MEET PROFESSOR WATTSON -
YOUR GO-TO GUY FOR POWER QUALITY BASICS

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Introduction


From plug and receptacle charts and facts about power problems to an overview of various UPS topologies and factors affecting battery life, you’ll find a wealth of pertinent resources designed to help you develop the optimum solution.

This handbook is your one-stop source for essential information ... whether you need power protection for small, medium or large data centers; health care facilities; or other environments in which ensuring uptime and safeguarding data are critical.

Why a UPS?

In general, a UPS protects IT equipment and other electrical loads from problems that plague our electrical supply, performing the following three basic functions:

1. Preventing hardware damage typically caused by surges and spikes. Many UPS models continually condition incoming power as well.
2. Preventing data loss and corruption. Without a UPS, devices that are subjected to a hard system shutdown can lose data completely or have it corrupted. In conjunction with power management software, a UPS can facilitate a graceful system shutdown.
3. Providing availability for networks and other applications while preventing downtime. In some cases, they provide enough battery runtime to ride through brief outages; in other cases, they provide hours of runtime to ride through extended power outages. UPSs are also paired with generators to provide enough time for them to power up.

Thanks to Eaton, IT pros are spending fewer nights and weekends at work, leaving their desk toys at the office all alone.

NOW I SPEND MY TIME FOCUSING ON WORLD DOMINATION.

WILL YOU ADOPT US?
WE’RE A SOLID TEAM.
When it comes to backup power, here are some basic questions to ask yourself.

Applications
1. How often do you refresh and maintain your IT hardware (including servers)? What about your UPS equipment?
2. If you have a converged data-voice network, have you protected all critical switches?
3. If you have virtualized your servers, have you considered the impact on your UPS equipment?
4. What would happen if the power went out at your facility right now?
5. Have you thought about the impact of damaged or corrupted data?
6. How much energy do your UPS units consume? How efficient are they?

UPS-specific
1. What size UPS do you need? (kVA or amperage)
2. What voltage is currently available at your site?
3. What voltage do you need?
4. What runtime do you want?
5. Are there any clearances or size constraints?
6. Do you have bypass requirements?
7. What types of input and output connections are required?
8. Is there a generator on site?
9. Does the UPS need to be scalable?
10. Do you need redundancy?

Accessories
1. How is power getting from the UPS to your equipment?
2. Do you have a need for enclosures, communications, seismic mounting, floor stands or rail kits?
3. Is a maintenance bypass switch needed?
4. Are unorganized cables hindering your efficiency or coming a safety concern?

Software
1. Is there a need to have orderly scheduled shutdowns?
2. Do you want to remotely monitor the UPS?
3. Would you like to remotely notify others of UPS events?
4. How will your UPS software manage virtual servers during an extended power outage?
5. Does your power management software integrate easily with your virtualization platforms?

Service
1. Do you need immediate factory response?
2. What kind of parts and labor coverage do you need?
3. Do you want any type of preventive maintenance?
4. When’s the last time you checked the batteries in your existing UPS units?
Top UPS design considerations

The following factors outline the key design considerations to take into account when analyzing your needs.

1. **Power environment: single- and three-phase**
   Understanding your existing power infrastructure is a crucial step in the qualification and sales process. While you may focus on larger, three-phase power systems, the majority of IT managers are dealing primarily with single-phase equipment, often at the rack level.
   Many existing computer rooms and small to mid-sized data centers have single-phase loads at the rack level. Ground-up designs are increasingly moving three-phase power to the point of utilization to gain efficiencies and reduce costs, creating great opportunity for three-phase solutions in new construction.

2. **Installation environment**
   It’s imperative to understand how a prospective UPS will be deployed. Since most environments support several different solutions, you may need to evaluate these options.

3. **Power load**
   The VA or watt rating of your power loads is one of the most important factors in identifying the right UPS. After identifying the power environment (if the UPS needs to be single- or three-phase), the size of the UPS further narrows the selection. In single-phase deployments especially, it often makes sense to select a UPS that exceeds current power requirements but offers greater runtimes and allows for future growth.

4. **Availability and battery runtime**
   This is where you need to determine your true runtime requirements. While runtime may seem like a simple thing to quantify, understanding the facts behind the numbers help contribute to the development of end-to-end solutions.
   Generally, the amount of runtime required can significantly affect the solution cost, but many Eaton solutions are actually more cost-effective in extended runtime applications.

   There are four basic battery runtime configurations:
   1. UPS with 10 to 15 minutes of runtime and no generator. You are covered for 90 to 95 percent of power outages. You can either use UPS shutdown clients to save your data or stay online as long as possible before the system crashes.
   2. UPS with 10 to 15 minutes of runtime and a generator. You have a very reliable setup and most generators will startup within one minute (five minutes maximum). You are covered for most situations.
   3. Redundant UPSs, generator and two power feeds for dual-corded servers. You have a lot of money and/or are really worried about the power failing. It’s time to get a consultative person on-site to help you figure it out.
   4. UPS with two or more hours of battery runtime. In some cases, generators may not be practical and you must rely entirely upon batteries.

---

MY IT PRO SAYS EATON HELPS HIM TRIM THE FAT. FRANKLY, I’M A LITTLE WORRIED.
5. Form factor
How much space are you willing to designate to your UPS? Where do you plan to install it? Answering these questions will help you determine whether your environment is better suited for a tower or rackmount model. Some UPSs have a 2-in-1 form factor, allowing you to deploy the unit either way.

6. Scalability
It’s always important to consider your future expansion needs when evaluating solutions. Eaton’s scalable UPS solutions provide a competitive advantage by offering a cost-effective way to increase capacity. Virtually all Eaton UPSs with a 6 kVA or greater power rating offer some form of scalability, either through a simple firmware upgrade, the addition of modular hardware components or the paralleling of multiple UPSs. For cost-conscious or budget-constrained customers, a UPS with inherent scalability often proves to be the best value in the long run, allowing you to increase capacity without purchasing additional hardware. A simple kVA upgrade is all that’s needed to enable a UPS with inherent scalability to operate at full capacity.

You may want to service the UPS yourself. If that’s the case, look for a unit that allows you to add capacity with power and/or battery modules.

While modular solutions—including multiple, paralleled systems—are often a more affordable option initially, they can be a more expensive solution over the long term due to added hardware and installation costs. Depending on your needs, a larger, centralized, non-modular system with inherent scalability might ultimately be the most cost-effective solution.

7. Power distribution
It is important for you to consider how power will be delivered to your critical equipment. In some cases, you may simply plug loads directly into the UPS. In others, you may need large PDUs to distribute power. You may also incorporate rack-based power strips or ePDU units into your design.

8. Manageability
While a UPS protects the attached load during a power outage, power management software is required to ensure that all work-in-progress is saved and that sensitive electronic equipment is gracefully shut down if the power outage exceeds the battery runtime of the UPS. Without software, the UPS simply runs until its batteries are depleted and then drops the load. In addition to this basic functionality of UPS software, you should consider the following monitoring and manageability capabilities:
- Power event notifications, including emails, pop-up alerts and text messages to pre-designated recipients
- Logging of power events
- Advanced capabilities in virtual environments, including integration into VMware’s ESXi and vSphere and Microsoft’s Hyper-V
- Dedicated battery monitoring and advanced service notifications
- Remote monitoring by service personnel from the UPS manufacturer.

9. Operation and maintenance
While you may value the ability to service your own equipment, the vast majority of IT and facility management professionals prefer the peace of mind that comes with full factory support through on-site service or an advanced UPS exchange agreement. To make an informed decision on service support, you must accurately assess your own technical and service capabilities. Consider UPS and battery safety as there is inherent danger when maintaining them. The more complicated the equipment, the more important it is to have experts perform the maintenance.

