

Variable Module Management System (VMMS) technology

Maximizing UPS efficiency without compromising reliability

Introduction

Balancing the need for consistent, reliable power against the pressure of controlling energy costs is increasingly challenging for IT and facility managers. Uninterruptible power systems (UPSs) are essential power infrastructure components that enable business-critical technology to withstand inevitable inconsistencies in power quality and availability. However, as the reliability of the UPS increases, there is a corresponding decrease in efficiency, making the equipment more costly to operate.

Eaton's [Variable Module Management System \(VMMS\)](#) is a technology aimed at increasing efficiency without compromising reliability. VMMS is part of Eaton's [Energy Advantage Architecture](#), a suite of technology options that helps businesses answer to economic, environmental and regulatory pressures related to energy consumption.

What sets VMMS apart is its ability to maintain high levels of efficiency in notoriously energy-hungry environments and configurations—such as lightly-loaded 2N or N+1 redundant systems—or in critical data centers where the UPS feeds dual-corded servers. By considering VMMS in their calculus when determining how to maximize efficiency and reliability at the same time, IT and facility managers can achieve two goals that used to be mutually exclusive. Simply put, the desire for efficiency and reliability is no longer an either/or proposition.

Rising energy costs drive innovation

According to the U.S. Department of Energy (DoE), global demand for energy is poised to grow by 57 percent while the energy supply decreases and prices increase simultaneously. Higher operating costs will result, leading to reduced profitability unless organizations take actions to control energy usage. This reality is driving the “green IT” movement, which includes finding ways to increase computing and power density while reducing consumption at the same time.

Utility costs now account for 20 to 30 percent of data center operating costs. For many IT organizations, energy costs have the greatest impact on total cost of ownership (TCO), and can greatly limit a company's ability to expand its data center to meet growing operational needs. As a result, TCO in the data center is being dominated more and more by the costs of running the data center rather than the costs associated with building it. In fact, the cost of electricity is already outpacing the cost of hardware. According to International Data Corporation (IDC), for every dollar spent on new IT hardware, an additional 50 cents is spent on power and cooling, more than double the ratio of five years ago. For example, \$1 million worth of servers purchased today will consume \$1.5 million in electricity over a three-year operating life—a figure that will only increase with rising utility rates. Addressing this rise in energy costs is key for IT and facility managers if they hope to gain control over their own operating costs.

UPS technology: the efficiency conundrum

The most reliable UPS topology is double-conversion. In this type of UPS, power is conditioned because the incoming sine wave is completely broken down. Power is then re-converted into a perfect sine wave with zero anomalies. Because double-conversion corrects any irregularities in the incoming sine wave, it is the gold standard of UPS technology and is the preferred method for protecting vital equipment. However, double-conversion UPSs are typically less efficient than UPSs using other topologies. This means they consume more electricity and emit more heat, and therefore can have higher operating costs. In the reality of rising energy costs and constrained IT budgets, improving UPS efficiency by even a few percentage points can have a positive impact on the bottom line—but at what price? Putting critical

systems at risk with less reliable UPS technology might save money in the short term, but could prove to be a costly miscalculation in the long run.

In legacy UPSs, the main obstacle to improving efficiency is the transformer-based design. Transformer-based UPSs utilize a phase-controlled rectifier. This produces large, harmonic input currents and reduced input power factor (PF), which is unacceptable at many sites and is incompatible with some generators. As a result, large input inductors and harmonic filters are needed, which often create inefficiencies. These components are typically only effective above 60 percent of full load, further eroding efficiency. Given the fact that many UPS systems operate at less than 60 percent of full load, the costs associated with loss of efficiency become increasingly evident.

Advances in electronic control of UPSs have led to the development of transformerless UPS designs (excluding 600V UPS applications). By removing the transformer, the main obstacle to achieving high efficiency is also eliminated.

Another issue affecting efficiency in large UPSs is multi-module configurations. In these systems, each uninterruptible power module (UPM) shares the load equally. As the number of UPMs increases, each operates at a lower point on its efficiency curve.

VMMS: cost-saving efficiency for double-conversion

The advent of three-phase transformerless UPS designs paved the way for Eaton's breakthrough in high-efficiency UPS technology: VMMS. Similar to automotive adaptive sensing technology, VMMS achieves full-system efficiency by automatically optimizing the system according to load level. In other words, the system automatically senses how much is needed to support the load, putting unneeded UPMs into ready state. This is calculated according to the VMMS load threshold of each UPM (80 percent by default) and the system configuration, including redundancy requirements. In ready state, the UPM maintains the DC link voltage, generates logic-level PWM signals, syncs to utility and filters EMI and lightning strikes, standing ready to flash to double-conversion mode when needed.

