STARSINE™ Advanced Rotary Series of Uninterruptible Power Supplies

Installation Manual

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Limited Warranty

SatCon Power Systems provides a limited warranty to this product.

> SatCon Power Systems shall warrant the unit equipment for repair or replacement due to defects in materials or workmanship for one (1) year from its commissioning or 15 months from shipment, whichever occurs first.
>
> To purchase an extended warranty, the yearly maintenance contract must be purchased as well. The level of the extended warranty depends on the level of the maintenance plan purchased. True extended warranties are priced into the original purchase, or added as a supplement before an in-place warranty expires.
>
> The SatCon Power Systems UPS authorized maintenance contract for all unit equipment shall be available during the entire useful life of the equipment.
>
> The engine manufacturer's standard warranty including extended warranty options shall apply to the engine.

Ordering Information.

To order copies of this document, contact your SatCon account representative or visit the Satcon website: www.satcon.com.

Technical Support

For technical support and other services, contact your local account representative or visit the Satcon website: www.satcon.com.

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Safety

Important Safety Instructions

Save these Safety Instructions

This manual contains important instructions for the SatCon STARSINE™ Advanced Rotary Series of Uninterruptible Power Supplies, Models 315 kVA and 2.2 MVA. Follow these instructions during installation, operation and maintenance of the UPS system and batteries.

This manual contains important installation and operation instructions as prescribed by UL Standards for an uninterruptible power supply, a remote power supply/cabinet assembly, and a maintenance bypass cabinet assembly for the SatCon Power Systems advanced rotary Uninterruptible Power Supply (UPS).

The UPS power distribution system provides short circuit protection, isolates branch faults, and isolates critical loads from sources of harmonics, surges, and spikes using panel boards, circuit breakers, and fuses.

The UPS system is grounded to ensure the safety of the operating personnel. The control cables are shielded by running power cables, in bonded metal enclosures, separately from the control cable enclosures.

Refer to Chapter 7, "System Maintenance" for instructions on maintaining UPS system.

General Precautions

1. Before using the UPS, read all instructions and cautionary markings on:
   - **a.** the Inverter Machine Generator
   - **b.** the batteries
   - **c.** all appropriate sections of this manual

This UPS System contains hazardous voltages and rotating mechanical parts. Equipment damage or personal injury can result if the following guidelines are not observed.

2. Only qualified personnel should be permitted to install, operate, troubleshoot, or repair the apparatus. A qualified person must be previously trained in the following procedures:

- Energizing, de-energizing, grounding and tagging circuits and equipment in accordance with established safety practices.
- Using protective equipment such as rubber gloves, hard hat, safety glasses or face shields, flash clothing, etc., in accordance with established safety practices.
- Rendering first aid.

3. During normal operation, keep all covers in place and cabinet doors shut.

Emergency Stop

There are one or more ways to stop the machine in an emergency:

- Emergency Stops
  - The Local Operator Interface provides an Emergency Stop. Press the EMERGENCY STOP [F9] key, displayed on every screen, to stop the system using the Emergency Discharge Circuit Control. Refer to section 6.4 “The Local Operator Interface” on page 6-3 for more information.
  - Press the Emergency Stop push button, (optional) located on the UPS frame.
  - Press the Emergency Stop, push button located on the Control Cabinets.
- Automatic Emergency Stop

  The PLC initiates an Emergency Stop automatically if an abnormal condition occurs. Refer to section 1.4.1 “Master Control” on page 1-14 for more information.

Batteries

The servicing of engine starting batteries should be performed or supervised by personnel knowledgeable of batteries and the required precautions. Keep unauthorized personnel away from batteries.

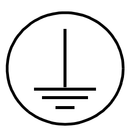
⚠ **CAUTION** - Do not dispose of battery or batteries in a fire. The battery may explode.

⚠ **CAUTION** - Do not open or mutilate the battery or batteries. Released electrolyte is harmful to the skin and eyes.

CAUTION - A battery can present a risk of electrical shock and high short-circuit current. The following precautions should be observed when working on batteries:

- **a.** Disconnect charging source prior to connecting or disconnecting battery terminals.
- **b.** Determine if the battery is inadvertently grounded. If inadvertently grounded, remove source of ground. Contact with any part of a grounded battery can result in electrical shock. Removing such grounds during installation and maintenance greatly reduces the risk of shock.
- **c.** Remove watches, rings, or other metal objects.
- **d.** Use tools with insulated handles.
- **e.** Wear rubber gloves and boots.
- **f.** Do not lay tools or metal parts on top of batteries.

Symbols

	Protective Conductor Terminal. Used for functional earth terminals that provide an earth reference point.

Faults and Abnormal Conditions

The Mechanical and Thermal Monitoring System panel, located at the central control station, reports the UPS system condition and alerts the operator to any faults or abnormal conditions.

When an abnormal condition occurs, visual alarms activate at the operator control panel. The system self-diagnostics also detects if the alarm components themselves fail (such as a burned out lamp) and alerts the user. Refer to the section 6.4 “The Local Operator Interface” on page 6-3 for more information.

Fault Detection System

The system fault detection and diagnostics capability alerts the operator to any faults or abnormal conditions in the UPS itself such as overspeed, bearing failure, or misalignment detection. The fault detection system incorporates monitoring accelerometers, thermocouple temperature sensors, and dimension sensors. Refer to sections 1.3.2.7 “Mechanical Couplings (Clutch, Flexible Couplings)” on page 1-8 and 6.4 “The Local Operator Interface” on page 6-3 for more information.

Flywheel

The flywheel provides the transient energy storage required for the time from the loss of line feed to the time that the engine is ready to pickup the load. The use of a steel wheel in an enclosure provides an inherently safe design.

Prior to any stress induced failure the steel wheel will start to yield. The sensors at the periphery of the wheel detect this incipient growth, trigger alarms, and shut-down the system. The sensors also measure balance and thermal changes which can indicate factors such as bearing degradation which might influence safe operation. Refer to sections 6.5.1.1 “Monitoring Events/ Event Reporting” on page 6-7 and 6.5.1.1.1 “Event Acknowledgement” on page 6-7 for more information.

▷ Built-in sensors monitor the steel flywheel status as a safety precaution

Clutch

The clutch is supplied with continuous vibration monitoring and protective covers to prevent personnel injury.

How to Use this Manual

This guide describes the features, and components of the SatCon Advanced Rotary Uninterruptible Power Supply Models 315 kVA and 2.2 MVA. Specifically, this guide describes how to set up, install, and configure and maintain the UPS system.

Intended Audience

This guide is intended for three audiences:

- Customers who prepare the site for the system and install the chassis.
- SatCon Service representatives who install the modules in the chassis and configure the system.
- Customers and Service representatives who operate and maintain the system.

Product Documentation

The following documentation supports the SatCon Rotary Uninterruptible Power Supply.

- SatCon Advanced Rotary UPS Operation and Installation Manual, Part Number: 755550016.
- Installation Drawings, provided in Appendix A.
- Manufacturer Documentation

  User manuals of each of the major sub-assemblies listed below:

  – Bearings
  – Clutch
  – Diesel Engine
  – Flexible Couplings
  – IMG
  – Pillow Block Mounting Procedure
  – Shaft Locking device
  – Torsional Couplings

Conventions

This manual uses the following conventions:

Convention	Indicates	Example
BRACKETS [ ]	The action caused by pressing a function key	START [F1] Press the F1 key on the keyboard to start the system.

Warnings

This guide uses the following conventions to call attention to important information.

Notes provide additional information or helpful suggestions that may apply to the subject text.

Cautions notify the reader to proceed carefully to avoid possible equipment damage or data loss.

Warnings notify the reader to proceed carefully to avoid the risk of possible personal injury.

Acronyms and Abbreviations

The following table lists acronyms and abbreviations used in the documentation:

Acronym	Meaning
BPC	Bi-directional Power Converter
ECM	Electronic Control Module (Diesel)
EMB	External Maintenance Bypass
EPC	Electronics Power Controller
BICB	Bi-directional Inverter Circuit Breaker
BPCB	By-pass Circuit Breaker
ICCB	Input Control Circuit Breaker
IMG	Induction Motor /Generator
LBCB	Load Bus Circuit Breaker
SSCB	Stator Shorting Circuit Breaker
LPR	(Reverse Power Line) Protection Control and Monitoring Relay
MGCB	Motor Generator Circuit Breaker
MTBF	Mean Time Between Failures
MTTR	Mean Time to Repair (or replace)
PMS	Power Management System (refer to Figure 3-1 on page 3-5).
PGS	Power Generating System (refer to Figure 3-1 on page 3-5).
PLC	Programmable Logic Controller
PWM	Pulse Width Modulation
RMS	Root Mean Square Refers to the most common mathematical method of defining the effective voltage or current of an AC waveform.
UDCB	Utility Disconnect Circuit Breaker
rpm	revolution per minute
RPM	Reliable Power Meter
VAC	Voltage Alternating Current

Regulatory Compliance Operational Policies and Constraints

Diesel powered UPS systems are subject to restrictions based upon relevant sections of some or all of the following federal, state, and local regulations governing power quality, environmental emissions, and personnel safety.

- UL 1778, Standard for Uninterruptible Power Supply Equipment
- UL 1004, Electric Motors
- NEC, NFPA 70
- OSHA Safety Standards
- NEMA PE 1-1983 UPS Standard
- IEEE 519 Guide for Harmonic Control and Reactive Compensation
- IEEE 115 Test Procedures
- CSA C22.2 No. 107.1 Commercial and Industrial Power Supplies

1

System Description

This chapter describes the UPS system. It provides the following information:

- Key Features
- System Configuration
- UPS System Components
- Controlling the System
- Operating Modes

The SatCon Rotary UPS acts as both a power conditioner and an uninterruptible power source. The UPS provides reliable, high quality power by constantly conditioning incoming power from the electric utility grid, and acts as a substitute for the electric utility in the case of power outages.

The rotary UPS is comprised of an Induction Motor/Generator (IMG) operating in conjunction with a surge-limiting line reactor, Electronics Control Package (ECP), low-speed flywheel, and an engine and connecting clutch required for long-term standby power. The UPS uses chemical batteries only to power the engine starters, a well established and understood use.

The IMG acts both as a motor to keep the flywheel fully charged and as a generator to convert the flywheel mechanical energy back into electrical energy. In normal operation, the electronic power controller operates the IMG as a motor to control the flywheel speed, and maintain a full charge on the flywheel.

Together, the flywheel, IMG, and power electronics provide continuity of output power for any short-term grid outage. As back-up power sources during a longer power outage, the UPS converts the energy stored in the flywheel to electricity to power the facility until the integral engine/generator starts or the utility returns.

When utility power deviates from the specified voltage or frequency tolerances, the flywheel and IMG combine to operate as a generator, providing completely uninterrupted power to the load. If the out-of-tolerance condition on the grid persists for longer than the pre-programmed delay (2 to 5 seconds), the stored energy in the flywheel provides “ride through” until the engine/generator comes up to full operating speed and replaces the utility as the primary power source to the load.

The ECP provides the system command and control and regulate the IMG rotor excitation to condition the power, removing unwanted variances. As a power quality conditioner, the UPS draws power from the utility grid and improves the quality of power supplied to a facility by compensating for utility sags and surges.

1.1 Key Features

The SatCon Power Systems advanced rotary uninterruptible power supply (rotary UPS) provides:

- Multimode Capability: UPS mode, Standby mode, Peak Shaving mode, Prime Power or Continuous mode, both grid parallel or grid independent operation.
- Flywheel Rotary UPS System with twelve seconds of battery-less ride through for power line sags, swells, and outages.
- Fewer engine starts, when operating in UPS mode. Built in 2 second UPS mode ride through delay covers 90 +% of grid events, prevents unnecessary engine starting and running, and increases system availability.
- Electronic control of power quality for high speed of response.
- Electric machine generation of power for inherent peak load capability.
- Off-the-shelf components coupled with novel control features.
- Fewer series power components for high reliability.
- No double conversion in main power path in any operating mode for efficiency.
- Parallelable with the grid and with each other.
- Soft start, low inrush starting from grid.

Table 1-1. 2.2 MVA UPS System Specifications

Specification	Description
Nominal Input Voltage	480 V, ± 10% Options available at other standard supply voltages and frequencies.
Input Frequency	50 Hz or 60 Hz, +0.4 Hz/-0.3 Hz
Input Power Factor	1.0 to 0.95 Inductive
Efficiency at Rated Load	> 96%
UPS to Input Short Circuit Current	200% for less than 100 ms
Voltage and Phase Balance	• Unbalanced Loads – ± 2% phase voltage – ±2% phase displacement for up to 20% unbalanced load • Balanced Loads ±1% phase displacement
Output Voltage	Same as Input Voltage, ±1%

Specification	Description
Output Frequency	< ±1.0% upon loss or return of the Input Voltage
Ride-through	12 seconds, minimum at full rated load
Output Voltage Distortion	≤ 5% for linear loads (< 3% for any single harmonic)
Running Overload Capability (on grid only, not on engine)	150% for 1 minute 125% for 5 minutes 110% for 1 hour (10% duty cycle)
Transient Condition Ratings	• Output Voltage Regulation 5% +6% of Nominal for 50 ms. • Frequency Regulation ≤ ± 1% • Frequency Rate of Change ≤ 0.5Hz per second
UPS Mode	• Output Voltage – ± 1% of nominal – 60Hz ± 0.1Hz

1.2 System Configuration

The general UPS One-line diagram presented in Figure 1-1 is provided as a reference.

- The SatCon drawing 751110077 Appendix A, provides the UPS 315 kVA 480 VRMS system one-line diagram.
- The SatCon drawing 752220121, Appendix A, provides the UPS 2.2 MVA 575V 3-Phase system one-line diagram.

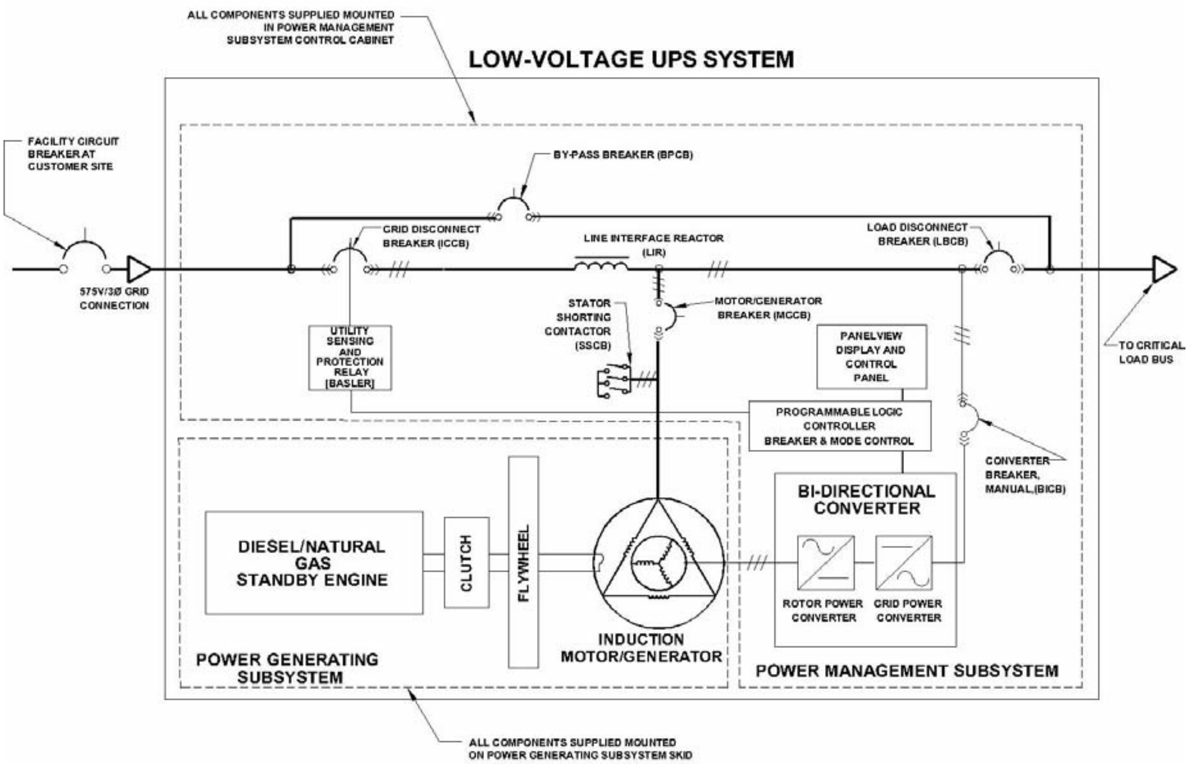


Figure 1-1. UPS System One-line Diagram

1.2.1 Parallel Unit System

UPS systems are capable operation in a parallel configuration with units of the same or similar size for N+1, N+2, … redundancy or for load service capacity expansion.

Failure of one unit in an N+1 configuration will leave the load supported by the remaining N units. The malfunctioning unit is isolated from the parallel load bus before causing an out of tolerance bus voltage condition.