10. Budget
Although the latest performance features of a UPS may fit nicely with what you are looking for, budget constraints may force you to make trade-off decisions. Be prepared to prioritize your needs for redundancy, scalability, efficiency, software management, modularity and serviceability.
The following design guidelines should be reviewed and followed prior to ordering the appropriate UPS solution.

1. Check to see if there’s an adequate electrical supply near the UPS.
   Compare UPS fuse ratings (amps) and breaker types and whether any electrical work may be needed (i.e., cabling to the UPS terminal block input).

2. Find out the dimensions of the UPS and include any battery cabinets.
   Make sure your installation site has enough space available.

3. Ensure the UPS can be placed in its final position.
   Will the UPS components fit through doors? Are there any stairs? Do you have existing racks that the UPS must fit into? Please consult Eaton’s website for detailed UPS dimensions and specifications: powerquality.eaton.com.

4. Verify that the floor is strong enough to support the UPS and battery cabinets.
   The UPS and its battery cabinets can be heavy, so make sure the site has the proper floor loading capacity.

5. Confirm that the UPS will have adequate ventilation.
   Eaton UPS models use internal fans to cool them. You shouldn’t install the UPS in a sealed container or small, sealed room.

6. Always be sure which wall receptacle is required to plug in the UPS.
   Only UPSs with power ratings up to 1500 VA plug into a standard 15-amp wall outlet. All others require a larger receptacle, which must be installed by an electrician. Things go more smoothly if you aren’t waiting for this to be done after all of the equipment has arrived. Most small and rackmounted computers run on normal 120 volt, 15-amp electrical service. Some computers have power cords that require a higher voltage of 208V or 240V, in which case you’ll need a 3000 VA or larger UPS.

   Hardwired outputs are generally useful if you want the UPS output to be distributed via electrical panels. Using an electrical distribution panel allows for flexibility with receptacles types. If there’s no other UPS that fits your receptacle and power requirements, you may need to hardwire it. Hardwired UPS models typically require the use of a certified electrician to wire them to the electrical distribution panel, which could be a more costly option.

8. Installing small UPS models behind larger UPS models.
   If you’re installing a smaller UPS behind a larger UPS, you must consider the total potential power of the smaller UPS as well as other loads that will be powered by the larger UPS. For example, if you’re plugging a 1500 VA UPS into a 10,000 VA UPS, you must consider the load of the smaller UPS rather than just the load that’s plugged into it. In addition, the larger UPS must be at least five times larger than the smaller UPS. This design guideline must be followed due to charging capacity that may be required by the smaller UPS; any anomalies associated with the building power, and to avoid overheating or potential over loading of the larger UPS which may result in failure of the all UPS models in the string.

9. Using a UPS and a generator together.
   A UPS provides backup power and actively conditions and regulates voltage. Similarly, an auxiliary generator provides backup power, but typically takes 10-15 seconds to start up, depending on its type. For long-term backup servers and IT equipment, this isn’t an optimal situation, so during that downtime the UPS kicks in. Basically, the UPS bridges the power gap between loss of power and generator coming online.
   When choosing your UPS solution, it’s important to keep power ratings in mind; you cannot size a generator in a 1:1 match to the UPS and expect successful results. There are two reasons for this: first, UPSs aren’t 100 percent efficient and second, generators need to account for step loads. In addition, very small generators don’t often provide enough kinetic energy to provide a smooth transition. As a rule of thumb, for 20 kVA and above, auxiliary generators should be sized 1.5 times the size of the output rating of the UPS in kW, while for 20 kVA and below, they should be two times larger. It’s also important to note that gas-powered generators should be sized a bit larger.

    Verify that the final UPS solution meets local building codes.
# How to size a UPS

You have decided that you need a UPS. What’s next? Well, you have to pick the right one!

**Alternative #1:**
Visit Eaton.com/UPSselector

**Alternative #2:**
Call our knowledgeable inside sales team: 800.356.5794

**Alternative #3:**
Do it the old fashioned way. Completing these steps is also very useful for the first two alternatives.

1. List all equipment to be protected by the UPS. (Remember to include monitors, external hard drives, routers, etc.)
2. List the amps and volts for each device. These ratings can typically be found on the label on the back of the equipment. Multiply amps by volts to determine VoltAmps (VA). Some devices may list their power requirements in watts. To convert watts to VA, divide the watts by power factor. For servers, the power factor is often 0.9.
3. Multiply the VA by the number of pieces of equipment to get the VA subtotals.
4. Add the VA subtotals together.
5. Multiply the total by 1.2 to get the grand total. This step accounts for future expansion.
6. Use the grand total to select a UPS. When choosing a UPS, be sure that the total VA requirement of supported equipment does not exceed the VA rating of the UPS.

**Alternative #4:**
Eaton’s UPS Tool for iPhone®, iPad® and iPod touch helps you find the best UPS solution without being tied to your desk: www.powerquality.eaton.com/upstools

## UPS sizing worksheet

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<tr>
<th>Equipment</th>
<th>1</th>
<th>2</th>
<th>2</th>
<th>2</th>
<th>3</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amps</td>
<td>x</td>
<td>Volts</td>
<td>x</td>
<td>VA</td>
<td>x</td>
<td>Quantity</td>
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</table>

4 Total

5 x1.2

6 Grand Total

---

I CHAT WITH THE INSIDE SALES TEAM ALL THE TIME. THEY’RE COOL.
You’ve narrowed down your UPS choices to two or three models. Now what? How can you make sure that you’re making an apples-to-apples comparison? Are you considering all aspects related to total cost of ownership (TCO)? We’ve created this quick checklist so you can ask yourself the right questions for network closet and server room applications.

### Head-to-head UPS comparison for network closet and server room applications

<table>
<thead>
<tr>
<th>Factor</th>
<th>UPS 1</th>
<th>UPS 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Voltage</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Be sure the input and output voltages are the same. For example, a 208V UPS will cost more than a standard 120V UPS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Power rating</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UPSs are typically rated in volt-amperes (VA) and watts. Watts measures real power and is the key rating. For example a UPS rated at 1000 VA / 900 watts provides one third more power than one rated at 1000 VA / 600 watts.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Input plug</strong></td>
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<td></td>
</tr>
<tr>
<td>Do both UPSs have the same input plug? Does it match your wall socket? UPSs 1500 VA and below plug right into a standard wall socket. Larger models may require you to hire an electrician to install a new wall socket.</td>
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<td></td>
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<tr>
<td><strong>Output receptacles</strong></td>
<td></td>
<td></td>
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<tr>
<td>Does each UPS have the same quantity of output receptacles? The same type? Be sure the UPS has enough output receptacles and that they'll accommodate the power cords of your servers, etc.</td>
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<td></td>
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<tr>
<td><strong>Warranty</strong></td>
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<tr>
<td>Are the warranties the same duration? How long does the warranty cover the batteries?</td>
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<td></td>
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<tr>
<td><strong>User interface</strong></td>
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<tr>
<td>Do both UPSs utilize the same interface? Do both have an intuitive LCD or basic LEDs?</td>
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<tr>
<td><strong>Network card</strong></td>
<td></td>
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<tr>
<td>If you need/want a network card, does the UPS price include one? Some UPSs include a card while others do not and this can impact the price.</td>
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<td></td>
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<tr>
<td><strong>Software</strong></td>
<td></td>
<td></td>
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<tr>
<td>Do both UPSs have equivalent software capabilities? For example, if integration into VMware vCenter is a priority, be sure the UPS software can do it.</td>
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<tr>
<td><strong>Mounting hardware</strong></td>
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<tr>
<td>Do you plan to mount the UPS in a rack enclosure or 2-post rack? If the mounting is not included with the UPS, you’ll likely need to purchase hardware separately.</td>
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<td></td>
</tr>
<tr>
<td><strong>Rack height</strong></td>
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<tr>
<td>If you are evaluating rack mount UPSs, are they the same rack height (U)? For example, going with a 1U UPS over a 2U model may allow you to fit another server in your rack.</td>
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<tr>
<td><strong>Maintenance bypass</strong></td>
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<tr>
<td>Have you considered the price of a maintenance bypass module that will allow you to keep your IT equipment up and running if you ever need to replace the UPS or if the UPS fails?</td>
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<tr>
<td><strong>Batteries</strong></td>
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<tr>
<td>Have you considered the cost of additional battery packs? The cost of replacing the batteries in the UPS?</td>
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Professor Wattson has lessons on demystifying sizing, ratings, maintenance bypass and network-class UPSs on Switchon.eaton.com/power101
## UPS cost justification worksheet

This worksheet helps you determine the estimated dollar savings that a UPS can deliver. Simply fill in the information to calculate the costs of one hour of downtime. Actual dollar amounts will vary from company to company, location to location, and industry to industry.

