either Notices or Alarms, depending on which functions are chosen.

Available output functions are as follows:

1 – 100	Flywheel Percent Energy – Available flywheel energy has decreased to the programmed percentage with system on-line
101	On-line (normal)
102	On Bypass
103	Flywheel Discharging
104	Notice or Alarm Condition is active
105	Alarm Condition is active
106	Overload
107	Cabinet over temperature
108	External Alarm Active – Activated by any one or more of Building Alarm 1-4 or Fire Alarm input contacts
109	Aux Generator Set Start unavailable
110	Overload Bypass – System is on bypass due to an overload condition
111	DC Bus Capacitor Fusible Link Blown
112	Fan Failure
113	Run Generator Set – Used with Generator Set start, enables manual start

114	Pulsed Generator Set Start – Used with Generator Set start, enables manual start
115	Pulsed Generator Set Stop – Used with Generator Set start, enables manual stop
116	ATS Command – When in discharge and total system energy drops below preset level, the contact activates.
117	Motoring – Indicates when a system is in the motoring mode.

TVSS recommended – Although the UPS will protect the load from line surges, and complies with IEEE 587/ANSI 62.41 standards for surge with stand ability, extreme voltage surges may damage the UPS equipment. Therefore, it is recommended that all installations have appropriately sized Transient Voltage Suppression Systems at building electrical service entrance.

14.1.2 Performance/Operation

Voltage regulation and power factor improvement – Using reactive current circulating from the input source through the line inductor and the inverter, output voltage is regulated to +/-2% for +/-10% input voltage at rated load. For input voltages outside the +/-10% range, regulation corrects the voltage by 8% (i.e., -15% input voltage will result in voltage regulation of -7% on the output at full load). At reduced load levels the UPS can regulate the output to 2% over wider input voltage ranges. This same current interchange 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 IGBT inverter switches can 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.

Voltage and Frequency window – In normal operation the utility power passes through the surge protection, static switch, and inductors of the system, is regulated to the specified tolerance value, and passed to the protected load. If the power deviates beyond a selectable range of frequency and voltage (password protected and configured at startup), the on-line inverter will draw power from the flywheel to support the load.

Default settings without flywheel intervention:

Voltage: ±10%
Frequency: ±5%

Typical switching power supplies for computer systems can tolerate higher levels of voltage and frequency variance without any degradation in performance. Therefore, it is possible to adjust to a wider voltage and frequency window for such applications to preserve flywheel energy if deviations greater than the default settings occur regularly.

Walk-in – After input power returns (generator set or utility), the UPS system synchronizes the output to the input (at a maximum slew rate of 2 Hz per second), and varies the inverter voltage phase angle so that it slightly leads the input voltage. The UPS then moves the utility inverter voltage phase angle from slightly ahead of the input voltage to slightly behind at the rate needed to produce the desired load current walk-in rate that is selected for the input source.

Overload while in flywheel discharge mode – In normal operation, the Cat UPS System has a 10x-overload capability for up to 10 milliseconds. The UPS 150i, UPS 250, and UPS 300 systems will immediately transfer to bypass whenever the overload is 200% or greater and utility is within specified tolerances. This assures maximum fault clearing capacity. While on flywheel power (when utility power is not available), the overload rating is 125% either during load discharge or carryover after running overloaded at 125% on utility power. 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 prior to adding them to critical load on the UPS output.

14.1.3 Overloads in Bypass

Line Mode:		
	125%	10 minutes
	150%	2 minutes
	200%	30 seconds
Flywheel Mode:		
	120%	10 seconds
Bypass Mode:		
	125%	Continuous
	200%	1 minute
	500%	1 second
	1000%	10 ms

Overload ratings for the UPS 150i, 250, and 300 kVA systems on the spec sheet indicate the capability of the inverter, when operating from a utility source. If the UPS is overloaded at 200% or more of rated output current, it will transfer to bypass immediately whenever possible. Under overload conditions, the output voltage regulation is not maintained and the output voltage will decrease substantially for overloads of 200% and greater, ultimately approaching zero for short circuit conditions.

Harmonic current distortion – When operating with primarily linear loads the input current harmonic distortion is less than 3% of full load input current. With loads having common harmonic current content levels, the input current distortion will be less than 5%. Under unusual circumstances with large loads having very high harmonic current content, the input current harmonics will still be less than 8%.

Load power factor – The Cat UPS 150i, 250, and 300 systems are configured to maintain specified performance for loads with 0.7 lagging to 0.9 leading power factor. The UPS will continue to operate at full load with load power factors lower than 0.7 lagging, however, the output voltage regulation will not be as good at high load levels. If applying system to loads outside of this range, consult a Cat UPS System sales rep.

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.

Return of utility power – Default setting is automatic restart of the Cat UPS System and powering of protected load. Manual restart is also an option, when operator intervention is desired before re-starting.

14.2 Cat UPS Multi-Module Systems

14.2.1 General

Feeder sizing – Size the input feeder for maximum input current rather than nominal. This higher value includes current for maximum voltage regulation at low line and simultaneous recharging of the flywheel. Nominal input current is the input current at full load, nominal input voltage and fully charged flywheel. Please see the appropriate table below for maximum input currents for the various Cat UPS models. If the N+1 option is added to the UPS 250iE, UPS 300E UPS 500 or UPS 600, add 80 amps to the maximum input current.

If the dual input option is included, size the UPS input for the maximum input current as stated above and size the bypass input for rated output current. Always be sure to size input and output conductors for any planned capacity expansion of the UPS. The power source for the second input must be from the same source as the UPS (matching phase and rotation).

Always size the output feeder the same as the UPS input feeder, unless external over current protection is present on the output. The table below gives output current ratings as well as input to allow output feeder sizing if an external output breaker is used.

Please note that nominal input current is less than rated output current. This is not a mistake. Nominal input current is measured at nominal input voltage and rated output. Rated output is specified as 300 kVA, 0.8 power factor load per MMU. The input power factor is between 0.99 and 1.0 at rated load and nominal input voltage. The power factor improvement under these nominal conditions more than offsets efficiency losses of the UPS and results in the nominal input current being lower than the rated output current. However, since over-current protection is supplied by the customers upstream protection device supply, the UPS input and output feeders must be the same size.

Currents used for conductor sizing

480V

	UPS 300E	**UPS 600**	**UPS 900**	**UPS 900N+1**
Max input Current – 480V	440 A	880 A	1320 A	1320 A
Rated Output Current – 480V	361 A	722 A	1084 A	1084 A

380V, 400V, 415V

	UPS 250iE	**UPS 500**	**UPS 750**	**UPS 750 N+1**
Max input Current	440 A	880 A	1320 A	1320 A
Rated Output Current – 380V	380 A	760 A	1140 A	1140 A
– 400V	361 A	722 A	1084 A	1084 A
– 415V	348 A	696 A	1044 A	1044 A

Neutral – The standard configuration for 480V systems is 3-wire and ground. An optional 4-wire and ground configuration is available as an SER for 480V systems. The standard configuration for 380V, 400V, and 415V is 4 wire and ground, capable of supporting a double sized neutral. If the UPS output supports single-phase loads without an intermediate transformer, then the 4-wire and ground system is required, regardless of system voltage. A neutral is recommended for 4-wire ground systems.

ATS – Over voltage sensing of the utility and generator (normal and emergency) three-phase voltage is required. Some ATS models do not support this feature, it is available optionally with other models and many models (particularly those using microprocessor control) come with this feature standard. When retrofitting a system into an existing power system with an existing ATS, contact applications engineering.

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.

External Maintenance bypass – The system is available with an optional 2- or 3-device maintenance bypass circuit installed in the Input/Output cabinet. Some engineers and users may require this function be included within their existing switchgear instead. Size the power source for an external bypass to accommodate full system load from the same source as the UPS (matching phase and rotation). Some external bypass schemes may require a signal from the UPS system to indicate the UPS is on bypass. This signal is one of the standard output contacts available on the UPS.

Heat rejection – Cooling should be sized for maximum heat rejection shown on the data sheets. This will ensure adequate cooling for continuous operation under worst-case conditions. When installing an N+1 configuration use the heat rejection of the next larger size. This will add more than enough cooling to cover the additional losses for the redundant unit. Although HVAC is sized for worst case, actual losses and heat rejection usually are at or near nominal values.

	UPS 300E	UPS 600	UPS 900	UPS 900 N+1
Maximum Heat Rejection	15.3 kW 52,200 btu/hr	30.6 kW 104,500 btu/hr	45.9 kW 156,700 btu/hr	50.9 kW 173,750 btu/hr

	UPS 250iE	UPS 500	UPS 750	UPS 750 N+1
Maximum Heat Rejection	14.1 kW 48,200 btu/hr	28.3 kW 96,400 btu/hr	42.4 kW 144,750 btu/hr	47.4 kW 161,800 btu/hr

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.

Ducting ventilation & Ceiling Height – Operation in a small, enclosed space, such as a Power Module, is possible if a minimum unobstructed airflow of 1800 CFM per MMU (power stage) plus 900 CFM per System Cabinet and 900 CFM per Input/Output cabinet is provided. The maximum tolerable backpressure is estimated to be 0.05" of H_2O. All units (single and multi module) are designed for installation in locations with 8 ft. (2438 mm) minimum ceiling height.

Anchoring –The anchoring structure for the system must be designed to withstand a shearing force of 7650.9 N (1,720 lbf) and lifting force of 3113.8 N (700 lbf) per Anchor. 5/8 inch anchors must be used. The System and I/O cabinets do not require anchoring in non-seismic installations. Minimum distance of the anchors from the edge of slabs or housekeeping pads will vary with the anchor used. See the specification data for the selected anchor for this information. Use the seismic kit for installations that must meet seismic requirements. This kit will allow anchoring the MMUs, System Cabinet, and I/O Cabinet in accordance with seismic zone 4 and California OSPHD requirements.

Dry contact relays – The UPS provides 6 input (relay coil) and 6 output (form C normally open or normally closed) dry contacts with 6 user selectable functions on input and 6 on output.

Available input functions are as follows:

1 On Generator (allows activation of alternate settings for transient voltage detection, maximum input current and walk-in rate operating parameters)
2 Remote switch UPS to Bypass
3 Remote switch UPS on-line (inhibited if a Notice or Alarm is active)
4 Building Alarm 1 – Triggers External Alarm output contact
5 Building Alarm 2 – Triggers External Alarm output contact
6 Building Alarm 3 – Triggers External Alarm output contact
7 Building Alarm 4 – Triggers External Alarm output contact
8 Fire Alarm – Triggers External Alarm output contact

9 Remote Alarm Silence – Silences the buzzer if a Notice or Alarm is Active

10 Generator Set Start Breaker Open (i.e., if a circuit breaker is required by code, an auxiliary contact of the breaker initiates display of breaker open/closed status.)

11 Room Temperature Abnormal – Indicates excessively high ambient temperature

12 Synchronize to the External Source

13 User Defined Input 1 Notice Message

14 User Defined Input 2 Notice Message

15 User Defined Input 1 Alarm Message

16 User Defined Input 2 Alarm Message

17 Generator Start Output Monitoring Group 1 – Used with GENSTART Option

18 Generator Start Output Monitoring Group 2 – Used with GENSTART Option

19 Generator Start Output Monitoring Group 3 – Used with GENSTART Option

20 Generator Start Output Monitoring Group 4 – Used with GENSTART Option

The 4 building alarms, generator set start breaker open, and room temperature abnormal indications are logged as Notices. User Defined Inputs 1 and 2 are either Notices or Alarms, depending on which functions are selected.

When the Cat UPS is used with a generator set, it is useful to use the building alarm inputs 1 through 4 to alarm an open generator set output breaker, a failed generator set battery charger, or any other abnormal generator set condition that is not included in the generator alarms.

Available output functions are as follows:

1– 100 Flywheel Percent Energy – Available flywheel energy has decreased to the programmed percentage with system on-line

101 On-line (normal)

102 On Bypass

103 Flywheel Discharging

104 Notice or Alarm Condition is active

105 Alarm Condition is active

106	Overload
107	Cabinet over temperature
108	External Alarm Active – Activated by any one or more of Building Alarm 1-4 or Fire Alarm input contacts
109	Aux Generator Set Start unavailable
110	Overload Bypass – System is on bypass due to an overload condition
111	DC Bus Capacitor Fusible Link Blown
112	Fan Failure
113	Run Generator Set – Used with Generator Set start, enables manual start
114	Pulsed Generator Set Start – Used with Generator Set start, enables manual start
115	Pulsed Generator Set Stop – Used with Generator Set start, enables manual stop
116	ATS Command – When in discharge and total system energy drops below preset level, the contact activates to command the ATS to start the generator sets and to transfer.
117	Motoring – Indicates when a system is in the motoring mode.