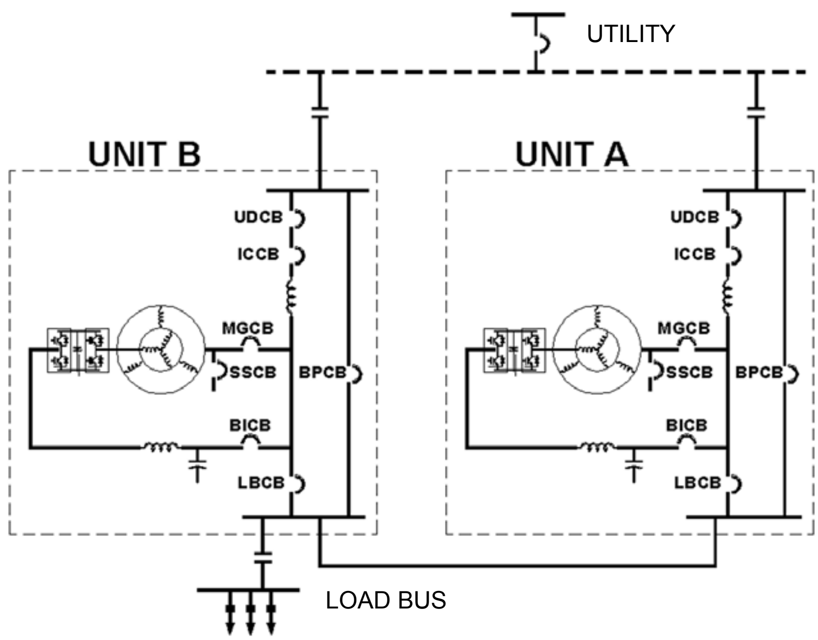


Figure 1-2. Parallel N+1 Redundant Unit System [N=1]

1.3 UPS System Components

UPS systems are comprised of two major sections: the Power Generating Subsystem, mounted to the UPS frame and the Power Management Subsystem. The electrical components are mounted in the cabinets as shown in Figure 1-1. "UPS System One-line Diagram" on page 1-4.

1.3.1 Control Cabinets

The Control Cabinets have hinged doors with three keyed latches. The bottom of the enclosure is open for entry of bottom fed cabling.

1.3.2 Power Generation System

The Power Generation System (PGS) contains an Induction Motor Generator, a Flywheel Energy Storage System, a mechanical clutch, and a diesel engine.

1.3.2.1 Induction Motor Generator

The IMG is a wound-rotor induction machine that serves as a motor generator and provides voltage, frequency, and phase control of both real and reactive power.

The IMG controls the rotor current (amplitude and frequency) to maintain the stator voltage at a regulated 480V, 60 Hz independent of the rotor speed, power source, and whether the UPS is motoring or generating.

The bearing and winding temperatures are monitored. The detection of an excessive temperature displays an alarm on the control panel, and shuts down the machine after a 30-second delay. In a non-redundant UPS, the load transfers to bypass without interruption.

1.3.2.1.1 Induction Machine

The Induction machine is a three-phase, four-pole machine with a wound rotor separately excited by slip rings. The Bi-directional Power Control unit (refer to section 1.3.3.1.1 “Bi-directional Power Converter” on page 1-9) provides the excitation. During normal operation on the grid, it runs supersynchronously at 1980 rpm (2.2 MVA unit) or 1900 rpm (315 kVA unit) to maintain full charge on the flywheel.

1.3.2.2 Flywheel Energy Storage System

The flywheel provides the transient energy storage needed for the time from the loss of line feed to the time that the engine is ready to pick up the load. The flywheel, manufactured from selected steel, provides the maximum energy for the volume, weight and operating speed.

Pillow blocks, contained within a solid-steel, rotary-shielded enclosure, support the flywheel. The flywheel wheel is mounted in an enclosure; the mounting shaft is supported on its bearing and is connected to the IMG shaft. Designed to support the IMG generator field for twelve seconds using the Bi-directional converter, the flywheel spins down after the twelve-second period and recovers when the engine starts.

The 2.2 MVA flywheel is 7ft x 9.8 in wide and weighs 15300 lb. Prior to any stress induced failure a steel wheel will start to yield and sensors at the periphery of the wheel detect this incipient growth and trigger alarms and shut-down. Sensors also check for balance and thermal changes that can indicate factors such as bearing degradation, which might influence safe operation. Any out of tolerance condition will immediately shut down the flywheel.

The 315 kVA flywheel is 4ft x 10.7 in wide, 5500 lb.

1.3.2.3 Diesel Engine Subsystem

The diesel engine provides the long-term standby power when required. The engine block includes preheaters to keep the engine in a fast-start state.

1.3.2.4 Starting Batteries

The starting batteries have sufficient capacity for cranking the engine for at least three (3), thirty-second intervals with a 10-second rest period between each attempt at the minimum ambient temperature. The system ships with a non-corrosive battery rack along with all necessary cables and clamps.

1.3.2.4.1 Battery Charger (Optional)

Use one (optional) battery charger to maintain each bank of starting batteries. For example: connect two battery chargers to the 2.2 MVA system. Connect one charger to the 315 kVA system. The battery charger, designed for industrial applications, should be connected to the start batteries and energized at all times. Refer to the battery charger manufacturer’s manual and the engine manufacturer’s manual for safety, installation, and operation instructions.

1.3.2.5 Fuel System

The Fuel system includes a day tank, fuel level indicator, high fuel alarm contacts, low fuel alarm contacts, and critical low fuel alarm contacts. Fuel demanded contacts are also provided for interface with local bulk fuel storage and fuel oil transfer pump, if required.

1.3.2.6 Cooling System

The cooling system (mounted on the Power Generating System) has sufficient capacity for cooling the engine when the engine is delivering full-rated load up to the radiator ambient design temperature of 113°F (45°C). The coolant circulation pump is an engine mounted, direct drive, centrifugal type.

1.3.2.6.1 Coolant Preheater

The diesel engine requires a temperature of 90°F minimum for startup and ramp-to-rated speed applications. The diesel engine is equipped with a preheater that increases the engine block and component temperature. Refer to the 7.2.5 “Engine Water Heater (Block Heater)” section on page 7-5 for more information.

1.3.2.6.2 Lubrication Oil System

The lubrication system supplies oil to the flywheel pillow block bearings. It contains 20 gallons of bearing oil. Refer to Table 2-6. "Bearing and Coupling Oils" on page 2-12, for the recommended bearing oil type and quantity required for the Lubrication System and 7.2.11 “Lubrication” on page 7-11 for maintenance information.

1.3.2.7 Mechanical Couplings (Clutch, Flexible Couplings)

The engine automatically starts when needed. When the engine speed matches that of the flywheel and IMG, the clutch connects it to the motor/generator. The engine then supports the load requirements of the connected facility.

The clutch is an off-the-shelf, over-running clutch. The free-wheel clutch mechanically couples the engine to the IMG and Flywheel during the Backup Mode of operation for power transfer from the engine to the IMG and Flywheel shafts. The clutch engages only when the engine speed ramps up and equals the speed of the rotor and flywheel. The clutch disengages when the torque reverses during IMG speed overtake. The clutch couples the engine and IMG shafts through a flexible coupling designed to compensate for slight axial and radial misalignments.

1.3.3 Power Management Subsystem

The Power Conditioning System, Master Control System, and Switchgear make up the Power Management Subsystem.

1.3.3.1 Power Conditioning System

The PCS interfaces with the ac power from the induction machine output to the utility power line in various modes of operation. The PCS provides the three-phase output connection of 480 VAC at 60 Hz for North American applications.

During normal grid parallel operation in the UPS/Power Conditioning mode, the diesel engine is not running. The induction machine acts as a motor to keep the flywheel at super-synchronous speed against the flywheel and machine rotor windage, and electrical losses, and attenuates input transients and sags from the grid.

Should the grid go out of a prescribed tolerance range for longer than a pre-determined period (typically 50 msec) then the input grid breaker opens. Since well over 90% of anomalies on the grid last less than two seconds, for the first two seconds the load is supported by the UPS function of the flywheel/induction machine combination without starting the engine. If the grid returns to normal during this two-second interval, the unit re-synchronizes to the grid and the input grid breaker is closed; no engine start takes place. If due to repeated such events there is insufficient energy left in the flywheel (determined by the flywheel rpm), to both provide a two-second wait period and a ten-second engine start, then the engine is started without the two-second wait.

1.3.3.1.1 Bi-directional Power Converter

The Bi-directional Power Converters (BPC) provides the variable frequency, variable voltage, 3-phase power to the IM rotor to control the IM stator terminal voltage amplitude, stator terminal voltage phase angle and, in emergency mode running off the engine, the load power frequency.

The BPC limits current, to/from the IM rotor, to 150% of full load current. This peak over-current compensates for transient line drop on the grid. The flywheel charging current continuously field adjusts between 5% and 100% of the full load discharge current and normally recharges the flywheel at a 5% rate when on the engine, or a 10% rate when on the grid.

The BPC, controlled by its own microprocessor, regulates the speed of the flywheel while it is being recharged or maintained in a charged state, and prevents acceleration beyond the operating speed range. The controls also regulate the IM frequency during discharge to maintain specified output frequency and during resynchronization to the grid.

The BPC consists of the following main sections:

- Rotor and Grid converter sections and controls
- Switchgear Section
- Monitoring Option

The BPC has ten modes of operation. These modes are selected automatically, or manually through the Standard Operator control panel:

- Grid Connected
- Grid Out of Tolerance
- Grid Out (Stand Alone Mode)
- Grid Return
- Cold Start (Normal)
- Black Start (Option)
- Reverse Power Flow

1.3.3.1.1.1 Rotor Power Controller

The Rotor Power Controller (RPC) provides variable frequency, variable voltage three-phase power to the IMG rotor windings, controlling both the stator terminal voltage magnitude and phase angle in respect to input utility voltage and in Emergency Mode of operation the load power frequency.

The RPC limits the currents, both sourced to and absorbed, from rotor windings to maximum of 300% or 3 pu of normal rotor full load current. This RPC overload capability is sufficient to provide for specified load voltage regulation while the input feeder is line-to-ground short-circuited and during the time required for over-current device to clear the fault.

The RPC also controls the speed of the flywheel/ IMG rotor, while it is recharging or maintains its speed in the charged state and prevents over-speeding, out-of-operating speed range. The RPC controls the rotor slip frequency and phase during flywheel discharge to maintain a constant IMG stator and load voltage magnitude and frequency within specified output tolerances.

1.3.3.1.1.2 Grid Power Controller

The same RPC slip frequency and phase control applied to the IMG Stator, is applied during resynchronization to the utility grid upon the Emergency Mode of operation.

1.3.3.1.2 Load Isolating Reactor

The Load Isolating Reactor (LIR) combined with the IMG, and RPC, provides the input power conditioning and load harmonics filtering required to maintain the input voltage within the specified limits. In Normal Mode of operation, the utility source supplies real power (kW) directly to the load through the Load Isolating Reactor (LIR).

The LIR is equipped with winding over-temperature sensors.

1.3.3.2 Automatic Bypass Switchgear

Under normal operation, the system operates with the bypass breaker in the OPEN state. A breaker in each module trips on temperature to bypass the UPS and connect the load directly to the input power source (e.g. the grid). The bypass engages automatically when the UPS output is out of tolerance, or manually, when commanded by an operator to isolate the UPS as may be required to perform periodic testing or maintenance. The bypass does not transfer unless the input voltage is within 10% of nominal, and frequency is within ± 0.5 Hz of nominal.

The UPS automatically transfers to bypass if it detects any of the following fault conditions:

- Excessive bearing and winding temperature

  The IMG is a class H (180°C) insulation system. The temperature rise is less than the maximum allowable by UL for the specified class at full load, 1000m elevation, and 40°C (104°F) ambient temperature.

  Bearing and winding temperature is monitored for excessive temperature rise. In case of bearing or winding over-temperature trip, the UPS unit shuts down automatically and transfers the prior load to bypass without interruption.
- Excessive vibration
- Output frequency deviation, or output voltage deviation

The Table 1-2 describes the individual circuit breakers for the 2.2 MVA and 315 kVA systems.

Table 1-2. Circuit Breaker Descriptions

Circuit Breaker	2.2 MVA Unit	315 KVA Unit
ICCB - Input Control Circuit Breaker - 480 V, 3-phase Used as an electrical control in response to control circuit commands, it reverse power flow sense, grid out of spec sense, grid back in spec sense, or isolates the UPS for maintenance etc.	3200 A	600 A
LBCB - Load Bus Circuit Breaker - 480 V, 3-phase Connects the UPS to the load and isolates it from the load and grid when the bypass breaker is activated. Electrically controllable in response to control circuit commands.	3200 A	600 A
BPCB - By-Pass Circuit Breaker - 480 V, 3-phase Electrically bypasses the total UPS system from the control circuit or is manually controlled. A detected failure or maintenance request causes the control circuit to close the By-Pass Circuit Breaker and open the Load Bus Circuit Breaker and Input Control Circuit breaker.	3200 A	600 A
MGCB - Motor/Generator Circuit Breaker - 480 V, 3-phase Protects against a motor/generator short, is electrically controlled from control circuit during start up sequences (regular and black start).	3200 A	600 A
SSCB - Stator Shorting Contactor - 480 V, 3-phase The SSCB is electrically controlled from control circuit during initial start up (regular and black start); makes with zero current, breaks with rated current.	3200 A	600 A
BICB - Bi-directional Inverter Circuit Breaker - 480 V, 3-phase Protects against faulted I-directional inverter. Manually controlled.	600 A	125 A
UDCB - Utility Disconnect Circuit Breaker Isolates the UPS system from the grid.	3200 A	600 A

1.3.3.3 Surge Inductor

The surge inductor isolates the load from surge events that may occur on the grid side of the UPS. It also provides impedance between the IMG and any short that might happen on the grid side of the system, limiting the contribution to the fault current from the IMG. A reverse power flow sensor prevents power from the UPS being back fed into the grid.

The inductor has a three-phase winding that limits the available input fault current contribution of the UPS to less than 200% of nominal rated output current. The winding limits the output fault current to no more than 5 times the full load current.

1.4 System Control

The UPS contains four major software components:

1. Master Control

   The local operator display acts as the master control for the system. The software provides overall system mode control, controls relays contained in the switchgear, provides communications to a local operator interface, provides communications to a remote computer and /or human machine interface, and interfaces to the grid and rotor control software.

2. Grid Control

   This control software resides on a Digital Power Controller Board (DPCB). See section 1.3.3.1.1.2 “Grid Power Controller” on page 1-10. The software develops Pulse Width Modulation (PWM) signals for use by the Grid Control Converter section of the PCS. In addition, the Grid Control software monitors various voltages and currents for the grid and internal buses associated with the UPS.

3. Rotor Control

   This software resides on a DPCB. It develops PWM signals for use by the Rotor Control Inverter section of the PCS. See section 1.3.3.1.1.1 “Rotor Power Controller” on page 1-10 for more information. This controller manages the operation of the induction motor / generator in response to the various system modes. In addition, the Rotor Control software monitors various voltages and currents for the internal buses associated with the UPS.

4. Remote Computer / Human Machine Interface

   Some products of the UPS family product line may include a remote computer capability or a local Human Machine Interface (HMI). The software residing on either of these units collects and displays information from the Master Control, Grid Control, and Rotor Control.

   The Human Machine Interface (HMI) contains function keys to start or stop the system, and enable or inhibit the diesel engine. The HMI also provides the running-system electrical data. Refer to section 6.4 “The Local Operator Interface” on page 6-3 for more information.

1.4.1 Master Control

The Programmable Logic Controller (PLC) is the heart of the control system; it monitors the grid for out of tolerance conditions that would require initiation of the UPS function.

The PLC controls the engine controller and the Bi-directional inverter controller (both the rotor controller and grid controller). Together, these controllers monitor and control the system both in watchdog mode (keeping the flywheel charged and providing power line quality improvement), and in UPS and stand-by-power modes (when the UPS is the sole provider of power to the load). Refer to Figure 1-3. "UPS Control Block Diagram" on page 1-15 for more information.

The PLC also monitors the state of the UPS system components, reports any alarm conditions to the Condition Monitoring panel, and shuts the system down if necessary. Refer to section 6.4 "The Local Operator Interface" on page 6-3" and section 1.4.1.4 "Mechanical and Thermal Monitoring System" on page 1-16 for more information.

The Master Control Software provides the overall control of the UPS System and includes the following functionality:

- Local Operator Interface
- Master Control of the engine
- Control of all circuit breakers
- Monitoring and reacting to system fault conditions

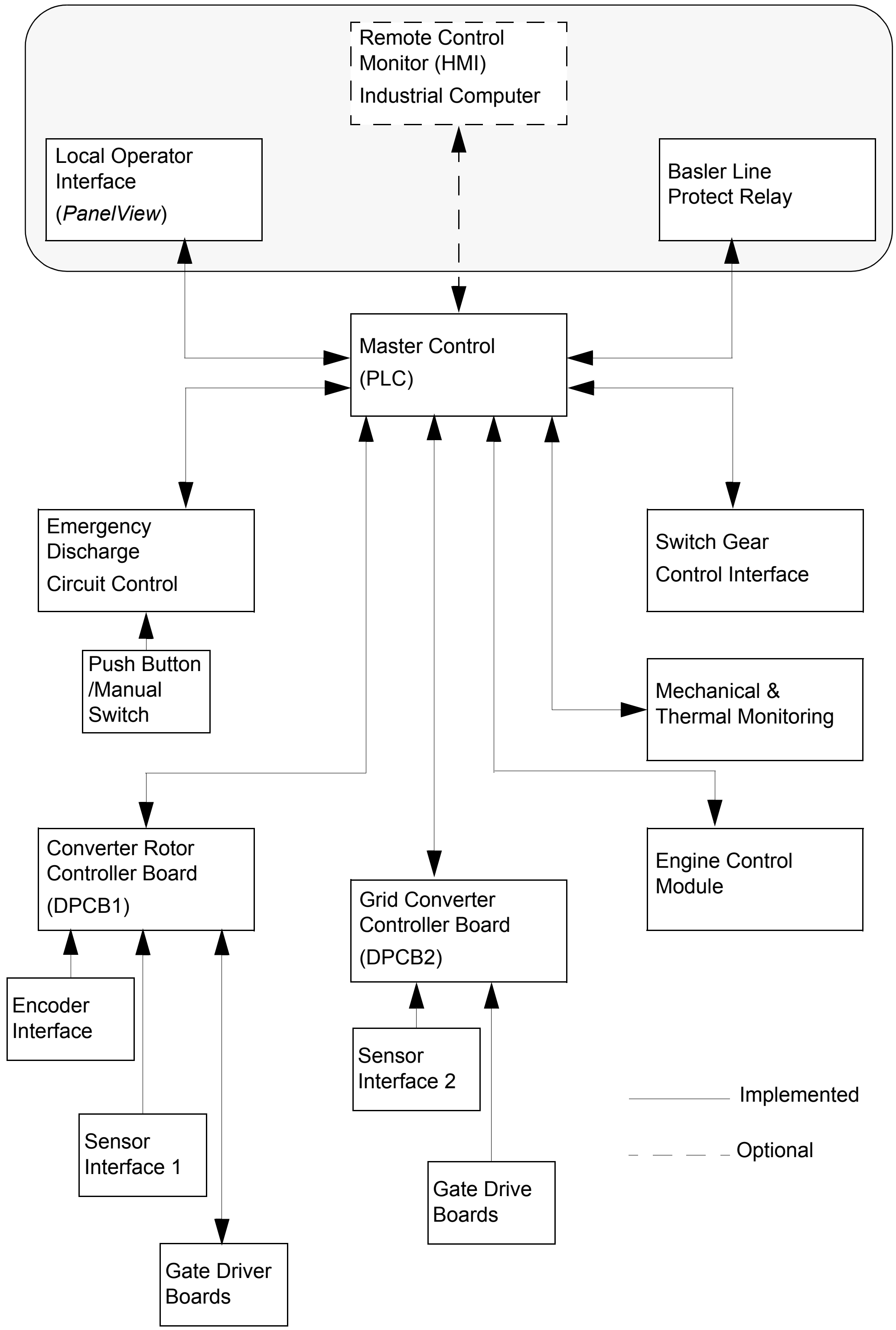


Figure 1-3. UPS Control Block Diagram

1.4.1.1 Engine Control Module

The Engine Control Module (ECM) is an electronic digital control device. The primary function of the ECM is to govern the engine speed. The PLC (section 1.4.1 "Master Control" on page 1-14) monitors the ECM.