1. **Number of critical loads:**  
   *Critical loads* = any equipment running or supporting your applications (servers, routers, PCs, network devices, etc.)

2. **Number of employees using critical loads:**

3. **Employees’ average hourly earnings:**

4. **Estimated cost of lost business per hour of downtime**  
   ($7,000, $5,000, $10,000,...)

5. **Cost of service calls per hour:**

6. **Cost of recreating or salvaging data (if applicable):**

7. **Cost of replacing hardware (if applicable):**

8. **Cost of reinstalling software (if applicable):**

9. **Lost employee time (line 2 x 3):**

10. **Lost business (line 4):**

11. **Service (line 5):**

12. **Recreating or salvaging data (line 6):**

13. **Replaced hardware and software (line 7 + 8):**

14. **Estimated total cost per hour of downtime:** $_____

---

This is only one hour. Imagine if your systems were down all day!
With applications spanning from desktops to large data centers, UPSs come in a variety of form factors.

1. **Desktop and tower UPS**
   a. The Eaton 3S UPS also fits easily on top of or under a desk.
   b. The Eaton 9130 tower UPS fits under a desk or in a network closet.

2. **Wall-mount UPS**
The Eaton 5P rackmount UPS includes hardware to mount it to a wall.

3. **Rackmount UPS**
The Eaton 9130 rackmount UPS occupies only 2U of rack space (fits both 2- and 4-post racks).

4. **Two-in-one rackmount/tower UPS**
The Eaton 5PX UPS can be mounted in a rack or installed as a tower model.

5. **Scalable UPS**
   a. The Eaton BladeUPS is a scalable, redundant rackmount UPS.
   b. The Eaton 9170+ is also a scalable, redundant UPS.
   c. The Eaton 93PM is a vertical or horizontal scalable white or grey space solution.

6. **Large tower UPS**
The Eaton Power Xpert™ 9395 UPS is designed to be a central backup for multiple loads, including data centers.

---

A SOLUTION FOR ANY SITUATION. I COULDN’T HAVE DESIGNED IT BETTER.
When you receive a UPS, you should be able to plug it in right away. If a UPS can’t be plugged into the wall socket, or their equipment can’t be plugged into it, you’ve got a problem.

Any UPS with a rating of 1500 VA or below can be plugged into a standard household receptacle/socket. UPS models with ratings higher than 1500 VA use input plugs that can’t be plugged directly into a standard receptacle. Many higher rated UPSs (above 1500 VA) may also be hardwired directly into the electrical distribution panel at the installation location by a licensed electrician.

Many UPS models offer a fixed set of input and output receptacles. Other UPS models can be configured with a custom set of input and output connections.

For reference we’ve included the following chart to help you visually confirm input and output plug/receptacle options:

### Input plug and output receptacle chart

<table>
<thead>
<tr>
<th>Input Plug</th>
<th>Output Receptacle</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-15R</td>
<td>S-15P</td>
</tr>
<tr>
<td>L5-30R</td>
<td>L5-30P</td>
</tr>
<tr>
<td>L6-20R</td>
<td>L6-20P</td>
</tr>
<tr>
<td>IEC-320-C13 (female)</td>
<td>IEC-320-C14 (male)</td>
</tr>
<tr>
<td>L14-30R</td>
<td>L14-30P</td>
</tr>
<tr>
<td>L6-30R</td>
<td>L6-30P</td>
</tr>
<tr>
<td>Terminal Block (Hardwired)</td>
<td></td>
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</tbody>
</table>

Know your North American receptacles

In North American markets, most facilities utilize plugs and receptacles conforming to standards established by the National Electrical Manufacturer’s Association (NEMA), which uses a smart code to define what each part number represents. If you know the part number of your connector, you can find its voltage and amperage ratings. Always check with your local electrician to verify proper wiring and installation.

### How big can I go?

<table>
<thead>
<tr>
<th>Value</th>
<th>Max Voltage</th>
<th>Wires in connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>125V</td>
<td>L1, N, G</td>
</tr>
<tr>
<td>6</td>
<td>250V</td>
<td>L1, L2, G</td>
</tr>
<tr>
<td>14</td>
<td>125/250V</td>
<td>L1, L2, N, G</td>
</tr>
<tr>
<td>16</td>
<td>250V</td>
<td>L1, L2, L3, G</td>
</tr>
<tr>
<td>21</td>
<td>250V/125V</td>
<td>L1, L2, L3, N, G</td>
</tr>
</tbody>
</table>

*5-15P can plug into 5-20R
R = Receptacle, P = Plug, L = Locking
For the number before the hyphen:
5 = 125V, two-pole, three-wire (grounded)
6 = 250V, two-pole, three-wire (grounded)
14 = 125/250V, three-pole, four-wire (grounded)
The number after the hyphen indicates the amperage. For example, the L5-30R is a 30A receptacle.
A common question from IT managers is, “I have a receptacle at my facility; what is the biggest UPS can I connect to it?” If you’re looking at UPSs 6 kVA or lower, it’s a pretty straightforward question to answer as shown below:

**Local outlet**  | **Typical largest UPS rating per outlet**
--- | ---
5-15R | 1500VA 120V
5-20R | 2200VA 120V
L5-30R | 3000VA 120V
L6-20R | 3000VA 208V
L6-30R | 6000VA 208V
IEC C13 | 2200VA 230V
IEC C19 | 3000VA 230V

1. **Fixed**
   Smaller UPS models like the Eaton 9130 UPS provide a fixed set of output receptacles.

2. **Customized**
   UPS models like the Eaton 9355 can be customized with a variety of output receptacles.

3. **Hardwired**
   Large UPS models like the Eaton 93PM are hardwired to incoming utility power though some models leverage output receptacles.

4. **Additional receptacles**
   Eaton ePDU products mount easily into racks and provide additional receptacles.

---

**IEC C13**

**IEC C19**

**5-15R**

**5-20R**

**L5-30R**

**L6-20R**

**L6-30R**

**IEC C13**

**IEC C19**

---

120V

208-240V
UPS startup

Self-startup

UPSs equipped with a standard input plug (units 1500 VA and below) that fits into standard wall sockets are very easy to install. Units 2000 VA and above require a different wall socket that may not already exist in the location where the UPS will be installed. In these cases, an electrician can install the proper wall socket, after which you should have little problem with UPS installation.

Assisted startup

You may not feel comfortable installing electrical equipment—justifiably so. UPS installation deals with electrical power and batteries—both of which can be dangerous if not handled properly. In addition, UPS batteries can be very heavy and some units require a hardwired connection. As a result, UPS manufacturers usually offer a startup service for an additional fee. You can also hire a systems integrator, electrician or third-party service organization for UPS installation.

