Powerware

White Paper

Are your batteries up to the task?

How Eaton maximizes runtime and service life in Powerware BladeUPS systems for high-density data centers

Abstract

The continually increasing price of raw materials, namely lead, has caused UPS battery module prices to skyrocket—disrupting worldwide production and delaying key projects. Batteries represent as much as 35 to 40 percent of total data center power investment, driving the focus on ways to maximize battery runtime and increase system reliability.

When developing the revolutionary Powerware® BladeUPS® for high-density data centers, Eaton® incorporated several technologies that optimize battery performance and service life, such as: redundant internal batteries, premium quality batteries, optional external battery modules, innovative charging techniques and integrated battery management.

But what really distinguishes Powerware BladeUPS is its unique load-sharing feature for parallel configurations. This paper describes this and other Eaton innovations that maximize battery performance and service life in Powerware BladeUPS systems.

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Introduction

You can't let rolling blackouts, storms, natural disasters or utility problems keep you from running your business. That's why you have uninterruptible power systems (UPS) on the job, protecting critical systems.

The "uninterruptible" part of that equation relies heavily on batteries. Batteries boost power to normal voltage during sags and brownouts. Batteries provide ride-through power when switching from utility power to auxiliary generators. Batteries can run your most essential systems for hours during total power outages, if necessary.

And batteries are the leading cause of load loss.

That means battery health is a decisive factor in UPS performance. Fresh batteries in good health offer all their rated runtime and recharge after use. Aging batteries, which have been discharged and recharged many times, accept less of a recharge over time, which results in shorter runtime. In multi-module UPS configurations, the reliability of the whole system can depend on the status of the weakest battery in the setup.

That means it is essential to consider ways to extend the runtime and service life of batteries, especially in multi-module UPS systems.

Is battery service life and runtime really all that important?

Yes, for several reasons.

Batteries are expensive. Prices have increased dramatically in the last few years, primarily due to price increases in lead, the primary raw material in valve-regulated lead-acid (VRLA) batteries. Due to worldwide restrictions on the sale of lead, the price of battery modules for UPSs rose an average of 46 percent in 2007. Depending on runtime requirements, batteries represent about 30 to 35 percent of the total cost of a UPS.

Downtime is even more expensive. A typical data center might only resort to battery power for a few minutes a year, or perhaps a few minutes over the entire lifetime of the UPS. But for most data centers, the cost of downtime due to battery failure is unacceptably high. Batteries are a lifeline for business continuity.

Battery demand will continue to escalate. High-density servers and storage devices consume exponentially more power than their legacy counterparts. That means the need for backup battery capacity is growing exponentially as well, and batteries will become an even bigger component of the IT budget.

Batteries have a limited life span. If you have a cell phone, iPod or cordless tools, you know the syndrome very well; with every discharge, batteries lose some of their ability to accept a recharge. Even if the data center doesn't suffer an outage that drains batteries, UPS batteries must routinely be discharged during test simulations to check battery health. The higher the operating temperature, the faster degradation occurs. Under normal operating conditions, VRLA batteries have an average service life of three to five years.

Batteries age and deteriorate at different rates. That makes it difficult to determine the total runtime available in a multi-module configuration where several UPSs rely on a set of batteries, if the weakest battery module determines the whole system's runtime.

Batteries must always be ready on demand. A typical commercial customer location experiences an average of 24 power disturbances a month and three to five power outages. You need a healthy battery system that can work to its full potential whenever these problems occur.

For all these reasons, data center managers should be very interested in technologies that maximize battery health, runtime and service life. Eaton focused very seriously on this issue when developing battery technologies for the Powerware BladeUPS system for high-density data centers. The result is a range of approaches and innovations that ensure customers get the best performance and protection from their battery investments.

Optimizing battery performance in Powerware BladeUPS systems

Innovative technologies that maximize battery health, runtime and service life

The Powerware BladeUPS from Eaton Corporation is a rack-based UPS optimized for high-density computing environments. This modular, three-phase system delivers the features needed most in data centers and network centers:

- **High power density**. With 12KW of power protection in a 6U unit—expandable to 60kW N+1 in one 19" rack—the Powerware BladeUPS delivers twice the backup power of other vendors' modular solutions, while dissipating only one-third the heat.
- **Highest efficiency**. The Powerware BladeUPS operates at a leading 97 percent efficiency in normal operation. Even at <30% load, where you would expect much lower efficiency, this UPS is more efficient than others' modular products at full load, saving thousands of dollars per year.
- **High availability**. The Powerware BladeUPS incorporates leading technologies that Eaton developed for multi-megawatt UPS systems, such as: patented Powerware Hot Sync® paralleling technology, hot-swappable components, external battery modules, remote monitoring and automated bypass capabilities.