The ECM hardware and software provides the following additional features:

- Engine Monitoring
- Engine Protection
- Diagnostic Mode (Fault Flash Out)

1.4.1.2 Line Protection Relay

The Reverse Power Line Protection Relay (LPR) monitors the utility grid for voltage and frequency limits. If the utility voltage or frequency goes beyond the set specifications, the LPR signals the PLC to disconnect from the utility and go into the UPS mode.

1.4.1.3 Emergency Stops

Use one or more of the Emergency Stop push buttons, to stop the flywheel in approximately five minutes. Refer to "Emergency Stop" on page xv for more information.

1.4.1.4 Mechanical and Thermal Monitoring System

The Mechanical and Thermal Monitoring system provides predictive maintenance using performance, temperature, and vibration sensors. Sensors measure flywheel clearance, balance, and bearing temperatures. The Mechanical and Thermal Monitoring system immediately shuts down the flywheel upon any out of tolerance condition. Refer to section 6.5 "Mechanical and Thermal Monitoring System" on page 6-6 for more information.

1.4.1.4.1 Induction Motor Generator Over-temperature Fault Response:

Excessive IMG bearing or winding temperature causes an alarm indication on the Mechanical and Thermal Monitoring system panel. After a 30-second delay, the UPS system shuts down. In a non-redundant UPS, the load transfers to bypass without interruption.

1.4.1.4.2 Induction Motor Generator Over-speed Fault Response:

Excessive IMG speed, causes the display of an alarm indication on the Mechanical and Thermal Monitoring system panel. The UPS system shuts down immediately. In a non-redundant UPS, the load transfers to bypass without interruption.

1.4.1.4.3 Flywheel Sensor Fault

The Flywheel assembly includes sensors to monitor the following:

- Bearing temperatures
- Bearing shock pulse
- Flywheel vibration
- Flywheel dimensions

If any of these parameters are detected as being excessive, an alarm is displayed on the control panel, and the module shuts down after a 30-second delay. The BPC gradually brakes the flywheel to a stop. In non-redundant UPS, the load transfers to bypass without interruption.

1.4.2 Digital Power Control Board

The DPCB generates Pulse Width Modulation (PWM) gating signals for the Rotor Converter (DPCB1) and Grid Converter (DPCB2) control and regulation, start / stop sequence, diagnostics and protection. Programmable software used for overall system control allows for system flexibility without the need for hardware change.

1.5 Operating Modes

1.5.1 Normal Operation

In normal operation, the UPS runs in parallel and in synchronism with the grid and provides localized improvement of waveforms against dips and surges.

During normal operation, the UPS regulates both the voltage and phase of the load power (with respect to the grid power) and protects the load from input transients and sags on the grid. In addition, the IMG acts as a motor to keep the flywheel at super-synchronous speed.

1.5.2 Ride-through Mode

When grid input power deviates more than plus 0.4% or minus 0.3% in frequency for longer than 250 milliseconds, or more than +/- 10% in voltage for longer than 50 milliseconds, the system disconnects the load from the grid source and supplies the load from the UPS. This transfer occurs without interruption in continuity of waveform. The flywheel energy supplies power for up to twelve seconds until the diesel generator back-up system starts up, synchronizes, and comes on line.

1.5.3 Standby Mode

Should the grid not return within tolerance within the 2-second period, the diesel engine starts. The flywheel/Induction Motor combination supplies full power to the load up to 10-seconds longer and assumes the full load for extended outage protection. The flywheel absorbs all transients are transparent to the protected load.

If the grid is out of tolerance for more than two seconds, the UPS uses the flywheel and motor/generator to provide power for up to ten-seconds longer while the engine starts. Once the engine starts, it is clutched into the flywheel and assumes the full load for extended outage protection. All transfer transients are absorbed by the flywheel and are transparent to the protected load.

1.5.4 Normal Start

With the grid present, the PCS uses the motor/generator to spin the flywheel from 0 rpm to 1980 rpm. Once the flywheel has achieved the appropriate speed, the PCS synchronizes and matches the stator voltage from the motor/generator to the grid and closes the motor generator circuit breaker (MGCB) onto the grid bus.

1.5.5 Emergency Mode (Standard)

Should the grid go out of tolerance either by a voltage deviation beyond the preset default tolerance (± 10% for 50 ms) or by frequency deviation beyond the preset default tolerance (± 0.3% for 250 ms), the UPS opens the input control circuit breaker (ICCB) and supports the load with the flywheel.

The flywheel and motor/generator provides power to the load for a pre-programmed delay (2 to 5 seconds), until either the grid returns to normal, or the engine starts, whichever comes first. In order to reduce the wear and tear on the engine due to repeated startups, the UPS uses the flywheel to provide power to the load for a minimum of two seconds before commanding the engine to start.

1.5.6 Restore Mode

In restore mode the grid returns, the system re-synchronizes with the grid frequency, closes the input control circuit breaker and the returns to normal grid parallel operation.

1.5.7 Black Start (Optional)

The optional Black Start capability starts the engine when the grid is not present. With Black Start, the flywheel is initially uncoupled from the system with the grid and load breakers open, and the DC power from the cranking battery of the engine is supplied to the IMG. As the engine cranks, starts, and speeds up, the PCS bootstraps itself, as the grid and rotor control inverters take control and provide voltage and frequency regulation. After establishing the input voltage and frequency, the PCS closes the load breaker. A farm of UPS systems requires only one system with the Black start capability; the other systems start from this Black-start unit using the normal cold start procedure.

2

Site Planning Requirements

This chapter describes the site requirements and the specifications required to prepare the site for the system installation and operation. It provides the following information:

- Mechanical, Environmental and Electrical Specifications
- Optional Enclosures
- System Location requirements
- Crane or Lifting Beam requirements
- System Power Requirements
- Noise Reduction
- Water Taps and Drains
- Fire Protection
- Off-loading and Positioning
- Grounding the system

Refer to the installation drawings provided in Appendix A.

SatCon Power Systems does not provide rigging, installation labor and installation materials (including all interconnections between detached pieces of equipment).

2.1 Specifications

This section provides the UPS system mechanical, environmental and electrical specifications.

Table 2-1. 2.2 MVA System Mechanical Specifications

Specification	Description
Power Generating System Dimensions	• Length: 30ft, $2^{5}/_{8}$ in (9.21 m) • Width: 8ft, 4in (2.54 m) • Height: 11ft, $11^{5}/_{8}$ in (3.65 m) • Weight (dry): 83933.3 lb. (38071.5 kg)
Control Cabinets - NEMA-3R/4 (Includes the Power Conditioning system, Inductor cabinet and Switch Gear cabinet)	Dimensions (W x H x D) 190 in. W x 90 in. H. x 16 in. D (4.83 m W x 2.29 m H x 4.9 m D) Control Cabinets Weight: • 480V system = 28000 lb. (12701 kg) – PLC = 5000 lb. (2268 kg) – PCS and Switchgear = 23000 lb. (10433 kg) • 575V system 17555 lb. (7963 kg) – PLC = 5000 lb. (2268 kg) – PCS and Switchgear = 12555 lb. (5695 kg)
Options	• Remote Monitoring • Outdoor Weatherproof Enclosure • Noise-attenuating Enclosure Contact your SatCon representative for more information.

Table 2-2. 315 kVA System Mechanical Specifications

Specification	Description
Power Generating System Dimensions	• Length: 17ft. 6in (5.33 m) • Width: 5ft. 8-1/8 in (1.73 m) • Height: 7ft. 10-7/16 in (2.40 m) • Weight: – Total UPS system weight 26952.2 lb. – Control Cabinets 4181 lb.

Specification	Description
Control Cabinets - NEMA-1 (Includes the Power Conditioning System, Inductor cabinet and Switch Gear cabinet)	Dimensions (W x H x D) 109.66 in. W x 85.40 in. H x 30.61 in. D (2.79 m W x 2.29 m H x 0.777 m D))
Options	• Remote Monitoring • Outdoor Weatherproof Enclosure • Noise-attenuating Enclosure Contact your SatCon representative for more information.

Table 2-3. 2.2 MVA and 3.15kVA Environmental Specifications

Specification	Description
Temperature Range	• Operating: - 4°F to 104°F (-20°C to 40°C) • Non-operating: - 4°F to 140°F (-20°C to 60°C)
Relative Humidity	10-95%, Non-condensing
Altitude	0-3000 feet (0-914m) without derating
Audible Noise	• 315 kVA unit inside the enclosure 3ft from the equipment 3ft high. * Measured with unit installed in standard enclosure at SatCon facility – Diesel Off: 94 - 91 dB (max at flywheel) – Diesel Running: 109 - 104 dB (max at diesel) • 315 kVA unit outside of the enclosure 3ft from the enclosure wall 3ft high: – Diesel Off: 78-68 dB (max at diesel air intake vent louvers) – Diesel Running: 101 - 77 (max at diesel cooling vent louvers) • 315 kVA unit outside the enclosure 10ft from the enclosure wall 3ft high: – Diesel Off: 72 - 61 dB (max at doorway (closed)) – Diesel Running: 95 - 73 dB (max at diesel cooling vent louvers) • 2.2 MVA unit installed inside of the SatCon facility, 3 feet from the ground, three feet from system – Diesel engine off: 100 dB - 8 dB (without noise attenuation) – Diesel engine on: 102 dB - 112 dB

2.2 Enclosures

Optional outdoor weatherproof enclosures are available to house the UPS units and protect them from the elements. You can install the system in your own weather and soundproof enclosures. In either case, SatCon does not provide special facilities and environmental controls (i.e. air conditioning) associated with installing the UPS systems. Refer to the installation drawings provided in Appendix A and to manufacturer documentation for proper installation.

2.3 System Location

Install the system in a restricted access location. Provide access only to authorized customer or SatCon service representatives.

2.3.1 Layout

The overall layout places the components as close together as possible, while allowing room for maintenance. UPS systems are capable of operating in a parallel configuration with units of the same or similar size. Refer to "Parallel Unit System" section on page 1-5 and the installation drawings provided in Appendix A for more information.

2.3.2 Foundation

Provide a properly prepared, solid, level concrete sub-base per civil design, capable of supporting the UPS system, equipment, and cabinets during operation. Refer to the installation drawings provided in Appendix A.

The UPS system operates constantly and therefore vibrates continuously. The client is responsible for the civil design of the sub-base and or the required foundation pads. If local code is different from the following listed suggestions, let local code prevail.

- The foundation pad must be capable of supporting 1.5 times the total weight of the UPS system, equipment, and cabinets during operation.
- The foundation mass must be 3 times the weight of the rotating equipment, the mass must be concentrated under the system frame.
- The surface must be level and must have a deviation less than ± 2 mm per meter. It should extend 30 mm around the UPS system frame.
- To reinforce the concrete pad, use No. 8 gauge, steel, wire mesh placed horizontally on 150 mm centers, or No. 6 rebars on 300 mm centers horizontally, using 76 mm cover (minimum) over the bars.

- The recommended concrete mixture follows:
  – 1part of cement, 2 parts sand, and 3 parts aggregate
  – Maximum slump is 100 mm with 28-day compressive strength of 4000 psi.
- Do not exceed 25% of specified torque before concrete has had a 90-day curing time.

2.3.3 Airflow

Choose air inlets and outlets such that cool air flows from the air inlet over the IMG and the diesel engine to the air outlet.

2.3.3.1 2.2 MVA Unit

- The IMG on the 2.2 MVA unit requires an airflow of 6000 CFM @ $1^1/_2$ inches of water.
- The fan consumes 2.86hp (has a 3hp motor)

2.3.3.2 315 kVA Unit

- The IMG on the 315 kVA unit requires an airflow of 2100 CFM @ 1 inches of water.
- The fan consumes 0.73hp (has a 1.5hp motor). Fan operating Speed: 1750 rpm

2.3.4 Maintenance Clearances

Site preparation must consider clearance requirements for system maintenance. These clearances should be in accordance with OSHA, NESC, and NEC. These working clearances are not required if the equipment is not likely to require examination, adjustment, servicing, or maintenance while energized. However, sufficient access and working space is still required. For example, allow at least two feet of space around the UPS frame. Include enough space in front of the Control Cabinets to allow people to pass in front of the cabinet with the doors completely opened.

2.3.5 Cooling Space

The 2.2 MVA Control Cabinets require a minimum of 36 in. (91.44 cm) of cooling space between the back of the panels and the wall.

Set the cabinets for the 315 kVA system a few inches from the wall to be sure they are free standing.

2.4 Crane or Lifting Beam

In order to lift the equipment without damage for installation and maintenance, you must provide a means of lifting and rigging over the system. The installing or rigging contractor must provide spreader bars.

2.5 System Power Requirements

To operate the UPS you must have a connection to the mains and provide 120 V outlets to power the tools required for installation, service, and maintenance; and 230 V power source for the engine heaters.

2.5.1 Electrical Requirements

Table 2-4. Input / Utility Source Terminals

Nominal Voltages:	480V (Standard) 600 V, (575 Option)
Connection:	• 3 phase, 3 wire + ground (Standard) • 3 phase, 4 wire + ground (Option)
Voltage Range:	• +/- 10% of Nominal (Standard) • +15% to -20% of Nominal (Option)
Nominal Frequency:	60 Hz (Standard) 16 2/3 Hz, 25 Hz, 50 Hz (Option)
Frequency Range:	+0.4 Hz to -0.3 Hz of Nominal
Maximum Input Current:	Not to exceed the calculated amps per: 1.1 x Unit kVA/ (1.73 x Nominal Voltage)
Peak Inrush Current:	None, Variable Frequency Drive type of Soft Start
Harmonic Currents (TDD): Reflected to Utility	• Less than 3% for Linear Load • Less than 5% for 100% Non-Linear Load
Power Factor (PF):	Unity to 0.95 at Rated Load, Nominal Voltage and for Unity to 0.8 Load PF
Input Fault Contribution:	• Less than 250% of maximum Input current for Source Line-to-Line and 3-Phase faults • Less than 200% of Max. Input current for Source Single Line to Ground Faults

Table 2-5. Output / Load Bus Terminals

Specification	Description
Unit Power Ratings	• 315 kVA / 250 kW • 2.2 MVA / 1760 kW
Rated Current	As calculated per: unit kVA / (1.73 x Nominal Voltage)
Nominal Voltage	Same as input/utility source nominal
Connection	• 3 Phase, 3 wire + ground (standard) • 3 phase, 4 wire + ground (option)
Voltage Regulation	• Steady State: 2% of nominal for +/- 10% input, balanced or 100% unbalanced loads • Transient: +/- 10% for 100% step load change +/- 10% for input/utility source faults • Recovery time: less than 250 milliseconds
Frequency Regulation	• Normal mode: Utility Source Synchronized • Ride-through mode: +/- 0.5% steady state +/- 1.0% transient 0.5 Hz/second maximum slew rate • Standby mode: same as for Ride-through mode
Phase Displacements	• 120° +/- 1.2° for balanced load • 120° +/- 2.4° for 20% unbalance load
Harmonic Voltages (THD)	• Less than 3% for linear load • Less than 5% for 100% non-linear load
Overload Capability	• 110% of rated current for 1 hour • 125% of rated current for 5 minutes • 150% of rated current for 1 minutes
Fault Clearing Capability	500% of rated current for 0.1 seconds into the short circuited load
Voltage Adjustment Range	0 to +5% for feeder voltage drop compensation

2.5.2 Bypass Breaker

Connect an automatically and manually operated bypass breaker directly between the utility input and output load terminals. Refer to Figure 1-3. "UPS Control Block Diagram" on page 1-15.