Manufacturer-required startup

Many three-phase UPS models (typically >40 kVA) must be started up by the UPS manufacturer to ensure they’re properly installed and calibrated. In general, electricians and contractors don’t have the required in-depth knowledge of the UPS. Manufacturer-trained field technicians provide an overview of the equipment and a tutorial of how to operate the UPS.
The engineering answer: To correctly size a UPS, it’s important to understand the relationship between watts and VA. However, we must first have a brief discussion about power terminology. Real power (measured in watts) is the portion of power flow that results in the consumption of energy. The energy consumed is related to the resistance in an electrical circuit. An example of consumed energy is the filament in a light bulb.

Reactive power (measured in VAR or volt-amperes reactive) is the portion of power flow due to stored energy. Stored energy is related to the presence of inductance and/or capacitance in an electrical circuit. An example of stored energy is a charged flash bulb in a camera.

Apparent power (measured in VA or volt-amps) is a mathematical combination of real power and reactive power.

The geometric relationship between apparent power, reactive power and real power is illustrated in the power triangle below:

Mathematically, real power (watts) is related to apparent power (VA) using a numerical ratio referred to as the power factor (PF), which is expressed in decimal format and always carries a value between 0 and 1.0. For many newer types of IT equipment, such as computer servers, the typical PF is 0.9 or greater. For legacy personal computers (PCs), this value can be 0.60 – 0.75.

Using one of the following formulas, a calculation can be made to determine the missing quantity:

\[ \text{Watts} = \text{VA} \times \text{Power Factor} \]
\[ \text{VA} = \frac{\text{Watts}}{\text{Power Factor}} \]

Since many types of equipment are rated in watts, it’s important to consider the PF when sizing a UPS. If you don’t take PF into account, you may under size your UPS. As an example, a piece of equipment that’s rated at 525 watts and has a power factor of 0.7 results in a 750 VA load.

\[ 750 \text{ VA} = 525 \text{ Watts} / 0.7 \text{ PF} \]

Sizing the UPS to operate at 75 percent capacity results in a UPS with a 1000 VA rating (750 VA / 0.75 = 1000 VA).

The answer for the rest of us:

Converting amps to VA

Single phase: Multiply amps by voltage (120 volts in the U.S.). \( 10A \times 120V = 1200 \text{ VA} \).

Three phase: Amps x volts x 1.732 = VA.
Decentralized or central UPS?

Is a single, larger UPS better, or is it best to have multiple, smaller UPSs? Naturally, the answer is that it depends on a number of factors. In a decentralized (also known as distributed) UPS configuration (see Figure 2), multiple UPSs support a handful of devices or perhaps only a single piece of equipment. Decentralized UPSs typically use plug and play connections and are usually less than or equal to six kVA. In a central UPS configuration (see Figure 1), a larger UPS supports multiple devices. A centralized UPS is typically hardwired into an electrical panelboard. The following tables include a number of factors to consider when making a decision between a decentralized and central UPS. In the end it’s often best to simply go with the strategy that you are comfortable with.

### Central UPS

<table>
<thead>
<tr>
<th>Why you’d choose a central UPS solution</th>
<th>Why you wouldn’t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typically, the sales and service life of the UPS is longer.</td>
<td>A single UPS can mean single point of failure. You can overcome this concern with an N+1 or N+X UPS for redundancy.</td>
</tr>
<tr>
<td>A single UPS is easier to monitor, service and maintain than lots of smaller UPSs.</td>
<td>The single UPS may not be close physically to the equipment it will protect. A single electrical distribution panel may not feed all equipment.</td>
</tr>
<tr>
<td>Larger UPSs will be three-phase and/or 208V, 400V or 480V and often result in more efficient operation and lower operating costs.</td>
<td>There is no space for a large UPS.</td>
</tr>
<tr>
<td>A central UPS is often housed away from high traffic areas. As a result, it’s less easily disrupted, accidentally damaged or maliciously interfered with.</td>
<td>A central UPS generally requires a trained service technician or electrician to service, maintain or install.</td>
</tr>
<tr>
<td>A central UPS can be located where cooling is more tightly controlled. Remember, heat is the enemy of the batteries inside a UPS.</td>
<td>A central UPS may incur higher installation and wiring costs.</td>
</tr>
<tr>
<td>Though a technician may need to replace the batteries, you only have to worry about a single UPS. A distributed UPS configuration may result in various models that require different batteries. Do you want to take the time to replace the batteries on five to 20 UPSs?</td>
<td></td>
</tr>
</tbody>
</table>
Combining the configurations

It's important to keep in mind that decentralized and centralized power protection deployment strategies aren't necessarily mutually exclusive. The two strategies can be used in combination to provide redundancy to mission-critical applications. For example, an entire facility may be protected by a large, centralized UPS, but a specific department such as a 24x7 call center may have decentralized UPSs as well to provide redundant protection and possibly extend runtime for call center equipment.

Decentralized UPS

<table>
<thead>
<tr>
<th>Why you’d choose a decentralized UPS configuration</th>
<th>Why you wouldn’t</th>
</tr>
</thead>
<tbody>
<tr>
<td>No rewiring is required. Use existing wall sockets. Easy plug and play installation. Can also be redeployed easily if IT systems are moved.</td>
<td>If a generator supports the building, smaller standby and line-interactive UPSs may not be able to function while it’s running.</td>
</tr>
<tr>
<td>Requires lower capital outlay and installation costs. Fits within IT manager purchase limits. Generally don’t need to approve a large capital expense. Will most likely not require additional installation costs from electrician.</td>
<td>No central panelboard exists or there’s no room for the UPS.</td>
</tr>
<tr>
<td>You have no idea how much your company will grow and don’t want to get locked into a particular UPS.</td>
<td>You don’t want to monitor or service a bunch of UPS units. A decentralized design may require more time and focus to keep up with replacing batteries and maintaining multiple UPSs.</td>
</tr>
<tr>
<td>You already have a number of smaller UPS units that are fairly new and you don’t want to discard them. (Most UPS manufacturers offer a trade-in program.)</td>
<td>You want a single UPS that can be shut down using emergency power off. Also, a decentralized design may not offer redundancy and other capabilities provided by a larger, central UPS.</td>
</tr>
<tr>
<td>Power conditioning is implemented at the point of use, which mitigates any electrical disturbances that may be coupled into the distribution wiring of a centralized system.</td>
<td>Adding redundancy, extended runtime or maintenance bypass functionality to multiple UPSs can be costly.</td>
</tr>
<tr>
<td>Diverse applications within a building may require varying levels of power protection and functionality. For example, extended runtime can be configured for specific applications, eliminating the need to add additional battery modules for less critical equipment.</td>
<td>Multiple audible alarms/alerts may be irritating.</td>
</tr>
</tbody>
</table>
What is three-phase power?

Three-phase power, the most efficient way to distribute power over long distances, allows for large industrial equipment to operate more efficiently. It’s characterized by three single-phase waves that are offset in their phase angle by 120 degrees, or one-third of the sine wave period as illustrated in Figure 1.

Three-phase voltage can be measured from each phase to neutral or from one phase to any other. The voltage relation between phase-to-neutral and phase-to-phase is a factor of the square root of three (e.g., 120V versus 208V).

Conversely, single-phase power is distributed through common household outlets to power everyday equipment such as laptops, lighting and televisions. When looking at an oscilloscope image of the voltage coming out of a single-phase outlet as illustrated in Figure 2, there’s only a single wave. Single-phase power is obtained by simply using only one phase of a three-phase system. Its root mean square (RMS) voltage is 120V (for North America) and it oscillates between its peaks of ±170V at 60 Hz (or 60 times a second).

Single-phase or three-phase power?

