



W H I T E P A P E R



Tough Decision: On-Line or Line-Interactive UPS?

How to Choose the Right Protection for Your Network

Executive Summary

In today's data-driven, technology-dependent world, no organization – large or small – can afford the financial cost, customer frustration and business disruption caused by network downtime. That means complete protection against all potential power problems, including blackouts, brownouts, surges and line noise, is a must. The good news is there are plenty of options for protecting your network. But with so many different types of uninterruptible power supply (UPS) systems available, the challenge is selecting the one that best matches your needs and budget. For 120 V equipment loads up to 3,000 VA, on-line, double-conversion UPS systems and network-grade line-interactive UPS systems both offer high-performance protection. This document provides an in-depth comparison to help you determine which UPS type is the better choice for your application.

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Your critical IT equipment requires around-the-clock protection.

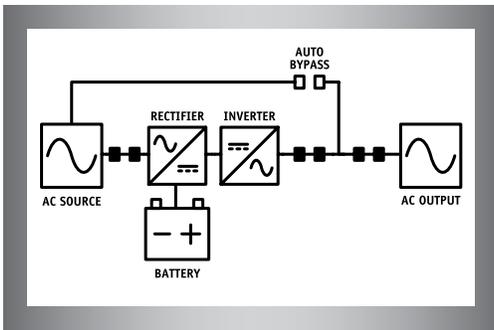
How Much Protection is Enough?

IT is the lifeblood of virtually any business in today's highly connected, data-centric environment. Whether you have a few server racks, a back-office network closet or a small data center, you're under constant pressure to keep your network up and running. And you're no doubt well aware just how vital the right UPS system is to protecting your equipment against damage, downtime and data loss.

UPS systems deliver varying levels of protection, ranging from basic battery backup and surge protection to on-line operation and zero transfer time to battery. Factors that influence your selection include:

- The amount of power your connected equipment requires
- The sensitivity of your equipment
- The length of backup runtime you need
- Whether you have whole-site generator backup
- The voltage of the equipment you're supporting
- How critical your application is
- Your available budget

Both line-interactive and on-line, double-conversion UPS systems provide excellent protection for 120 V equipment loads up to 3,000 VA. In addition to providing battery backup power, they automatically regulate high- and low-voltage conditions to ensure reliable operation without relying on their batteries. And both types are relatively simple to install, operate and maintain, even for a one-person IT department or an organization with no IT department at all. Although the UPS systems share many similarities, there are also key differences that are important to understand when deciding which type is most appropriate for your particular application. In some cases, you'll even find that an on-line UPS is the right choice for protecting some of your equipment and a line-interactive UPS is the right choice for protecting other equipment.



On-line UPS systems use continuous double conversion (AC to DC to AC) to supply consistently pure output regardless of input power conditions.



On-line UPS systems have an automatic AC bypass to keep equipment powered if there is an internal fault or overload.

What You Should Know about On-Line, Double-Conversion UPS Systems

On-line UPS systems provide the highest level of power protection for servers and other network equipment in data centers, server rooms and network closets.

How They Work

On-line UPS systems deliver power to connected equipment in a two-step process. First they convert incoming AC power to DC power, then they convert the DC power to conditioned AC power with a pure sine wave. As a result of this continuous double-conversion process, on-line UPS systems eliminate voltage irregularities, frequency variations, EMI/RFI line noise and other power problems. Regardless of the condition of incoming power, on-line UPS systems supply consistently pure power at output.

During an outage, on-line UPS systems convert stored DC battery power into AC power. In addition, they automatically bypass internal components and deliver power directly to connected equipment in the case of an internal fault or overload that exceeds the overload capacity of the UPS.

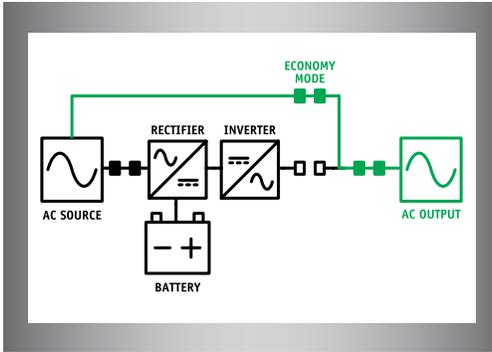


Extending runtime is as simple as plugging in an external battery pack.