2.5.3 Cabling

The cables, from the stator to the control panel, and from the rotor to the control panel are provided by the installation contractor; they are not a SatCon provided item. Follow local standards and codes for the required cable and lug sizes. Calculate the required cable size based on the nominal current for the on-site cable installation. For example:

$$IL = (MachinePowerCapability)/(480VLineVoltage)\sqrt{3}$$

For example for the 315 kVA:

$$IL = 315KVA/(480V)\sqrt{3}$$

$$IL = 315000/(480)1.73$$

$$IL = 380 \text{ Amps per phase}$$

Always follow local standards and codes for the required cable and lug sizes. The following list is provided only as a reference:

- For the 2.2 MVA UPS stator:
  - Wire size 646 MCM, 4 conductors per phase, a total of twelve wires for UPS power (four wires per phase).
  - Connect each wire to the motor bus bars, using a two hole NEMA pattern lug Manufacturer ILSCO, PN: FE 646L2.
- For 2.2 MVA UPS rotor
  - Wire size 4/0, one conductor per phase, a total of three wires for UPS rotor. No lug is necessary at the rotor junction box.
- For the 315 kVA Stator
  - Wire size 313MCM, 1 conductor per phase.
- For 315 kVA UPS rotor
  - Wire size 4AWG, 1 conductor per phase.

Use highly stranded cable for flexibility, rated for a temperature of 194°F (90°C) and 2000 Volts. This type of cable is rated for service in diesel locomotives and offshore oil rigs, and is highly recommended for motor and generator leads.

2.5.4 Ventilation

The UPS system contains equipment that generates heat including: engine, radiator, generator, pumps, clutches, exhaust pipes, electrical equipment, etc. Install a ventilation system to avoid a build-up of room temperature. For optimum engine operation, design the ventilation system to limit the temperature rise in the room to 27°F or 15°C from ambient. Refer to the operating temperature range listed in Table 2-3 on page 2-4.

If the room temperature exceeds the maximum operating temperature listed in Table 2-3 on page 2-4, duct the aspiration air directly from the atmosphere to the engine, or apply an engine derate. Be sure to consider other factors such as the provision of acceptable working conditions for personnel.

2.5.5 Cooling Air Flow Calculation

The most convenient method of controlling the UPS/engine room temperature utilizes a ventilating fan, entrance duct, and exhausting duct. For estimating air flow requirements in an environment the following formula applies:

$$\text{Air flow (cfm)} = \frac{\text{Rejected Heat (KW) X 58}}{\text{Air Density (0.07) x Specific heat of air (0.238) x temperature Rise (F°)}}$$

For example:

$$\frac{\text{HR X 58}}{.018\ \Delta T} = \frac{\text{260KWm x 58}}{\text{.018 x 25°F}} = \frac{15080}{.27} = \text{33,511 CFM}$$

Total Room Heat Rejection = Engine + Alternator + Exhaust Piping + Other Heat Sources.

2.5.6 Lubrication

Table 2-6 lists the recommended oil and quantity required for the Lubrication System and bearings, coupling and clutch maintenance.

Table 2-6. Bearing and Coupling Oils

Oil	Recommended	SatCon Part Number	Quantity
Bearing Oil	• Castrol (Hi Perf): Tribol 1715-150 Synthetic (for high temperatures above 160 F) • Castrol (less expensive): Hyspin R & O 150 • Fiske Brothers: Lubriplate SPO-244	750000104	20 Gallons
Coupling Oil	• Fiske Brothers: Lubriplate #8 • Citgo Corp: Citgo EP Compound 460 • Exxon: Teresstic 460 • Castrol (Hi Perf): Tribol 1100-460 (high performance) • Castrol (less expensive): Alpha EP 460	750000103	2 Gallons
Clutch Oil	• ISO VG32 oil with extreme pressure additives • Fiske Brothers: Lubriplate APG-75 • Castrol (Hi Perf): Tribol 943-32 • Castrol: Hyspin AW 32	750000105	2 liters

2.5.7 Diesel System

The recommendations for exhaust systems, cooling systems, and fuel systems vary according to the configuration of the machine, such as installed indoors or outdoors, in an enclosure, length of exhaust system required, and relative location of fuel storage. Refer to the engine manufacturer's specifications. The following sections are provided as an example.

2.5.7.1 Exhaust System

The exhaust system draws the combustion gases from the engine to the outside of the building and reduces the noise level to meet local code requirements. Table 2-7 provides general information; refer to the engine manufacturer's application manuals and specifications.

Table 2-7. Exhaust System Guidelines

Considerations	Guidelines
Maximum Backpressure at Standby Power	• 315 kVA - 3 inches of Hg (76 mm Hg) • 2.2 MVA - 2 inches of Hg (51mm Hg)
Exhaust Outlet location	• Exhaust gases must exit away from building vents, windows, and doors. • Direct the exhaust outlet away from workers and neighbors. • Exhaust outlet must consider prevailing winds and stagnant air pockets • Exhaust outlet must direct gases/heat away from engine air intake.
Piping Design	• Exhaust Pipe Size (normally acceptable inside diameter) single stage 9 in. (230 mm) • Do not mount the muffler directly onto the turbo housing. • Muffler must be well supported. • Must have condensate trap and drain close to engine. • Each engine must have separate exhaust pipe system from engine to open air exit. • Exhaust pipe must have cap to prevent rainwater, snow from entering system.
Blanketing	Covering of the turbo housing voids any warranty and may result in engine and/or personnel damage.

2.5.7.2 Recommended Exhaust/Silencer Installation

- Silencer supported from building
- Exhaust pipes/silencers insulated and away from intake

2.5.7.3 Recommended Exhaust Outlet

- Opposite end from Intake
- Rain caps installed

2.5.8 Fuel System

The fuel system supplies diesel fuel to the engine. Additional fuel storage tanks may be installed as desired. Refer to the “Fuel Storage Tank,” section on page 2-15.

Hard piping materials are not supplied. However, both the piping for the fuel transfer pump to the day tank fuel inlet connection and the day tank overflow port to the fuel storage tank connection must be hard piped.

2.5.8.1 Fuel

Diesel fuel supplies all of the energy for the engine, and cools and lubricates the precision parts of the engine fuel pump and injectors.

Use fuel that meets the Grade No. engine 2-D requirements of the American Society for Testing and Materials (ASTM) D975, Standard Specifications for Diesel Fuel Oils. Also, refer to the engine manufacturer's manual on fuel and additives.

2.5.8.2 Fuel Storage

Many installation sites are subject to regulations concerning the design, size, location, and installation of the main fuel storage tank as well as float tanks/day tanks. The fuel tanks used must conform to all applicable codes.

SatCon recommends that the bulk fuel storage tank also include a low-fuel-level alarm.

2.5.8.2.1 Day Tank

The day-tank mounting allows gravity feed of the fuel to the unit. Each system uses a day tank that has a 50-gallon capacity, and contains a rupture basin of 125% capacity. An alarm indicates the presence of fluid in the rupture basin.

2.5.8.3 Fuel Storage Tank

The installation facility must include a bulk fuel supply tank, with adequately sized fuel lines for supply and return fuel ports. The fuel lines must comply with prevailing local codes at the job site, and must be brought to the main base rail for contractor connection to the engine fuel supply (day tank).

2.5.8.4 Fuel Consumption

SatCon recommends that the diesel fuel storage tank be of sufficient size to run the diesel engine at full load for 10 hours.

- The 2.2 MVA UPS requires 140 gallons of fuel per hour.
- The 315 kVA UPS requires 16 gallons of fuel per hour.

Refer to local fire codes, regulatory agencies, and the National Fire Protection Association codes.

2.5.8.5 Fuel Lines

See the engine manufacturer's recommendations for the type and size of fuel lines.

2.5.9 Diesel Fluids

The Engine ships dry. Table 2-8 lists the recommended engine fluid type, and quantity required to commission the system.

Table 2-8. Engine Fluids

Fluid	Recommended	SatCon Part Number	System Capacity	
			315 kVA	2.2 MVA
Engine Lube Oil	SAE 15W-40 engine oil	---	24 gallons (91 liters)	74 gallons (280 liters)
Antifreeze	Fleetguard SC Complete Extended Life antifreeze or equivalent. 50% - 50% mixture of distilled water and propylene glycol	751110026	28.25 gallons (107 liters)	195 gallons (738 liters)

2.6 Noise Reduction

Optional housings and upgraded exhaust silencers are available to reduce noise. Refer to Table 2-3.

2.7 Water Taps and Drains

No water taps or drains are required.

2.8 Fire Protection

Comply with local fire protection standards and codes. Pay particular attention to the type of fires that can exists, such as fuel, oil, and electrical.

2.9 Off-loading and Positioning

Use a qualified company to off-load the equipment. Keep the equipment covered during site preparation until placed into final position.

3

Installation

The Installation chapter describes how to safely set up the system and provides the following information:

- Installation Safety Guidelines
- Verifying the Shipment
- Positioning the Equipment
- Installing the optional enclosure
- Protective vibration and thermal sensors
- Setting up the site-installed cabling
- Accessing a remote connection
- Grounding the system

A SatCon representative will be available for consultation during the installation and commissioning of the UPS frame and the Control Cabinets.

Prepare the site as defined in Chapter 2, "Site Planning Requirements" to ensure correct installation and operation.

Install the UPS frame and Control Cabinets in compliance with the National Electrical Code. Only properly licensed contractors may install, off load, and connect the system according to state or local codes.

3.1 Installation Safety Guidelines

Observe the following safety guidelines to prevent physical injury and damage to the equipment when installing or operating the SatCon Uninterruptible Power Supply:

- Follow lockout and tagout safety procedures to shut power off and secure the partially installed system.
- Locate the main breaker, and ensure it is set to Off.
- Do not work alone if potentially hazardous conditions exist.
- Never assume that power is disconnected from a circuit, always check.
- Carefully examine your work area for possible hazards such as wet floors, ungrounded power extension cables, or missing safety grounds.

Before beginning to work, read and comprehend the information provided in the "Safety" chapter on page xiv.

3.1.1 Equipment Security

Hazardous conditions may be present during installation of the system. Restrict installation site access to only trained personnel.

This system contains high voltages and rotating mechanical parts. Hazardous conditions may exist during installation of the system.

3.2 Shipment Verification

The main frame fits on a lowboy flatbed. The system dimensions are within the over the road limits (for non-wide loads).

Inspect the shipment for obvious shipping damage. If damage is found, file a claim with the shipping agency and notify your SatCon representative immediately.

To verify complete shipment, refer to Table 3-1. "Shipment Contents". If any items are missing, contact your shipping carrier and notify your SatCon representative.

Table 3-1. Shipment Contents

Box/Crate	Contents
315 kVA System	The complete 315 kVA frame ships on one skid, with the cabinets shipping separately.
2.2 MVA System	The 2.2 MVA cabinets, frame, and radiator ship separately to avoid additional transportation licensing.

3.2.1 Equipment Lifting

Use the lifting points defined on the installation drawings, provided in Appendix A. Use a minimum of one Caldwell lifting spreader or equivalent on both ends of the frame. Refer to the machine weight listed on the installation drawings to properly size the spreader(s).

Before you begin, be sure to clear the staging area and the installation area.

3.3 Equipment Positioning

Refer to section 2.3 "System Location" on page 2-5. The layout must comply with both the installation drawings provided in Appendix A and local and state codes.

3.3.1 Mounting

Mount and anchor the UPS system frame to the sub-base as defined in the installation drawings provided in Appendix A.

Place the Control Cabinets directly on the floor in an environmentally controlled space. Refer to section 2.3.5 “Cooling Space” on page 2-7.

3.4 Equipment Protection

To protect the equipment during installation and site preparation, follow the recommendations listed below:

- Dust and Moisture Protection

  Dust and dirt from a construction environment may damage the equipment. Protect the system against dust and moisture during installation. Keep the system covered with a tarp.

  A dusty environment may require additional air filtration. Contact your SatCon representative for more information.

- Diesel Engine Storage

  The diesel engine requires special conservation if the system arrives at the site more than 6 months before commissioning. Contact the diesel engine manufacturer for proper storage procedures to avoid corrosion in the diesel engine and bending of the shaft.

3.5 Enclosure Installation (Option)

Follow the enclosure manufacturer’s installation guidelines to install the enclosure.

3.6 Sensors

The system ships with the Mechanical and Thermal Monitoring system sensors installed.

3.7 Site Installed Cabling

Follow local standards and codes when cabling the system. For safe operation, install proper grounding, conductor sizing and short circuit protection. Refer to section 2.5.3 “Cabling” on page 2-10 for more information.

3.7.1 Cable Access

Access the Power Conversion and Control Cabinet cables from the top (standard) or bottom. Access the cabling and wiring to rotating equipment on the main base through overhead conduit. Refer to the installation drawings provided in Appendix A.

3.7.1.1 Trenches

When using trenches, the necessary depth depends on the radius of the power cable. Be sure to provide provisions for draining liquid within the trenches. Water may accumulate in the trenches and cause damage to the cables and short circuits.

3.7.2 Power Cabling

The general System Block Diagram and Interconnection Diagram presented in Figure 3-1 is provided as a reference.

- To connect the 315 kVA, 480 VRMS system power cables refer to Table 3-2. "315 kVA, 480 VRMS System Power Cabling Connections" and the SatCon "System Block Diagram and interconnection Diagram" drawing 751110083, provided in Appendix A.
- To connect the 2.2 MVA 575 VRMS system power cables refer to Table 3-3. "2.2 MVA, 575 VRMS System Power Cabling Connections" and the SatCon "System Block Diagram and Interconnection Diagram" drawing 752220122, provided in Appendix A. Figure 3-1 is provided as a reference.

Follow local standards and codes for required cable and lug sizes. Calculate the proper wiring size selection and wiring installation size based on the nominal current for the on-site cable installation. Refer to section 2.5.3 "Cabling" on page 2-10 for examples of sample calculations.

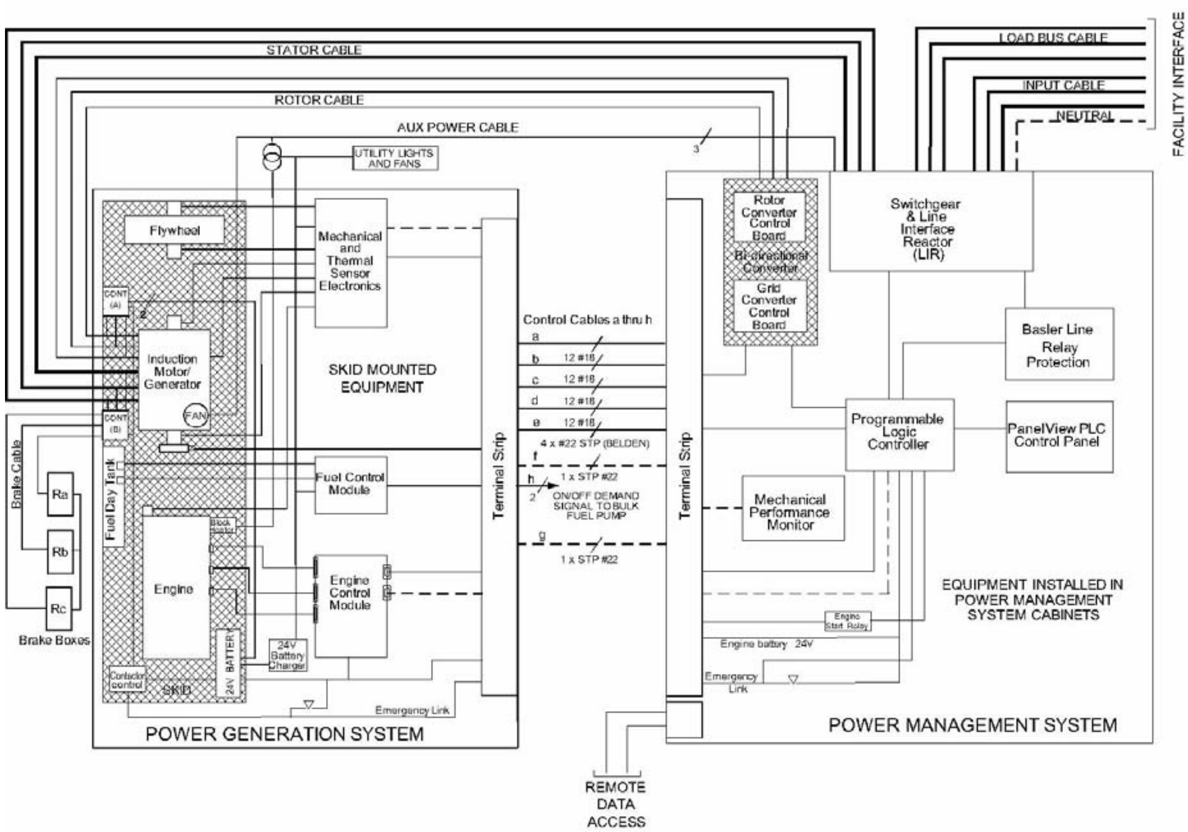


Figure 3-1. System Block Diagram and Interconnection Diagram

Table 3-2. 315 kVA, 480 VRMS System Power Cabling Connections

Item	Rating	From	To	Specs
Input Cable	3 Phase 480 Vrms 380A	Facility Breaker • Phase (a) • Phase (b) • Phase (c)	Cabinet Input Power Terminals • UA • UB • UC	Per code
Load Cable	3 Phase 480 Vrms 380A	Cabinet Output Terminals • LA • LB • LC	Critical Load Distribution Panel • Phase (a) • Phase (b) • Phase (c)	Per code
Stator Cable	3 Phase 480 Vrms 380A	Cabinet Stator Terminals • 2 • 3 • 1	IMG Stator Junction Box • Phase (a) 1 • Phase (b) 2 • Phase (c) 3	Per code
Rotor Cable	3 Phase 700 Vrms 50A	Cabinet Rotor Terminals • M1 • M2 • M3	IMG Rotor Junction Box • Phase (a) M1 • Phase (b) M2 • Phase (c) M3	Per code
Brake Cable	3 Phase 480 Vrms 200A	IMG Stator Junction Box • Phase (a) 1 • Phase (b) 2 • Phase (c) 3	Cont. (B) Terminals • Phase (a1) • Phase (b1) • Phase (c1)	Per code
Brake Box Neutral	1 Phase 480 Vrms 200A	Brake Box • R(a) Terminal 2 • R(b) Terminal 2	Brake Box • R(b) Terminal 2 • R(c) Terminal 2	Per code
Contactor (A) Cable	3 Phase 700Vrms 50A	IMG Rotor Junction Box • Phase (a) M1 • Phase (b) M2 • Phase (c) M3	Cont (A) Terminals • Phase (a) • Phase (b) • Phase (c)	Per code