<table>
<thead>
<tr>
<th>Single-phase advantages</th>
<th>Three-phase advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>The standard for locations where three-phase power is unavailable.</td>
<td>Can help balance the loads on the utility power of the building.</td>
</tr>
<tr>
<td>Usually easier to distribute power in low kVA and low-density applications.</td>
<td>Usually easier to distribute power in higher kVA and high-density rack applications.</td>
</tr>
<tr>
<td></td>
<td>Allows for smaller amperage electrical devices within the solution (breakers, wiring, panels, etc.).</td>
</tr>
</tbody>
</table>

I LIKE THE RHYTHM OF THREE-PHASE POWER.
Increase server energy efficiencies by using high-voltage power supplies and 208V UPSs

Maximizing energy efficiencies in today’s data centers has become an important factor in saving costs and reducing an organization’s carbon footprint. While there are new energy-saving tools and technologies being introduced every day, understanding existing methods and systems can bring immediate efficiencies and savings, often without an additional investment.

One such method is to operate equipment at high-line voltage and use 208V UPSs, which maximizes energy efficiency and uptime, and saves money. IT devices equipped with a C14 plug are capable of running on high voltage, which can dramatically increase efficiency.

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

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 and 80 percent, with some special-purpose products able to reach 90 percent efficiency. Lower voltage causes the power supply to operate at the lower end of this range.

When operating at 208 volts, a 1 to 2 percent difference in efficiency can be experienced for a 1000W power supply, depending on the load level. When the loss in the power distribution transformer (PDU) needed to get to the 120V is added, there’s an additional 1.5 to 2 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 justifies making the switch to 208 volts, especially when expanding or moving into a new location.

One of the main reasons that U.S. customers have been reluctant to switch to high voltage is that high voltage UPSs are typically fitted with IEC outlets (or even inlets) and customers don’t know how to connect them to IT equipment with a traditional NEMA plug. However, all IT power supplies come with a detachable input cord with a NEMA plug on one side and an IEC plug on the other. By simply changing the standard NEMA/C13 power cord to an IEC C13/C14 power cord, these additional IT equipment efficiencies can be captured. IEC cables are fully UL-listed and are the standard method of connection in large mission-critical data centers across the U.S.

Making the connections

Remove the standard 5-15P/C13 power cord that shipped with your IT equipment and replace it with one of the C13/C14 jumper cables that shipped with your UPS. Your IT equipment is now operating at 208V, running more efficiently and saving you money.
Worldwide voltage map

*Mixed voltages are present in several countries, including Vietnam, South Korea, Philippines, Brazil, Peru and Saudi Arabia.

I ROAMED THE WORLD BEFORE THERE WERE VOLTAGES.
## Worldwide Voltages

<table>
<thead>
<tr>
<th>Country</th>
<th>Single-phase Voltage (V)</th>
<th>Three-phase Voltage (V)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>220</td>
<td>380</td>
<td>50</td>
</tr>
<tr>
<td>Albania</td>
<td>230</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>Algeria</td>
<td>127/220</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>American Samoa</td>
<td>120/240</td>
<td>208</td>
<td>60</td>
</tr>
<tr>
<td>Andorra</td>
<td>230</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>Angola</td>
<td>220</td>
<td>380</td>
<td>50</td>
</tr>
<tr>
<td>Antigua</td>
<td>230</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>Armenia</td>
<td>230</td>
<td>380</td>
<td>50</td>
</tr>
<tr>
<td>Argentina</td>
<td>220</td>
<td>380</td>
<td>50</td>
</tr>
<tr>
<td>Aruba</td>
<td>110/127</td>
<td>220</td>
<td>60</td>
</tr>
<tr>
<td>Australia</td>
<td>240</td>
<td>415</td>
<td>50</td>
</tr>
<tr>
<td>Austria</td>
<td>220-230</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>Australia</td>
<td>220</td>
<td>380</td>
<td>50</td>
</tr>
<tr>
<td>Austria</td>
<td>220</td>
<td>380</td>
<td>50</td>
</tr>
<tr>
<td>Azerbaijan</td>
<td>220</td>
<td>380</td>
<td>50</td>
</tr>
<tr>
<td>Azores (Portugal)</td>
<td>220</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>Bahamas</td>
<td>120</td>
<td>208</td>
<td>60</td>
</tr>
<tr>
<td>Bahrain</td>
<td>220</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>Balkan Islands</td>
<td>230</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>220</td>
<td>380</td>
<td>50</td>
</tr>
<tr>
<td>Barbados</td>
<td>115</td>
<td>200</td>
<td>50</td>
</tr>
<tr>
<td>Belarus</td>
<td>220</td>
<td>380</td>
<td>50</td>
</tr>
<tr>
<td>Belgium</td>
<td>220-230</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>Belize</td>
<td>110</td>
<td>190/208</td>
<td>60</td>
</tr>
<tr>
<td>Benin</td>
<td>220</td>
<td>380</td>
<td>50</td>
</tr>
<tr>
<td>Bermuda</td>
<td>120</td>
<td>208</td>
<td>60</td>
</tr>
<tr>
<td>Bhutan</td>
<td>230</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>Bolivia</td>
<td>110/115/220</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>Bosnia-Herzegovina</td>
<td>220</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>Botswana</td>
<td>220</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>Brazil</td>
<td>110-127</td>
<td>220/230/240</td>
<td>60</td>
</tr>
<tr>
<td>Brazil</td>
<td>220</td>
<td>440</td>
<td>60</td>
</tr>
<tr>
<td>Brunei</td>
<td>240</td>
<td>415</td>
<td>50</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>220</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>Burkina Faso</td>
<td>220</td>
<td>380</td>
<td>50</td>
</tr>
<tr>
<td>Burundi</td>
<td>220</td>
<td>380</td>
<td>50</td>
</tr>
<tr>
<td>Cambodia</td>
<td>220</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>Cameroon</td>
<td>220</td>
<td>380</td>
<td>50</td>
</tr>
<tr>
<td>Canada</td>
<td>220</td>
<td>380</td>
<td>50</td>
</tr>
<tr>
<td>Canary Islands (Spain)</td>
<td>220</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>Cape Verde</td>
<td>220</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>Cayman Islands</td>
<td>120</td>
<td>208</td>
<td>60</td>
</tr>
<tr>
<td>Central African Republic</td>
<td>220</td>
<td>380</td>
<td>50</td>
</tr>
<tr>
<td>Chad</td>
<td>220</td>
<td>380</td>
<td>50</td>
</tr>
<tr>
<td>Channel Islands</td>
<td>220</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>Chile</td>
<td>220</td>
<td>380</td>
<td>50</td>
</tr>
<tr>
<td>China</td>
<td>220</td>
<td>380</td>
<td>50</td>
</tr>
<tr>
<td>Colombia</td>
<td>110-220</td>
<td>440</td>
<td>60</td>
</tr>
<tr>
<td>Congo</td>
<td>220</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>Congo, Dem. Rep. of (formerly Zaire)</td>
<td>220</td>
<td>380</td>
<td>50</td>
</tr>
<tr>
<td>Cook Islands</td>
<td>240</td>
<td>415</td>
<td>50</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>120</td>
<td>240</td>
<td>60</td>
</tr>
<tr>
<td>Croatia</td>
<td>220</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>Cuba</td>
<td>120</td>
<td>190</td>
<td>60</td>
</tr>
<tr>
<td>Cyprus</td>
<td>240</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>220</td>
<td>400</td>
<td>50</td>
</tr>
</tbody>
</table>
The nine power problems

In an ideal world, your wall socket would provide an infinite stream of perfect power, at constant voltage and cycling exactly the same number of times per second. Don’t count on it.