TVSS recommended – Although the UPS will protect the load from line surges, and complies with IEEE 587/ ANSI 62.41 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 at building electrical service entrance.

14.2.2 Performance/Operation

Voltage regulation and power factor improvement – Using reactive current circulating from the input source through the line inductor and the inverter, output voltage is regulated to +/-2% for +/-10% input voltage at rated load. For input voltages outside the +/-10% range, regulation corrects the voltage by 8% (i.e., -15% input voltage will result in voltage regulation of -7% on the output at full load). At reduced load levels, the UPS can regulate the output to 2% over wider input voltage ranges. This same current interchange 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 somewhat 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 IGBT inverter switches can 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.

Voltage and Frequency window – In normal operation the utility power passes through the surge protection, static switch, and inductors of the system, is regulated to the specified tolerance value, and passed to the protected load. If the power deviates beyond a selectable range of frequency and voltage (password protected and configured at startup), the on-line inverter will draw power from the flywheel to support the load.

Default settings without flywheel intervention:

Voltage: ±10%
Frequency: ±5%

Typical switching power supplies for computer systems can tolerate higher levels of voltage and frequency variance without any degradation in performance. Therefore, it is possible to adjust to a wider voltage and frequency window for such applications to preserve flywheel energy if deviations greater than the default settings occur regularly.

Walk-in – After input power returns (generator set or utility), the UPS system synchronizes the output to the input (at a maximum slew rate of 1 Hz per second), and varies the utility inverter voltage phase angle so that it slightly leads the input voltage. The UPS then moves the utility inverter voltage phase angle from slightly ahead of the input voltage to slightly behind at the rate needed to produce the desired load current walk-in selected for the input source.

Overload while in flywheel discharge mode – In normal operation, the Cat UPS System has up to 10x-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. 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.

14.2.3 Overloads in Bypass

Line Mode:

125%	10 minutes
150%	2 minutes
Up to 200%	30 seconds

Flywheel Mode:

120%	10 seconds

Bypass Mode:

125%	Continuous
200%	1 minute
500%	1 second
1000%	10 ms

Harmonic current distortion – When operating with primarily linear loads the input current harmonic distortion is less than 3% of full load input current. With loads having common harmonic current content levels, the input current distortion will be less than 5%. Under unusual circumstances with large loads having very high harmonic current content, the input current harmonics will still be less than 10%

Load power factor – The Cat UPS System maintains specified performance for loads with 0.8 lagging to 0.8 leading power factor. The UPS will continue to operate at full load with load power factors as low as 0.65 lagging. However, the output voltage regulation will not be as good at high load levels.
If applying system to loads outside of this range, consult a Cat UPS System sales rep.

Running out of flywheel energy – The default action is to transfer to internal bypass (if the bypass is available) when the flywheel runs out of energy before input power returns. Alternatively, the UPS can be set to shut down, turning off power to the load.

Return of utility power – Default setting is automatic restart of the Cat UPS System and powering of protected load. Manual restart is also an option, when operator intervention is desired before re-starting.

15 Generator Set Parameters

v 3.2x

A service-level password provides access to all of the parameters in this list.

The Field Adj. Column represents parameters that are most likely to be set when a UPS is commissioned for a specific customer. Many parameters will not be set to their default values, especially on a 400V, 50 Hz system.

The Low and High limits are only software limits, not functional limits.

	Field Adj.	OP PARAM	Low (L)	High (H)	Default (D)	Comments	Passwd Level (SMS level in paren. if different)
52	g	Generator Set Transient Tol	1	50.0	25.0	Sets the **Transient VAC Tolerance** while the On Generator signal from a Remote Input is high (closed).	SERVICE
53	g	Generator Set Walk-in Rate	10	750.0	85.0	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.	SERVICE
54	g	Generator Set Max. Current	10.0	400.0	400.0	Sets the **Maximum Input current** while the On Generator signal from a **remote input** is high (closed). This could be used with **GS Max. Mtr In Current** to prevent a generator overload when the generator rating smaller than the UPS. A successful installation involving an undersized generator requires the transient response of the generator to be very good.	SERVICE
56	g	Generator Set Motoring Delay	0	120	0	Sets the amount of time the controller will wait after the walk-in before it will start motoring the flywheel. (MMS)This parameter has to be set in each MMU. It can also be a different value in each MMU.	SERVICE
136	g	GS Max Motor Current	10	400	200	Sets the **Maximum Motor Current** while the On Generator signal from a Remote Input is high (closed). A smaller number will reduce the step un-load that occurs at the end of flywheel motoring. This is useful on generators with poor transient performance. This parameter should not be set to 0 and be greater than the **Min. motoring current**.	SERVICE
81	g	GS Max. Mtr In Current	10.0	440	440	Sets the **Max. Mtring In Curr.** while the On Generator	SERVICE

						signal from a Remote Input is high (closed).	
100	g	Generator Set Dis. Volt. Match	0	1	1	When the UPS is ready to start a walk-in from a discharge and the On Generator signal from a **remote input** is high, it will match the input and output voltages before closing the main static switch. If this parameter is set to 0 it will not. Instead it will maintain the **Nominal Voltage** setpoint throughout the walk-in.	SERVICE
4	u	Transient VAC Tolerance	1	50.0	15.0	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.	SERVICE
8	u	Walk-in Rate	10	750.0	85.0	Sets the rate in which the real part (kW) of the load is transferred from flywheel to the input when the system is transitioning from Discharge mode to Online mode. This rate is used at the system level regardless of the number of MMUs. A fast Walk-in Rate can result nuisance trips back into discharge during the Walk-in due to a sagging input voltage.	SERVICE
9	u	Maximum Input Current	10.0	400.0	400.0	Sets the Max 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.	SERVICE
43	u	Max. Mtring In Curr.	10.0	440	440	Sets the Max input current per MMU when the UPS is motoring. If the input voltage (-10%) and load conditions (100% load, 0.8pf lag) exist such that the input current hits this number, the UPS will reduce the amount of voltage correction until the conditions change.	SERVICE
50	u	Maximum Motor Current	10	400.0	200.0	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.	SERVICE

II SERIES 1200

16 Document Scope

The purpose of this document is to provide an overview of the configuration and operation of the Series 1200 UPS and 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 Caterpillar 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 Cat organization and Cat 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 jurisdiction, nor does this document supersede the published specifications for the product.

17 Product Overview

17.1 Configurations

The Series 1200 UPS is a fully integrated 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.

Typical 3-wire UPS 1200 module configurations are shown in the following block diagram. This diagram is simplified and not intended to replace product schematics. Two CSHVs are shown but the UPS can accommodate two, three, or four CSHVs

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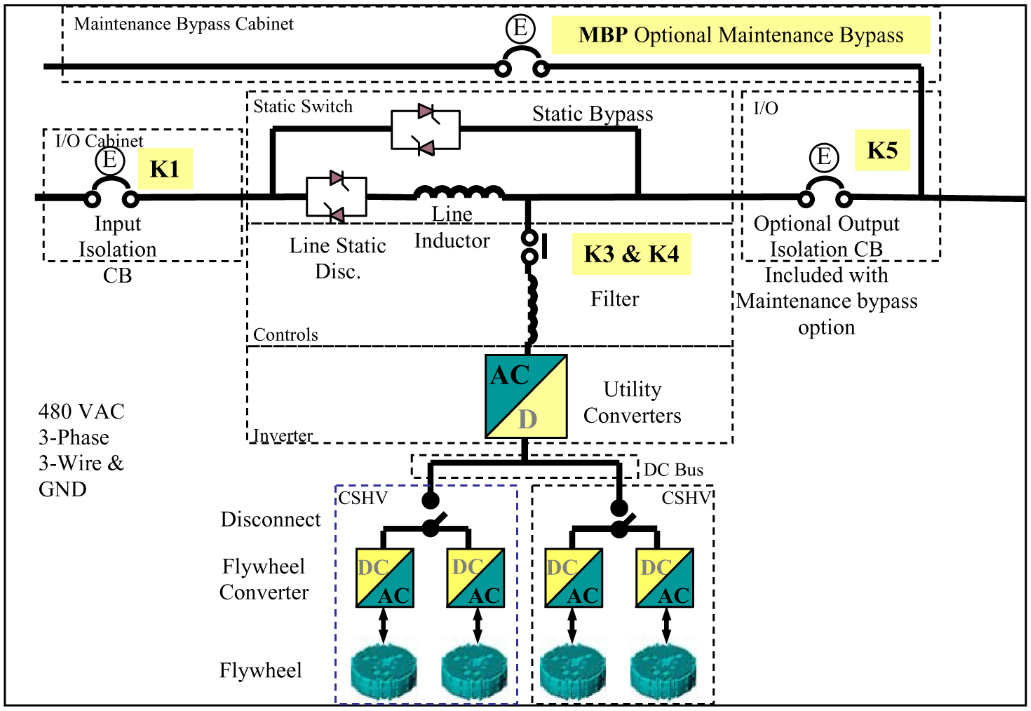

Figure 39: UPS 1200 3-Wire with 2 CSHVs, Maintenance Bypass and Output Breaker Options

The major 3-Wire UPS system components and the cabinets in which they are located are shown in the following list:

- Input Circuit Breaker (K1) – I/O Cabinet
- Bypass Static Switch – Static Switch Cabinet
- Line Static Switch – Static Switch Cabinet
- Line Inductor – Static Switch Cabinet
- Inverter 1 Contactor (K3) – Controls Cabinet
- Inverter 2 Contactor (K4) – Controls Cabinet
- Filter Inductors – Controls Cabinet
- Utility Inverter 1 – Inverter Cabinet (Note inverter 1 and 2 operate in parallel as a single unit)
- Utility Inverter 2 – Inverter Cabinet (Note inverter 1 and 2 operate in parallel as a single unit)
- Optional maintenance bypass – Maintenance bypass cabinet (K5 is also included in this option)
- Output (K5) – I/O Cabinet (Optional)
  - K5 with Maintenance Bypass is a motorized output circuit breaker in 3-W systems and is provided as part of the maintenance bypass.
  - K5 without Maintenance Bypass is available as the output breaker option **in 3-wire systems**, is a manually operated output isolation breaker except in parallel systems, in which it will be electrically operated.
  - Without maintenance bypass option or output breaker option, there is no K5 breaker

Each CSHV cabinet contains the following components:

- DC Disconnect Switch
- Flywheel A Inverter
- Flywheel B Inverter
- Flywheel A
- Flywheel B

The UPS system records and displays messages that refer to these components and their operating states.

The DC Bus is common to the Inverter Cabinet and the CSHVs that make up the system. The DC Bus is located in the wire way above the inverter and CSHV cabinets. Each CSHV has a manually operated internal DC disconnect switch, which is used to isolate it from the rest of the system. The CSHV must be isolated for safety reasons when being serviced unless the entire UPS is shut down.

Typical UPS 1000 and UPS 1200 4-wire module configurations are shown in the following block diagram. This diagram is simplified and not intended to be product schematics. Two CSHVs are shown but the UPS can accommodate two, three, or four CSHVs.

