
Increase Server Energy Efficiencies by Using High-Voltage Power Supplies and 208V UPSs

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Abstract

Maximizing energy efficiencies in today's SMB IT enterprise is rapidly becoming an important factor in saving costs and reducing an organization's carbon footprint.

One element of the power supply scheme that often is overlooked relates to the voltage level of power supplies. The selection of the proper input voltage has a direct impact on power supply output capacity, power conversion efficiency, power supply thermal operation and power supply reliability—all of which affect the bottom line.

This paper examines how using equipment that operates at high-line voltage maximizes energy efficiency and saves money.

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Dense computing continues its insatiable appetite for power

As C-level executives, IT and facility managers continually examine and implement various technologies and initiatives to increase computing power and save precious dollars, there is mounting pressure to implement server technologies that not only meet budget parameters, but increase reliability and availability. However, the compromise is usually increased energy usage.

While this paper focuses on the SMB enterprise, it is interesting to note that according to a 2007 EPA report entitled "Report to Congress on Server and Data Center Energy Efficiency," the power demand of data centers in the U.S. is growing. Consider these findings:

- The energy consumption of servers (including cooling and auxiliary infrastructure) in U.S. data centers has doubled in the past five years and is expected to almost double again in the next five years [2011] to more than 100 billion kilowatt-hours (kWh), costing more than \$7.4 billion annually (2005 dollars). The peak load on the power grid from these servers and data centers is currently estimated to be approximately 7 gigawatts (GW), equivalent to the output of about 15 baseload power plants. If current trends continue, this demand would rise to 12 GW by 2011, which would require an additional 10 power plants.

The good news is that new power distribution schemes and products make the IT infrastructure more adaptable and easier to manage.

Saving energy with high voltage

When the U.S. rolled out the first electrical grid, light bulb filaments were very fragile and quickly burned out on 208-volt lines. Dropping the voltage to 110/120 volts increased filament life—thus, 120 volts became the standard in the U.S. By the time Europe and the rest of the world built out their power grids, advances in filament design had largely eliminated the high-voltage problem, which is why the 230/250 volt power system is more prevalent across most of the rest of the world.

It's important to note that each time voltage is stepped down, a transformer is used, and power is lost. The loss may be as little as 1 or 2 percent per transformer, but over time, the penalty for transformer use adds up. By switching to a 208-volt system, one less transformer is needed in the chain, thereby reducing wasted energy.

Moreover, 208-volt systems are safer and more efficient as less current is required to push the same wattage through 208 volts than 120, lowering the risk of injury and minimizing power losses in transit.

High-efficiency power supplies

While most users don't pay much attention to the internal power supply unit (PSU) in a server, it definitely pays to consider power supplies that are highly efficient. Today's major server manufacturers now equip their boxes with auto-sensing input circuitry that automatically adjusts to the applied input voltage. The only exceptions are devices that are defined as high-voltage operation only. (Make sure to always review a device's input specifications prior to connecting it to the power distribution system.)

High-voltage vs. low-voltage input power

At first glance, high-voltage input power seems counter-intuitive when thinking about energy savings. However, in the real world, power supplies operate more efficiently at high voltage. The typical server switch-mode power supply has an efficiency rating between 65 percent and 80 percent, with some special-purpose products able to reach 90 percent efficiency. The lower voltage causes the power supply to operate at the lower end of this range.

When operating at 208 volts and depending on load level, a 1.0 to 2.0 percent difference in efficiency can be experienced for a 1000W power supply. When the loss in the power distribution transformer (PDU) needed to get to the 120V is added in, there is an additional 1.5 to 2.0 percent savings. Factor in cooling efficiencies and the savings can add up to between 4 and 8 percent, which translates to about \$70 per power supply. When multiplied by the number of power supplies in the server rack, the savings certainly justify making the switch to 208 volts, especially when expanding or moving into a new location.

Power supply thermal operation is also affected by the choice of input voltage. Input components run hotter when operating with low-voltage input power, which is caused by the almost doubled input current. The formula for heat generated in a component is $I^2 \times R$, with I being the input current and R the resistance of the component. Therefore, if the input current is doubled, the heat generated in any given component is going to be four times greater. Because the life of a component is significantly shortened when it continuously runs at higher temperatures, operating at a higher voltage can have an impact on the overall life expectancy of the power supply.

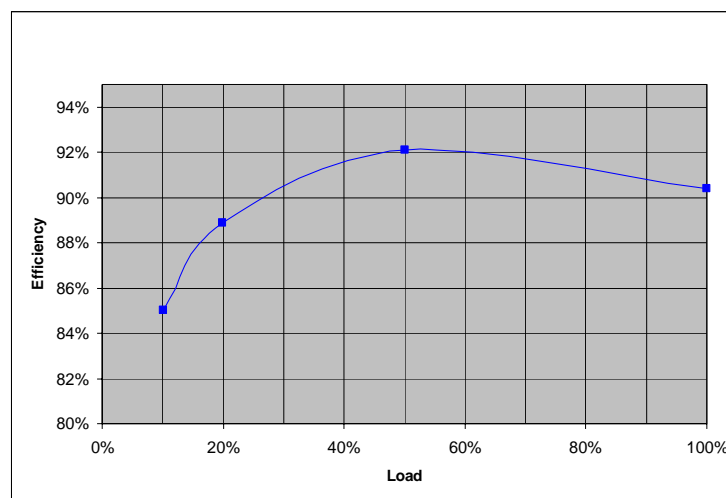


Figure 1. Vendor A: 1000W PSU operating at 115V.

