

Configuration and Monitoring of the Symmetra PX 250/500kW Premium Battery Solution

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Abstract

This paper presents strategies for configuring and monitoring Symmetra PX250/500 premium battery solutions for common data center configurations.

Introduction

The APC Symmetra PX UPS utilizes a premium battery solution consisting of managed, user-replaceable, swappable, fused battery units. The number of battery units may be scaled to achieve many different levels of reserve run time and redundancy options. This unique configuration provides a highly available battery reserve for mission critical applications.

Battery Solution Configuration

The premium battery solution used in the Symmetra PX 250/500kW UPS consists of individually enclosed, user replaceable, swappable, removable battery units each weighing approximately 60lbs (27kg). Each removable battery unit contains eight, 12V, 9 AH, sealed, eight year design life@77 Deg F(25 Deg C), Valve Regulated Lead Acid (VRLA) batteries connected in series (96V total). The battery units are fully enclosed in a steel casing, and each has a semiconductor fuse installed on the most positive pole. Each removable battery unit also contains a printed circuit board, which is used to record battery performance and monitor temperature. The monitoring capabilities of the system will be explained later in this application note.

The battery solution is made up of horizontal battery shelves within an external battery frame. Each shelf has positions for six of the 96V battery units. The battery units that are populated in each shelf are electrically connected in two series-connected 288V half strings by the UPS backplane, and in this configuration, are also referred to as a “battery module”. Each battery module is connected in parallel with each of the other populated battery modules in the system, and makes up a common battery solution for the UPS power modules. A Symmetra PX 250/500kW UPS has no internal batteries and requires a minimum of one external battery frame to operate for 125KW configuration and additional one external battery frame each for additional each 125KW configuration. Up to eight external battery frames may be connected for additional battery reserve runtime. Figure 1 is an electrical diagram of a Symmetra PX 250/500kW internal battery solution. Figure 2 shows the front view of one row of battery modules.

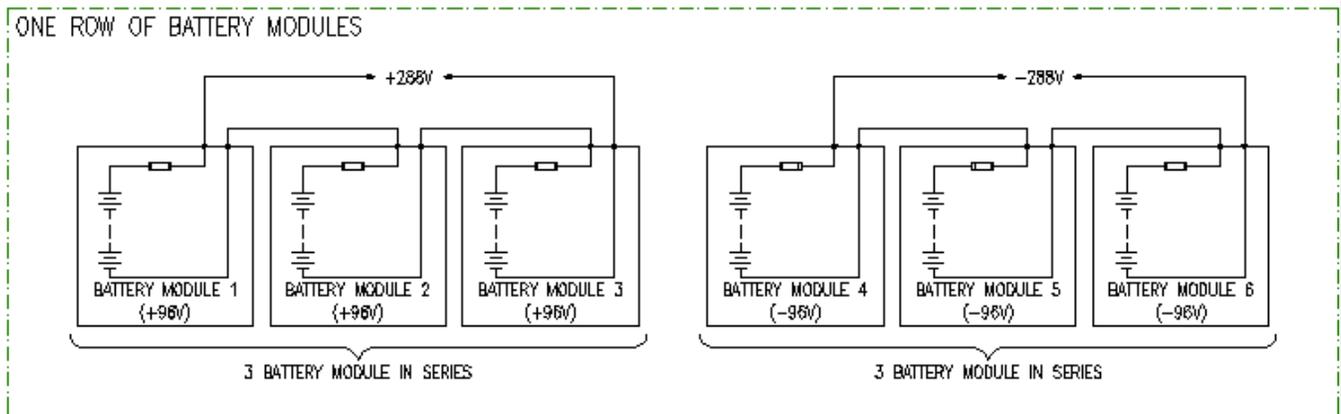


Figure 1



Figure 2

One battery frame, when fully populated, will deliver 6 minutes of reserve battery runtime with 125kW of load applied. As a minimum, one fully populated battery frame must be used for the system with 125kW load. For example, a Symmetra PX 250 UPS system with two fully populated battery frames will offer 6 minutes runtime at 250kW load and a Symmetra PX 500 UPS system with four fully populated battery frames will offer 6 minutes runtime at 500kW load. Additional battery frames can be added for extended runtime or for redundancy. Each battery frame has its own DC motor operated breaker that connects /disconnects (shunt tripped) the battery frame to the UPS. The DC motor operated breaker can be operated manually using the spring-loaded charging handle. The adjacent line up and match premium batteries are bus connected with the UPS, eliminating the need for site cabling work and improving the installation time. It is also possible to install line up and match premium batteries remotely using a battery side car, adding more flexibility in the room layout design.