The UPMs in ready state are able to instantly react to an increase in load level, transitioning to full double-conversion mode in less than two milliseconds by connecting the existing PWM signals to the IGBT gates. The ability to have ready-state UPMs instantly flash on is possible because there is no transformer to be energized, which takes too much time to transition from ready state to completely on. In ready state, the input and output contactors remain closed so that the UPM still matches and locks to the output phase. Voltage to the critical bus and the DC link is primed. This allows the UPM to return to active double-conversion online instantly in the case of disturbances or load-level increases. Because VMMS is firmware-controlled and doesn't have to depend on mechanical devices in order to flash on, it can react faster than was previously possible. See Figure 1:

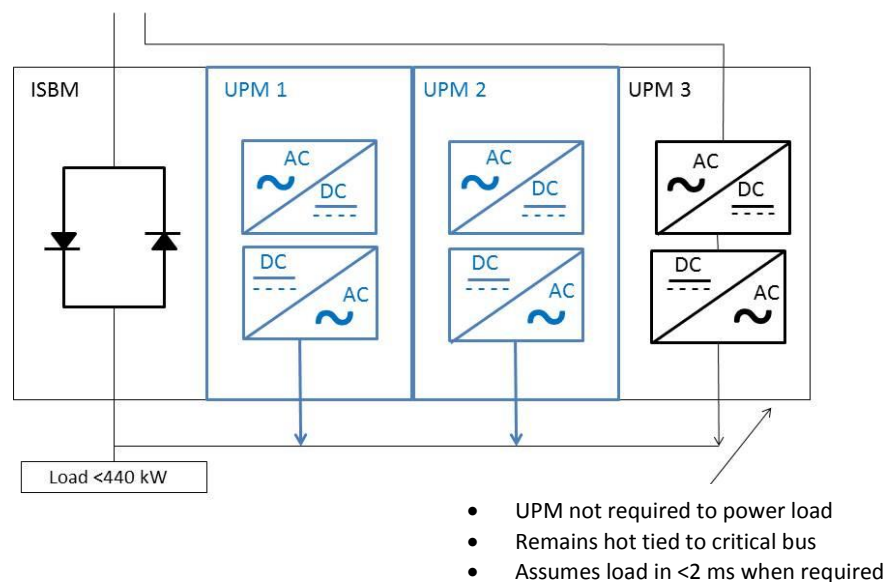


Figure 1: N+1 redundant system operating in VMMS mode, with the third UPM in ready state

The gains in efficiency with VMMS are significant. For example, in system configurations with two 825 kVA UPSs—with an A and B feed design—and 440 kVA total load, there can be more than a 3 percent increase in system efficiency. See Table 2:

UPS configuration	Conventional 600V UPS	9395 600V with VMMS
Efficiency at 440 KVA load	93.6%	95.2%
UPS energy savings	--	49 MWh/year

Table 2: Energy savings using VMMS

Predictive algorithms

Operating efficiency of large-scale UPSs is improved through the execution of real-time, predictive algorithms that identify pending and future changes in direction and magnitude of supply, demand voltages and current. Using this predictive module, VMMS can wave-shape DC components to reduce power waste and maintain better operating envelopes. VMMS also engages full UPS protection and load assumption within two milliseconds of any load step, remaining well within IT industry specifications.

Transfer from VMMS to double-conversion online mode

There are several situations that can trigger a transfer from VMMS ready state to double-conversion mode:

- A utility outage that results in the UPS transitioning to battery
- >3 percent adjustable voltage variation on the output
- Any UPM that hits current limit
- A UPS overload (using three-phase MCU Output Idq)
- Battery test initiated
- Battery charging required
- Downstream static switch activation (reaction time of VMMS can be coordinated with static switch)
- Any UPM being serviced (a UPM can be serviced while other(s) maintain the load)

The parameters for transfer from VMMS to double-conversion can be customized to users' specific needs.