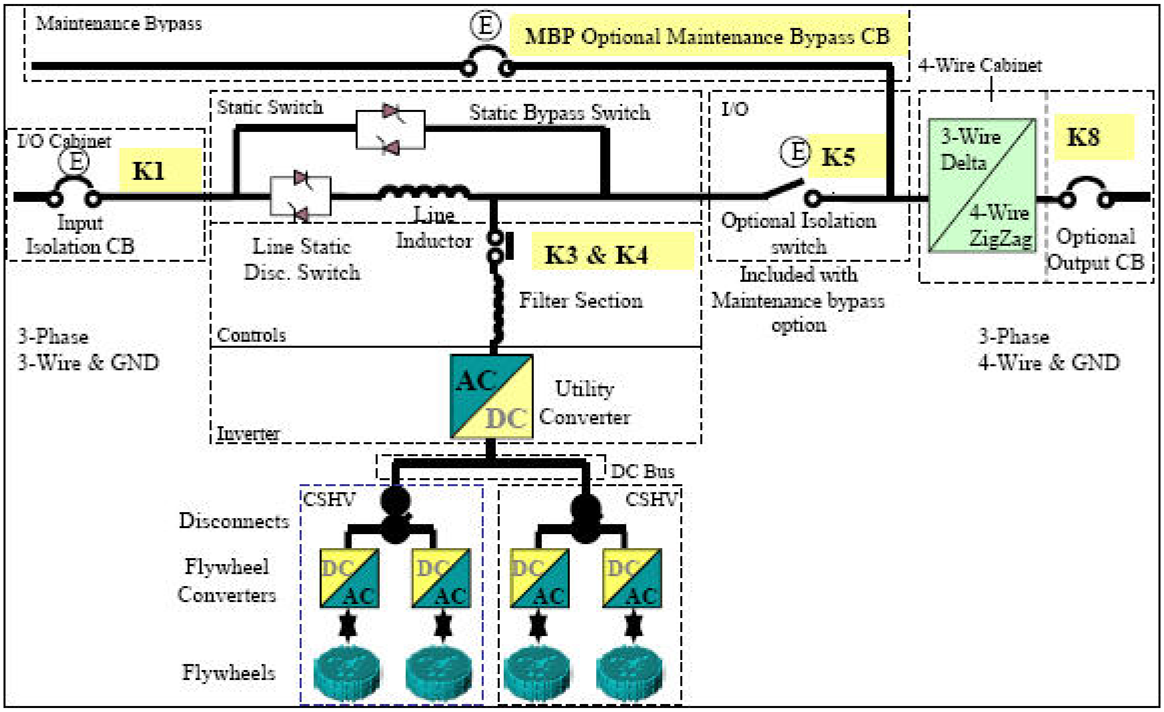

Figure 40: UPS 1200 4-Wire or UPS 1000 with 2 CSHVs, Maintenance Bypass and Output Breaker Options

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

- Input Circuit Breaker (K1) – I/O Cabinet
- Bypass Static Switch – Static Switch Cabinet
- Line Static Switch – Static Switch Cabinet
- Line Inductor – Static Switch Cabinet
- Inverter 1 Contactor (K3) – Controls Cabinet
- Inverter 2 Contactor (K4) – Controls Cabinet
- Filter Inductors – Controls Cabinet
- Utility Inverter 1 – Inverter Cabinet (Note inverter 1 and 2 operate in parallel as a single unit)
- Utility Inverter 2 – Inverter Cabinet (Note inverter 1 and 2 operate in parallel as a single unit)
- Optional maintenance bypass (MBP and K5 are both included in this option)

- Bypass Isolation (K5) –
  I/O Cabinet (optional)
  - K5 with Maintenance Bypass is a motorized non automatic circuit breaker (switch) and is provided as part of the maintenance bypass.
  - K5 without Maintenance Bypass is normally not included in 4-wire systems
- Transformer Cabinet with Delta/ZigZag transformer
- 4-wire Output Cabinet with Optional 4-Wire Output Breaker (K8)
  - K8 Output Breaker not included unless an output breaker option is selected
  - K8 Output Breaker is manually operated except in paralleled systems
  - K8 is available as a 3-pole or 4-pole breaker in 380V – 415V systems but only as a 3-pole breaker in 480V 4-wire systems
  - K8 is never part of 3-wire systems

Each CSHV cabinet contains the following components:

- DC Disconnect Switch
- Flywheel A Inverter
- Flywheel B Inverter
- Flywheel A
- Flywheel B

Become familiar with these components, their designations, and their system locations. The system records and displays messages that refer to these components and their operating states.

The DC Bus is common to the Inverter Cabinet and all the CSHVs that make up the system. The DC Bus is located in the wire way above the Inverter and CSHV Cabinets. Each CSHV has a manually operated internal DC disconnect switch, which is used to isolate it from the rest of the system. The CSHV must be isolated for safety reasons when being serviced unless the entire UPS is shut down.

17.2 Operation

The UPS automatically supplies AC electrical power to the critical load during certain 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 Graphical User Interface (GUI). The GUI is located on the Control Cabinet.

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.

17.2.1 Operating Modes

The main operating modes are:

- Online Mode
- Bypass Mode
- Automatic Voltage Regulation (AVR) Mode
- Shutdown Mode

The operator can command the system to enter the online or bypass modes via the GUI. When an operator presses the EPO button on the front of the Controls Cabinet, the system enters the Shutdown mode. The operator cannot directly place the system into the AVR mode. AVR is a special operating mode to which the system transitions only under certain conditions. If the system is in the Online Mode, it may automatically transition to the Bypass, Shutdown, or AVR modes depending on internal and external UPS system conditions.

17.2.2 Online Mode with 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. When online, output voltage is being regulated in steady state to within +/-2% of its nominal set point. Online Mode has three major states. The first two occur when input power is present and are the following:

Online Charging – The system enters this state when the flywheel reaches 4000 RPM. The system is charging in this state. The system can sustain discharge in this state.

Online Standby – When the speed of the flywheel reaches full charge speed, 7700 RPM, the system is in the Online standby state.

The following diagram shows the current flows in these Online Mode states:

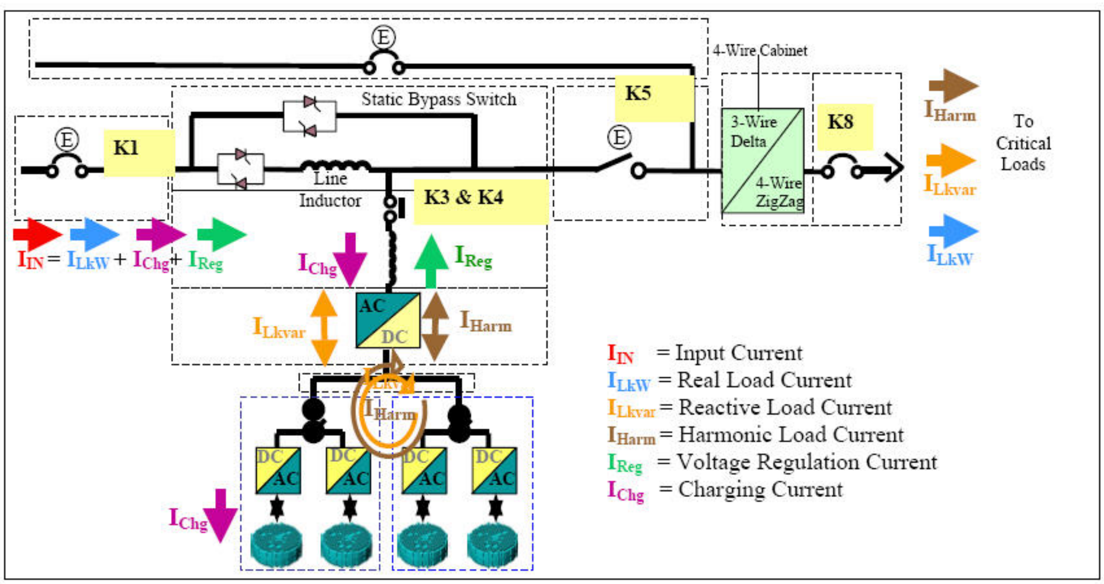

Figure 41: Online Mode With Input Power Present

In the online standby state, the current I_{LkW} to provide kilowatts for the load flows from the input to the load. No energy is taken from the flywheel. The Utility Converter regulates output voltage by exchanging reactive regulating current, I_{Reg}, with the input through the line inductor. A small amount of charging current, I_{Chg}, flows into the flywheels to maintain them at full speed. The reactive and harmonic currents, I_{Lkva} and I_{Harm}, are provided to the load by the utility converter, not by the input power source to the UPS. Please note that Online Standby state does not imply that the UPS is a standby UPS. The UPS is an online UPS 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.

In 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.

17.2.3 Online Discharging

The UPS system automatically enters this state when it is in Online Mode and input power to the UPS is disrupted.

The UPS disconnects from the failed input power supply and supplies all of the current, including the real current, I_{LkW}, which supplies kilowatts to the load. A discharge is triggered by the input voltage or frequency deviating outside of the tolerance limits set for the UPS. These limits are adjustable. There are separate tolerance limits for fast input voltage deviation detection and RMS voltage deviation detection. A discharge will also be triggered if the DC bus voltage of the UPS drops below a preset limit, indicating that power is not being delivered to the UPS from the input source.

The UPS turns off the static disconnect switch as soon as it starts discharging and 5 seconds later opens the input breaker (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 flywheels gradually slow down as they deliver power. When input power returns, 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. The ramp rate is adjustable in kW per second.

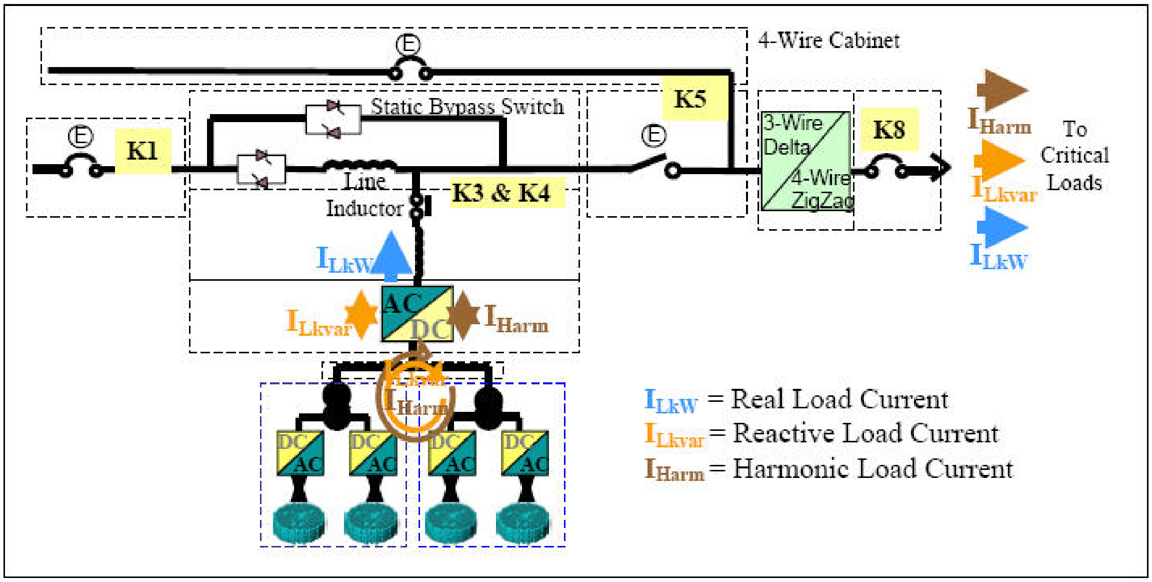

Figure 42: Online Discharging Mode

17.2.4 Automatic Voltage Regulation (AVR) Mode

The UPS will enter AVR mode if the UPS is operating form input power and there is insufficient flywheel energy available to support the load. In this mode the UPS is regulating and conditioning output power and as it does in Online-Mode, but it will not be able to support the load if the input source fails. The system will enter AVR mode automatically if the UPS has transferred to bypass during an exhaustive discharge. (i.e. the input power was present but the UPS ran out of flywheel energy before walk-in was completed). As soon as the UPS restarts the load will be transferred from bypass but it will not discharge until the flywheels RPM exceed 4000 RPM. At that point, the unit returns to Online Charging mode. The UPS will also enter AVR Mode if insufficient CSHVs are operating to support the load actually connected to the UPS (as opposed to rated load).

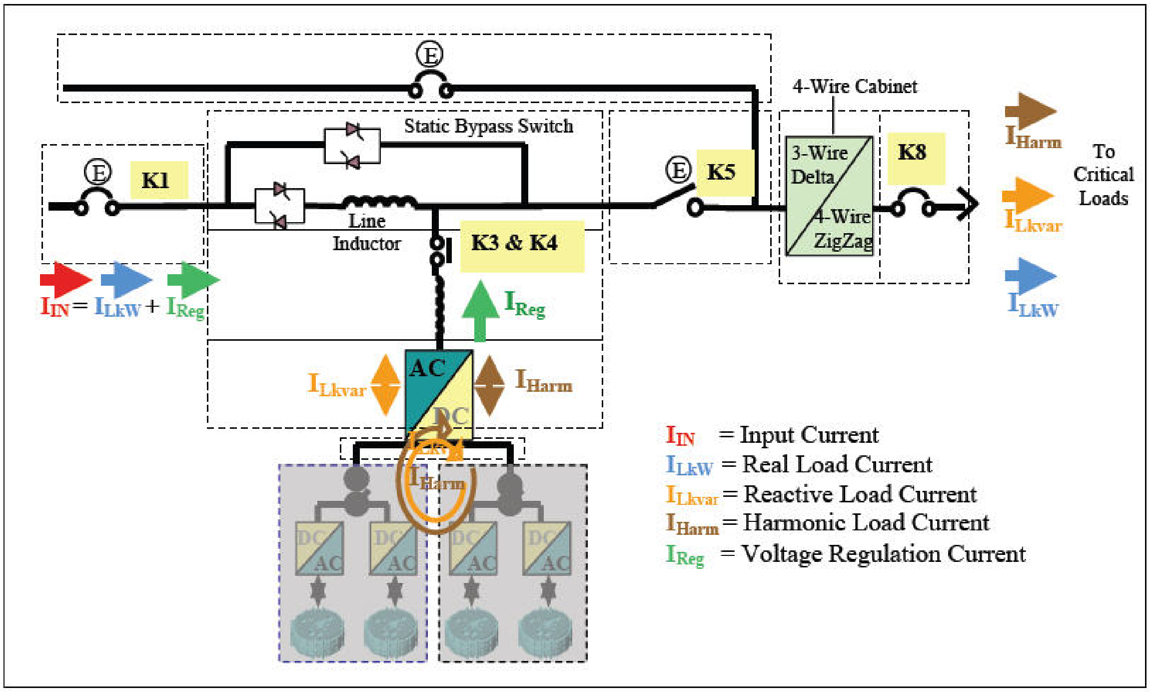

Figure 43: AVR Mode – Flywheel Energy Not Available

17.2.5 Bypass Mode

Bypass Mode directly connects the incoming utility power to the load through the Static Bypass, bypassing the UPS system. The next figure shows system power flow when in bypass mode. The load **is not protected** when the system is in Bypass Mode and will be affected by a disruption of the incoming power.