Item	Rating	From	To	Specs
Contactor (B) Cable	3 Phase 480 Vrms 200A	Cont(B)Terminals • Phase (a2) • Phase (b2) • Phase (c2)	Brake Box Terminals • R(a) Terminal 1 • R(b) Terminal 1 • R(c) Terminal 1	Per code
Aux Cable	3 Phase 480 Vrms 10A	Cabinet Output Aux Terminals • LAfuse • LBfuse • LCfuse	Terminal Block in NEMA box • Phase (a) • Phase (b) • Phase (c)	Install NEMA box per code in unit enclosure (see below)
Aux Transformer	1 Phase 480V/240/120V 2kVA, 60Hz			Supply and install per code in NEMA box in enclosure
IMG Fan Cable	3 Phase 480 Vrms 10A	Terminal Block in NEMA box • Phase (a) • Phase (b) • Phase (c)	IMG Fan Terminal Box • Phase (a) • Phase (b) • Phase (c)	Per code NB: Air blows downwards when phased correctly
Engine Block Heater	1 Phase 240/208Vrms 10A	Aux Transformer 240/208V secondary	Block Heater Electrical Terminal box	Per code
120V Utility	2 phases 120Vrms 20A	120V Distribution bus in NEMA box	Outlets, lights and fans as required	Per code
Battery Charger	1 phase 120Vrms 20A	Aux Transformer 120V Distribution	Battery Charger utility outlet	Per code

Table 3-3. 2.2 MVA, 575 VRMS System Power Cabling Connections

Item	Rating	From	To	Specs
Input Cable	3 Phase 575 Vrms 3000A	Facility Breaker • Phase (a) • Phase (b) • Phase (c)	Cabinet Input Power Terminals • UA • UB • UC	Per code
Load Cable	3 Phase 575 Vrms 3000A	Cabinet Output Terminals • LA • LB • LC	Critical Load Distribution Panel • Phase (a) • Phase (b) • Phase (c)	Per code
Stator Cable	3 Phase 575 Vrms 3000A	Cabinet Stator Terminals • 2 • 3 • 1	IMG Stator Junction Box • Phase (a) 1 • Phase (b) 2 • Phase (c) 3	Per code
Rotor Cable	3 Phase 700 Vrms 300A	Cabinet Rotor Terminals • M1 • M2 • M3	IMG Rotor Junction Box • Phase (a) M1 • Phase (b) M2 • Phase (c) M3	Per code
Brake Cable	3 Phase 575 Vrms 1000A	IMG Stator Junction Box • Phase (a) 1 • Phase (b) 2 • Phase (c) 3	Cont (B) Terminals • Phase (a1) • Phase (b1) • Phase (c1)	Per code
Brake Box Neutral	1 Phase 575 Vrms 1000A	Brake Box • R(a) Terminal 2 • R(b) Terminal 2	Brake Box • R(b) Terminal 2 • R(c) Terminal 2	Per code
Contactor (A) Cable	3 Phase 700Vrms 300A	IMG Rotor Junction Box • Phase (a) M1 • Phase (b) M2 • Phase (c) M3	Cont (A) Terminals • Phase (a) • Phase (b) • Phase (c)	Per code

Item	Rating	From	To	Specs
Contactor (B) Cable	3 Phase 575 Vrms 1000A	Cont(B)Terminals • Phase (a2) • Phase (b2) • Phase (c2)	Brake Box Terminals • R(a) Terminal 1 • R(b) Terminal 1 • R(c) Terminal 1	Per code
Aux Cable	3 Phase 575 Vrms 10A	Cabinet Output Aux Terminals • LAfuse • LBfuse • LCfuse	Terminal Block in NEMA box • Phase (a) • Phase (b) • Phase (c)	Install NEMA box per code in unit enclosure (see below)
Aux Transformer	1 Phase 575V/240/120V 2kVA, 60Hz			Supply and install per code in NEMA box in enclosure
IMG Fan Cable	3 Phase 575 Vrms 10A	Terminal Block in NEMA box • Phase (a) • Phase (b) • Phase (c)	IMG Fan Terminal Box • Phase (a) • Phase (b) • Phase (c)	Per code NB: Air blows downwards when phased correctly
Engine Block Heater	1 Phase 240/208Vrms 10A	Aux Transformer 240/208V secondary	Block Heater Electrical Terminal box	Per code
120V Utility	2 phases 120Vrms 20A	120V Distribution bus in NEMA box	Outlets, lights and fans as required	Per code
Battery Charger	1 phase 120Vrms 20A	Aux Transformer 120V Distribution	Battery Charger utility outlet	Per code

3.7.2.1 Control Cabinet Cabling

Before making any connections to the Control Cabinets, mark both ends of the cables with the terminal strip alphanumeric identifier using a waterproof tag.

- To connect the 315 kVA System Control Cabinet cables refer to Table 3-4. "System Control Cabinet Cabling" and the SatCon "315 kVA UPS System Block Diagram and Interconnection Diagram" drawing 751110083, provided in Appendix A. Figure 3-1. "System Block Diagram and Interconnection Diagram" is provided as a reference.
- To connect the 2.2 MVA System Control Cabinet cables refer to Table 3-4. "System Control Cabinet Cabling" and the SatCon "System Block Diagram and Interconnection Diagram" drawing 752220122, provided in Appendix A. Figure 3-1. "System Block Diagram and Interconnection Diagram" is provided as a reference.

Table 3-4. System Control Cabinet Cabling

Item	Rating	From Frame Terminal Strips	To Power Management System Terminal Strips /For	Specifications
a	#16	TBECM	/misc	12 Conductor
b	#16	TBECM & TBMECH-1	/misc	12 Conductor
c	#16	TBMECH-1	/misc	12 Conductor
d	#16	TBMECH-1 & TBMECH-2	/misc	12 Conductor
e	#22	TBMECH-2	/encoder	4 shielded twisted pair Belden Cable
f	#22	TBECM	/ECM data link	1 shielded twisted pair
g	#22	TBMECH-2	/SKF data link	1 shielded twisted pair
h	#16	TBMECH-2	External Connection /Fuel Demand	2 Conductor

3.8 Remote Connection Access

Remote monitoring of the UPS system by the customer and SatCon Power Systems is possible over a LAN or Telephone Modem. Remote monitoring over a network connection requires connecting the system to the customer LAN, and granting SatCon access to that connection. Dial-up modem access requires a telephone line connection and modem, rated for utility interconnected equipment applications.

⚠ Do not connect the system to the Internet. This Windows 2000 system is not secure for Internet connection.

To monitor the UPS system remotely, refer to Table 3-5. "Remote Access Cabling".

Table 3-5. Remote Access Cabling

Item	Rating	From Power Management System Terminal Strip	To Customer Terminal for:	Specifications
i	Per Spec.	TBD	Lan Socket	Cat-5 LAN Cable
j	#22	TBD	Telephone Modem	1 Shielded Twisted Pair

3.9 System Ground

Consult the National Electrical Code and other local codes for specific equipment grounding requirements when grounding the system. Ensure that the frame and the Control Cabinets are properly grounded. Subsystems such as the day tank and radiators are grounded to the frame.

4

Commissioning

Commissioning the Rotary UPS system includes the test and exercise of all functions and modes of a single system. The commissioning chapter provides information on:

- Visually inspecting the system
- Performing a complete Functional Test
- Customer Training

4.1 Required Equipment

Table 4-1. Test Equipment

Description
Digital Volt Meter
Machine Alignment Tool
Oscilloscope
Reliable Power Meter (RPM)
Temperature Indicator

4.2 Initial Inspection

The Commissioning engineer performs the visual checks listed below. If expected results are not produced at any step, consult with SatCon Service before proceeding to the next step.

Record the results of the visual inspection on Table B-1. "Initial Inspection Data" on page B-2 of Appendix B.

1. Check all electrical components for any signs of damage.
2. Verify the system is connected to Ground. Measure and record resistance.
3. Ensure all connections are properly fixed and tight.
4. Verify all power cables are terminated to the correct location, Refer to section 3.7 "Site Installed Cabling" on page 3-3.

5. Verify that the Flywheel Lubrication System contains 20 gallons of bearing oil (refer to section 2.5.6 “Lubrication” on page 2-12)
6. Verify that the engine coolant is filled to the proper level (refer to section 2.5.9 “Diesel Fluids” on page 2-15).
7. Verify that the diesel engine oil is filled to the proper level (refer to section 2.5.9 “Diesel Fluids” on page 2-15)
8. Verify that the flexible coupling oil is filled to the proper level (refer to section 2.5.6 “Lubrication” on page 2-12).
9. Ensure that all protective covers are in place and secured, all nuts and bolts are tight.
10. Check the alignment to the levels listed on Table B-2 of data sheet B.2 “Alignment Record Sheet” on page B-3. Record the levels on Table B-3.

4.3 Functional Test

Perform the following steps as a final functional test. If expected results are not produced at any step, consult with SatCon Service before proceeding to the next step.

Record the results of the visual inspection in Table B-4. "Functional Test Data" on page B-4 of Appendix B.

▷ Disconnect the customer load before performing the testing listed below.

1. Ensure the engine block heater has been running for approximately 8 hours. Record coolant temperature.
2. Manually close circuit breakers UDCB and BICB.
   - **a.** Turn on grid power using the wall isolation switch.
   - **b.** Verify circuit breakers BPCB, LBCB, ICCB, SSCB, and MGCB are open and charged.
3. Apply grid voltage.
   - **a.** Turn on the auxiliary uninterruptible power supply unit, located inside of the control cabinet.
   - **b.** Verify that the two DCPB control boards and the PLC are energized. Refer to Figure 4-1. Location of DPCB1, DPCB2, and PLC for the 2.2 MVA System, Figure 4-2. Location of DPCB1 and DPCB2 for the 315 kVA System and Figure 4-3. Location of the PLC for the 315 kVA System.

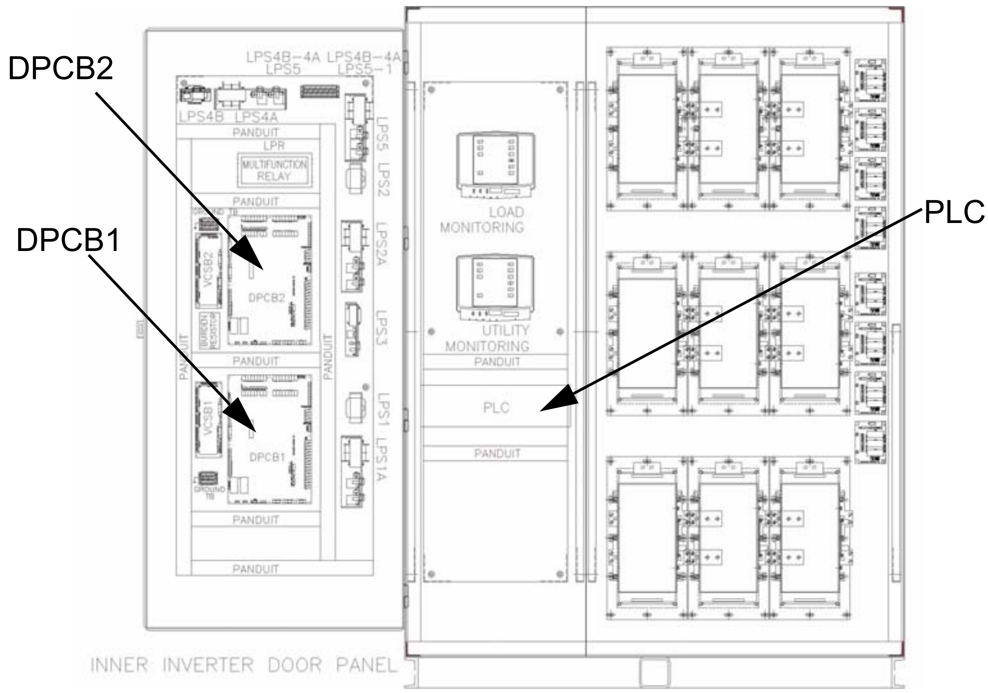


Figure 4-1. Location of DPCB1, DPCB2, and PLC for the 2.2 MVA System

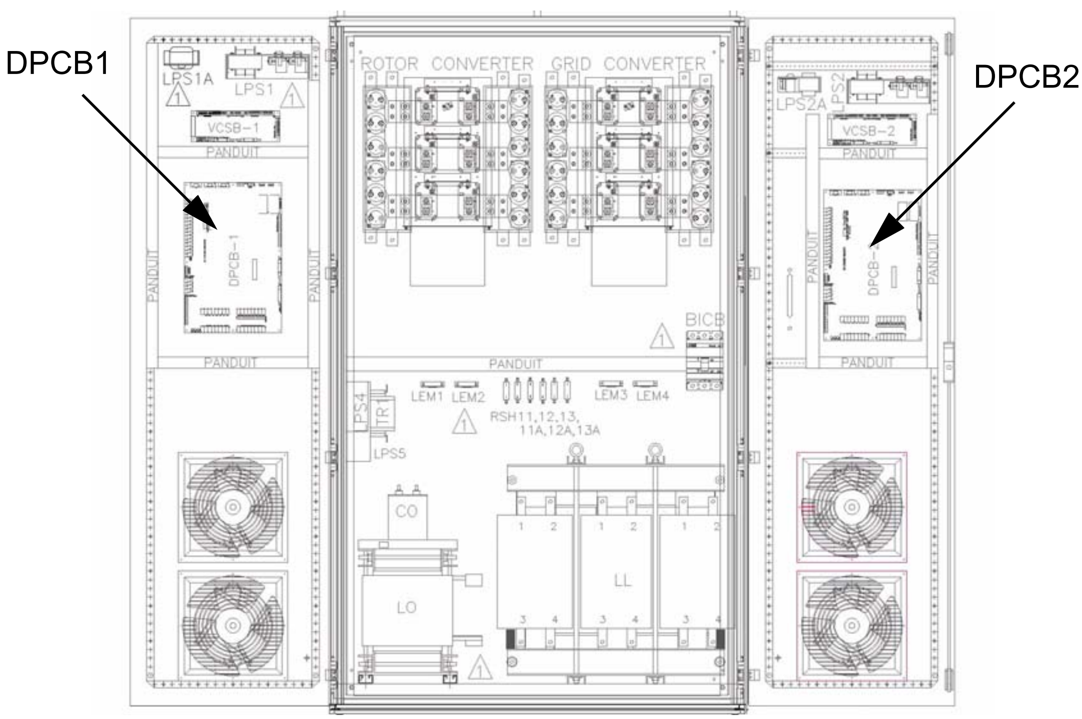


Figure 4-2. Location of DPCB1 and DPCB2 for the 315 kVA System

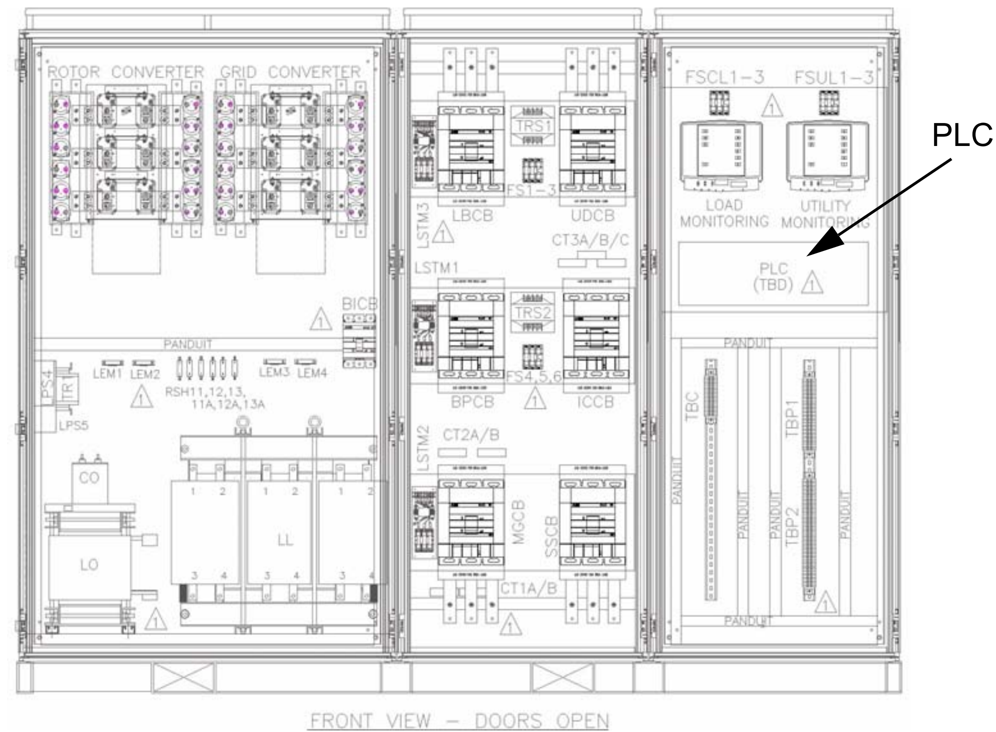


Figure 4-3. Location of the PLC for the 315 kVA System

4. Check the grid voltage signal and phasing at LSTM3.

   Ensure there are 3, 120° phase shifts, in the proper sequences A, B and C.