The Biggest Benefits

On-line UPS systems provide top-quality protection for even your most mission-critical equipment. Here are several reasons why:

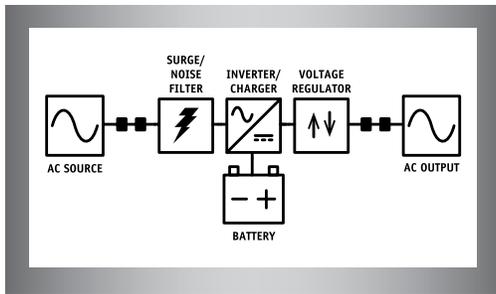
- **Isolation of sensitive equipment.** The continuous double-conversion process effectively isolates sensitive equipment from power problems.
- **Zero transfer time.** Since DC-to-AC power conversion is integrated into normal operation, there is zero transfer time (0 milliseconds) between the loss of AC input power and the supply of AC backup power converted from stored DC battery power. Zero transfer time ensures that there is no risk of losing or corrupting valuable data.
- **Nearly perfect voltage regulation.** On-line UPS systems set the standard for voltage regulation, continuously supplying output within $\pm 2\%$ of the nominal (ideal) voltage.
- **Battery-independent restart.** On-line models with this feature are able to pass through power after utility power is restored, even if the battery dies. This eliminates the need for manual restarts at remote sites in the middle of the night.
- **Intelligent operation.** Power management software enables remote monitoring and management of energy usage and detailed reporting on operating conditions, as well as the ability to reboot unresponsive equipment from anywhere, anytime.
- **Frequency regulation and conversion.** When utility power goes out and generator power kicks in, the frequency of the generator output can be erratic. The double-conversion process ensures that frequency is regulated to prevent equipment damage. Most on-line systems also support frequency conversion from 60 to 50 Hz and vice versa.
- **Extended runtime.** External battery packs increase battery backup runtime to last through lengthy power outages. Expandable battery packs support daisy-chaining to increase runtime to match any practical requirement.



Most on-line UPS systems have an “economy mode” option that increases efficiency, lowers operating costs and reduces heat output.

Things to Think About

On-line UPS systems clearly deliver high-performance protection. But it’s important to look at the big picture. Delivering these extra benefits through continuous double conversion requires extra energy, which reduces efficiency and raises operating costs. Heat output is also higher than other UPS options, an important consideration when including on-line models in a rack configuration, especially in a location with limited cooling capacity. However, most on-line systems do have an “economy mode” option that increases efficiency and reduces heat output by suspending the double-conversion process while the power source remains reliable.



Line-interactive UPS systems use a built-in voltage regulator (transformer) to correct voltage problems without switching to battery.

What You Should Know about Network-Grade Line-Interactive UPS Systems

Network-grade* line-interactive UPS systems also protect servers and other network equipment in data centers, server rooms and network closets. Although they don't isolate equipment from power problems to the degree of their on-line counterparts, they still deliver excellent protection against blackouts, brownouts, surges and line noise. And they typically have lower acquisition and operating costs than on-line UPS systems.

How They Work

Line-interactive UPS systems work quite differently than on-line UPS systems. Line-interactive models include a surge/noise filter, a battery, an inverter/charger and a voltage regulator.

Under normal power conditions, line-interactive UPS systems pass input power through the surge/noise filter and voltage regulator to the connected equipment, while the inverter/charger charges the battery for emergency use during an outage (blackout).

If voltage fluctuates to abnormally low levels (called a power sag or brownout) or abnormally high levels (called an overvoltage), line-interactive UPS systems use the built-in voltage regulator to increase or decrease the output voltage to acceptable levels. This feature is also known as automatic voltage regulation (AVR). As long as the input voltage is within the AVR correction range, line-interactive UPS systems regulate the output voltage without using battery power. This is an advantage because frequent switching to battery drains the reserve power intended for an outage and causes wear and tear that reduces the battery's useful lifespan.

During an outage, the line-interactive UPS converts the stored DC (battery) power into regulated AC output power to support the connected equipment load. Network-grade models provide sine-wave output from battery.

* Line-interactive models intended for desktop applications are usually not recommended for network applications. Desktop models typically do not offer rack installation and sine wave output, nor the same degree of voltage regulation, manageability, serviceability, expandability, availability and resilience as network-grade line-interactive models.



Power management software helps you remotely monitor energy usage and operating conditions, as well as reboot unresponsive equipment.