Premium Battery Frame

The Symmetra PX250/500 premium battery frame is enclosed in an APC NetShelter Heavy Duty 750 mm enclosure. The connection between the UPS and the battery frame is via three busbars (positive, midpoint and negative) located in the

middle of frame. Each row (or string) of batteries has positions for six of the 96V battery units. There are 8 rows (or strings) of batteries in each battery frame and maximum of 8 battery frames can be used for one UPS. Four strings are on the top half of the frame and four strings are on the bottom half. There are two battery monitoring boards (BMB) in each card cage in the middle. Each battery monitoring board will monitor 4 strings of batteries. The first BMB monitors the 4 strings in the top half of the frame while the second BMB monitors the 4 strings in the lower half of the frame. A motor-operated DC breaker will connect the battery frame with the UPS. The motor operated DC breaker is powered by a separate power supply located in the card cage. The battery information is communicated to the UPS via "A BUS" through A BUS communication PCB located in the card cage. The A BUS communication board also has a rotary selector switch that will tell the UPS controller the battery frame number on that UPS. The battery frame has a board that is part of the UPS EPO system. When EPO is activated, this board sends a trip signal to shunt trip the battery breaker. This action will disconnect the batteries from the UPS, thus removing the source of power from the UPS. The motor-operated breaker is standard for premium battery frames and there is no need to turn on all breakers if multiple battery frames are used during start up or after batteries are fully discharged. The DC motor-operated breaker can be operated manually using the spring-loaded charging handle, if required.

Center Tapped Battery String

The Symmetra PX UPS is a transformerless, high frequency, pulse-width modulated, IGBT based, double conversion power array. The power train of the UPS is divided among multiple swappable, 25kW power modules. The boost converter and output inverter contained in each of these power modules is of a ½ bridge design topology. One IGBT device is used to switch the positive half-cycle voltage, and one IGBT device is used to switch the negative half-cycle voltage of the input and output phase. The internal DC bus of the Symmetra PX power module is regulated to a precise +/-390VDC by the input boost converter. +/-390VDC voltage is bucked down by a buck converter to +/-327VDC as nominal charge voltage, which can be adjusted. The boost converter is fed either rectified input AC or pulsed battery power, depending on the operating state of the UPS. The center-tapped battery design is a requirement that is used to support the half-bridge converter (boost converter & output inverter) design. On the system output, three single-phase inverters are arranged in a wye configuration and fire in reference to the system neutral, which is connected to the center tap of the battery solution. The positive half-cycle IGBT switches the +327V DC half-battery string in reference to the system neutral to create the positive half-cycle of output voltage. The negative half-cycle IGBT switches the -327V DC half-battery string in reference to the system neutral to create the negative half-cycle of output voltage. Load may be connected in both phase to neutral and phase to phase configurations. The power supplied to the output is never drawn directly from the batteries, but always through boost converter and output inverter, even during battery operation. Rectification is done in the same ½ bridge fashion on the input boost converter of the Symmetra PX power module. Figure 3 illustrates the ½ bridge inverter and battery used in the Symmetra PX UPS.

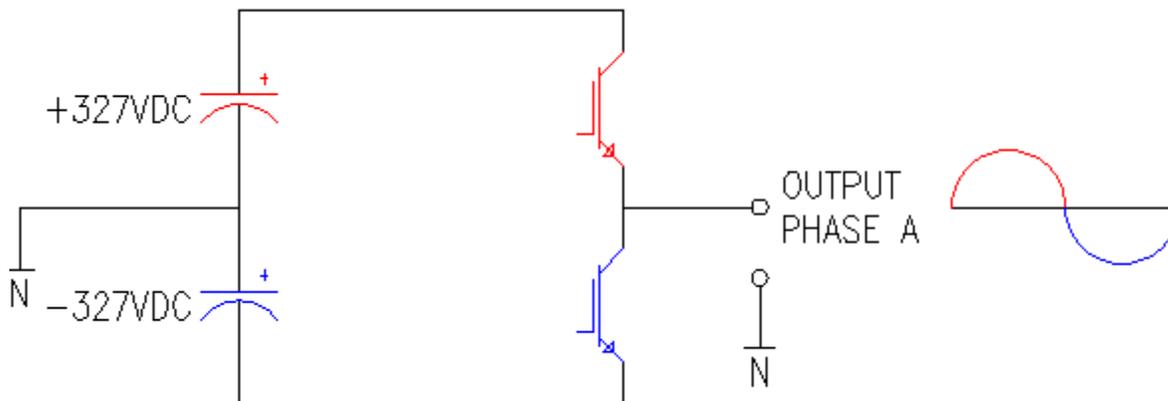


Figure 3

The $\frac{1}{2}$ bridge inverter design provides the Symmetra PX with a wye connected input / output without the use of an isolation transformer, which improves overall system efficiency.

