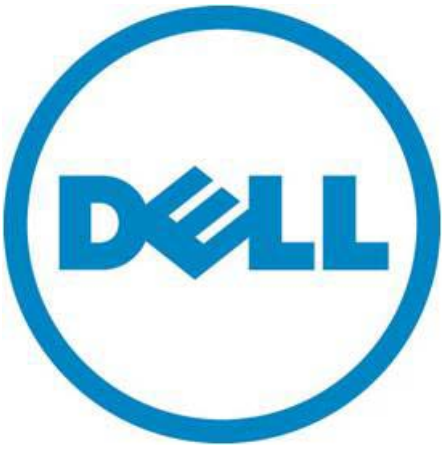
Which UPS is Right for the Job?

A Dell Technical White Paper

Dell



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Abstract

Traditionally, office managers, IT managers, and facilities managers could choose from three UPS topologies: standby, line-interactive, and double-conversion (online)—offering widely varying levels of efficiency, performance, and protection.

Until recently, selecting a UPS configuration was a matter of compromise. Standby and line-interactive UPSs offered highest efficiency, but they sacrificed level of protection because they didn't go through the double power conversion process. Online UPSs offered highest protection, but only about 91–93 percent of incoming power actually was available for powering equipment; the rest was used or wasted by the UPS.

Dell has eliminated that tradeoff between efficiency and protection. Dell high-efficiency online UPSs use an industry-leading multi-mode technology that enables the UPS to operate at 98-percent efficiency or better under normal utility conditions. The UPS continually monitors incoming power and balances the need for efficiency with the need for premium protection, to match the conditions of the moment. The result is a significant saving in energy costs without compromising protection for your IT systems.

This guide describes how various UPS internal designs work, and how that design affects four key elements of UPS performance:

- Maintaining output voltage within tolerances
- Transferring among modes without affecting the protected equipment
- Delivering reliable, always-on power to protected equipment
- Reducing energy costs and carbon footprint

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Introduction

Which uninterruptible power system (UPS) design is right for protecting your office, retail location, local area network or data processing systems? The answer depends on a combination of factors that have been influenced by industry trends and technology advances—and complicated by marketing hype.

At its most basic level, a UPS performs two primary and complementary functions:

- *Conditioning incoming power* to smooth out the sags and spikes that are all too common on the public utility grid and other primary sources of power
- *Providing ride-through power* as a temporary power replacement during sags or short-term outages (say, five minutes to an hour) by dynamically selecting and drawing power from the utility grid, batteries, backup generators, and other available sources

UPSs provide these services to meet the requirements of the power supply units in electronics as set forth by industry standards and specifications. However, there are differences in the degree of protection they provide and the way they provide it.

UPS designs for business and IT applications

Three different UPS topologies are commonly available today:

- **Standby UPSs** allow electronics to run off utility power until the UPS detects a problem, at which point the UPS switches to battery power to protect against sags, surges, or outages.
- **Line-interactive UPSs** regulate voltage by boosting input utility voltage up or moderating (bucking) it down as necessary before allowing it to pass to the protected equipment or resorting to battery power.
- **Double-conversion UPSs** isolate equipment from raw utility power—converting power from AC to DC and back to AC again—to deliver the cleanest power and highest protection.

Dell High-Efficiency Online UPSs offer the best of line-interactive and double-conversion topologies. These UPSs operate in high-efficiency mode unless power conditions warrant a switch to the higher protective level of double-conversion mode. As such, these UPSs provide exactly the level of power protection needed under the conditions of the moment.

With energy costs continuing to rise, the efficiency gains of this multi-mode strategy are notable. An organization with even a modest number of servers can significantly reduce energy bills without compromising data center performance or reliability.

Which UPS design is right for your application?

The way a manufacturer designs a product to these *topologies* can have a significant effect on overall power performance, equipment uptime, and total cost of ownership. This guide provides an objective view of four key criteria to consider when selecting the best UPS internal design for your requirements.