Lighter loads decrease efficiency

In redundant N+1 and 2N systems, UPSs are lightly loaded—typically operating at less than 45 percent load level—and are considered to be inefficient. Because UPSs using VMMS do not have all of the UPMs fully engaged at all times, efficiency is improved and reliability is maintained. See Figure 3:

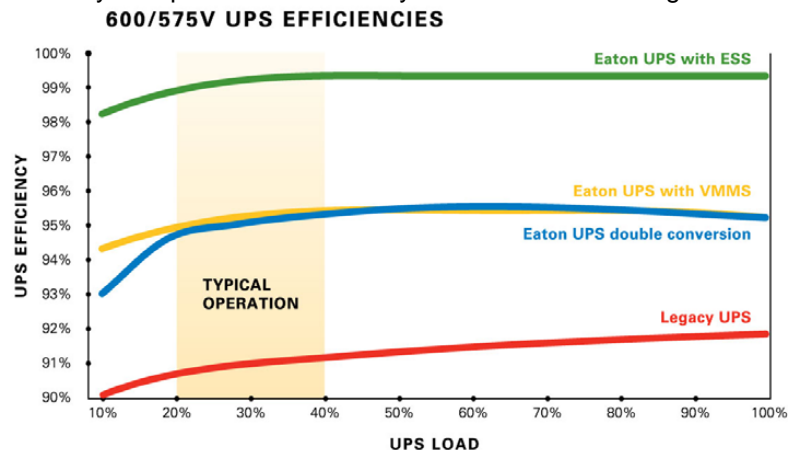


Figure 3: Efficiency gains using VMMS versus conventional mode

Increasing efficiency for data centers with dual-corded servers

A/B bus systems are typically lightly loaded, usually at less than 30 percent. For example, the A bus could be running in a conventional mode and the B bus could be using VMMS. After six months, a comparison could be conducted, identifying efficiency gains on the B bus and validating no loss of reliability when compared to the A bus. See Figure 4:

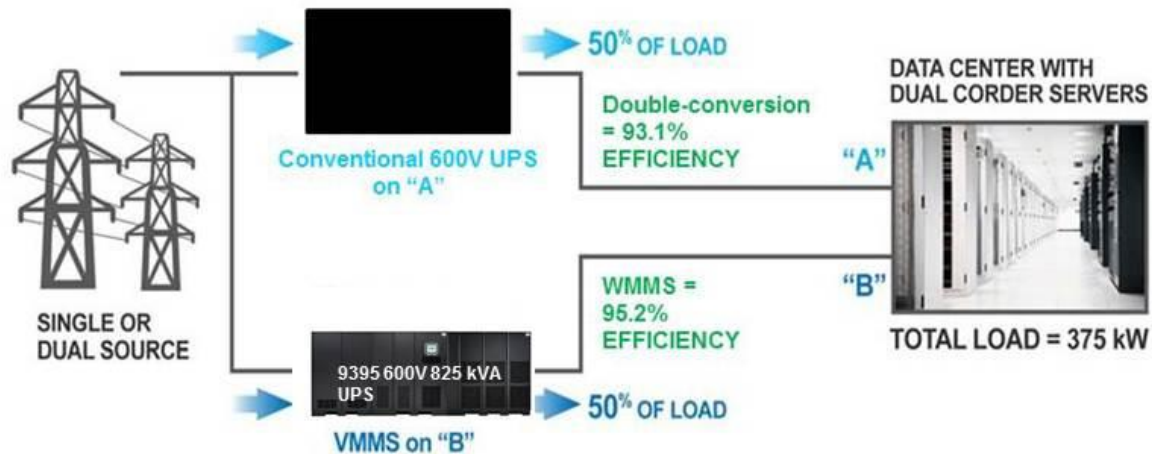


Figure 4: VMMS in a data center with dual-corded servers

Deploying VMMS for eco-friendly cost-savings

VMMS comes standard for the Power Xpert™ 9395 high performance UPS models. It can be used in single- (multiple UPM) and multi-UPS systems. The 9395 UPS is designated as an Eaton Green Leaf Solution in its sustainable design. Eaton only qualifies products that adhere to all sustainability guidance offered by recognized organizations such as the U.S. Federal Trade Commission (FTC), European Union, and ISO. The 9395's Energy Saver System (ESS) allows the UPS to maintain excellent input THD without the use of input filters, enabling 99 percent energy efficiency. The 9395 UPS with VMMS also qualifies for the LEED® (Leadership in Energy and Environmental Design) certification, a third-party verification that the product is environmentally responsible. This allows companies to benefit from utility credits and important tax incentives. The 9395 UPS is also the first UPS of its class to be SMART™ Certified.

VMMS is offered in single 9395 units from 550 to 1200 kW, in distributed parallel systems of 9395 UPSs and in SBM centralized bypass systems. Existing 9395 installations may be VMMS upgradeable. For information, please contact Eaton customer service technical support at 1-800-843-9433.

Conclusion

Though once faced with compromising UPS reliability to reduce operating costs, IT managers no longer have to make that tough choice. VMMS technology from Eaton increases the efficiency of double-conversion online UPSs while maintaining redundancy by intelligently controlling UPM load levels. VMMS helps IT managers mitigate rising energy costs and ensures system integrity.