Let's take a closer look at the technologies that Eaton incorporated in Powerware BladeUPS systems to optimize the performance and service life of batteries, including:

- Redundant internal batteries
- Optional external battery modules (EBM)
- Premier battery quality
- Innovative charging techniques
- Integrated advanced battery management (ABM®) technology
- Cool operating temperatures
- Separate battery breakers
- *Battery load-sharing in parallel configurations*—
  an innovation that differentiates Powerware BladeUPS systems

Redundant internal batteries

Each 12kW BladeUPS module has redundant internal battery strings that provide 4.8 minutes of runtime at full load, 13 minutes at 50-percent load (240V @ 100Ah per string). With the redundancy, even if one internal battery string were to fail, the unit would still provide about two minutes of runtime to enable graceful shutdown of connected servers. There is no single point of failure.

Furthermore, these batteries are hot-swappable, which means they can be removed and replaced without powering down the UPS.

Optional external battery modules

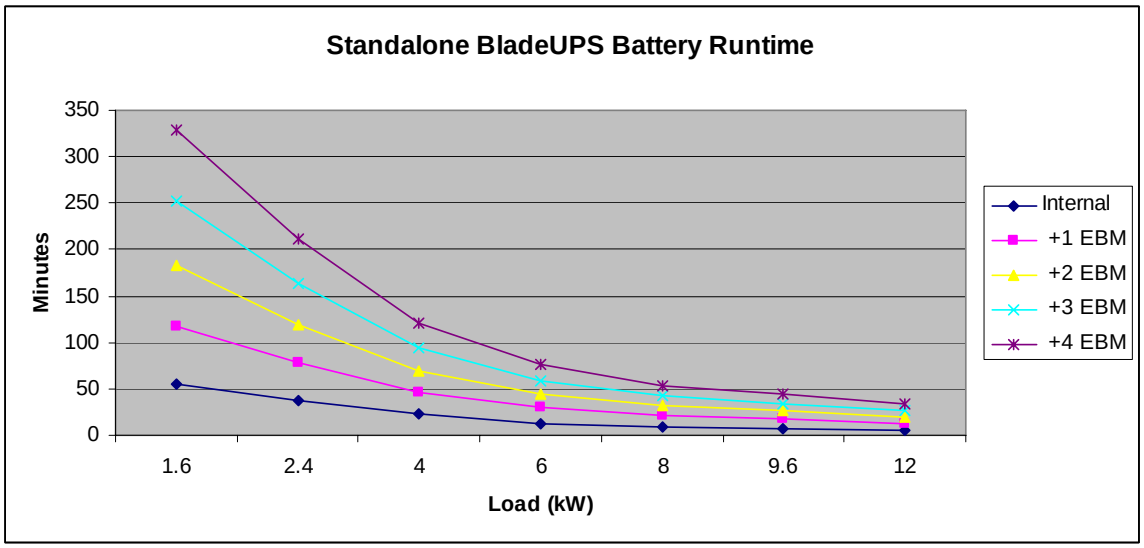
If additional runtime is needed you can simply add a 3U battery extension pack (Extended Battery Module, or EBM) that plugs into the back of a UPS module. These modules have bigger batteries with higher amperage discharge to provide longer runtime than the internal batteries. Up to four EBMs can be connected to a single unit, increasing runtime at full load from just under 5 minutes to 34 minutes per module.