5. Manually close circuit breakers BPCB and LBCB.

   Check the load voltage signal and phasing at LSTM2. Ensure there are 3, 120° phase shifts, in the proper sequences A, B and C.

6. Check the IMG blower fan for correct rotation.

7. Verify that the Mechanical and Thermal Monitoring System is energized and monitoring the Engine/IMG/Fly7wheel vibration levels.

8. Ensure the starting batteries are fully charged and connected to the charger, and battery chargers are operational.

   Charge on each of the batteries must be:

   > 12.5 VDC with out charger

   >13.5 VDC with charger

4.3.1 Emergency Stop Test

Perform the following steps to test the Emergency Stop. If expected results are not produced, consult with SatCon Service before proceeding to section 4.3.2 “Normal Mode Test”.

Record the results on Table B-5. "Emergency Stop Data" on page B-5 of Appendix B.

1. Select the Engineering Interface 1 from the PanelView Local Operator Interface Main Menu Screen (Figure 4-4). Enter the password when prompted and press the [Enter] key to display the Engineering Interface 1 Screen (Figure 4-5).

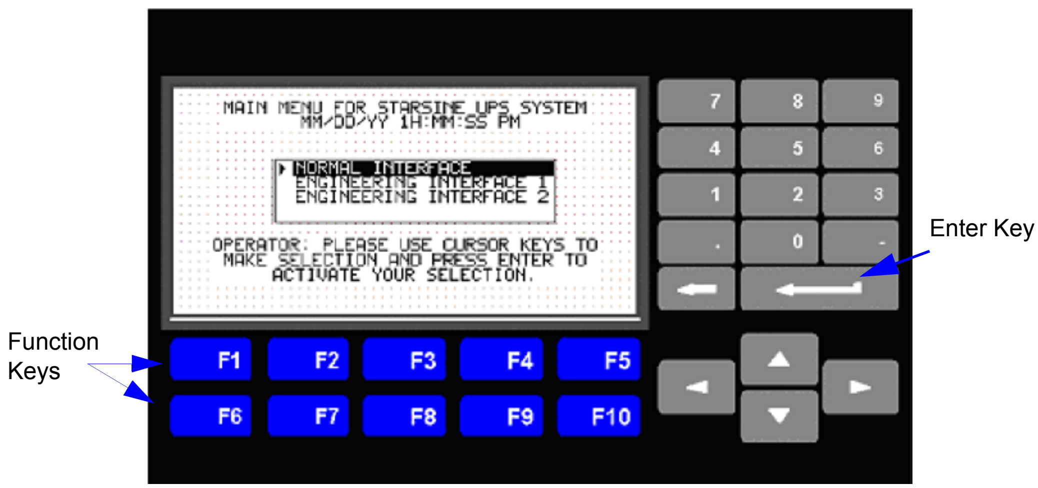


Figure 4-4. Main Menu

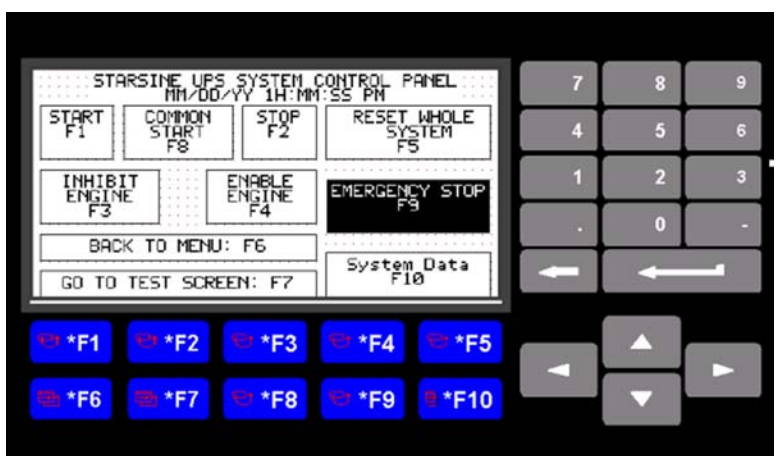


Figure 4-5. Engineering Interface 1 Screen

2. Test the Emergency Dump circuit by pressing EMERGENCY STOP [F9] from the Engineering Interface 1 Screen.

   Verify that all circuit breakers opened except for BPCB.

3. Press RESET [F5] to reset the system to the default values and to clear the Emergency Stop.

4.3.2 Normal Mode Test

Perform the following steps to test the system in Normal Mode. If expected results are not produced, consult with SatCon Service before proceeding to section 4.3.3 "UPS Mode Test".

Record the results on Table B-6. "Normal Mode Test Data" on page B-6 of Appendix B. Export the RPM data and include hardcopy with this datasheet.

1. Press START [F1] from the Engineering Interface 1 Screen to start the system.
   - **a.** Verify that system sequentially closes circuit breaker BPCB, followed by the LBCB and ICCB.
   - **b.** Verify the pre-charge circuit begins to charge the DC bus.
   - **c.** Verify the facility circuit breaker is closed.
   - **d.** Ensure the grid converter regulates the DC bus voltage and the rotor converter starts.
   - **e.** Confirm Circuit breaker SSCB closes and the Flywheel/IMG begins to rotate.
   - **f.** Check the speed indication and proper rotation of the Flywheel/IMG.

> ▷ When the machine first starts some vibration levels displayed on the Main Alarm Screen of the Mechanical and Thermal Monitoring System panel will cause warnings and alarms. This is normal. Ignore these alarms and warnings when first starting the UPS, as it will automatically shut down if problems arise.

2. As the flywheel approaches the preset speed of 1800 rpm, verify that system sequentially:
   - **a.** opens circuit breaker SSCB.
   - **b.** closes circuit breaker MGCB.
   - **c.** opens BCPB.

   The UPS is now in the Normal Mode and running on grid.
3. Check the stator voltage signal and phasing at LSTM1 Ensure there are 3, 120 ° phase shifts, in the proper sequences A, B, and C.
4. Confirm the flywheel comes up to a nominal speed of 1980 rpm.

> ▷ The system is not fully charged until the flywheel speed reaches 1980 rpm.

5. If a resistive load bank is available, switch in the load in 20% increments up to 100%.

   Monitor electrical data with RPM and verify that at each 20% step the recorded current is within ± 10% the expected current.

4.3.3 UPS Mode Test

Follow the steps listed below to test the system in UPS mode. If expected results are not produced, consult with SatCon Service before proceeding to the next step.

Record the results on Table B-7. "UPS Mode Test Data" on page B-7 of Appendix B. Export RPM data and include hardcopy with this datasheet.

1. Enter the Test Mode by pressing the GO TO TEST SCREEN [F7] key from the Engineering Interface 1 (Figure 4-6. "Engineering Interface 1 Test Screen" on page 4-7).
   - **a.** Press UPS [F3] to enter UPS mode.
   - **b.** Verify circuit breaker ICCB opened.

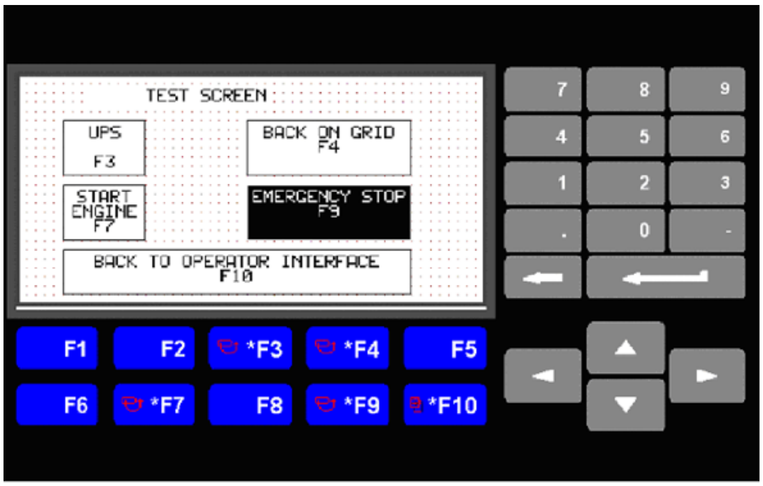


Figure 4-6. Engineering Interface 1 Test Screen

2. Verify the diesel engine started after approximately 2 seconds.

> With the diesel engine turning the system, the flywheel speed drops to approximately 1800 rpm.

3. If a resistive load bank is available, switch in the load in 20% increments up to 100%.
4. Return to Normal Mode by pressing BACK ON GRID [F2]
   - **a.** Confirm circuit breaker ICCB closed.
   - **b.** Confirm the flywheel speed increases to 1980 rpm.
   - **c.** Confirm the diesel engine shuts down after the preset cool down period (5 minutes).
5. Run the system in Normal Mode for one hour.
   - **a.** Press [F10] to go back to the Normal Interface.

b. Monitor and record voltage signals, current signals from the Normal Interface Screen. (refer to Figure 4-7 on page 4-8).

c. Record the initial vibration data for all sensors displayed on the Mechanical and Thermal Monitoring System Main Alarm Screen. Use Table B-8. "Initial Vibration Measurements Data" on page B-8, located in Appendix B.

d. Record the initial temperature data for all sensors displayed on the Main Alarm Screen. Use the Table B-9. "Initial Temperature Measurement Data" on page B-9, located in Appendix B

6. Press STOP [F2] on the Normal Interface Screen to stop the system in a normal way.

   Verify that system sequentially:

   – closes circuit breaker BPCB.

   – opens MGCB, ICCB, and LBCB.

7. Press BACK TO OPERATOR INTERFACE [F10] to access the Engineering Interface 1 Screen.

   a. From the Engineering Interface 1 Screen, press Back to Main Menu [F6].

   b. To access the Normal Interface Screen, use the arrow keys from the Main Menu (Figure 4-4), to select the Normal Interface. Press the Enter key to display the Normal Interface (Figure 4-7).

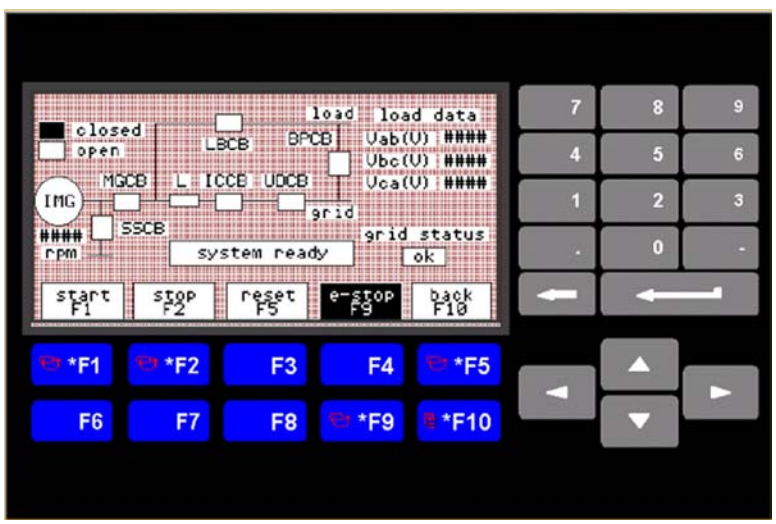


Figure 4-7. Normal Interface Screen

4.4 Customer Training

SatCon provides one day of on site customer training after the completion of the site acceptance testing. This training includes instruction on the startup, operation, and basic maintenance of the UPS system. A typical outline of the instruction is as follows:

- Reading and using SatCon drawings and manuals.
- System walk through identifying the components and subsystems as shown in the SatCon documentation.
- UPS system startup.
- UPS system operation.
- Operational information and data available on front panel instruments.
- Warnings and maintenance information available on front panel instruments.
- Daily, weekly, and monthly preventative maintenance checks.
- Question and answer period.

5

Applying Power to the System

This chapter describes how to safely apply power to the system.
It provides instructions on how to:

- Perform the Pre-operational Check.
- Apply Power to the system.

5.1 Pre-operational Check

Ensure to implement the following safety precautions and checks. Before powering the system, verify that:

- No lockout and tagout safety devices are applied to the machine.
- At least two people are in the area while unit is under power.
- No one is around or on the UPS frame.
- The Emergency push button, (optional) located on the UPS frame and the Emergency Stop, push button located on the Control Cabinets are in the "Run" position.
- An Emergency Stop is within reach of the operator.
- All personnel working in the area are aware of power application and the voltage and power levels involved.
- All personnel are wearing hearing protection and safety glasses as required.
- All safety shields are in place.
- The input power (house supply) is "off" (i.e. facility breaker open).
- There is 12.5 - 13.5 V on each battery and the battery connections are sound.

> Charge on each battery is approximately 12.5 VDC with out charger, and >13.5 VDC with charger.

- There are no loose items on machines.
- The integrity of insulation for all cables, terminations, and connections.
- The absence of condensation, or puddles of oil or water.
- The area is clear of any debris and obstacles.
- There is unobstructed access to all disconnect switches.
- The engine exhaust manifold is unobstructed.
- Engine intake manifold is unobstructed.
- The power to the fuel pump is on.

5.2 System Power Up

To power the Control Cabinets, close the "Grid Main Power Service Disconnect Switch".

5.2.1 Self-Test

The Master Control Software performs a self-test when power is applied to the UPS system. During initial power on, the Programmable Logic Controller (PLC) performs a self-test of the system and verifies:

- PLC has successfully powered on and passed a self-test.
- Grid Controller has successfully powered on and passed a self-test.
- Rotor Controller has successfully powered on and passed a self-test.
- Engine Controller has successfully powered on and passed a self-test.

Refer to section 1.4.1 "Master Control" on page 1-14 for more information.

5.2.2 Initial States of PLC Outputs

After performing all self-tests, the PLC initializes the outputs to the states shown in Table 5-1.

Table 5-1. Initial Power On States of PLC Outputs

Output	Initialized State
Grid Controller	Stopped
Rotor Controller	Stopped
Engine Controller	Stopped
Pump Control	On

5.2.3 Initial States of Circuit Breakers

After completing all self-tests, the PLC reads the positions of the circuit breakers and either initializes the outputs to the states shown in Table 5-2 or prompts the operator to set the circuit breakers manually.

Table 5-2. Initial Power On States of Circuit Breakers

Output	Initialized State	Control
Utility Disconnect Circuit Breaker (UDCB)	Closed	Manual (prior to power up)
Input Control Circuit Breaker (ICCB)	Open	PLC
Load Bank Circuit Breaker (LBCB)	Open	PLC
Motor Generator Circuit Breaker (MGCB)	Open	PLC
Stator Short Circuit Breaker (SSCB)	Open	PLC
Bypass Circuit Breaker (BPCB)	Unchanged from startup state	Unchanged from startup state
Bi-directional Circuit Breaker (BICB)	Closed	Manual

6

System Operation

This chapter describes the following instructions required to operate the UPS System.

- Safety Pre-Start Check
- Starting and Stopping the System
- Monitoring the system remotely
- Using the Operator Interface
- Using the Mechanical and Thermal Monitoring System
- Controlling the fuel supply

6.1 UPS System Pre-Start Check

Before starting the system, verify that:

1. No lockout and tagout safety devices are applied to the machine.
2. No one is around or on the UPS.
3. Each battery is fully charged to 12.5 V - 13.5 V, and the battery connections are sound.

> The charge on each battery should be approximately 12.5 VDC with out charger, and >13.5 VDC with charger.

4. Emergency Stops are in the “Run” position (refer to section 6.3.1 “Emergency Stop” on page 6-2).
5. Both the fuel-transfer pump control and the pump power are on.
6. No puddles of oil and coolant puddles are on or around the machine.
7. Engine block heater is powered.
8. Make sure all of the Control Cabinet breakers except for the UDCB are open (indicated as green). The UDCB breaker may be either open or closed (indicated as red).
9. The Mechanical and Thermal Monitoring System displays the Main Alarm Screen; the system status block (upper left-hand corner) is green. Refer to Figure 6-4 on page 6-7.

6.2 UPS System Start

To start the system, press the START [F1] function key on the Normal Interface Screen (see page 6-4).

The Mechanical and Thermal Monitoring System displays the system speed on the Main Alarm Screen as the UPS system begins to rotate. The system will go on grid at a speed between 1620 rpm to 1980 rpm.

▷ The system is not fully charged until the flywheel speed reaches 1980 rpm.

▷ When the machine first starts some vibration levels displayed on the Main Alarm Screen on the Mechanical and Thermal Monitoring panel will cause warnings and alarms. This is normal. Ignore these alarms and warnings when first starting the UPS, as the systems will automatically shut down if problems arise.

6.3 Stopping the System

6.3.1 Emergency Stop

There are one or more ways to stop the machine in an emergency. Using any Emergency Stop will quickly stop the flywheel within 5 minutes.

- Press the EMERGENCY STOP (F9) function key, displayed on each screen of the Normal Interface Screen.
- Press the Emergency Stop push button (optional), located on the UPS frame.
- Press the Emergency Stop, push button located on the Control Cabinets.

6.3.2 Slow Stop

Stop the system by pressing the [F2] function key from the Normal Interface Screen (refer to page 6-4). The flywheel slows to a stop within five hours when shutting down the system in this manner. To quickly stop the flywheel see section 6.3.1 “Emergency Stop”.

6.4 The Local Operator Interface

The PanelView Local Operator Interface displays the running system electrical data. When powered, the system performs self-tests and displays the main menu (Figure 6-1). The main menu displays function keys on each screen; use the function keys to Start, Stop or Reset the system and access system data.

The main menu provides three options.

- Normal Interface

  Use the Normal Interface for daily system operation. The Normal Interface is not password protected.

- Engineering Interface 1

  Used to test, and maintain the system. Refer to 7.2.7 “Engine Exercise” on page 7-5 for more information on using the Engineering Interface 1.

- Engineering Interface 2

  Use the Engineering Interface 2 for balancing and troubleshooting the system. Refer to 7.6.4 “Flywheel Balancing” on page 7-51 for more information on using the Engineering Interface 2 Screen.