- Maintaining output voltage within tolerances
- Transferring among modes without affecting the protected equipment
- Delivering reliable, always-on power to protected equipment
- Reducing energy costs and carbon footprint

Maintain output voltage within tolerances

For most IT equipment such as servers, storage systems and network devices, UPS output voltage must remain within the acceptable zone specified by the Information Technology Industry Council (ITIC) curve under all input power conditions. The acceptable zone is a function of both voltage and duration—that is, how long the IT equipment can be expected to tolerate a variety of conditions.

The UPS must ensure that output voltage is not in the prohibited range above the acceptable zone, since that could damage the IT equipment. Voltages below the threshold could cause the power supply unit (PSU) to shut down or exhibit erratic behavior.

To manage high-frequency transients and intense spikes, such as from lightningalmost all system designs provide some surge suppression:

- **Most small standby and line-interactive systems** use some form of transient clamping device(s) that shunt excess energy to ground or self-destruct to absorb the hit.
- **Traditional double-conversion UPSs** convert incoming power from AC to DC and back to AC again to prevent such damaging input conditions from reaching your equipment.
- **Dell High-Efficiency Online UPSs** have sophisticated sensing circuitry to detect power problems before they can damage IT equipment. The UPS then applies its highest protection to the loads.

Whichever UPS design is used, Dell recommends the use of surge protection at the utility entrance to protect UPS input monitoring circuitry and to provide surge protection on the electrical circuits and equipment that do not have UPS protection.

To manage more moderate voltage conditions such as minor power sags or over-voltage UPS designs differ in their approach:

- A **standby UPS** can deliver output voltage within ITIC tolerances if input voltage is within about 10 percent of the ITIC curve. Since this is a relatively narrow window, the UPS resorts to batteries frequently which can reduce battery runtime and service life. Some standby systems accept voltages in a wider range before resorting to battery power, but IT equipment might operate less reliably under those conditions. Furthermore, most standby UPSs deliver output power that is not adequate for Dell IT systems.
- A **line-interactive UPS** can provide some voltage regulation and doesn't have to resort to batteries as often as a standby system although it may use some battery power to support the transition between normal mode and voltage regulation mode. Battery usage is lower than a standby UPS but still higher than a double-conversion topology.
- A **double-conversion UPS** provides output voltage within 1–3 percent of nominal, no matter what kind of input power it receives—without resorting to batteries as often or for as long as for standby and line-interactive designs. As a result, the double-conversion design has longer battery runtime and service life.
- **Dell High-Efficiency Online UPSs** combine the best of line-interactive and double-conversion approaches. Battery usage and duration is similar to the double-conversion UPS and in some instances may even be lower.

All these UPS designs meet ITIC-specified input voltage requirements one way or the other. They just differ on how often and for how long they have to put demands on the battery to do it.

Transfer among modes without affecting protected equipment

By industry standards, power supply units inside IT servers and storage devices are designed to store enough energy to maintain the device during an approximately 12 millisecond (ms) of power interruption. This is known as "hold-up" time. That means the device can withstand brief interruptions in power while a UPS transitions between modes of operation, such as from normal operating mode to battery and back again.

However, transfer time should actually be much faster than 12 ms, because the longer the PSU goes without power, the larger the in-rush current it will draw when it receives power again. In-rush could exceed the current handling capacity of the UPS and cause it to shut down.

- **Standby UPSs** switch to battery mode in 5–12 ms (8 ms typical). Most power supplies can tolerate this interruption. However, when transfer time is greater than 5 ms or output voltage drops too much, the in-rush current may exceed the capability of the UPS inverter and cause connected equipment to reset, resulting in data corruption or shut-down.
- **Line-interactive UPSs** typically switch to battery mode in 3–8 ms (5 ms average), within acceptable limits for most power supplies. Some PSUs could draw in-rush currents of more than 400 percent if the transfer time is longer than 5 ms; the UPS inverter could have problems supporting this high current requirement.
- **Double-conversion UPSs** begin drawing current from the battery with zero interruption in output power. Therefore there is no risk of the transfer disrupting IT systems or causing any in-rush.
- Like traditional double-conversion UPSs, **Dell High-Efficiency Online UPSs** switch to battery mode so instantly that IT equipment is not aware of any disruption and generates no out-of-tolerance inrush current.