<table>
<thead>
<tr>
<th>Power Problem</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Power Failure</td>
<td>When a superhero loses his ability to fly or a total loss of utility power.</td>
</tr>
<tr>
<td>2 Power Sag</td>
<td>Post-lunch sleepiness or short-term low voltage.</td>
</tr>
<tr>
<td>3 Power Surge (Spike)</td>
<td>Rush of energy following a double shot of espresso or short-term high voltage more than 110 percent of normal.</td>
</tr>
<tr>
<td>4 Under-voltage (Brownout)</td>
<td>When your amp’s too wimpy to handle the bass line or reduced line voltage for an extended period of a few minutes to a few days. Often happens during the summer months when everyone is cranking up their air conditioners.</td>
</tr>
<tr>
<td>5 Over-voltage</td>
<td>Inhuman cheerfulness exuded by aerobics instructors or increased line voltage for an extended period of a few minutes to a few days.</td>
</tr>
<tr>
<td>6 Electrical Line Noise</td>
<td>Excuse you use to get off the phone quickly or a high power frequency power wave caused by radio frequency interference (RFI) or electromagnetic interference (EMI).</td>
</tr>
<tr>
<td>7 Frequency Variation</td>
<td>Fluctuation in how often you do laundry from week to week or a loss of stability in the power supply’s normal frequency of 50 or 60 Hz.</td>
</tr>
<tr>
<td>8 Switching Transient</td>
<td>Breaking up with your significant other only to get back together every six months or instantaneous under-voltage in the range of nanoseconds.</td>
</tr>
<tr>
<td>9 Harmonic Distortion</td>
<td>“Music” blaring from your nephew’s headphones or the distortion of the normal power wave, generally transmitted by unequal loads.</td>
</tr>
</tbody>
</table>
UPS topologies

There are several different UPS topologies that provide varying degrees of protection. Selecting the best fit depends on several factors, including the level of reliability and availability desired, the type of equipment being protected and the application/environment. While all four of the most common UPS topologies outlined below meet the input voltage requirements for IT equipment, there are key differences in how the result is achieved, as well as the frequency and duration of demands on the battery.

**Standby UPSs** allow equipment to run off utility power until the UPS detects a problem, at which point it switches to battery power to protect against sags, surges or outages. This topology is best suited for applications requiring simple backup such as small office/home office and point-of-sale equipment.

**Line-interactive UPSs** actively regulate voltage either by boosting or decreasing utility power as necessary before allowing it to pass to the protected equipment or by resorting to battery power. Line-interactive models are ideal for applications where protection from power anomalies is required, but the utility power is relatively clean. MDF and IDF communication closets, non-centralized server and network rooms, and general IT enclosures are ideally suited for this topology.

**Online UPSs** provide the highest level of protection by isolating equipment from raw utility power—converting power from AC to DC and back to AC. Unlike other topologies, double conversion provides zero transfer time to battery for sensitive equipment. This topology is best applied to mission-critical equipment and locations where power generally is poor.

**Ferroresonant UPSs** operate similarly to line-interactive models with the exception that a ferroresonant transformer is used to condition the output and hold energy long enough to cover the time between switching from line power to battery power which effectively means a no-break transfer. Many ferroresonant UPSs are 82-88 percent efficient and offer excellent isolation. Although no longer the dominant type of UPS, these robust units are still used in industrial settings such as the oil and gas, petrochemical, chemical, utility and heavy industry markets.
Valve-regulated lead acid (VRLA) batteries, also known as sealed or maintenance free are most commonly used in UPSs. VRLA batteries are sealed, usually within polypropylene plastic, which offers the advantage of not containing any sloshing liquid that might leak or drip. Because water can’t be added to VRLA batteries, recombination of water is critical to their life and health, and any factor that increases the rate of evaporation or water loss—such as temperature or heat from the charging current—reduces battery life.

Frequently asked questions: batteries

1. What is the “end of useful life”?
The IEEE defines “end of useful life” for a UPS battery as the point when it can no longer supply 80 percent of its rated capacity in ampere-hours. When your battery reaches 80 percent of its rated capacity, the aging process accelerates and the battery should be replaced.

2. Is there any difference between the batteries used by smaller UPSs, from 250 VA to 3 kVA, and the ones used by larger UPSs?
While basic battery technology and the risks to battery life remain the same regardless of UPS size, there are some inherent differences between large and small applications. Smaller UPSs typically have only one VRLA battery that supports the load and needs maintenance. As systems get larger, increasing battery capacity to support the load gets more complicated. Larger systems may require multiple strings of batteries, introducing complexity to battery maintenance and support. Individual batteries must be monitored to prevent a single bad battery from taking down an entire string, and putting the load at risk. Also, as systems get larger, wet-cell batteries become much more common.
3. My UPS has been in storage for over a year. Are the batteries still good?
As batteries sit unused, with no charging regimen, their life will decrease. Due to the self-discharge characteristics of lead-acid batteries, it is imperative that they be charged after every six to 10 months of storage. Otherwise, permanent loss of capacity will occur between 18 and 30 months. To prolong shelf life without charging, store batteries at 10°C (50°F) or less.

4. What is the difference between hot-swappable and user-replaceable batteries?
Hot-swappable batteries can be changed out while the UPS is running. User-replaceable batteries are usually found in smaller UPSs and require no special tools or training to replace. Batteries can be both hot-swappable and user-replaceable.

5. How is battery runtime affected if I reduce the load on the UPS?
The battery runtime will increase if the load is reduced. As a general rule, if you reduce the load by half, you triple the runtime.

6. If I add more batteries to a UPS, can I add more load?
Adding more batteries to a UPS can increase the battery runtime to support the load. However, adding more batteries to the UPS doesn’t increase the UPS capacity. Be sure your UPS is adequately sized for your load and then add batteries to fit your runtime needs.

7. Can I mix batteries by type or age?
No, it’s important that you never mix batteries by manufacturer, type or age. Always remove and replace all the batteries in the device at the same time, and follow the manufacturer’s recommendations to which to use. Remember to read the warnings and small print before installing.

8. If my UPS is in storage, how often should I charge the batteries?
The batteries should be charged every three or four months to prevent loss of capacity.

9. What is the average lifespan of UPS batteries?
The standard lifespan for VRLA batteries is three to five years. However, expected life can vary greatly due to environmental conditions, number of discharge cycles, and adequate maintenance. Have a regular schedule of battery maintenance and monitoring to ensure you know when your batteries are reaching their end-of-life. The typical life of an Eaton UPS with ABM technology is 50 percent longer than with standard models.

10. Why are batteries disconnected on small, single-phase UPSs when they’re shipped?
This is done to ensure they’re in compliance with Department of Transportation regulations.

11. Does the UPS need to have a load on it to charge its batteries?
The UPS should have a minimum of 10 percent load to charge its batteries. Once connected to a standard supply of electricity (via input plug or hardwiring), your UPS should charge its batteries regardless of how much load, if any, is attached to it.

12. How can you be sure UPS batteries are in good condition and ensure they have maximum holdover in the event of a power failure? What preventive maintenance procedures should be done and how often?
The batteries used in the UPS and associated battery modules and cabinets are sealed, lead-acid batteries often referred to as maintenance-free. While these types of batteries are sealed and you don’t need to check their fluid level, they do require some attention to assure proper operation. You should inspect the UPS a minimum of once per year by initiating a self-test.

13. How long does it take for the UPS batteries to recharge?
On average, it takes 10 times the discharge time for the UPS batteries to recover. (A 30-minute battery discharge requires about 300 minutes to recharge.) After each power outage, the recharge process begins immediately. It’s important to note that the load is fully protected while the batteries are recharging, but if the batteries are needed during that time, the holdover time available will be less than it would have been if the batteries were fully charged.

14. What are the risks associated with a lack of battery maintenance?
The primary risks of improperly maintained batteries are load loss, fire, property damage and personal injury.