The Biggest Benefits

Network-grade line-interactive UPS systems provide highly reliable protection to your network and connected equipment. Benefits include:

- **Extremely fast transfer time.** Because the inverter is not active during normal operation, there's a tiny delay – typically 2 to 4 milliseconds – during the transfer from AC power to battery backup power. The delay is barely detectable, however, and it is rare for it to cause issues with connected equipment.
- **Excellent voltage regulation.** Network-grade line-interactive UPS systems typically regulate voltage within +6% to -14% of normal voltage, which is more than acceptable for almost all equipment.
- **Intelligent operation.** Like on-line UPS systems, line-interactive models support power management software to help you remotely monitor energy usage and detailed operating conditions, as well as reboot unresponsive equipment from anywhere, anytime.
- **Extended runtime.** External battery packs increase battery backup runtime to last through lengthy power outages. Expandable battery packs support daisy-chaining to increase runtime to match any practical requirement. (Not all line-interactive UPS models support extended runtime, so confirm availability in the specifications if you need this feature.)
- **Operating efficiency.** Line mode efficiency is as high as 99%, reducing energy costs and heat output.



Network-grade line-interactive UPS systems provide excellent power protection, typically at lower cost than on-line models.

Things to Think About

Although network-grade line-interactive UPS systems are comparable in many ways to on-line models, they also have some key differences:

- First, the output voltage regulation is less precise than on-line model, although still compatible with almost all servers and network equipment.
- Second, the transfer time is excellent, but it is a notch below the standard set by on-line models.
- Third, most line-interactive UPS systems do not have an automatic bypass, so equipment will not remain powered in case of an internal fault or overload. In practice, however, the inherent reliability of the line-interactive architecture makes this feature somewhat less important.
- Last but not least, line-interactive models do not have battery-independent restart capability, meaning someone may need to manually restart the UPS when utility power is restored after an outage that exceeds the runtime.

On the plus side, line-interactive UPS systems are very cost-effective, requiring less investment in capital and operating costs than their on-line counterparts. And because they produce less heat than on-line models, they are well-suited for installations with limited cooling capacity.

What Do the Similarities and Differences Mean for Your Application?

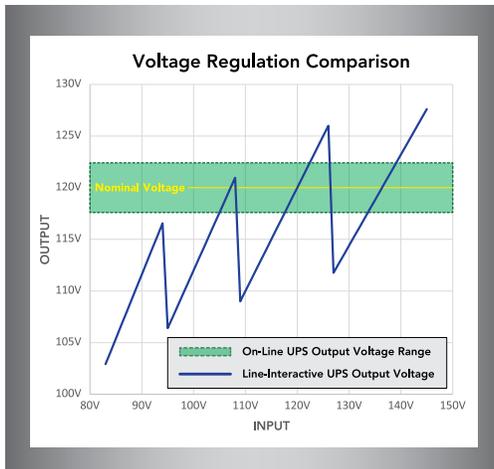
So now what? As this review indicates, high-performing on-line and line-interactive UPS systems share many similar characteristics but also feature some key differences and performance trade-offs.

In general, on-line, double-conversion UPS systems are recommended for:

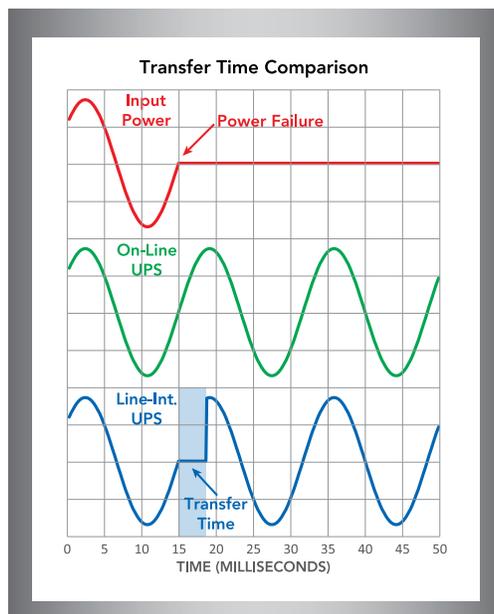
- All critical, high-availability network applications
- Sensitive equipment that requires zero transfer time
- Locations with frequent and/or severe voltage problems
- Locations (especially industrial sites) with exceptionally noisy power
- Locations with generator backup that requires frequency regulation
- Applications with frequency conversion needs

In general, network-grade line-interactive UPS systems are recommended for:

- Basic and price-sensitive network applications
- Applications requiring enhanced efficiency
- Applications requiring reduced heat output
- Locations with relatively good on-site power
- Locations with whole-site generator backup



A line-interactive UPS typically regulates output within +6 to -14% of the nominal voltage, while an on-line UPS system typically regulates within $\pm 2\%$. In practice, both types provide voltages well within the tolerances of most equipment.