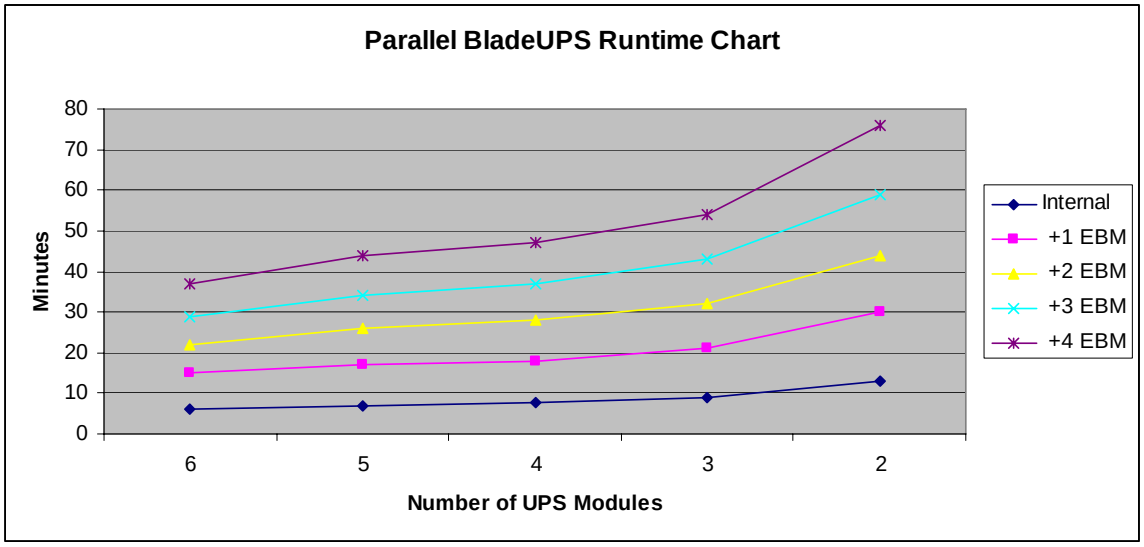
Powerware BladeUPS battery runtimes—*Standalone UPS module*

Load (kW)	% of capacity	Internal batteries	Internal batteries + one EBM	Internal batteries + two EBMs	Internal batteries + three EBMs	Internal batteries + four EBMs
1.6	**13%**	55 mins	118 mins	183 mins	253 mins	329 mins
2.4	**20%**	37 mins	78 mins	119 mins	163 mins	211 mins
4	**33%**	23 mins	46 mins	69 mins	94 mins	120 mins
6	**50%**	13 mins	30 mins	44 mins	59 mins	76 mins
8	**67%**	9 mins	21 mins	32 mins	43 mins	54 mins
9.6	**80%**	6.9 mins	17 mins	26 mins	34 mins	44 mins
12	**100%**	4.8 mins	12 mins	20 mins	27 mins	34 mins

Powerware BladeUPS battery runtimes—*Parallel configurations for N+1 redundancy*

UPS modules	Total load	Internal batteries	Internal batteries + one EBM	Internal batteries + two EBMs	Internal batteries + three EBMs	Internal batteries + four EBMs
6	60 kW	6 mins	15 mins	22 mins	29 mins	37 mins
5	48 kW	6.9 mins	17 mins	26 mins	34 mins	44 mins
4	36 kW	7.7 mins	18 mins	28 mins	37 mins	47 mins
3	24 kW	9 mins	21 mins	32 mins	43 mins	54 mins
2	12 kW	13 mins	30 mins	44 mins	59 mins	76 mins





External battery modules can be installed in the same rack as the UPS modules or in an adjacent rack—anywhere you have 3U of available rack space, even in a rack housing other IT equipment.

Whether you only need a few extra batteries or a fully populated rack of external batteries, there's no need to purchase a separate, proprietary battery enclosure. In contrast, if you wanted to add more battery runtime to a competitor's modular UPS system, you would have to buy a new proprietary battery enclosure.

Premier battery quality

UPS batteries can display very different performance characteristics depending on the manufacturer, model and even minor variances in manufacturing process and components. Eaton's engineering team tested more than 1000 batteries from multiple vendors, searching for the ones that showed the best performance, power density and runtime characteristics. In intensive lab testing, charge after charge, the batteries approved for the Powerware brand sustained high runtime levels, while performance of non-qualified batteries dropped off markedly after only 10 discharges.

Innovative charging techniques

Many UPS batteries on the market today are constantly 'trickle-charged'—a process that eventually degrades the battery's internal chemical composition, reducing potential battery service life by as much as 50 percent. In contrast, Powerware *Advanced Battery Management* (ABM) technology uses sensing circuitry and an innovative three-stage charging technique that doubles the useful service life of UPS batteries while optimizing battery recharge time.

Optional *temperature-compensated charging* monitors battery temperature and uses sophisticated algorithms to adjust the rate of charge, compensating for the ambient temperature, to prolong battery life.

Integrated battery management

The UPS automatically tests and monitors battery health and remaining lifetime, and provides advance notification when preventive maintenance is needed. Users receive visual and audible alerts—locally or over a communication network—of any battery that has less than 80 percent of its original capacity. With advance notification, there's ample time to hot-swap batteries without ever having to shut down the UPS or connected equipment.