Battery Charging

The Symmetra PX UPS continuously float charges its battery strings to $\pm 327\text{VDC}$. Each power module uses a 2.5kW, IGBT-based buck converter to take the $\pm 390\text{VDC}$ internal DC bus voltage down to $\pm 327\text{VDC}$ to charge the batteries. All operating power modules share the battery charging responsibilities equally. The charger capacity is 10% of the power modules' output capacity. Therefore, the batteries will charge to at least 80% of their capacity in 10x the time it takes to discharge them at full rated load. The Symmetra PX UPS will limit its charge rate when connected to a small battery plant as PX250/500 knows how many batteries are connected in the battery frames. This is done to meet with the battery manufacturers' maximum charge rate. The charger power rating can be adjusted from the display to 100%, 75%, 50%, 25% and 10% of the "normal" charger capacity level. The charger has a soft start of approximately 3 sec from 0-100%. The UPS control system monitors the internal temperature of each of the connected battery units in the system. The battery charger will reduce the string float voltage by 0.432V for each degree above 25°C on the "warmest" battery unit. This temperature compensating charger functionality extends battery life, and eliminates the possibility of a thermal runaway condition if the room ambient temperature control becomes unstable.

Battery Type Used

The individual battery jars that are used in the Symmetra PX UPS premium battery solution are Absorbent Glass Mat (AGM), Valve Regulate Lead Acid (VRLA). AGM VRLA batteries are sealed, non-gassing, and safe for human-occupied environments. Since the Symmetra PX UPS was designed for use on the data center floor, the use of AGM VRLA batteries was essential. The individual battery jars contained in the removable battery units are 12V, 9AH, 8 year@25°C design life batteries. APC has designed the battery solution of the Symmetra PX UPS in accordance with the recommendations of our battery vendors to achieve the highest system availability possible. The battery strings are arranged in a multiple string

parallel configuration, with each individual string (and removable battery unit) fused from one another. This allows for battery reserve to be available in the event of a battery cell failing open. With the loss of one battery string, the runtime will be reduced, but the Symmetra PX UPS will still have the ability to transfer to battery operation (battery operation is not inhibited) through the remaining parallel-connected battery strings. Full battery redundancy can be achieved by adding one more battery module than you have power modules populated for load capacity. A redundant battery module allows for the loss of a battery string, and still delivers the specified battery reserve time with full load applied. Advanced monitoring techniques allow for the UPS to detect a failing battery unit before it becomes a problem. These monitoring techniques will be discussed in the next section.

Battery Monitoring Capabilities

The Symmetra PX UPS continuously monitors each connected battery unit's temperature, voltage, and current during all operating states of the UPS. The battery charge percentage is continually calculated by the UPS control system. The control system monitors the discharge characteristics and performs battery diagnostics of each battery unit during an input AC power failure or a system battery self test. The battery self-test simulates the battery mode of operation. If AC utility/mains power fails during the test, the test stops and the UPS supplies battery power. A battery system self test can be manually initiated using the Symmetra PX UPS user interface, or set to automatically run on system start up, every N week(s). APC recommends a battery self test every 12 weeks. The Symmetra PX UPS will transfer all of its power modules to battery power for approximately 10% of the available runtime during a system battery self test. While on battery power, the reserve capacity of each battery unit is calculated by the UPS intelligence module, using the metered voltage and current which are provided by the system battery monitoring card. The intelligence module will compare the actual metered value discharge curve against an ideal calculated curve (based on a battery capacity algorithm supplied by the battery manufacturer). A battery unit will be identified as defective if the metered and ideal curves differ more than 10% when the calculated system battery capacity is greater than 40%, and 15% with a calculated battery capacity of 0-40%. The control system will not begin a battery diagnostic if the battery capacity is less than 50% at the time that a battery discharge condition is initiated. The battery monitoring card is polled as a node on the UPS internal Controller Area Network (CAN) along with the other system module nodes (power module, intelligence module, static switch module). Its polling rate will be determined by the total number of nodes that are connected to the CAN. Typical polling rate is once every 80ms for a UPS that is configured with 5 power modules. The UPS will issue an audible and visual alarm, as well as an SNMP trap, to notify the user of a defective battery unit. The local display or Web interface can then be used to identify exactly which battery unit has failed. It is APC policy to require replacement of all battery units of the affected ½ battery string upon the detected failure of a battery unit. This ensures that the battery units have similar internal impedance and charge / discharge characteristics. Advanced monitoring capabilities are available for both adjacent and remote UPS premium batteries, and the battery units that are installed in up to eight premium external battery frames.

Conclusions

The Symmetra PX UPS system offers a manageable, cost effective, highly available battery option for the mission critical load environment. The deployment of parallel-redundant battery strings, and premium battery monitoring capabilities, mitigate any availability shortfalls that may be seen by using VRLA battery technology over that of wet-cell battery technology. This is

achieved along with a reduction of cost and system complexity for the customer. Advanced monitoring capabilities eliminate the need for add-on battery management systems. This electrically and mechanically integrated, lab tested, field-proven redundant battery solution improves the reliability of the UPS system.

About the Author:

Milind Deshpande is a Snr Applications Engineer for APC by Schneider Electric. He is responsible for working with consultants, APC partners and customers regarding enterprise solutions. Milind received a Bachelor Degree in Electronics and Telecommunications from Pune University in 1991 and also holds a degree in Master of Business Administration from Johnson and Wales University, RI, USA.