15. What is thermal runaway?
Thermal runaway occurs when the heat generated in a lead-acid cell exceeds its ability to dissipate it, which can lead to an explosion, especially in sealed cells. The heat generated in the cell may occur without any warning signs and may be caused by overheating, excessive charging, internal physical damage, internal short circuit or a hot environment.

16. Why do batteries fail?
Batteries can fail for a multitude of reasons, but common reasons are:
• High or uneven temperatures
• Inaccurate float charge voltage
• Loose inter-cell links or connections
• Loss of electrolyte due to drying out or damaged case
• Lack of maintenance, aging

17. How is battery performance generally measured?
Batteries are generally rated for 100+ discharges and recharges, but many show a marked decline in charging capacity after as few as 10 discharges. The lower the charge the battery can accept, the less runtime it can deliver. Look for batteries with a high-rate design that sustains stable performance for a long service term.
Factors affecting battery life

All UPS batteries have a limited service life, regardless of how or where the UPS is deployed. While determining battery life can be tricky, there are four primary factors that contribute to a battery’s overall lifespan.

1. Ambient temperature
The rated capacity of a lead acid battery is based on an ambient temperature of 77°F. It’s important to know that any variation from this operating temperature can alter the battery’s performance and shorten its life. To help determine battery life in relation to temperature, remember for every 15°F average annual temperature above 77°F, the life of the battery is reduced by 50 percent. Ambient temperatures below 77°F may reduce the battery backup time, similar to a car battery on a cold morning.

2. Battery chemistry
Positive grid corrosion has been the most common end-of-life factor for UPS batteries, which is a result of the normal aging process due to UPS battery chemistry and involves the gradual breakdown of the inner segments of the positive grid within the battery.

3. Cycling
During a utility power failure, a UPS operates on battery power. Once utility power is restored, or a switch to generator power is complete, the battery is recharged for future use. This is called a discharge cycle. At installation, the battery is at 100 percent of rated capacity. Each discharge and subsequent recharge reduces its relative capacity by a small percentage. The length and quantity of discharge cycles determine the reduction in battery capacity.

A good analogy is a loaf of bread. It can be sliced into many thin slices, or a few thicker slices. You still have the same amount of bread either way. Similarly, a UPS battery’s capacity can be used up over a large number of short cycles or fewer cycles of longer duration.

Lead-acid chemistry, like what’s used in rechargeable batteries, can only undergo a certain number of discharge/recharge cycles before the chemistry is depleted. Once the chemistry is depleted, the cells fail and the battery must be replaced.

4. Maintenance
Battery service and maintenance are critical to UPS reliability. A gradual decrease in battery life can be monitored and evaluated through voltage checks, load testing or monitoring. Periodic preventive maintenance extends battery string life by preventing loose connections, removing corrosion and identifying bad batteries before they can affect the rest of the string.

Even though sealed batteries are sometimes referred to as maintenance-free, they still require scheduled maintenance and service. Maintenance-free simply refers to the fact that they don’t require added water.

Without regular maintenance, a UPS battery can experience heat-generating resistance at the terminals, improper loading, reduced protection and premature failure. With proper maintenance, the end of battery life can be accurately estimated and replacements scheduled without unexpected downtime or loss of backup power.

5. Shelf life, storage and acceptance testing
It’s important to ensure that batteries are properly stored prior to being installed and placed into service in order to improve service life expectations and reliability. Storage facilities should be climate controlled with proper ventilation capabilities so batteries can be kept cool and dry. Failure to comply with proper storage can lead to shortened runtimes and reduced capacity.

All battery manufacturers have shelf life and storage parameters. In terms of time, a good rule of thumb is no more than six months of storage in a properly designed storage facility.

To validate runtime and capacity expectations, an acceptance test should be performed. The acceptance test will be able to determine if there are any flaws within the manufacturing process, improper storage or perhaps even hidden damage as a result of shipping and handling. This test might be the most important procedure any operator can have performed to ensure reliability of the battery systems.

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For additional information on UPS batteries, to use the Eaton battery replacement selector, or to request a free copy of Eaton’s battery handbook, visit Eaton.com/upsbatteries.
UPS software overview

Operating UPS power without power management software is like driving in the rain without windshield wipers – you may be protected from the downpour, but your visibility is hindered. Together, a UPS solution and monitoring and management software is the perfect complement.

Most businesses today are leveraging some level of virtualization (whether it be application, storage, network, or server virtualization). Read the top two criteria to consider when choosing software that safeguards your equipment and expands the capabilities of your virtual environment.

1. Establish which software integrates with your virtualization platform
(VMware, Citrix, Microsoft, or Red Hat) and other devices that support a network interface (UPSs, environmental sensors, ePDUs, etc.)

2. Identify what you want to accomplish with the software.
- Do you want it to plug directly into your virtual dashboard?
- Do you want to initiate planned migrations?
- Do you want to perform load shedding?
- Do you want to remotely shut down a host in a cluster without needing to install shutdown agents on each host or each virtual machine?

Once you’ve selected a power management software solution that seamlessly integrates into your major virtualization platform and meets the needs of your environment, you will be able to enjoy a number of advantages.

Cost savings
- Less hardware, power used, cooling, and management
- Increased productivity – no need to recreate your work-in-progress

Business continuity and disaster recovery (BCDR)
- Data integrity and graceful shutdown in the event of an extended outage
- Initiate planned migrations to a cloud recover site
- Extended runtime to critical applications with load shedding

Management ease
- A global view across the network on one screen—often from any PC with an Internet browser A complete log of events and UPS utility data
- Centralized alarms
- Organized data by customized views
- Event logs for preventive maintenance of the entire installed equipment base

If you are interested in keeping a pulse on your network’s health and secure the availability on your data through software, view an online demonstration of Eaton’s power management software capabilities. Visit: Eaton.com/intelligentpower
Make health-checking your UPS a top priority

In order to avoid an unexpected breakdown, your vehicle needs regular preventive maintenance, such as routine oil changes and tune-ups. Likewise, an annual visit to your physician's office helps identify any potential problems that could become health concerns. Ensuring the ongoing optimal performance of your UPS is much the same.

The following checklist will help you keep it in tip-top shape:

1. **Make sure your batteries are in good health.**
   Batteries are the No. 1 cause of UPS failure, so it's wise to do the following:
   a. **Note their age.** UPS batteries can last anywhere from 2-5 years, so if yours are 4 years old or older, you should probably begin planning a replacement.
   b. **Run a UPS battery self-test.** Most network-class UPSs have the capability to run a quick self-check from the front menu.
   c. **Check under the hood.** Remove the front bezel and make sure there are no signs of battery swelling or damage.
   d. **Consider a preventive maintenance (PM) visit.** For customers with larger, centralized UPSs, consider having an electrician or factory-authorized technician test each individual battery, which provide a much more detailed picture of your system reliability.

2. **Perform an early spring cleaning.**
   Clutter, dust and general disorganization can cause unwanted issues and decrease the reliability of your system, so be sure to:
   a. **Check the air flow.** Make sure there is nothing blocking air-flow in your IT environment, since heat is one of the biggest reducers of battery life. You should have enough air flow to keep your UPS at room temperature (77 degrees is optimal).
   b. **Dust!** Caked-on grime can damage fans and cause electronics board damage. A simple wipe down is often all you need. If you have a larger, centralized UPS, you may need to replace your air filter or make sure that it is clean.

3. **Verify UPS communication.**
   Properly configured communications ensure that IT managers can respond to alerts and take corrective actions, so:
   a. **Run a test email.** If your UPS is equipped with a Network Interface Card (NIC), run a trial email. Sometimes changing email servers or domains can cause settings to be out of date.
   b. **Check the software.** Make sure the UPS and NIC both have the most up-to-date versions.