Cool operating temperatures

As noted earlier, hot environments shorten battery service life. So the Powerware BladeUPS provides physical separation between its battery modules and the electronics module. The unit is cooled by air intake in the front, from the cold aisle, and exhaust in the rear, to the warm aisle. The fans automatically adjust to internal temperature, pulling more cool conditioned air through the battery compartment whenever necessary.

In addition, the Powerware BladeUPS extends battery service life due to its low internal heat dissipation. This UPS is so efficient that a fully configured rack of six systems only puts out approximately the same heat as only six 1U servers.

Separate battery breakers

Each Powerware BladeUPS module has its own 70A battery breaker. In a multi-module parallel configuration, if one breaker trips, it affects only a small amount of the total runtime of the entire system. In contrast, a competitor's modular UPS has only one battery breaker for the entire parallel system. If that breaker trips or if a fault brings down the DC bus, the entire system goes offline, not just one module.

Battery load-sharing in parallel systems

A key merit of modular UPS systems such as Powerware BladeUPS is the ability to electrically and mechanically connect modules into a larger configuration that performs as a synchronized unit. For instance, up to six 12 kW Powerware BladeUPS modules can be paralleled to give the user 60kW (N+1) in one 42U enclosure. If any module is unavailable or cannot support the output load, another module can seamlessly take over. Parallel configurations therefore add important redundancy in the power protection architecture.

The challenge of battery management in traditional parallel UPS systems

In traditional parallel configurations, battery management has been a challenge. The entire system has been somewhat at the mercy of the weakest battery in the setup. Here's why…

Parallel UPS configurations are programmed to share the load evenly among all active UPS modules in the group. This strategy is designed to protect UPS modules from potential overload conditions or the stress of dramatic shifts in load volume as conditions change. Trouble is, although the UPS electronics modules are equally capable of handling equally shared loads, their batteries might not be. Batteries age and deteriorate at different rates. A parallel configuration could easily have a mix of strong batteries and weak ones.

If the parallel configuration must resort to battery power during a power outage, some batteries will be up to sharing the task equally, others might not. That reality can trigger a troubling chain of events. The weakest battery is depleted early on, causing its associated UPS module to go into under-voltage alarm and shut down in self-protection. If the remaining units in the parallel configuration cannot support the total load, the whole system will fail, even before completely draining all the available batteries.

This problem actually still exists with most parallel systems on the market today. In a well-known competitor's system, a fault in a single battery string may affect the performance of the overall system and create a single point of failure, potentially causing a system failure.

The Eaton solution to battery management in parallel systems

Eaton considered this domino effect to be an unacceptable risk for modern data centers. The Powerware BladeUPS system alleviates this problem by intelligently monitoring the health of each individual battery module and—during outage conditions—properly adjusting load distribution to take advantage of the strongest batteries, rather than being constrained by the weakest.

The Powerware BladeUPS Battery Load Sharing feature monitors system voltage over a controller area network (CAN) on the parallel bus. The CAN network transmits power and battery voltage information from each UPS, to enable the system to calculate the average battery voltage for the entire parallel configuration. Once a target voltage is calculated, the system determines which UPS modules can carry more or less load depending on their battery capacity.

Each UPS module can be phased forward (take more load) or phased backwards (take less load) to ensure the total load is being powered. Stronger batteries will assume more load, weak batteries will take less load, and all batteries will be drained evenly. The system also prevents any unit from going into overload or backfeed conditions.