  Selecting either Engineering Interface option causes the local display to prompt the operator to enter a password. Upon successful entry of the password, the Master Control Software transition to those operating states. Entering an incorrect password displays the Main Menu Screen. See Chapter 7, “System Maintenance” for more information.

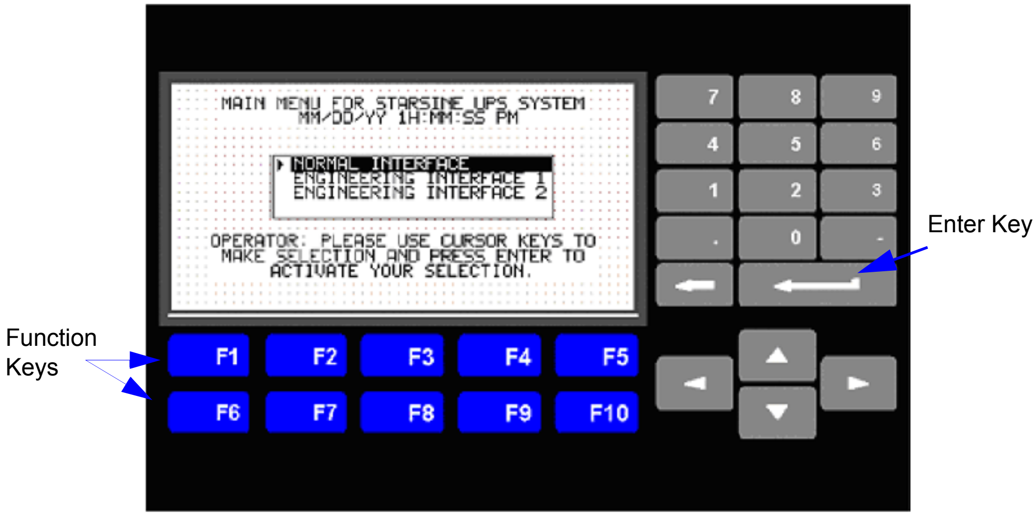


Figure 6-1. Main Menu

6.4.1 Normal Interface

Use the arrow keys from the Main Menu to select the Normal Interface (Figure 6-1). Press the Enter key to display the Normal Interface (Figure 6-2).

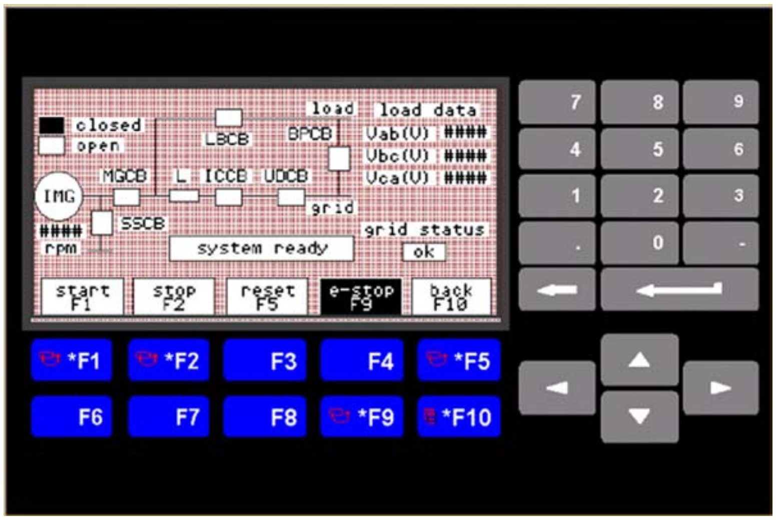


Figure 6-2. Normal Interface Screen

When the system is running in the normal mode, the Normal Interface Screen displays:

- IMG/rotor speed.
- Three line-to-line load bus voltages Vab, Vbc, and Vca.
- The status of the current operating mode.
- The status of the electrical circuit breakers ("closed" indicated by a black square, "open" indicated by a white square).

The following list describes the use of the function keys.

- START [F1] - used to start the system.
- STOP [F2] - used to stop the system in a normal way. Using the [F2] key stops the flywheel from turning within five hours.
- RESET [F5] resets the system to the default values, necessary after any Emergency Stop condition.
- e-STOP [F9], displayed on each screen, the Emergency Stop immediately halts the system (the flywheel stops turning within five minutes).
- Back [F10] - Return to the Main Menu.

6.4.2 Alarm Banner Screen

One or more active fault(s) in the system causes the display of the Alarm Banner Screen. The system logs all the faults (active and inactive) on the Alarm Banner Screen. When the display limit is reached, the oldest fault is deleted and the newest fault is added to the log.

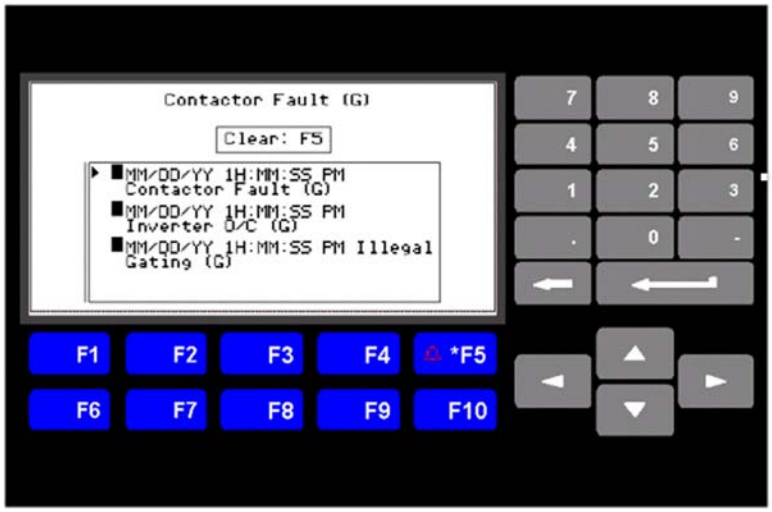


Figure 6-3. Alarm Banner Screen

The following lists of functions are available from the Alarm Banner Screen:

- CLEAR [F5] clears each fault log line.

  Pressing CLEAR [F5] returns you to the previous screen, once all of the fault logs are cleared.

6.5 Mechanical and Thermal Monitoring System

The Mechanical and Thermal Monitoring System panel, located at the central control station below the Local Operator Interface, reports the UPS system mechanical condition, and alerts the operator to any faults or abnormal conditions.

Using sensors, the system monitors specific machine and bearing performance parameters such as temperature velocity, acceleration, and acceleration enveloping. The system automatically reverts to a safe condition when fault conditions occur that could result in safety hazards if left unattended.

The panel uses an interactive touch screen input device. Touch the buttons on the bottom of the screen to display related screens. The following sections provide descriptions of the Mechanical and Thermal Monitoring System screens.

6.5.1 Main Alarm Screen

The Main Alarm Screen provides a quick visual overview of how the system is operating. Refer to the following list and the numbers referenced in Figure 6-4, for a description of the readings displayed on the Main Alarm Screen.

1. Flywheel Speed.
2. When a warning occurs in the system the Alarm Block flashes red, the corresponding fault is highlighted in yellow. When a fault occurs the corresponding reading is highlighted in red; the UPS system responds accordingly.
3. Temperature of the embedded thermocouple in each motor phase.
4. Flywheel Temperature.
5. Flywheel Housing Temperature.
6. Flywheel Housing Pressure.
7. Accelerometer readings, listed under corresponding bearings.
8. Bearing Impact readings, listed under corresponding bearings, provides predictive bearing life indication. High reading indicates a problem.
9. Bearing temperature, listed under corresponding bearings.
10. Flywheel diameter summary information. Refer to section 6.5.6 “Flywheel Screen”, page 6-12.

   Notify your SatCon representative immediately of any increase in the Actual Flywheel Diameter measurement.

11. System Status, located in upper left-hand corner of the screen. Green indicates the Mechanical and Thermal Monitoring System is communicating with the sensors.

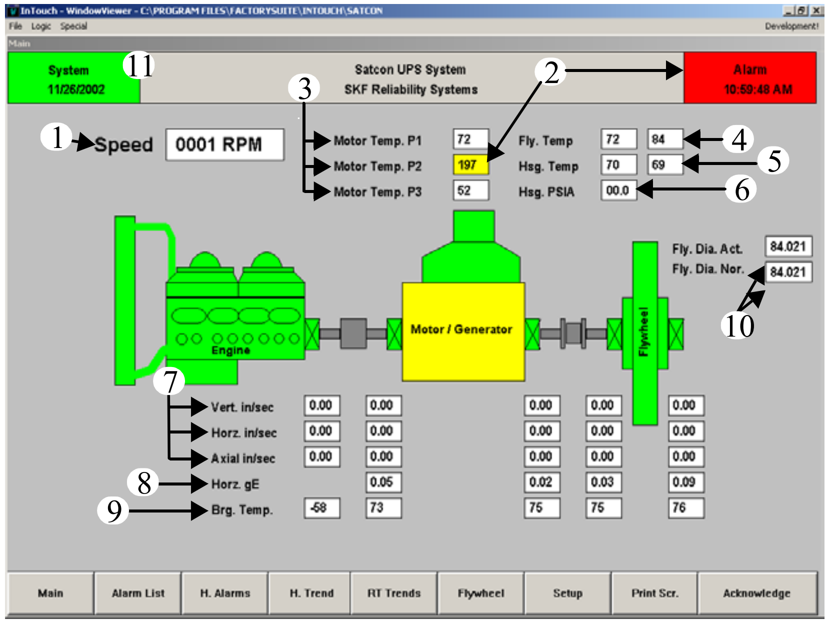


Figure 6-4. Mechanical and Thermal Monitoring System Main Alarm Screen

6.5.1.1 Monitoring Events/ Event Reporting

If an alarm condition occurs, the Monitoring system notifies the PLC, and the system responds accordingly. Refer to section 1.4.1 “Master Control” on page 1-14 for more information.

6.5.1.1.1 Event Acknowledgement

Touch the [Acknowledge] button to log that the alarm or fault condition was noted or recognized.

6.5.2 Alarm List Screen

Touch [Alarm List] to display any current alarms (Figure 6-5).

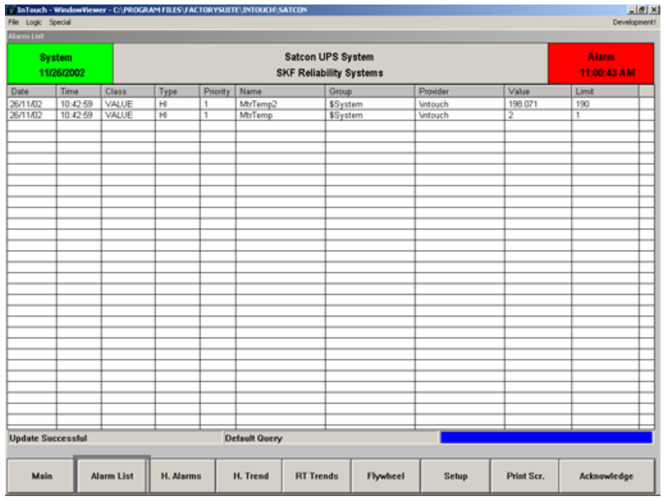


Figure 6-5. Current Alarm List

6.5.3 Historical Alarms Screen

Touch [H Alarms] to display historical information about the alarms (Figure 6-6). Black text indicates Acknowledged alarms, red text indicated unacknowledged alarms.

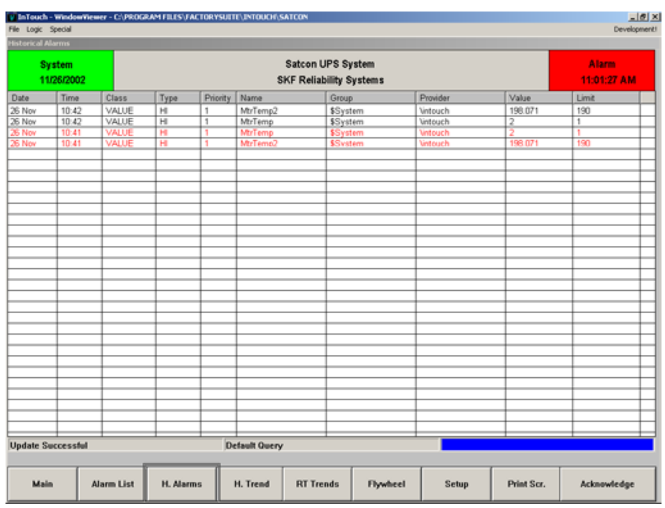


Figure 6-6. Historical Alarms Screen

6.5.4 History Trend Screen

Touch the [History Trend] to display the sensor data from any trend time. A change in the measured values indicates a change in the machine condition. Table 6-1 lists the available trend signals. Touch the graph to configure the eight signals to display.

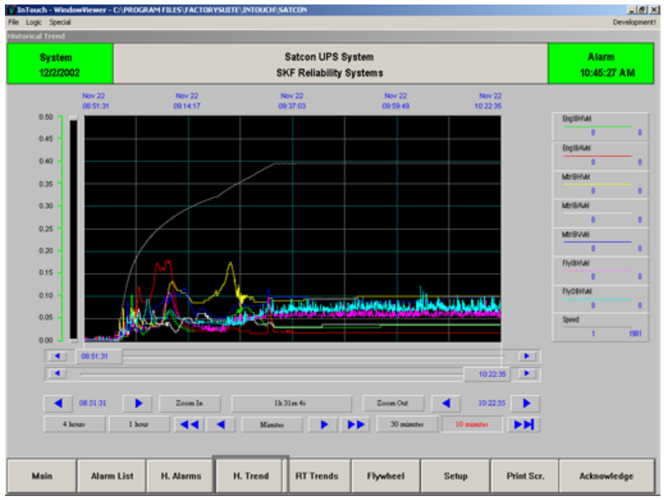


Figure 6-7. History Trends

Table 6-1 provides a description of the selectable History Trend signal names.

Table 6-1. Signal Names

Signal Name	Description	Signal Name	Description
Eng IB V Vel	Engine Inboard Velocity Vertical	Fly IB A Vel	Flywheel Inboard Velocity Axial
Eng IB H Vel	Engine Inboard Velocity Horizontal	Fly IB gE	Flywheel Inboard Acceleration Enveloping Horizontal
Eng IB A Vel	Engine Inboard Velocity Axial	Fly IB Deg F	Flywheel Inboard Temperature
Eng IB Deg F	Engine Inboard Temperature	Fly OB V Vel	Flywheel Outboard Velocity Vertical
Mtr IB V Vel	Motor Inboard Velocity Vertical	Fly OB H Vel	Flywheel Outboard Velocity Horizontal
Mtr IB H Vel	Motor Inboard Velocity Horizontal	Fly OB A Vel	Flywheel Outboard Velocity Axial
Mtr IB A Vel	Motor Inboard Velocity Axial	Fly OB gE	Flywheel Outboard Acceleration Enveloping Horizontal

Signal Name	Description	Signal Name	Description
Mtr IB gE	Motor Inboard Acceleration Enveloping Horizontal	Fly OB Deg F	Flywheel Outboard Temperature
Mtr IB Deg F	Motor Inboard Temperature	Speed	Flywheel Speed
Mtr Temp 1	Motor Winding Temperature 1	Fly EP 1	Flywheel Diameter 1
Mtr Temp 2	Motor Winding Temperature 2	Fly EP 2	Flywheel Diameter 2
Mtr Temp 3	Motor Winding Temperature 3	Fly Temp 1	Flywheel Temperature 1
Mtr OB V Vel	Motor Outboard Velocity Vertical	Fly Temp 2	Flywheel Temperature 2
Mtr OB H Vel	Motor Outboard Velocity Horizontal	Fly Hsg PSIA	Flywheel Housing Pressure
Mtr OB A Vel	Motor Outboard Velocity Axial	Hsg Temp 1	Flywheel Housing Temperature 1
Mtr OB gE	Motor Outboard Acceleration Enveloping Horizontal	Hsg Temp 2	Flywheel Housing Temperature 2
Mtr OB Deg F	Motor Outboard Temperature	AlarmRelay1	Alarm Relay 3 amps 24 VDC
Fly IB V Vel	Flywheel Inboard Velocity Vertical	NFlyDia	Normalized Flywheel Dia
Fly IB H Vel	Flywheel Inboard Velocity Horizontal	AFlyDia	Actual Flywheel Dia

6.5.5 Real Time Trends Screen

Touch the [RT Trend] to display the sensor data from the last 15 minutes. Touch the button to the right of the graph to toggle the display between the real-time flywheel and real-time IMG data.

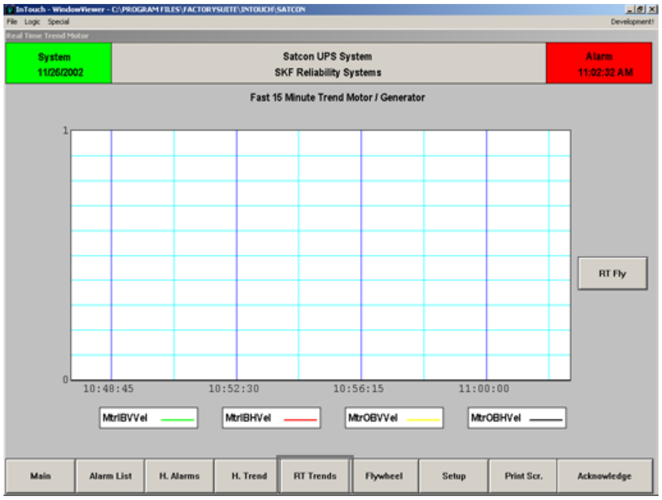


Figure 6-8. Real Time Trends

6.5.6 Flywheel Screen

This is the setup screen for the flywheel diameter calculation, as shown in Figure 6-4. "Mechanical and Thermal Monitoring System Main Alarm Screen" on page 6-7 (refer to item 10). The diameter of the flywheel expands due to heat and the flywheel rotation.