When in bypass mode, the power will still flow through k1 and K5 if it is included. In 4-wire systems the power will also flow through the 4-wire transformer and K8 if it is included. The static disconnect switch is off, and K3 and K4 are open.

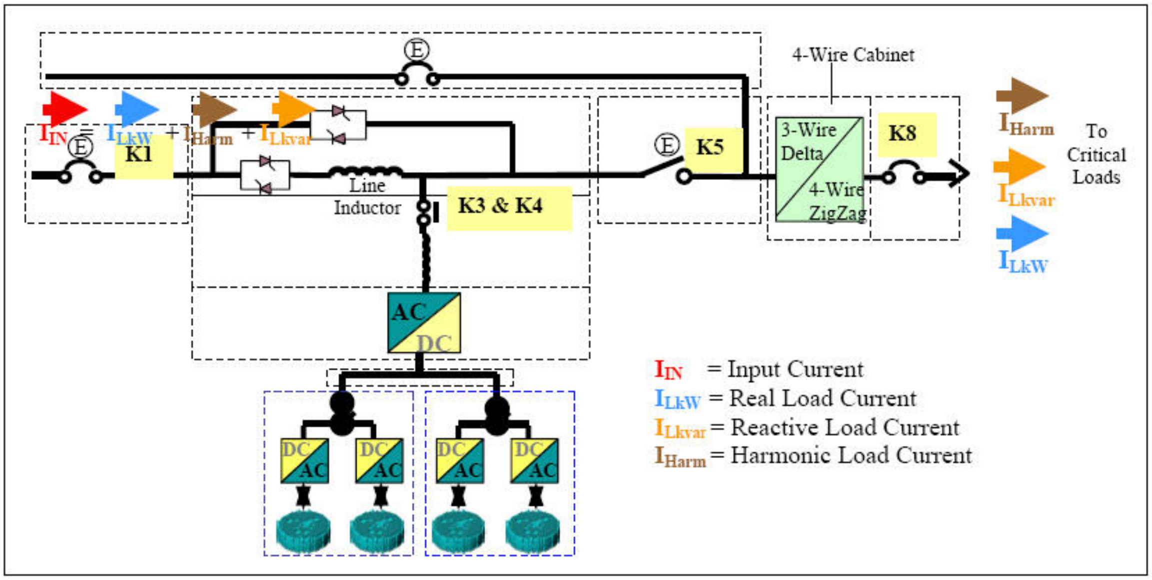

Figure 44: Bypass Mode

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

- System start-up
- Operator command via GUI or monitoring software
- Output overload
- Failure to recover from a fault

Repeated errors causing the system to switch between Bypass and Online Modes can lock the system in Bypass Mode. When the system is locked in Bypass Mode, the operator must intervene to bring the system back online. This is done either via the GUI or the monitoring software.

There are two important Bypass Mode states:

17.2.5.1 Bypassed-Offline

This is the state the system enters when it is commanded to bypass via operator input, or when the system has been locked into bypass because of a fault condition. The system can only leave this state when commanded by an operator via the GUI or monitoring software.

17.2.5.2 Bypassed-Verify Signals

When in this state, the system is verifying that the correct system telemetry is present. This state is used when starting the system and when recovering from errors. This is the state the system stays in if an operator tries to bring the UPS online and there are unacknowledged or active notices or alarms in the event log.

17.2.5.3 Shutdown Mode

When the system is in the Shutdown mode, K1 is open. There is no power flow through the system when the system is shutdown 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 any 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 (if installed).
- There are internal or external conditions that could lead to system failure.

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 control cabinet that needs to be moved to the “I” position.

18 Input

18.1 Input Currents and kW

The Series 1200 is a line interactive UPS. That means that the input current, kW and power factor vary not only with changes in the amount of load on the UPS but also as a function of input voltage. The more the input voltage varies from nominal the more reactive current is required to regulate the output voltage. This regulating current is the I_{Reg} current shown in Fig. 3 above.

UPS modules are constant power (kW) Loads. That means as input voltage falls for a given load on the UPS, the real input current to the UPS I_{LkW} rises because the UPS must delivers the same kW to its load. Actually, the UPS input kW actually rises as input voltage deviates from nominal because the utility converter in the UPS has to work harder to produce the additional voltage regulating current I_{Reg} which reduces UPS efficiency.

Calculating input currents is not easy to do. Real, reactive and harmonic currents must all be treated as vectors pointing in different directions. Therefore, tables have been developed for input currents and input kW at different load levels and input voltage variations from nominal. Close approximations for input voltages and loads between the points in the table can be made by using straight line interpolation. Except in very unusual cases, load harmonic currents do not significantly affect the amount of UPS Input current.

Input voltage tolerance limits are programmable in the field by service personnel. The maximum settings are +10%/-15%. Factory default settings are at +10%/-10%, which is the input voltage range for maintaining specified output voltage regulation **at full load.** At lesser load levels, regulation is maintained over a wider input voltage range but the UPS will discharge and disconnect from the input source if the input voltage deviates beyond the input voltage tolerance window that has been programmed, even if the UPS could have maintained regulation over a wider voltage range.

18.1.1 Input Currents and kW: Normal On-line Operation (Online Standby) UPS 1200 3W 480V

INPUT kW ONLINE STANDBY						
% Load	85% Nominal	90% Nominal	95% Nominal	Nominal	105% Nominal	110% Nominal
100%	999	997	994	990	985	980
75%	757	755	754	750	746	743
50%	512	510	508	505	505	508
25%	262	260	259	258	258	259

INPUT CURRENT (AMPS) ONLINE STANDBY						
% Load	85% Nominal	90% Nominal	95% Nominal	Nominal	105% Nominal	110% Nominal
100%	1536	1402	1245	1193	1277	1457
75%	1360	1154	968	909	1013	1221
50%	1275	950	705	605	753	1005
25%	1199	816	470	314	550	896

18.1.2 Input Currents and kW: Recharging (Online Recharge) at Default Recharge Rate UPS 1200 3W 480V

INPUT kW ONLINE RECHARGE DEFAULT RATE 2 CSHV						
% Load	85% Nominal	90% Nominal	95% Nominal	Nominal	105% Nominal	110% Nominal
100%	1074	1147	1144	1140	1135	1130
75%	907	905	904	900	896	893
50%	662	660	658	655	655	658
25%	412	410	409	408	408	409

INPUT CURRENT (AMPS) ONLINE RECHARGE DEFAULT RATE 2 CSHV						
% Load	85% Nominal	90% Nominal	95% Nominal	Nominal	105% Nominal	110% Nominal
100%	1600	1584	1430	1369	1430	1583
75%	1521	1324	1150	1086	1161	1338
50%	1398	1096	878	785	893	1106
25%	1276	916	614	493	659	962

18.1.3 Input Currents and kW: Recharging (Online Recharge) at Minimum Recharge Rate ups 1200 3W 480V

INPUT kW ONLINE RECHARGE MINIMUM RATE 2 CSHV						
% Load	85% Nominal	90% Nominal	95% Nominal	Nominal	105% Nominal	110% Nominal
100%	1074	1072	1069	1065	1060	1055
75%	832	830	829	825	821	818
50%	587	585	583	580	580	583
25%	337	335	334	333	333	334

INPUT CURRENT (AMPS) ONLINE RECHARGE MINIMUM RATE 2 CSHV						
% Load	85% Nominal	90% Nominal	95% Nominal	Nominal	105% Nominal	110% Nominal
100%	1600	1493	1337	1281	1353	1519
75%	1439	1238	1058	997	1086	1278
50%	1334	1021	790	695	821	1053
25%	1234	862	539	403	601	926

18.1.4 Input Currents and kW: Normal On-line Operation (Online Standby) UPS 1200 4W 480V

INPUT kW ONLINE STANDBY						
% Load	85% Nominal	90% Nominal	95% Nominal	Nominal	105% Nominal	110% Nominal
100%	1034	1032	1029	1025	1020	1015
75%	776	775	773	769	766	762
50%	527	524	522	519	519	522
25%	279	278	277	276	276	277

INPUT CURRENT (AMPS) ONLINE STANDBY						
% Load	85% Nominal	90% Nominal	95% Nominal	Nominal	105% Nominal	110% Nominal
100%	1543	1415	1289	1232	1289	1445
75%	1346	1152	992	930	1012	1194
50%	1243	944	725	622	752	976
25%	1160	825	502	334	564	869

18.1.5 Input Currents and kW: Recharging (Online Recharge) at Default Recharge Rate UPS 1200 4W 480V

INPUT kW ONLINE RECHARGE DEFAULT RATE 2 CSHV						
% Load	85% Nominal	90% Nominal	95% Nominal	Nominal	105% Nominal	110% Nominal
100%	1174	1182	1179	1175	1170	1165
75%	926	925	923	919	916	912
50%	677	674	672	669	669	672
25%	429	428	427	426	426	427

INPUT CURRENT (AMPS) ONLINE RECHARGE DEFAULT RATE 2 CSHV						
% Load	85% Nominal	90% Nominal	95% Nominal	Nominal	105% Nominal	110% Nominal
100%	1720	1601	1473	1408	1445	1575
75%	1513	1325	1174	1107	1163	1316
50%	1373	1094	897	802	895	1083
25%	1244	929	646	514	676	940

18.1.6 Input Currents and kW: Recharging (Online Recharge) at Minimum Recharge Rate UPS 1200 4W 480V

INPUT kW ONLINE RECHARGE MINIMUM RATE 2 CSHV						
% Load	85% Nominal	90% Nominal	95% Nominal	Nominal	105% Nominal	110% Nominal
100%	1109	1107	1104	1100	1095	1090
75%	851	850	848	844	841	837
50%	602	599	597	594	594	597
25%	354	353	352	351	351	352

INPUT CURRENT (AMPS) ONLINE RECHARGE MINIMUM RATE 2 CSHV						
% Load	85% Nominal	90% Nominal	95% Nominal	Nominal	105% Nominal	110% Nominal
100%	1637	1508	1381	1320	1366	1509
75%	1428	1238	1083	1018	1087	1254
50%	1305	1017	810	712	822	1027
25%	1198	873	571	424	616	901

18.1.7 Input Currents and kW: Normal On-line Operation (Online Standby) UPS 1000 4W 400V

INPUT kW ONLINE STANDBY						
% Load	85% Nominal	90% Nominal	95% Nominal	Nominal	105% Nominal	110% Nominal
100%	981	979	976	972	967	963
75%	736	735	733	730	726	723
50%	494	492	490	488	488	490
25%	265	264	263	262	262	263

INPUT CURRENT (AMPS) ONLINE STANDBY						
% Load	85% Nominal	90% Nominal	95% Nominal	Nominal	105% Nominal	110% Nominal
100%	1709	1580	1468	1405	1438	1586
75%	1483	1290	1143	1068	1136	1317
50%	1322	1028	817	702	826	1047
25%	1188	880	565	377	613	902

18.1.8 Input Currents and kW: Recharging (Online Recharge) at Default Recharge Rate UPS 1000 4W 400V

INPUT kW ONLINE RECHARGE DEFAULT RATE 2 CSHV						
% Load	85% Nominal	90% Nominal	95% Nominal	Nominal	105% Nominal	110% Nominal
100%	1041	1076	1116	1112	1107	1103
75%	876	875	873	870	866	863
50%	634	632	630	628	628	630
25%	405	404	403	402	402	403

INPUT CURRENT (AMPS) ONLINE RECHARGE DEFAULT RATE 2 CSHV						
% Load	85% Nominal	90% Nominal	95% Nominal	Nominal	105% Nominal	110% Nominal
100%	1720	1720	1675	1604	1618	1739
75%	1678	1491	1349	1269	1312	1460
50%	1473	1200	1010	904	990	1173
25%	1288	1001	724	577	742	988

18.1.9 Input Currents and kW: Recharging (Online Recharge) at Minimum Recharge Rate ups 1000 4W 400V

INPUT kW ONLINE RECHARGE MINIMUM RATE 2 CSHV						
% Load	85% Nominal	90% Nominal	95% Nominal	Nominal	105% Nominal	110% Nominal
100%	1041	1049	1046	1042	1037	1033
75%	806	805	803	800	796	793
50%	564	562	560	558	558	560
25%	335	334	333	332	332	333

INPUT CURRENT (AMPS) ONLINE RECHARGE MINIMUM RATE 2 CSHV						
% Load	85% Nominal	90% Nominal	95% Nominal	Nominal	105% Nominal	110% Nominal
100%	1720	1687	1571	1504	1527	1662
75%	1579	1390	1246	1169	1223	1387
50%	1395	1112	912	803	907	1108
25%	1234	936	641	477	674	941

18.1.10 Example of Linear Interpolation in Section 3.1.1 through Section 3.1.9 Tables

This example uses the input current table in section 3.1.1. Assume the UPS is operating at 80% of rated load with a source that provides 93% of nominal voltage. Determine the input current from the table as follows:

In the 90% voltage column:

$(0.8 - 0.75)/(1.0 - 0.75)*(I_{100\%} - I_{75\%}) + I_{75\%} = I_{80\%}$ at 90% Voltage

In the 95% voltage column:

$(0.8 - 0.75)/(1.0 - 0.75)*(I_{100\%} - I_{75\%}) + I_{75\%} = I_{80\%}$ at 95% Voltage

Using the two currents just calculated

$(0.93 - 0.9)/(.95 - 0.9)*(I_{80\%\text{ at }95\%V} - I_{80\%\text{ at }90\%V}) + I_{80\%\text{ at }90\%V} = I_{80\%\text{ at }93\%\text{ Voltage}}$

Note: $(I_{80\%\text{ at }95\%V} - I_{80\%\text{ at }90\%V})$ should be a negative number.