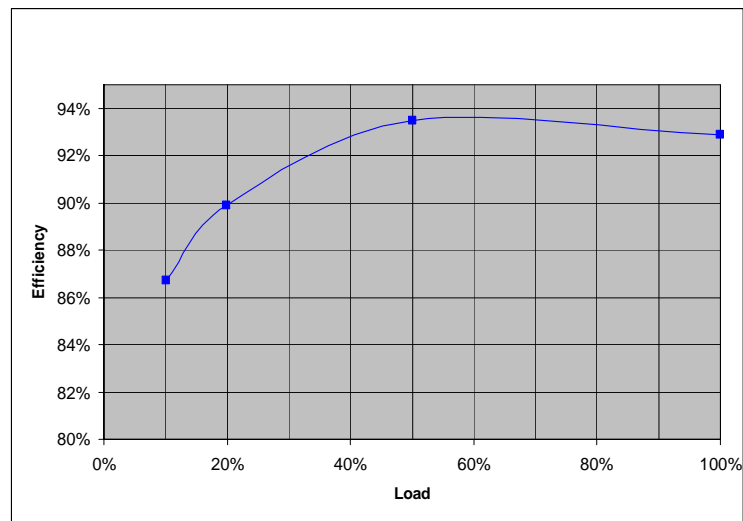


Figure 2. Vendor A: 1000W PSU operating at 230V.

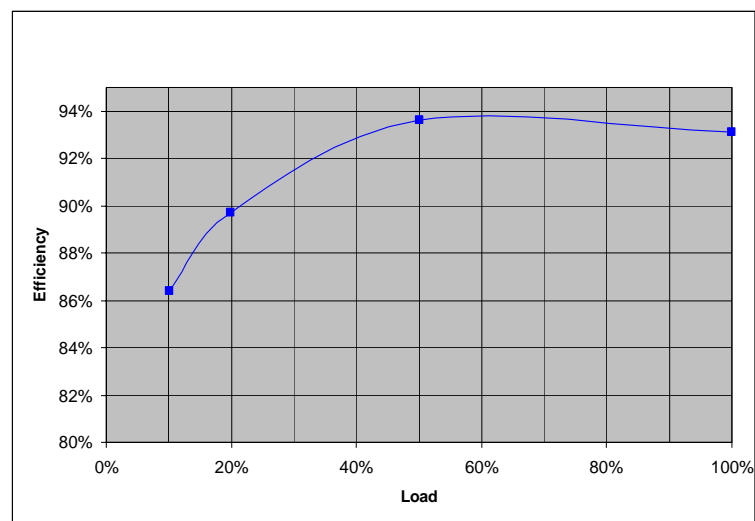


Figure 3. Vendor A: 1000W PSU operating at 240V.

Breaking tradition with 208V/230V power distribution

To satisfy global markets, virtually all IT equipment today is rated to work with input power voltages ranging from 100V to 240V AC. The higher the voltage, the more efficiently the unit operates. For example, an HP ProLiant DL380 Generation 5 server operates at 82 percent efficiency at 120V, 84 percent efficiency at 208V and 85 percent at 230V.

Many IT managers have not made this switch yet simply because they're not aware of the energy savings and how to go about making the change to high-voltage. The good news is that it's very simple to gain this incremental advantage simply by changing the input power (and the power distribution unit in the rack). In some cases, it may be necessary to change a switch setting on the device. Unfortunately, most equipment is automatically set to operate off lower-voltage power—sacrificing efficiency for tradition. In addition, if a facility does not have 208-volt service at the server rack, an electrician will need to pull wire and add receptacles.

Getting past the first impression

One of the key reasons why customers in the U.S. have been reluctant to switch to high voltage is a simple, practical issue: High voltage UPSs are typically fitted with IEC outlets (or even inlets) and customers do not know how to connect them to IT equipment with a traditional NEMA plug. Once again there is a very simple solution: All IT power supplies come with a detachable input cord with a NEMA plug on the one side and an IEC plug on the other. By detaching this input cord from the server, for instance, and connecting it to the input of the UPS, the various IEC jumper cables that come with the UPS can then be connected to the IT equipment. These IEC cables are fully UL-listed and are the standard method of connection in large mission-critical data centers across the U.S.