Deliver reliable, always-on power to protected equipment

The availability of a UPS configuration depends on its resilience to component outages. The most resilient designs have multiple internal power paths with no single point of potential failure.

- A **standby UPS** typically has two internal power paths, but a single power switch serves them both. That means a failure in the power switch will cause the protected equipment to lose power.
- A **line-interactive UPS** has two power paths, but without a shared power interface. If the power interface fails, this UPS could still operate in battery mode—long enough to transfer to generator power (if available) or gracefully shut down connected equipment.
- **Dell Online and High-Efficiency Online UPSs** have two power paths—from utility/generator and battery sources—plus an electronic system bypass that is used to bypass failed components or to synchronize the system to a mechanical bypass system to perform planned maintenance. An automated maintenance bypass system ensures uninterrupted transfers during UPS servicing.

Of course, continuity of power also depends on the health and runtime of UPS batteries. UPS design dictates the frequency of battery usage for any given power grid condition which in turn affects battery runtime and service life. Battery drain is lowest in double-conversion and Dell's high-efficiency double-conversion designs.

In addition, Dell UPSs use multi-stage charging techniques that offer a battery rest period, significantly extending battery service life compared to conventional trickle or float charging methods. For most Dell UPS models, you can also:

- Provision external battery modules to extend runtime many times over.

- Selectively shut down non-essential loads to conserve battery runtime for the most critical applications.
- Locally and remotely monitor battery health and available runtime.

Reduce energy costs and carbon footprint

The more efficient the UPS, the less utility power you have to buy to run your business. And since most of the lost power is dissipated as heat, the more efficient the UPS, the less you pay in air conditioning or other cooling systems to remove that heat.

This is a particular concern for organizations that have data centers. When overall data center infrastructure efficiency (DCiE) is high, cooling costs might only equal 50 percent of spending on energy to power the IT equipment. When energy efficiency is poor, it could cost almost as much to cool the data center as it does to run the equipment—as much as 80 to 100 percent of the cost of powering the IT equipment, according to industry studies. So it's no surprise that organizations are taking a close look at the efficiency of their power protection systems.

Efficiency is profoundly influenced by UPS design or operating mode.

- **Single-conversion (*standby* and *line-interactive*) UPSs** are more energy-efficient than *double-conversion* UPSs, because there is no power conversion from AC to DC and then back to AC.
- **Dell High-Efficiency Online UPSs** achieve very high efficiency because they only use the less energy-efficient double-conversion mode when necessary and operate as an energy-saving system the rest of the time.

  This industry-leading multi-mode technology enables the UPS to operate at 98 percent efficiency or better under normal utility conditions, compared to 91 to 93 percent for a traditional double-conversion UPS.

Even small increases in UPS efficiency translate into real savings in utility bills. Higher UPS efficiency also provides more battery runtime for the same battery capacity and produces cooler operating conditions within the UPS environment, which in turn reduces cooling requirements and extends the service life of components.

Closing thoughts

In the past, the popular assumption was that for important applications where any unplanned downtime was unacceptable, the only choice was a UPS that operated solely in double-conversion mode. That type of UPS provided premium protection, but there was a trade-off. Continuous double-conversion processing—whether or not it was needed at the moment—made these UPSs less efficient than single-conversion designs.

Dell now offers viable and remarkably cost-effective new choices with UPSs that combine the best of single- and double-conversion topologies: exceptional efficiency *plus* the high protective level of double-conversion operation.

With a more efficient allocation of power, you not only reduce utility bills and total operating cost, but also achieve more with available backup power and cooling systems—delaying the point where those systems would have to be upgraded to support business expansion.

So, which UPS internal design is right for your organization? Where there once was only one "right" answer, Dell now offers effective choices specifically designed to deliver premium protection at minimum operating cost.