18.1.11 Input Current Limits

The RMS input current to the UPS is limited by the Firmware. The factory default setting is the maximum setting. Lower limits are field programmable. However, reducing the input current limit will reduce some or all of the following: maximum load the UPS can support, amount of voltage regulation the UPS can provide, available recharge current available (which lengthens the recharge time). When the UPS reaches input current limit during operation, it will first reduce any recharge current until the recharge current reaches the minimum allowable value. If further restriction is required, the UPS will then start to reduce the amount of voltage regulation that it provides, and finally, if the current limit has been set so low that the UPS is cannot support the load, the UPS will go to bypass. **Depending on load power factor, and input voltage at a particular moment in time, the load may actually draw higher current (but not kW) from the source than the UPS.**

The factory default (Maximum) input current limits are the following:

UPS 1200 3W 480V	UPS 1200 4W 480V	UPS 1000 4W 400V
1600 amps	1720 amps	1720 amps

18.1.12 Inrush Currents

Three-wire UPS have no inrush currents. Only 4-wire UPS have inrush currents under a few unusual circumstances. In a normal starting sequence the 4-wire transformer is initially energized by the static bypass. The bypass uses a soft start feature, to hold magnetizing inrush current to the transformer below full load current. However If the transformer is initially energized through the maintenance bypass breaker the inrush current cannot be controlled. Then the inrush lasts less than two cycles and the estimated worst case half cycle RMS inrush currents are less than 3 times the full load input current.

There is no inrush for three wire units or when the line inductor of 4-wire units are energized because the input and output voltages of the UPS are frequency and phase matched before the static disconnect switch is turned on and the UPS also has a soft start feature to energize the DC bus of the UPS.

18.1.13 Input Power Factor

Input Harmonic currents to the UPS are normally low. Therefore input power factor is determined by displacement power factor, the cosine of the angle between input voltage and current. 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 (as viewed from the input source) 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 a given voltage difference, the amount of reactive current is always the same regardless of the load on the UPS. The input power factor however, will not always be the same for a given voltage difference (except at nominal where the difference is zero) because the power factor depends on the reactive current and the real current (kW). Therefore, input power factor swings over a wider range at light kW loads than at heavy loads even though the amount of reactive current stays the same. Typical power factors at various voltages and loads can be obtained from the current and kW tables in 3.1.1 through 3.1.9. Using corresponding entries from the current and kW tables in the same section,

$$\text{P.F.} = \frac{\text{kW}}{(\text{amps} \times 1.73 \times \text{nominal volts} \times \text{voltage \%})}$$

The voltage percentage is in the first row of each table.

Nominal voltage is either 480 or 400 depending on the table used.

Please note that **you cannot determine the correct input voltage of the UPS for the purposes of this calculation by reading the UPS input voltage with the UPS Online**. See the section on voltage regulation for details.

18.2 Input Current Harmonics

The input current harmonics reflected into the input supply by the UPS are low. With a linear load input current harmonic content is less than 3%. 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, US 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 bottom line is that the UPS **adds** very little harmonic content and greatly attenuates harmonic content that would be present if the load were attached directly to the input. The load needs these harmonic currents to operate properly, but they are supplied primarily by the utility converter of the UPS and are shown as I_{Harm} Fig. 3 through Fig. 6 above. 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).

18.3 Utility Sources

In general Utility sources should be sized by professional engineers who are aware of all of the load characteristic, 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.

18.3.1 Voltage

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 Series 1200 UPS does not require a neutral. See the section on grounding for more detail.

18.3.2 Utility 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.

18.3.3 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 37.5 kW per CSHV at 480V or 35 kW at 400 V (18.75 kW and 17.5 kW per flywheel, respectively).
- 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 voltage regulation.

18.3.4 Breaker Sizing

The input breakers (K1) maintenance bypass breakers (MBP) and output breakers (K5–3W or K8–4W) used in the UPS Modules are the following:

UPS Module	Breaker Designation and Type	Trip Unit Settings	
UPS 1200 3W 480V	K1 and MBP (when included) ABB S8 insulated case circuit breakers electronic trip units 1600 amps Dual listed and labeled CE and UL/CUL	L I1 x In t1 S I2 x In t2 I^2 I I3 x In G	 1.0X D 6.0X C Off 10X N/A
UPS 1200 3W 480V	K5 (output, when included) ABB S8 insulated case circuit breakers electronic trip units 1600 amps Dual listed and labeled CE and UL/CUL	L I1 x In t1 S I2 x In t2 I^2 I I3 x In G	 1.0x D 2.0X C On Off N/A
UPS 1000/1200 4W	K1 (input) and MBP (maintenance bypass, when included) Breaker Rating and Type ABB S8 insulated case circuit breaker electronic trip unit 2000 amps Dual listed and labeled CE and UL/CUL	L I1 x In t1 S I2 x In I2 x In t2 I^2 I I3 x In G	 0.9x C 6.0X w/o K8 6.0X w K8 C Off 8X K1 10X MBP N/A
UPS 1000/1200 4W	K8 (output, when included) breaker rating and type ABB E3S16 3 pole or ECS16 4 pole	L I1 x In t1 S I2 x In It2 I^2 I I3 x In G I4 x In t4	 1.0x C 2.0X D On Off 0.4x A(0.1s)

The circuit breaker settings **must not** be changed. Doing so violates the product UL listing or CE mark.

The **minimum** supply breaker sizes are shown in the following table.

UPS Module	Minimum Breaker Rating
UPS 1200 3W 480V	1600 amps input and MBP
UPS 1000/UPS 1200 4W	2000 amps input and MBP

The minimum supply circuit breaker size is the same as the corresponding K1, and the minimum maintenance bypass supply breaker sizing is the same as the corresponding MBP. **It may not be possible in all cases to use this minimum breaker size, particularly in the case of a 1600 amp supply breaker upstream of the UPS 1200 3-wire**. In the case of the UPS 1200 3-wire, the UPS input current limit is the same as the breaker rating. Different breakers may have characteristics including trip tolerance bands or de-rating requirements that require use of a 2000 amp breaker in the customer's electrical system. When sizing breakers the following should always be considered:

- The characteristics of the breaker are known to accommodate the maximum input currents that it may be subject to **under the conditions in which it will be installed,** and
- A coordination study has been performed to determine that it will properly coordinate with the breakers in the UPS.
- 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 1200 kVA 3-wire, 480 volt unit operating at rated capacity supplies 1445 amps to the load. If that load transfers to bypass at 10% low voltage, the bypass current to this load will be 1600 amps, not the 1445 amps that it draws at nominal voltage. You cannot assume that because the UPS breaker is rated 1600 amps that any 1600 amp breaker installed under any conditions can provide the same current carrying capability.
- **If the breaker characteristics are unknown or are inadequate to accommodate full UPS performance at design load, use a larger supply beaker than the minimum size.** This also means that the wiring on the input of the UPS must be increased and, for 3-wire systems the output wiring.

18.3.5 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, 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 wire de-ratings** for the rating of the breaker supplying it. A wiring guide is attached as appendix 1. It lists wire sizes appropriate for the minimum breaker size. If you use a larger breaker you cannot use the wire sizes in the table. The sizes in the guide assume a set of installation conditions and also assume an appropriate type of wire is used for the stated temperature and installation conditions. Metric equivalent sizes are also included in the guide.

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 for the Series 1200 UPS.

18.4 Diesel Generator Set Power sources

The Cat series 1200 is designed to work with diesel generator sets. **Consult the factory before using with natural gas generator sets.** Natural gas generator sets have operating characteristics that can make them unsuitable for use with UPS systems.

18.4.1 General Requirements

Generator sets used with Cat UPS 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.

18.4.2 Generator Set Sizing

A generator set has to be sized not only to operate the UPS, but also to supply the UPS load directly on bypass while the UPS is started and the flywheels are charged. The general rule is that the generator should have **1 kW of available capacity for every kVA of rated UPS capacity**. Note that this is based on rated UPS capacity not the actual load on the UPS. For example, a 1000 kW generator set is the minimum generator set size that should be used with a 1000 kVA UPS when no other loads will be supplied by that generator set. This sizing provides sufficient generator capacity to supply nameplate UPS load, UPS losses and default or nearly default UPS recharging power (12 kW less than default for UPS 1000). It also allows sufficient capacity for normal UPS loads to operate on bypass while supply power to start the UPS.

With loads that have unusually low power factor or high harmonic content, the generator set size may need to be increased to supply the high reactive or harmonic currents of the load. Consult the appropriate generator set applications guide for information on sizing generator sets for such loads. In addition to the UPS load operating in bypass, the generator set must support UPS charging Power in the range of 150 kW (default recharge) to 75 kW (minimum recharge) with the standard compliment of 2 flywheel cabinets (4 flywheels) plus no load losses of 11 kW for 3-wire UPS and 32 kW for 4-wire UPS. Each additional flywheel cabinet (2 flywheels) attached to a UPS module adds 75 kW (default) or 37.5 kW (minimum) to the charging power up to the maximum of four flywheel cabinets. All flywheels recharge at the same rate. The on Generator Signal should be connected to the UPS as covered below in section 3.4.4. When sizing using less than the default recharge power, the GS Max Charging In Curr. Parameter must be set to the reduced recharge value at start-up. The UPS does no voltage regulation until the load is committed to it. Therefore, the input power factor of the UPS while starting is unity.

System	Charging Rate	2 Flywheel Cabinets	3 Flywheel Cabinets	4 Flywheel Cabinets
3-Wire	Default	161	236	311
3-Wire	Minimum	86	124	161
4-Wire	Default	182	257	332
4-Wire	Minimum	107	146	182

UPS system Starting kW/kVA

The general rule above can result in significantly oversized generator sets in situations involving redundant UPS systems. For example suppose two 1000 kVA UPS modules are being used in a system-plus-system redundant manner (also known as 1+1 redundant in this case). In normal operation each UPS supplies half of the load. However, if one UPS fails, its portion of the load is seamlessly assumed by the other, using means such as static transfer switches, dual power cord loads paralleling, or similar non-interruptive techniques. In this case, using a 2 MW generator set sized according to the general rule provides more power than is needed for the UPS modules alone. When encountering situations in which the maximum capacity that a group of UPS module must support will **always** be significantly less than the total rated capacity of the modules, use the input current and power tables in section 3.1. With the maximum number of UPS modules operating, calculate the input current and kW for each of the UPS modules, including recharge, with the entire critical power system operating at design capacity. Add the currents and kW that each UPS will draw in redundant operation. Also calculate the current and the kW that the UPS requires when the UPS is operating in bypass. The generator set must be sized to supply the highest current and highest kW that results from either calculation. Where the loads on the UPS operate at poor power factor, it is possible that the highest kVA load occurs with the UPS operating in bypass while the highest kW occurs when supplying power to the UPS. That will give you the current and kW the generator set needs.