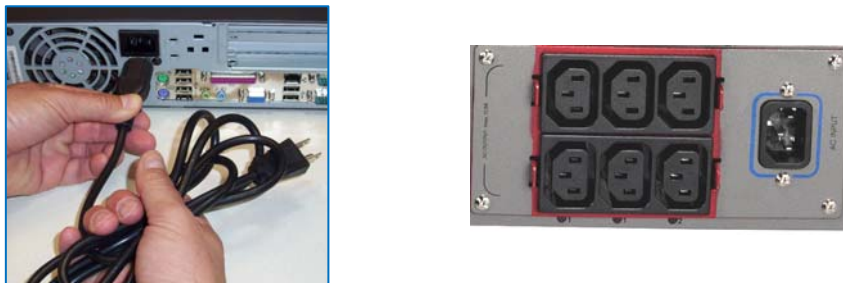


Figure 4. Remove the input cable from your IT equipment and simply plug it into the input IEC receptacle of the UPS (blue circle). Use the various jumper cables provided with the UPS to connect the IEC outlets of the UPS (red) with the various IT devices you want to protect.

Further increase savings by using high-efficiency UPSs

Advances in UPS technologies have greatly improved efficiency. In the 1980s, a state-of-the-art UPS operated at 75 to 80 percent efficiency at best. With the advent of faster switching devices in the 1990s, efficiency jumped to 85 to 90 percent, and later to 90 to 94 percent.

Even higher efficiency is now possible. In 2007, Eaton[®] introduced the BladeUPS[®] power system for high-density computing environments. With an input voltage of 208V AC or 400V AC, this modular UPS operates at an industry-leading 97 percent efficiency in normal operation. Even at less than 30 percent load, where one would expect much lower efficiency, this UPS is more efficient than other modular products at full load.

Even small increases in UPS efficiency can quickly translate into tens of thousands of dollars. For example, assuming a utility rate of 10 cents per kWh, a 60 kW N+1 redundant configuration would save more than \$30,000 in five years. High UPS efficiency also extends battery runtimes and produces cooler operating conditions.

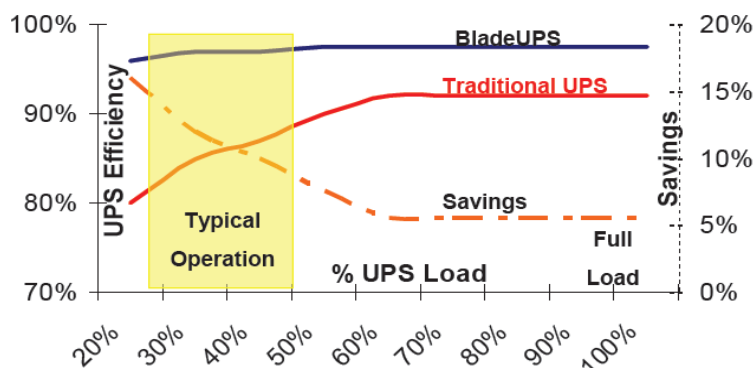


Figure 5. Efficiency savings with the Eaton BladeUPS.

The compact, modular BladeUPS opens up new options for efficient and adaptable power distribution. A single 6U UPS module delivers 12 kW and up to six modules can be paralleled to support up to 60 kW in a single 19-inch rack, with N+1 redundancy. The BladeUPS delivers twice the backup power of competitive modular solutions, and requires much less floor space than traditional stand-alone three-phase UPSs of comparable power levels.

High-voltage scalable power without costly transformers

Being able to scale up power protection is a very cost-effective solution for the SMB enterprise. With the Eaton MX Frame™, users can purchase the right amount of protection they need now and then expand as needs increase. To increase efficiency levels, the MX Frame comes standard with 208V power, which allows for the elimination of expensive and bulky step down transformers and/or split-phase inverters that require special four-wire cabling.

Unique to the Eaton MX Frame is the fact that the same power and battery sub-modules can be used for both the stand-alone Eaton MX RT™ 5 kVA UPS and the modular chassis, which significantly reduces the entry cost to scalability. Through this innovative approach, users can decide to acquire a cost-competitive Eaton MX 5000 RT UPS and migrate to a fully scalable, redundant solution using the Eaton MX Frame while still using the original power and battery sub-modules of the original 5 kVA stand-alone UPS. Should a customer still require low voltage, 120V service for legacy IT equipment that cannot use high voltage, Eaton provides a convenient, modular step-down transformer in 5 kVA increments. In this manner, there is no need to use a fully rated transformer when low voltage is only needed for 25 percent of the available power.



Figure 5. Eaton MX UPS and Frame provides seamless migration from 5 kVA to 20 kVA.

Summary

While there are new tools and technologies being introduced every day to save energy, understanding existing methods and systems can bring immediate efficiencies and money to the bottom line—often without an additional investment. Utilizing state-of-the-art power supplies and 208V UPSs results in higher efficiencies and uptime, power conservation and meaningful green initiatives.

About Eaton

Eaton Corporation is a diversified power management company with 2008 sales of \$15.4 billion. Eaton is a global technology leader in electrical components and systems for power quality, distribution and control; hydraulics components, systems and services for industrial and mobile equipment; aerospace fuel, hydraulics systems for performance, fuel economy and safety. Eaton has approximately 75,000 employees and sells products to customers in more than 150 countries. For more information, visit www.eaton.com.

About the author

Hervé Tardy is the vice president and general manager of Eaton's Distributed Power Quality Business Unit. Tardy has more than 20 years of global experience in the UPS industry including sales, channel and product marketing management positions in Europe, Asia and North America.

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