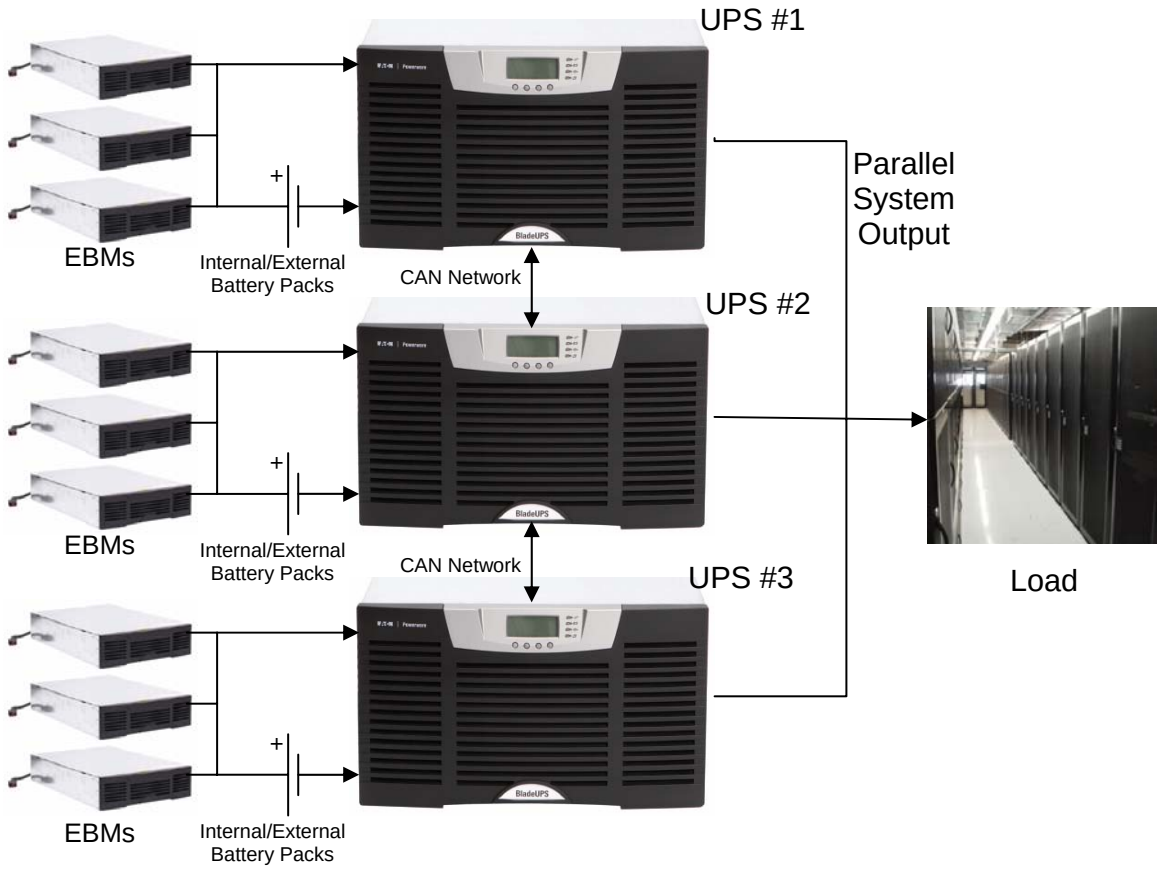
This innovative feature ensures maximum runtime out of the connected batteries, while protecting UPS inverters from exceeding their rated capacity.

The difference between runtime and capacity

Although the two terms are related and often used interchangeably, there is a difference:

- *Battery capacity* refers to the amount of charge for which the battery is rated or can hold when recharged. Capacity will diminish over time.
- *Battery runtime* refers to the length of time the battery can support the load during a power outage. Runtime naturally will vary depending on the load. For example, a healthy Powerware BladeUPS battery provides 4.8 minutes of runtime at full load, 13 minutes at 50-percent load.

In a parallel system, runtime refers to the length of time the batteries collectively can support the load. That figure will vary depending on load and the load-sharing algorithm used to distribute the load among available batteries.



A typical Powerware BladeUPS parallel system

Conclusion

Batteries represent a significant investment in the data center power infrastructure, and battery health is a decisive factor in UPS performance. So it is essential to consider ways to extend the runtime and service life of batteries. This is especially true in multi-module UPS configurations, where the reliability of the whole system can sometimes be determined by the weakest battery in the setup.

Eaton incorporated a number of technologies to optimize battery performance and service life for Powerware BladeUPS systems, such as: redundant internal batteries, premium quality batteries, optional external battery modules, innovative charging techniques and integrated battery management.

But what really distinguishes Powerware BladeUPS is its unique load-sharing feature for parallel configurations. Whereas other parallel systems are vulnerable to a weak battery anywhere in the configuration, the Powerware BladeUPS maximizes total runtime—distributing more load to UPS modules with stronger batteries, less to modules with weaker batteries. This approach ensures that the independent batteries are all discharged evenly, and in case of a battery failure, there is no effect on other battery modules. This result is an added layer of protection for critical IT assets.

About Eaton

Eaton is a global leader in power protection and management. The company delivers a full line of power protection, power distribution, power management and data center infrastructure solutions, plus professional services.

Powerware-branded products protect critical systems around the world in medical, networking, financial, industrial, communications, military, and aerospace applications—wherever continuous quality power is essential to operations.

To find our more about Powerware products, services, and support from Eaton Electrical, visit us on the Web at www.powerware.com.

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