When operating on generator set, it is not realistic to assume the input voltage will always remain at nominal. It is also not realistic in most circumstances to assume that the generator set voltage will vary over a +10%/-15% voltage window. Under normal conditions it is assumed that the input voltage when operating on generator set will stay within the range of 95% – 105% of nominal. Add the maximum currents and kW of the UPS modules that you derive using these limits to determine the generator set capacity. Note when operating on generator set it is possible to supply a contact closure to the UPS to limit the charging power to any value between the minimum and maximum values. Charging power cannot be set to zero or any value lower than the minimum. See the On Generator signal section below for more information on this feature. It is usually acceptable to reduce charging to the minimum level when operating on generator set provided the system is constrained to remain on generator set power and not retransfer in less than 7 minutes.

18.4.3 Sizing Example with Redundant UPS Modules

Assume the 2 x UPS 1000 system-plus-system configuration described above. With both modules operating the maximum load that either will carry is 50% of the rated module capacity. The tables in section 3.1.9 apply to this model with the UPS set for minimum recharge. From these tables the input current per UPS module is 912 amps and the input power is 560 kW. Since both UPS modules are running the minimum current and kW that must be available from the generator sets to support the UPS are 1824 amps and 1120 kW. Also remember the generator set must be sized to handle the load on the output of the UPS when the UPS is in bypass. You must also check the load currents and current harmonics to make sure the generator set is adequately sized. For loads with very poor power factor the currents (but not the power) may be higher than the current needed to support the UPS. Extra generator set capacity may also be required if the load has high harmonic current content.

18.4.4 On Generator Signal

One of the programmable input contacts of the UPS (See OMM manual for information about these contacts) 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. A list of the parameters with functional descriptions is included as appendix 2. These parameters adjust the walk-in rate of load onto the generator set, the maximum flywheel charging Power, and the input frequency and voltage deviations that put the UPS into discharge. The factory settings are chosen to be appropriate for most generator sets sized using the general rule stated above.

18.4.5 Continuous Power Sequence

A typical continuous power sequence for a power outage and UPS ride through to generator set power is shown in the figure below for a UPS 1000 or UPS 1200. The times shown in the figure are for 2 Flywheel Cabinets (4 flywheels). The UPS supplies power to the load during the time needed to start the generator set and allow the UPS to ramp up its input current (walk-in) on generator set power. Since the UPS flywheels are only supplying about half 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 generator set with 2 flywheel cabinets.
UPS 1000 and UPS 1200 can be equipped with up to 4 Flywheel cabinets. See the Flywheel cabinet option section below.

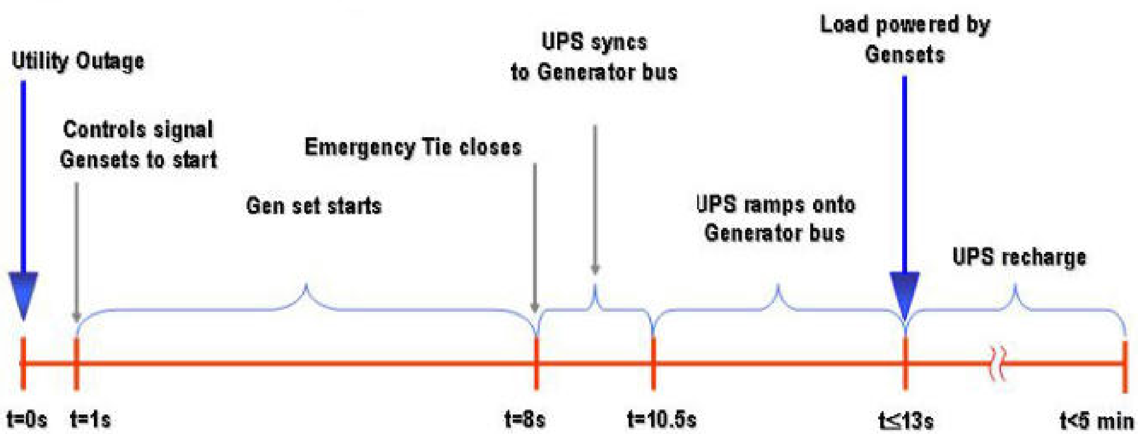

Figure 45: Continuous Power Sequence

18.4.6 Generator Set Paralleling

As system power levels Increase a single generator set may not be adequate to support the UPS Load. If possible it is often preferable to divide the UPS modules between generator sets since paralleling increases the time that the UPS systems must discharge before the generator sets are able to accept the UPS load. In some cases there is no choice except to parallel generator sets. This may because the output of multiple UPS systems must be kept synchronized (see the section on static transfer switches) or because the customer is using a parallel configuration specifies a parallel configuration of generator sets to supply UPS power and essential non UPS loads as well.
In those cases try to configure the parallel bus to allow individual generator sets to quickly connect to individual UPS modules and then slowly parallel together. If a parallel system requires more time than the ride through provided by 2 flywheel cabinets, additional flywheel cabinets can be added or the UPS systems can be configured so that they will only have to operate at partial load. Consult the factory if there is any doubt about the ability of the UPS to provide the ride through needed for the generator system to parallel and assume the load.

18.4.7 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 gen 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. See the On Generator Signal section above for more information about alternate operating parameters that can be put into effect when operating from a generator set(or other alternate power source). A diagram is supplied in the section titled ATS notes and connections.
7. The UPS can issue a contact closure to a transfer switch to start the generator set and transfer by programming on of the UPS output contacts as an ATS Command. The contact is closed when the stored energy remaining in the flywheels reaches a programmed level (85%, for example). See ATS notes and connections.

19 Output

19.1 Rating

The output ratings of the 1200 Series UPS units are as follows

- UPS 1000: 1000 kVA @ 0.9 p.f. (1000 kVA/900 kW with a 0.9 p.f. load)
- UPS 1200 3W: 1200 kVA @ 0.8 p.f. (1200 kVA/ 960 kW with a 0.8 p.f. load)

The ratings of the UPS vary as you move away from these rating points. In many cases that only means the UPS will not be able to meet all of its specifications, voltage regulation in particular, if you try to operate at rated load (either kVA or kW) with loads with significantly different power factor. The UPS 1000 is designed to be operated at 50 Hz or 60 Hz. The UPS 1200 is designed to be operated at 60 Hz.

At 380V 50 Hz (or 60 Hz), the UPS 1000 must be proportionately de-rated to 950 kVA, 855 kW.

19.1.1 Limiting Factors

Worst case conditions for inverter loading occur at low line input with lagging power factor load or high line input with leading power factor load. Under these conditions UPS 1200 3W is rated for nominal at kVA 0.8 pf. lagging load. At lower power factors the UPS inverter current. The UPS 1200 3W is designed to provided specified voltage regulation at -10% input voltage and 0.8 lagging pf. Load or +10% input voltage and 0.9 leading pf. Load. UPS 1000 is designed to provide is designed to provided specified voltage regulation at -10% input voltage and 0.9 lagging pf. Load or +10% input voltage and 0.9 leading pf. Load.

At power factors closer to unity than the rating points listed in the previous paragraph, the kW of the UPS is limited to the rated kW of the UPS. The kVA is limited to the rated kW divided by the load power factor, which will be less than the rated kVA.

19.2 Voltage Regulation

The source impedance has an effect on voltage regulation. The following tables assume a source size approximately 2x the UPS rating and typical source impedance. Smaller sources or sources with higher per unit impedance will improve the regulation and larger sources or lower source impedances will reduce it.

You cannot determine the amount of voltage regulation by simply looking at the input and output voltages of the UPS while the UPS is operating. You must compare the input voltage of the UPS in bypass to the output voltage of the UPS when it is on-line. When on-line, the UPS has a correcting effect on the input voltage.

If the RMS output voltage drops below nominal by 10% or more, the UPS will transfer to bypass. There is also an instantaneous transient voltage threshold that will take the UPS to bypass. The transient voltage deviation trigger is disabled during discharge operation.

19.2.1 kVA and kW Limits at 2% Voltage Regulation

The following tables quantify the amount of load that the UPS can carry at various power factors and input voltages while maintaining 2% output voltage regulation. A positive power factor indicates leading and a negative indicates lagging.

UPS 1200 480V 3W @ 110% nominal		
Load P.F.	kVA	kW
+0.9	1067	960
+0.95	1011	960
1.00	960	960
-0.95	1011	960
-0.9	1067	960
-0.85	1129	960
-0.8	1200	960
-0.7	1200	840

UPS 1200 480V 3W @ nominal		
Load P.F.	kVA	kW
+0.9	1067	960
+0.95	1011	960
1.00	960	960
-0.95	1011	960
-0.9	1067	960
-0.85	1129	960
-0.8	1200	960
-0.7	1200	840

UPS 1200 480V 4W @ 110% nominal		
Load P.F.	kVA	kW
+0.9	1067	960
+0.95	1011	960
1.00	960	960
-0.95	1011	960
-0.9	1067	960
-0.85	1129	960
-0.8	1200	960
-0.7	1200	840

UPS 1200 480V 4W @ nominal		
Load P.F.	kVA	kW
+0.9	1067	960
+0.95	1011	960
1.00	960	960
-0.95	1011	960
-0.9	1067	960
-0.85	1129	960
-0.8	1200	960
-0.7	1200	840

UPS 1200 480V 3W @ 90% nominal		
Load P.F.	kVA	kW
+0.9	1067	960
+0.95	1011	960
1.00	960	960
-0.95	1011	960
-0.9	1067	960
-0.85	1129	960
-0.8	1200	960
-0.7	1059	741

UPS 1000 400V @ 110% nominal		
Load P.F.	kVA	kW
+0.9	1000	900
+0.95	947	900
1.00	900	900
-0.95	947	900
-0.9	1000	900
-0.85	1000	850
-0.8	1000	800
-0.7	1000	700

UPS 1200 480V 4W @ 90% nominal		
Load P.F.	kVA	kW
+0.9	1067	960
+0.95	1011	960
1.00	960	960
-0.95	1011	960
-0.9	1067	960
-0.85	1129	960
-0.8	1109	887
-0.7	761	533

UPS 1000 400V @ nominal		
Load P.F.	kVA	kW
+0.9	1000	900
+0.95	947	900
1.00	900	900
-0.95	947	900
-0.9	1000	900
-0.85	1000	850
-0.8	1000	800
-0.7	1000	700

UPS 1000 400V @ 90% nominal		
Load P.F.	kVA	kW
+0.9	1000	900
+0.95	947	900
1.00	900	900
-0.95	947	900
-0.9	1000	900
-0.85	825	700
-0.8	726	581
-0.7	610	427

19.2.2 Voltage Regulation at Nominal Rating

In some instances it may be important to know the regulation obtained at the rated kVA or kW. In the following tables Rated kVA applies to power factors equal to or less than the rating point (0.8 p.f. for UPS 1200 and 0.9 p.f. for UPS 1000) and rated kW applies to power factors equal to or greater than the rating point. A positive power is leading and a negative power factor is Lagging. In the following tables <2.0% means better than 2.0%.

UPS 1200 480V 4W @ 110% nominal			
Load kVA	Load kW	Load P.F.	Regulation %
1067/1000	960/900	+0.90	<2.0%
1011/947	960/900	+0.95	<2.0%
960/900	960/900	+1.00	<2.0%
1011/947	960/900	-0.95	<2.0%
1067/1000	960/900	-0.90	<2.0%
1129/1000	960/850	-0.85	<2.0%
1200/1000	960/800	-0.80	<2.0%
1200/1000	840/700	-0.70	<2.0%

UPS 1000 400V @ 110% nominal			
Load kVA	Load kW	Load P.F.	Regulation %
1000	900	+0.90	<2%
947	900	+0.95	<2%
900	900	+1.00	<2%
947	900	-0.95	<2%
1000	900	-0.90	<2%
1000	850	-0.85	<2%
1000	800	-0.80	<2%
1000	700	-0.70	<2%

UPS 1200 480V 4W @ nominal			
Load kVA	Load kW	Load P.F.	Regulation %
1067/1000	960/900	+0.90	<2%
1011/947	960/900	+0.95	<2%
960/900	960/900	+1.00	<2%
1011/947	960/900	-0.95	<2%
1067/1000	960/900	-0.90	<2%
1129/1000	960/850	-0.85	<2%
1200/1000	960/800	-0.80	<2%
1200/1000	840/700	-0.70	<2%

UPS 1200 400V @ nominal			
Load kVA	Load kW	Load P.F.	Regulation %
1000	900	+0.90	<2%
947	900	+0.95	<2%
900	900	+1.00	<2%
947	900	-0.95	<2%
1000	900	-0.90	<2%
1000	850	-0.85	<2%
1000	800	-0.80	<2%
1000	700	-0.70	<2%

UPS 1200 480V 4W @ 90% nominal			
Load kVA	Load kW	Load P.F.	Regulation %
1067/1000	960/900	+0.90	<2%
1011/947	960/900	+0.95	<2%
960/900	960/900	+1.00	<2%
1011/947	960/900	-0.95	<2%
1067/1000	960/900	-0.90	<2%
1129/1000	960/850	-0.85	<2%
1200/1000	960/800	-0.80	<32%
1200/1000	840/700	-0.70	435%

UPS 1000 400V @ 90% nominal			
Load kVA	Load kW	Load P.F.	Regulation %
1000	900	+0.90	<2%
947	900	+0.95	<2%
900	900	+1.00	<2%
947	900	-0.95	<2%
1000	900	-0.90	<2%
1000	850	-0.85	<3%
1000	800	-0.80	3.6%
1000	700	-0.70	5%

19.3 Load Current Harmonics

The UPS 1200 series achieves the stated output voltage THD when tested with 100% non linear load as specified by the IEC UPS performance standard EN 50091-3, Uninterruptible power systems (UPS): Method of Specifying the Performance and Test Requirements (also per the revised standard EN62040-3). This does not mean that you can apply non linear load equal to the rating of the UPS and achieve this performance. Tests conducting with a non linear load equal to the UPS rating having approximately 50% THD, and crest factor 2 result in approximately 16% voltage THD.