Because of its continuous double-conversion process, an on-line UPS system has zero transfer time between a power failure and the delivery of battery backup power. The transfer time of a line-interactive UPS system is extremely fast (2 to 4 milliseconds) and does not pose a problem for most applications.



Network-Grade Line-Interactive UPS
SMART1500RMXL2UA

Sample UPS System Comparison: Line-Interactive vs. On-Line



On-Line, Double-Conversion UPS
SU1500RTXLCD2U

Two high-performance
UPS systems with many similarities...

| | | |
|----------------------------|---|----------------------------|
| 120 V, 1,500 VA (1,350 W) | Voltage, Capacity | 120 V, 1,500 VA (1,350 W) |
| Pure Sine Wave | Output Waveform | Pure Sine Wave |
| Yes | External Battery Pack Options | Yes |
| Advanced LCD | Front Panel Display | Advanced LCD and LEDs |
| Yes (SNMPWEBCARD) | Network Management Card Option | Yes (SNMPWEBCARD) |
| USB, Serial (DB9), EPO | Built-in Communications Ports | USB, Serial (DB9), EPO |
| 2U / 46.5 lb | Rack Size / Weight | 2U / 45.2 lb |
| 5.9 minutes | Backup Runtime at 1,200 W (Internal Batteries Only) | 5.3 minutes |
| 33.8 min. (+1 BP36V27-2US) | Backup Runtime at 1,200 W (with External Battery Pack) | 44.7 min. (+1 BP48V27-2US) |
| Yes | Hot-Swappable Batteries | Yes |
| Add Hot-Swap PDU (PDUB15) | Maintenance Bypass Option | Add Hot-Swap PDU (PDUB15) |

...some notable differences...

| | | |
|----------------------------------|--|---|
| 2-4 milliseconds (Typical) | Transfer Time from AC to Battery Mode | Zero Transfer Time (On-Line Mode) |
| +6% / -14% (Worst-Case Scenario) | Output Voltage Regulation | ±2% (On-Line Mode), ±10% (Economy Mode) |
| No | Frequency Regulation | 50/60 Hz ±0.05 Hz in Regulation Mode |
| No | Frequency Conversion | Support for 60-to-50 Hz and 50-to-60 Hz |
| No | Automatic Internal Bypass | Yes |
| No | Battery-Independent Startup | Yes |
| 13.5 inches | Cabinet Depth | 18.5 inches |

...and cost and efficiency trade-offs...

| | | |
|-------------|--|---|
| \$55.19 | Annual UPS Energy Cost (1,200 W Load, \$0.10 per kWh) | \$116.51 (On-Line Mode), \$67.45 (Economy Mode) |
| 95% | UPS Line-Mode Efficiency | 90% (On-Line Mode), 94% (Economy Mode) |
| 237 BTU/hr. | Heat Output (1,200 W Load) | 455 BTU/hr. (On-Line Mode), 292 BTU/hr. (Economy Mode) |
| 0.7 | Estimated Acquisition Cost Factor | 1.0 |

Recommended for:

- Basic and price-sensitive network applications
 - Applications requiring enhanced efficiency
 - Applications requiring reduced heat output
 - Locations with relatively good on-site power
 - Locations with whole-site generator backup

...to consider when making the best
UPS choice for your application.

Recommended for:

- Critical, high-availability network applications
- Equipment that requires zero transfer time
- Sites with frequent/severe voltage problems
- Sites (like industrial sites) with very noisy power
- Generators that require frequency regulation
- Applications requiring frequency conversion

The Tipping Point

Ultimately, selecting the best option for your organization depends on your specific needs, risk tolerance and budget. The good news is that both on-line, double-conversion and network-grade line-interactive UPS systems deliver such high performance and high-quality power protection that you won't go wrong no matter which option you choose. If you would like additional advice and assistance, contact Tripp Lite UPS Application Support at 773.869.1236 or upsapplications@tripplite.com.

About Tripp Lite

Customers in the IT, telecom, industrial, commercial, corporate, healthcare, government and education sectors choose Tripp Lite for complete solutions to power, protect, connect and manage servers, network hardware and other equipment in data centers and related facilities. Tripp Lite makes more than 3,000 products, including UPS systems, battery packs, PDUs, rack enclosures, cooling solutions, surge protectors, KVM switches, cables, power strips and inverters. For more information about Tripp Lite's full line of data center solutions, visit www.tripplite.com.



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