Sensor reference data are factory set for use in the flywheel diameter calculation. The Main Alarm Screen displays the calculated value and measured value flywheel diameter. As a safety precaution, if the readings go out of specification the UPS automatically shuts down.

Notify your SatCon representative immediately of any increase in the Actual Flywheel Diameter measurement.

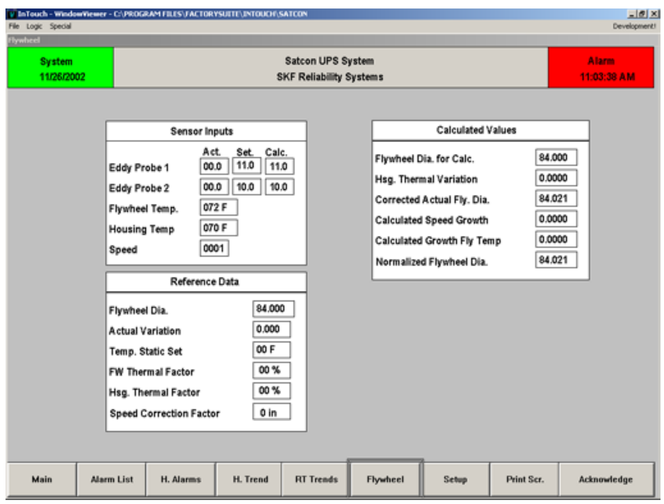


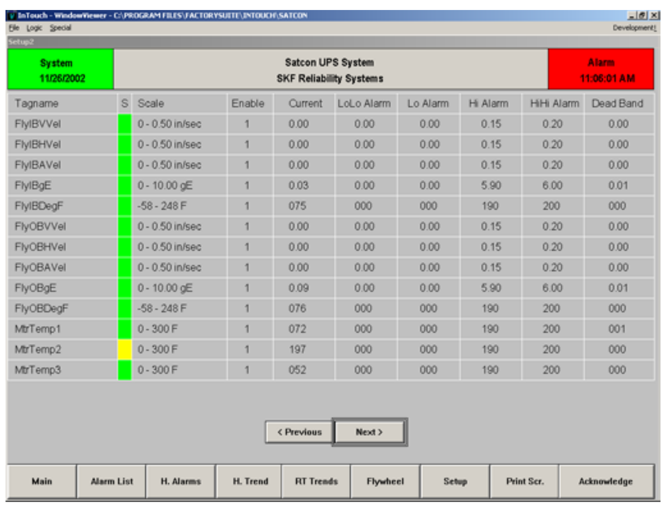
Figure 6-9. Flywheel Screen

6.5.7 Setup Screens

This password-protected screen allows the setup of the alarm thresholds.

Tagname	S	Scale	Enable	Current	LoLo Alarm	Lo Alarm	Hi Alarm	HiHi Alarm	Dead Band
EnglBVVel		0 - 0.50 in/sec	1	0.00	0.00	0.00	0.18	0.21	0.01
EnglBVVel		0 - 0.50 in/sec	1	0.00	0.00	0.00	0.15	0.20	0.01
EnglBAVel		0 - 0.50 in/sec	1	0.00	0.00	0.00	0.15	0.20	0.01
EnglBDegF		-58 - 248 F	1	-058	000	000	188	199	001
MtrIBVVel		0 - 0.50 in/sec	1	0.00	0.00	0.00	0.16	0.18	0.01
MtrIBHVel		0 - 0.50 in/sec	1	0.00	0.00	0.00	0.15	0.20	0.00
MtrIBAVel		0 - 0.50 in/sec	1	0.00	0.00	0.00	0.15	0.20	0.00
MtrIBgE		0 - 10.00 gE	1	0.05	0.00	0.00	4.90	5.00	0.01
MtrIBDegF		-58 - 248 F	1	073	000	000	190	200	001
MtrOBVVel		0 - 0.50 in/sec	1	0.00	0.00	0.00	0.15	0.20	0.00
MtrOBHVel		0 - 0.50 in/sec	1	0.00	0.00	0.00	0.15	0.20	0.00
MtrOBAVel		0 - 0.50 in/sec	1	0.00	0.00	0.00	0.15	0.20	0.00
MtrOBgE		0 - 10.00 gE	1	0.02	0.00	0.00	4.90	5.00	0.01
MtrOBDegF		-58 - 248 F	1	075	000	000	190	200	000

Figure 6-10. Setup Screen



Tagname	S	Scale	Enable	Current	LoLo Alarm	Lo Alarm	Hi Alarm	HiHi Alarm	Dead Band
FlyIBVVel		0 - 0.50 in/sec	1	0.00	0.00	0.00	0.15	0.20	0.00
FlyIBHVel		0 - 0.50 in/sec	1	0.00	0.00	0.00	0.15	0.20	0.00
FlyIBAVel		0 - 0.50 in/sec	1	0.00	0.00	0.00	0.15	0.20	0.00
FlyIBgE		0 - 10.00 gE	1	0.03	0.00	0.00	5.90	6.00	0.01
FlyIBDegF		-58 - 248 F	1	075	000	000	190	200	000
FlyOBVVel		0 - 0.50 in/sec	1	0.00	0.00	0.00	0.15	0.20	0.00
FlyOBHVel		0 - 0.50 in/sec	1	0.00	0.00	0.00	0.15	0.20	0.00
FlyOBAVel		0 - 0.50 in/sec	1	0.00	0.00	0.00	0.15	0.20	0.00
FlyOBgE		0 - 10.00 gE	1	0.09	0.00	0.00	5.90	6.00	0.01
FlyOBDegF		-58 - 248 F	1	076	000	000	190	200	000
MtrTemp1		0 - 300 F	1	072	000	000	190	200	001
MtrTemp2		0 - 300 F	1	197	000	000	190	200	000
MtrTemp3		0 - 300 F	1	052	000	000	190	200	000

Figure 6-11. Second Setup Screen

Figure 6-12. Third Setup Screen

6.5.8 Monitoring Screen Printing

Touch the [Print Screen] button to send the display to the printer, if connected.

6.6 Fuel Control Alarms

The Fuel Control panel provides a visual alarm indication for a high fuel level, low fuel level, and basin, an indication that there is a leak between the internal walls of the day tank.

6.6.1 Bulk Fuel Tank level low

The small control box by the diesel batteries monitors the Bulk Fuel Level. The Bulk Fuel Level Low is a non-critical fault.

A

Installation Drawings

A.1 SatCon 2.2 MVA UPS Installation Drawing

75550009

A.2 SatCon 2.2 MVA UPS One-line Diagram

752220121

A.3 SatCon 2.2 MVA UPS System Block Diagram

752220122

A.4 SatCon 315 kVA UPS Installation Drawings

755550012

A.5 SatCon 315 kVA UPS One-line Diagram

751110077

A.6 SatCon 315 kVA UPS System Block Diagram

751110083

B

Certification and Performance

This appendix provides the checklists/datasheets for the testing performed during the commissioning of the UPS system.

Perform the tests listed in Chapter 4, "Commissioning" beginning on page 4-1, and record results on the following data sheets:

- B.1 "Initial Inspection Checklist" on page B-2
- B.3 "Functional Test Checklist" on page B-4
- B.4 "Emergency Stop Test Checklist" on page B-5
- B.6.1 "Initial Vibration Data Checklist" on page B-8
- B.6.2 "Initial Temperature Measurements" on page B-9

B.1 Initial Inspection Checklist

Perform the tests listed in section 4.2 "Initial Inspection" on page 4-1 and record results on test data sheets Table B-1.

Table B-1. Initial Inspection Data

Step	Inspection	Accept /Reject
1.	Check all electrical components for any signs of damage.	
2.	Verify the system is connected to Ground, Measure and record resistance value: ____________	
3.	Ensure all connections are properly fixed and tight.	
4.	Verify all power cables are terminated to the correct location, Refer to section.	
5.	Verify the Flywheel Lubrication System contains 20 gallons of bearing oil.	
6.	Verify the engine coolant is filled to the proper level.	
7.	Verify the diesel engine oil is filled to the proper level.	
8.	Verify the flexible coupling oil is filled to the proper level.	
9.	Ensure that all protective covers are in place and secured, all nuts and bolts are tight.	
10.	Check the alignment to the levels listed on Table B-2 of data sheet B.2 "Alignment Record Sheet" on page B-3. Record the levels on Table B-3.	

Signature Date

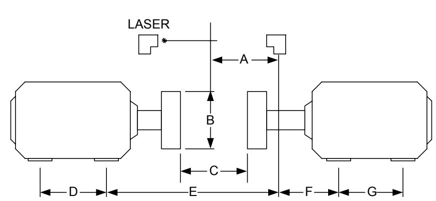
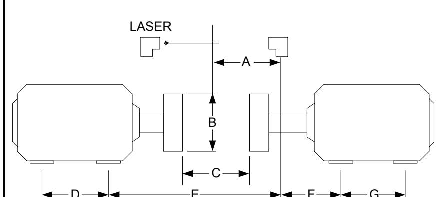
B.2 Alignment Record Sheet

The alignment levels are listed in the Table B-2. Record alignment results on Table B.2. See ”Initial Inspection” on page 4-1, step 10.

Table B-2. Alignment Specifications

	Diesel to IMG				IMG to Flywheel			
Vertical	0.007	0.007	2.6	2.6	0.007	0.007	2.6	2.6
	Angular (mils)	Parallel (mils)	Alpha (mrad)	Beta (mrad)	Angular (mils)	Parallel (mils)	Alpha (mrad)	Beta (mrad)
Horizontal	0.007	0.007	2.6	2.6	0.007	0.007	2.6	2.6

Table B-3. Alignment Results and Machine Setups

	Diesel to IMG				IMG to Flywheel			
Vertical								
	Angular (mils)	Parallel (mils)	Alpha	Beta	Angular (mils)	Parallel (mils)	Alpha	Beta
Horizontal								
Machine Geometry								
								
	A=		E=		A=		E=	
	B=		F=		B=		F=	
	C=		G=		C=		G=	
	D=				D=			

Signature Date

B.3 Functional Test Checklist

Perform the tests in section 4.3 "Functional Test" on page 4-2 and record results below in Table B-4.

Table B-4. Functional Test Data

Step	Test	Verification	Accept/ Reject
1	Ensure the engine block heater has been running for approximately 8 hours. Record coolant temperature.	Coolant temperature should be approximately 100 ° F (37.8 °C) Measured Value:	
2	Manually close circuit breakers UDCB and BICB. **a.** Turn on grid power using the wall isolation switch.	**b.** Verify circuit breakers BPCB, LBCB, ICCB, SSCB, and MGCB are open and charged.	
3	Apply grid voltage. **a.** Turn on the auxiliary uninterruptible power supply unit, located inside of the control cabinet.	**b.** Verify that the two DCPB control boards and the PLC are energized.	
4	Check the grid voltage signal and phasing at LSTM3.	Ensure there are 3, 120° phase shifts, in the proper sequences A, B, and C.	
5	Manually close circuit breakers BPCB and LBCB.	**a.** Check the load voltage signal and phasing at LSTM2. **b.** Ensure there are 3, 120° phase shifts, in the proper sequences A, B, and C.	
6	IMG Blower Fan	Check the IMG blower fan for correct rotation.	
7	Mechanical and Thermal Monitoring System verification.	• Verify that the Mechanical and Thermal Monitoring System is energized and monitoring the Engine/IMG/Flywheel vibration levels.	
8	Ensure the starting batteries are fully charged and connected to the charger, and battery chargers are operational.	Charge on each of the batteries must be: • > 12.5 VDC with out charger • >13.5 VDC with charger	

Signature Date

B.4 Emergency Stop Test Checklist

Perform the tests in section 4.3.1 “Emergency Stop Test” on page 4-5 and record results in Table B-5 below.

Table B-5. Emergency Stop Data

Step	Inspection	Verification	Accept/ Reject
1	Display the Engineering Interface 1 Screen (Figure 4-5) from the PanelView Main Menu Screen.	None	
2	Test the Emergency Dump Circuit by pressing EMERGENCY STOP [F9] on the PanelView Local Operator Interface.	The flywheel slows and stops in approximately five minutes. Check that: • BPCB is closed • LBCB, MGCB, SSCB, UDBC, and ICCB are open.	
3	Press RESET [F5] to reset the system to the default values and to clear the Emergency Stop	None	

Signature Date

B.5 Normal Mode Test Checklist

Perform the tests listed in section 4.3.2 “Normal Mode Test” on page 4-6 and record results in Table B-6. Export RPM data and include hardcopy with this datasheet.

Table B-6. Normal Mode Test Data

Step	Inspection	Verification	Accept/ Reject)
1.	Press START [F1] from the Engineering Interface 1 Screen to start the system.	**a.** Verify that system sequentially closes circuit breaker BPCB, followed by the LBCB and ICCB. **b.** Verify the pre-charge circuit begins to charge the DC bus. **c.** Verify the facility circuit breaker is closed. **d.** Ensure the grid converter regulates the DC bus voltage and the rotor converter starts. **e.** Confirm Circuit breaker SSCB closes and the Flywheel/IMG begins to rotate. **f.** Check the speed indication and proper rotation of the Flywheel/IMG/.	
2.	As the flywheel approaches the preset speed of 1800 rpm, verify that system sequentially:	**a.** opens circuit breaker SSCB **b.** closes circuit breaker MGCB **c.** opens BCPB.	
3.	Check the stator voltage signal and phasing at LSTM1	Ensure there are 3, 120 ° phase shifts, in the proper sequences A, B, and C.	
4.		Confirm the flywheel comes up to a nominal speed of 1980 rpm.	
5.	If a resistive load bank is available, switch in the load in 20% increments up to 100%	Monitor electrical data with RPM Verify that at each 20% step the recorded current is within ± 10% the expected current.	

Signature Date

B.6 UPS Mode Test Checklist

Perform the tests listed in section 4.3.3 “UPS Mode Test” on page 4-7 and record results in Table B-7.

Table B-7. UPS Mode Test Data

Step	Test	Verification	Results
1.	Enter the Test Mode from the Engineering Interface 1 and Press the UPS key.	**a.** Press UPS [F3] to enter UPS mode.. **b.** Verify circuit breaker ICCB opened.	
2.		Verify the diesel engine started after approximately 2 seconds.	
3.	If a resistive load bank is available, switch in the load in 20% increments up to 100%.	**a.** Monitor electrical data with the RPM. **b.** Verify that at each 20% step the recorded current is within ± 10% the expected current.	
4.	Return to Normal Mode by pressing BACK ON GRID [F2].	**a.** Confirm circuit breaker ICCB closed. **b.** Confirm the flywheel speed increases to 1980 rpm. **c.** Confirm the diesel engine shuts down after the preset cool down period (5 minutes).	
5.	Run the system in Normal Mode for one hour. **a.** Access the Normal Interface.	**b.** Monitor and record voltage signals, current signals from the Normal Interface Screen. (refer to Figure 4-7 on page 4-8). **c.** Record the initial vibration data in section B.6.1 “Initial Vibration Data Checklist” on page B-8. **d.** Record the initial temperature data in section B.6.2 “Initial Temperature Measurements” on page B-9.	
6.	Press STOP [F2] to stop the system in the normal way.	Verify that system sequentially: **a.** closes circuit breaker BPCB. **b.** opens MGCB, ICCB, and LBCB.	
7.	Access the Normal Interface		

Signature Date

B.6.1 Initial Vibration Data Checklist

Record initial vibration data for all sensors in Table B-8, and sign and date this sheet. Refer to section 4.3.3 "UPS Mode Test", step c. on page 4-8.

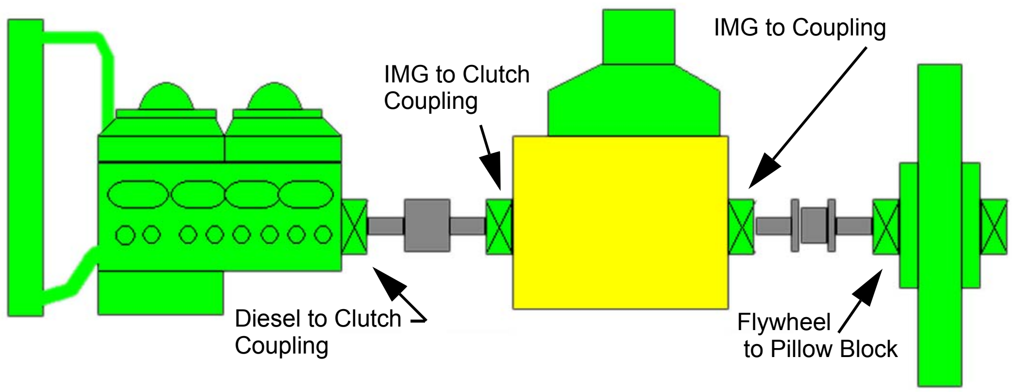


Table B-8. Initial Vibration Measurements Data

Vibration Measurement	Diesel to Clutch Coupling	IMG to Clutch Coupling	IMG to Flexible Coupling	Flywheel to Pillow Block Coupling
Vert. in/sec.				
Horiz. in/sec.				
Axial in/sec.				
Horz. gE				
Brg. Temp.				

Continue to B.6.2 "Initial Temperature Measurements" on page B-9.

Signature Date

B.6.2 Initial Temperature Measurements

Record the temperatures for all thermocouples in Table B-9, and sign and date this sheet. Refer to section 4.3.3 "UPS Mode Test", step d. on page 4-8.

Table B-9. Initial Temperature Measurement Data

Location	Measurement	Location	Measurement
Motor Temp. P1		Flywheel Temp.	
Motor Temp. P2		Hsg. Temp	
Motor Temp. P3		Hsg. PSIA	

Continue to B.6 "UPS Mode Test Checklist" on page B-7, Step 10.

Signature Date

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