19.4 Overloads

19.4.1 On-line with Bypass

This is the normal operating mode of the UPS. The times in the table below assume that a good bypass source is present and upstream supply breakers coordinate with the factory settings of K1.

UPS 1200 3W Overload	UPS 1200 3W Time	UPS 1000/ UPS 1200 4W Overload	UPS 1000/ UPS 1200 4W Time
Up to 105%	indefinitely	Up to 105%	indefinitely
Up to 125%	5 minutes	Up to 125%	3 minutes
Up to 150%	4 minutes	Up to 150%	2 minutes
≥1000 (short circuit current depends on bypass source impedance)	Sub-cycle short circuit current – I3 setting of K1t	≥800% (short circuit current depends on bypass source impedance)	Sub-cycle short circuit current – I3 setting of K1

19.4.2 On-line without Bypass

This is the condition for the overload ratings listed on the data sheet. This condition can only happen if the automatic bypass is inoperable.

Overload	Time
Up to 105%	indefinitely
Up to 125%	1 minutes
Up to 150%	5 seconds
Max instantaneous	150%

19.4.3 Discharging

Overload	Time
Up to 105%	indefinitely
Up to 125%	5 seconds
Max instantaneous	150%

20 Automatic Bypass

The automatic bypass of the series 1200 is a fully rated, continuous duty static bypass switch. It does not have an automatic wrap-around breaker, as can be seen in the configuration block diagrams in figures All Series 1200 units are single input units, which ensures that the automatic bypass will always be from the same source as the UPS input.

21 Efficiency, Heat Rejection and Airflow

21.1 Efficiency and Heat Rejection

Efficiency is defined as Output kW/Input kW. Heat rejection is input kW – output kW, and it is frequently converted from kW to BTU/hour, where 1 kW = 3,412 BTU/hour. The only efficiency specified for Cat UPS Series 1200 is for full load nominal input voltage and balanced 1.0 power factor load. The table contains typical (not guaranteed) data for UPS with 2 flywheel cabinets at quartile load points at nominal voltage. It also contains full load efficiencies and losses at 10% low line voltage conditions. Use the nominal data for life cycle costing and other economic calculations. Use Low Line condition to determine worst-case cooling capacity requirements. Add 2.1 kW of losses for each additional flywheel cabinet.

3-Wire UPS 1200	Nominal Efficiency/Losses	Low Line Efficiency/Losses
100%	97.0%/29.7 kW	95.1%/49.5 kW
75%	96.9%/23 kW	
50%	96.3%/18.4 kW	
25%	93.8%/15.9 kW	

4-Wire UPS 1200	Nominal Efficiency/kW Losses	Low Line Efficiency/Losses
100%	94.0%/61.3 kW	92%/83.5 kW
75%	93.9%/41.8 kW	
50%	92.6%/38.4 kW	
25%	86.4%/37.8 kW	

UPS 1000	Nominal Efficiency/kW Losses	Low Line Efficiency/Losses
100%	94.0%/57.4 kW	92%/78.3 kW
75%	93.9%/43.8 kW	
50%	92.6%/36.0 kW	
25%	86.4%/35.4 kW	

21.2 Airflow

Airflow is shown for exhaust air from the UPS. In some cases air enters from a different cabinet than the one from which it exits. That is why some cabinets have no airflow numbers, even though they may have airflow grills on the front doors.

Cabinet	**60 Hz Cu. ft/min. (Cu. m/hr.)**	**50 Hz Wire Cu. ft/min. (Cu. m/hr.)**
4-wire out	0	0
4-wire Transformer	1791 (3043)	1580 (2684)
Bypass	0	0
I/O	0	0
Static Switch	1406 (2388)	1240 (2107)
Control	113 (193)	100 (170)
Inverter	1360 (2311)	1200 (2039)
FW Cabinet 1	1337 (2272)	1180 (2005)
FW Cabinet 2	1337 (2272)	1180 (2005)
Total	7345 (12479)	6480 (11010)
Each Add'l FW Cabinet	1337 (2272)	1180 (2005)

22 Grounding

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.

Cat UPS has been designed to work with solidly grounded wye sources. The standard source configuration for Cat UPS Series 1200 480V systems is 3-wire solidly grounded and the standard for 380-415V systems is 4-wire solidly grounded. Series 1200 products are not designed to operate from impedance grounded sources, but impedance grounding of the output of 4-wire units is allowable. Please note, however, that the impedance grounding system must be externally provided and the output of the UPS must be treated as a separately derived source.

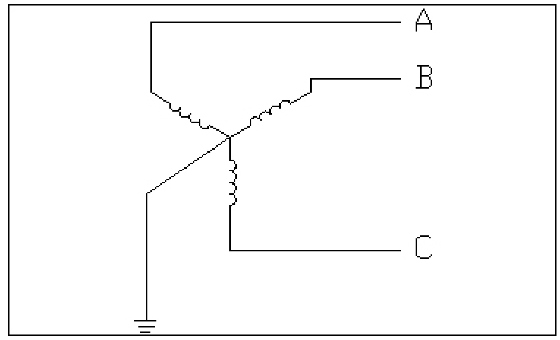

Figure 46: 3-Wire Wye Connected With Solid Ground

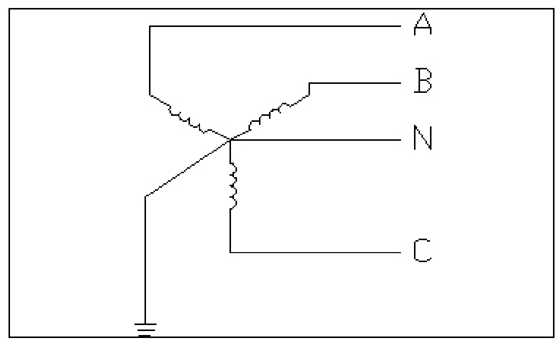

Figure 47: 4-Wire Wye Connected with Solid Ground

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.

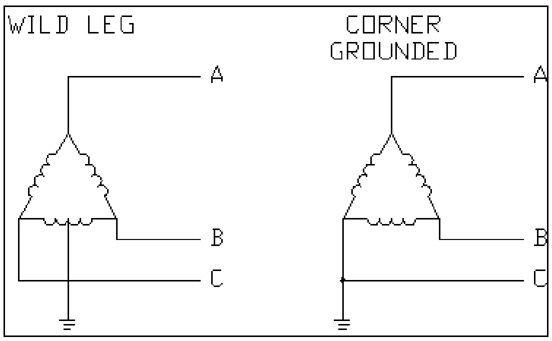

Figure 48: Incompatible Grounding Configurations

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).

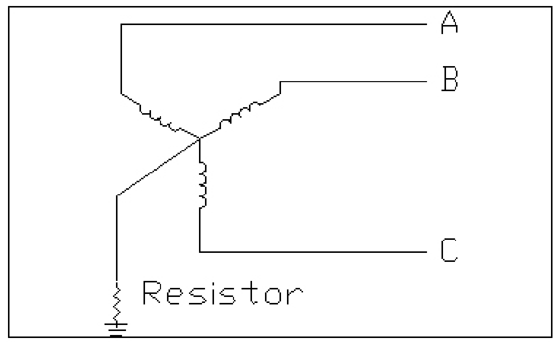

Figure 49: Impedance Grounded System

For further information regarding grounding configurations, refer to the paper titled, CSUPS Grounding Primer.

23 External Transformers

In some circumstances the UPS must be installed between external transformers (as may occur in 600V input and output systems). There is much more involved than simply inserting transformers on the input and output.

The input transformer must be sized to support the larger of the input kVA of the UPS including losses and max recharge current or the UPS load operating on bypass while starting the UPS. The input transformer must have a solidly grounded wye secondary. Both transformers should have suitable K-factor rating for the load. Input and output transformers must be installed with appropriate primary and secondary over current protection. If the UPS is equipped with an internal maintenance bypass, appropriate distribution must be installed on the secondary of the input transformer to allow the UPS input to be isolated when operating on maintenance bypass.

If an external maintenance bypass is to be installed around the UPS and transformers, then the transformers must be appropriately specified and installed so that the primary to secondary phase shift of the transformers cancel. Failure to properly specify and install the transformers could lead to the bypass having opposite phase rotation or 60 degree phase shift.

24 Options

24.1 Flywheel Energy Storage Options

Each UPS can be equipped with 2, 3 or 4 flywheel cabinets. Each flywheel cabinet contains two flywheels. The number of flywheel cabinets is specified as a line item in the Configuration. Additional flywheel cabinets extend ride through time but do not increase the output capacity of the UPS. All flywheel cabinets include disconnects so that cabinets can be isolated individually for maintenance without shutting down the UPS. However, at least 2 flywheel cabinets are required to support full load. Flywheel cabinets mount on the right hand end of the UPS and additional cabinets extend the length of the UPS by 43 inches per cabinet. Outline drawings are available showing the UPS with 2, 3 and 4 flywheel cabinets. Additional flywheel cabinets increase the input current and power needed for recharge. The default recharge power is 80 kW per cabinet and the minimum is 40 kW per cabinet when the recharge rate for the UPS has been set to minimum. All flywheel cabinets have the same recharge rate setting. It is not possible to set different flywheel cabinets at different recharge rates.

Ride through times with 2, 3 and 4 Flywheel cabinets per UPS are shown in the following tables:

UPS 1000 Ride Through Time – Seconds				
Number of Energy Storage Cabinets	**100% load**	**75% load**	**50% load**	**25% load**
2	14	19	28	53
3	21	28	42	80
4	28	37	56	106

UPS 1200 3-WIRE Ride Through Time – Seconds				
Number of Energy Storage Cabinets	**100% load**	**75% load**	**50% load**	**25% load**
2	13.5	17	26	50
3	20	25	39	75
4	27	34	52	100

UPS 1200 4-WIRE Ride Through Time – Seconds				
Number of Energy Storage Cabinets	**100% load**	**75% load**	**50% load**	**25% load**
2	13.1	17.0	25.0	46.0
3	19.6	25.5	37.5	69.0
4	26.2	34.0	50.0	92.0

24.2 Grounding Option – 4-Wire 480 Volt 60 Hz

This option only applies to UPS 1200 480V 60h Hz units. UPS 1000 units are always configured as 4 wire systems. While the majority of 480 VAC UPS applications will require 3-wire power out of the UPS, single-phase 277 volt loads may sometimes be directly connected to the UPS and can require 2x neutral connection for high harmonic content loads. The most common 277 volt loads are lighting, and it is usually better to derive power for these loads using one or more 480V/277V lighting transformers rather than running neutrals throughout the electrical system. Neutrals are almost always solidly connected in 480/277V systems which can create unwanted paths for common mode noise in critical electrical systems. If a 4-wire output is required on a 480V UPS, the 4-wire grounding feature must be included. This feature adds a delta primary, zig-zag secondary isolation transformer on the output of the UPS. This special transformer configuration avoids the normal 30° phase shift associated with delta-wye transformers and permits the use of an external maintenance bypass without adding an additional transformer in the bypass path. This transformer allows the 4-wire output to be connected as a separately derived source even when the Maintenance bypass option is included. Therefore, the transformer is downstream of the internal maintenance bypass. The 4-wire grounding option requires two additional cabinets and adds 84" (2134 mm) to the length of the UPS. The option does not include an output circuit breaker. An output circuit breaker is available as a separate option, listed below.

24.3 Output Circuit Breakers

Series 1200 UPS modules do not include output circuit breakers as a standard feature. A manually operated (as opposed to electrically operated) output circuit breaker is available as an option for both 3-wire and 4-wire systems. In 3-wire systems, it is designated as the K5 breaker in Figure 1. Please note that if the maintenance bypass option is included, an output circuit breaker for 480V 3-wire systems is automatically included and the output circuit breaker option does not apply. In 4-wire systems, the output circuit breaker option is not included as part of the maintenance bypass since it is located on the load side of the output transformer and is designated K8 in Figure 2.
In UPS 1000, both 3-pole and 4-pole output circuit breakers are available to allow integration into 380V – 415V systems employing 4-pole breakers. The neutral pole and trip of the 4-pole output breaker option is rated at 100% of the phase conductor capacity. An output circuit breaker option is never required on paralleled UPS modules.

Modules in parallel systems always include an electrically operated output circuit breaker.

24.4 Maintenance Bypass

The maintenance bypass option allows complete system isolation of power and control electronics in 3-wire systems. Only the I/O and Maintenance bypass cabinets remain energized. In 4-wire systems the output transformer and 4-wire transformer and 4-wire output cabinets also remain energized. In all configurations the power electronics, static bypass switch control cabinet and flywheel energy storage cabinets are isolated from external power and can be safely maintained without load interruption. This option requires the addition of the maintenance bypass cabinet. There is no power protection while in maintenance bypass mode, and the maintenance bypass always requires a separate input feeder.

24.5 Remote Emergency Power Off Switch

The remote emergency power off switch is a red mushroom button in a wall mounted box with contacts to activate the remote EPO input of the UPS.

24.6 Remote Status Panel

The Remote Status Panel provides the user remote summary status indication of the UPS. It contains 8 indications as shown in Figure 51:

- Bypass unavailable (amber)
- UPS notice (amber)
- On Bypass (amber)
- Discharge (amber)
- UPS overload (red)
- Low DC voltage (to the remote status panel) (red)
- UPS alarm (red)
- Off line (red)

In addition the panel contains an audible alarm, audible alarm silence button and lamp test button. The panel is designed for flush mounting or surface mounting in a panel box. Use 18 AWG or larger wire. The wire will consist of 3 conductors. The wire consists of a data conductor, a ground conductor, and a power conductor. There are 14 terminal screw connections on the back of the status panel. Refer to the manuals for detail information on connections.

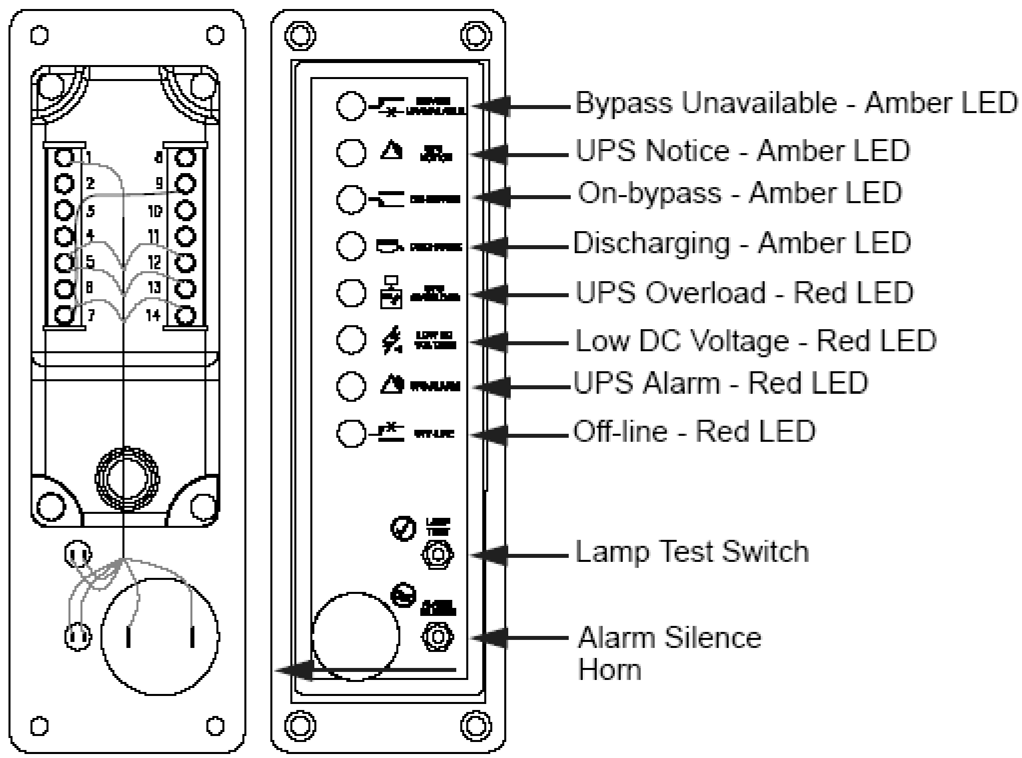

Figure 50: Remote Status Panel

24.7 Relay Contacts

The UPS includes 6 input and 6 output programmable contacts as a standard feature. This option includes a second set of 6 input and output potential-free (dry) contacts that can be programmed with the same functions. Connections for these contacts are provided on the DIN rail mounted terminals in the communications interface tray accessed from the top of the control cabinet. These contacts are used to communicate with various kinds of monitoring systems or building software. In addition, remote EPO buttons connects to one of the 6 input contacts. The input contacts can be used to bring in operational status of other equipment, such as the generator set, ATS, HVAC, etc. These inputs can be programmed to generate status indications on the user interface, on UPSView and through the Modbus serial interface.

All contacts can be configured using the user interface panel or UPSView in order to indicate if certain conditions exist. Each input is relay isolated and is intended to interface to a normally-open (closes when activated) or normally-closed (opens when activated) customer provided contact. Output contacts are “Form C” and can be wired as normally-open or normally-closed. Reference the user operating parameters screen information in the section of the manual on control screens for programming the contact functions. Reference the installation drawings and the user programmable remote contacts information in the installation section of the manual for connection information.

24.8 Cat UPS Monitoring Software – UPSView

UPSView is an optional data monitoring software package that tracks more than 40 operating parameters in real time and displays the data on a computer display. UPSView is compatible with Windows 98, NT 4.0, 2000, and XP. Refer to the UPSView manual for detail of the software features and operations.

The image below shows how the text comments and tiles are color coded to show normal (green), notice (yellow), and alarm (red) messages.

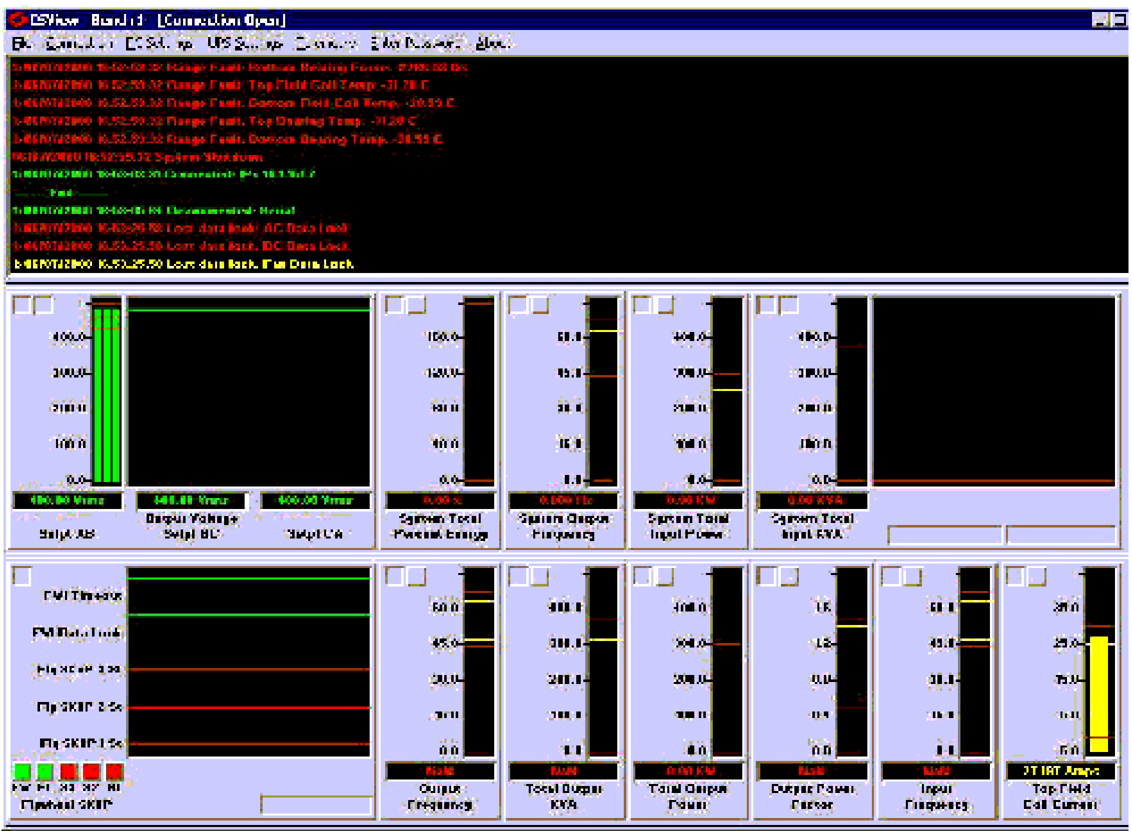

Figure 51: UPSView Screen

24.9 Modbus

Modbus Protocol is a messaging structure developed by Modicon in 1979. It is used to establish master-slave/client-server communication between intelligent devices. It is a de facto standard, truly open and the most widely used network protocol in the industrial manufacturing environment. It has been implemented by hundreds of vendors on thousands of different devices to transfer discrete/analog I/O and register data between control devices. The Modbus option provides both Modbus TCP and Modbus RS-485 communications capability. However, to use Modbus TCP the Ethernet option must also be purchased to provide an Ethernet network connection (similar to an Ethernet card for a computer).

24.9.1 Modbus TCP

Modbus TCP is the Modbus protocol that is used to communicate over most LANs. 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.

24.9.2 Modbus RS-485

Modbus RS-485 (also known as Modbus RTU) is another way to communicate using Modbus protocol. RS-485 defines a particular serial communications bus hardware (voltage levels, driving current, and wiring configuration) just as the familiar RS232 defines a different communications bus. However, RS-232 is limited to a maximum cable length of 30 to 60 meters and was designed for local communication between two devices (one transmitter and one receiver) RS-485 is intended for much longer distance communications and supports multiple devices on the same twisted pair (TP) line – two wires twisted around each other. This technique is referred to as multi-drop 'Balanced data transmission', or 'Differential voltage transmission'. For RS-485 the total cable length 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: many devices may be connected to a single signal bus. 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.

24.10 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 a 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.

24.11 Ethernet

Ethernet is a common type of network that allows interconnection between the UPS and other devices. It can give the user the following capabilities:

- E-mail (e-mail requires Ethernet connection to a local area network (LAN) with SMTP e-mail server)
- SNMP
- Modbus TCP
- Connection to UPSView over a LAN (network monitoring requires static IP address to be assigned to each UPS)

24.12 Generator Set Start Power Module

The Generator Set Start option (GSM) provides a redundant source of starting power for generator sets. The Generator Set Start increases the reliability of the standby power system by ensuring that the generator has power available to start, removing the common cause of generator set starting failures, dead starting batteries. The Generator Set Start can parallel power from the starting batteries to provide one reliable DC power source to the starting motor. The Generator Set Start receives 3-phase 380/400/415/480 VAC power from a reliable power source such as a UPS. The Generator Set Start converts the AC voltage into 24 VDC for the starter motor. Unlike batteries, the Generator Set Start 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. The Generator Set Start can be wall-mounted (standard) or floor-mounted with the optional floor mounting kit. In either installation, the module should be securely fastened, as detailed in the Generator Set Start manual, to a support rated to accept the loads of the Generator Set Start option, approximately 350 lbs.

The Generator Set Start generator starting module (GSM) is sized just like a battery, by Cold Cranking Amps. The GSM will reliably produce 1725 CCA. This number was arrived at by repetitive testing under conditions dictated by the ASME specification. 1725 CCA was the lowest number recorded, so to be conservative that is the rating. The GSM is a much stiffer source than a battery and hence the starting voltage will not drop as much as a battery alone.

If a generator set requires two starters, it is recommended that two GSM be used, one per starter. Alternatively, using one GSM to start multiple small generator sets has not been tested. However, total current still must remain at or below the 1725 CCA rating and thus seems reasonable. This should not be a common issue since smaller generator sets use 12VDC and the GSM output is 24VDC.

The input of the Generator Set Start is rated at 32 amps at 480V, which leads to a 40-amp breaker.

24.13 Generator Set Start Output Breakers

One or two 40-amp breakers to support two Generator Set Start modules can be installed in the UPS as an option. Options are available for a single generator set start and dual generator set start modules. If UPS power readily available to the GENSTART, it can be taken from an existing panel.

24.14 Export Crating

Export Crating is available for The UPS, module, Flywheel Cabinets, Maintenance bypass cabinet, 4 wire option, and Gen Start options. The export crating is a required option for shipment outside of the continental US or for shipment by airfreight.

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