4. **Keep service information up-to-date.**
   Nothing can be more frustrating than finding out your UPS is no longer under warranty after it fails. Be sure to:
   a. **Double-check your service contract.** Review your coverage and consider storing contract information in one place, either physically or electronically.
   b. **Register your product.** If you do not have a service contract, at least make sure your UPS is registered with the manufacturer. This helps you stay informed on updates, and allows the manufacturer to respond quickly if an issue does arise.

These simple steps will go a long way toward ensuring the ongoing reliability of your UPS, and in turn, the critical equipment and data it is protecting.

I HAVE A QUESTION.
WHICH DESERVES NEW LIFE MORE? YOUR IT INFRASTRUCTURE OR ME?
Types of UPS service

There are several UPS service delivery methods, including:

- **Factory warranty – repair or replace.** You contact the UPS service provider and ship your UPS to a repair facility. The service provider returns the repaired unit or a refurbished unit.

- **Extended warranty – advance swap depot exchange.** You contact your UPS service provider, which ships a refurbished unit to you; the original UPS unit is returned to a repair facility. Typically this expedites a replacement UPS by the next business day and freight costs are paid both ways by Eaton.

- **Onsite repair.** You contact your UPS service provider and factory-trained field technicians travel to your site to diagnose and repair electronic or battery-related problems.

Smaller UPS products (below 1000 VA) generally can be repaired at a depot, while products over 1000 VA and up to 18 kVA can either be repaired at a depot or serviced onsite. Larger UPSs that are either hardwired (can’t be unplugged) or too heavy to ship can only be serviced onsite by trained technicians.

Types of service agreements

A variety of different UPS service options are available, any of which will likely save you time and money by minimizing business interruption and the costs of downtime, as well as enhancing overall return on investment by extending the lifespan of critical power equipment.

- **Support agreements, or service contracts,** usually combine parts and labor coverage (electronics, batteries or both), one or more UPS preventive maintenance inspections annually, and a combination of coverage hours and arrival response time. Plans can be tailored to meet almost any need. Special features like remote monitoring, battery replacement insurance and spare part kits may also be added.

- **Time and material (T&M) service** is a pay-as-you-go approach through which the service provider makes a repair only when something breaks. T&M can be done either via depot repair or onsite, depending on the UPS. This method can be an unacceptable service solution for some customers, since it’s often expensive, and there’s the uncertainty of not knowing when a field technician will arrive. Because support agreement (contract) customers always take priority, T&M response times can be up to five days, based on the product and location.

Service overview

One of the best ways to protect your investment is by including a service plan. Scheduled preventive maintenance can help detect a wide range of ailments before they become serious and costly issues.

The Eaton service offering

Eaton offers power quality services for its UPS products as well as for related equipment such as power distribution units (PDUs) and batteries. Eaton also services products from legacy brands, including Powerware, Exide Electronics, Best Power, MGE Office Protection Systems, IPM, Deltec and Lortec. Eaton has more than 40 years of experience designing and servicing industry-leading UPSs for government, healthcare, industrial and data center applications.

For more information on UPS service, and to access service-related white papers, please visit Eaton.com/upsservices.
We compiled the following set of questions based on our extensive experience dealing with resellers and end users. For frequently asked questions about UPS batteries, please visit the UPS battery overview section on page 25.

1. What’s the difference between a surge protector and a UPS?
A surge protector provides just that—surge protection. In addition to surge protection, a UPS continually regulates incoming voltage and provides battery backup in the event of a power failure. You’ll often see surge protectors plugged into a UPS for added surge protection and additional output receptacles.

2. How much capacity of a UPS should I use?
To allow for future expansion, we recommend that you install a UPS at approximately 75 percent capacity. In addition, the batteries degrade over time; by oversizing, you provide room for error. In the online Eaton UPS sizing tool (Eaton.com/UPSsizer) we’ve included a “capacity used” column.

3. How much UPS battery runtime do I need?
During an outage, you need enough battery runtime to gracefully shut down systems or switch to backup generators. You may add an optional external battery module (EBM) to increase runtime.

4. How is battery runtime impacted if I reduce the load on the UPS?
There can be a significant increase in runtime. Generally speaking, a UPS that provides five minutes at full load will provide 15 minutes at half load.

5. My business is too small for protective measures. Do I really need a UPS?
Power problems are equal-opportunity threats. Your PCs, servers and network are just as critical to your business as a data center is to a large enterprise. Downtime is costly in terms of hardware and potential loss of goodwill, reputation and sales. Also add in the delays that inevitably occur when rebooting locked-up equipment, restoring damaged files and re-running processes that were interrupted. A sound power protection strategy is cost-effective insurance.

6. Why is power quality such a problem today?
Today’s high-tech IT equipment and control units are much more sensitive to electrical disturbances and are more important to the critical functions of many businesses than in the past. As a result, power quality problems today are more frequent and more costly than ever.

7. Are power quality problems always noticeable?
No. In many cases, disturbances can cause imperceptible damage to circuits and other components, a major cause of premature equipment failure and problems like computer lockups. Many power quality problems go unresolved, resulting in lost revenue and data.

8. How is reliability measured?
Power reliability is usually stated as a percent of time the power is available. For example, the power grid system in the U.S. provides three nines of reliability—the power is available for 99.9 percent of the time. Because those 8.8 hours of downtime translate into significant downtime and expense, IT and telephone network services require at least five nines of reliability.

<table>
<thead>
<tr>
<th>Reliability average</th>
<th>Non-availability per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>99%</td>
<td>88 hours</td>
</tr>
<tr>
<td>99.9%</td>
<td>8.8 hours</td>
</tr>
<tr>
<td>99.99%</td>
<td>53 minutes</td>
</tr>
<tr>
<td>99.999%</td>
<td>5.3 minutes</td>
</tr>
<tr>
<td>99.9999%</td>
<td>32 seconds</td>
</tr>
<tr>
<td>99.99999%+</td>
<td>3.2 seconds</td>
</tr>
</tbody>
</table>

9. How are phone systems and IT equipment affected by inconsistent power?
Fluctuating power is a waste of valuable time and money. If customers expose their telephone systems (and any other electronic equipment) to inconsistent utility power, they’re vulnerable to hardware and software damage, data corruption and communication breakdown. The time and cost of replacing equipment, as well as the business lost during breakdown and replacement, can greatly affect a company’s bottom line.

10. I have a UPS. Am I really protected by lightning?
No UPS or any other form of surge protection device can provide total protection against lightning-induced power surges. A good UPS will suppress the majority of surges without itself suffering damage. For larger surges, it will also offer one-off protection, where the surge protection device does its job of protecting the connected equipment, but is destroyed in the process and can, therefore, provide no further protection. While a well specified
good quality UPS will provide a very useful level of surge protection, it will do an even better job if it is used as part of a comprehensive surge protection system with several levels of protection with high-energy protection devices installed at the point where the supply enters the building, and smaller devices installed at other critical points throughout the building’s power distribution system.

11. We have a generator. Do I still need a UPS?
A generator will NOT protect your equipment against power problems. You need a UPS to guarantee that the equipment stays up until the generator kicks on and stabilizes—which often requires several minutes.

12. How much UPS capacity do I need?
Determine the total load (in watts) of the equipment you want to protect. Add 10–20 percent for future growth and decide the minimum amount of runtime you need. Use the online sizer at (powerquality.eaton.com) to identify the right solution for your application.

13. What are the different levels of surge protection?
There are three typical levels:
A. Lightning arrestors. Big and mean, usually found in large facilities located in high-risk areas. Takes an extremely high voltage and clamps it down.
B. Surge Protective Devices (SPD or TVSS). Mounted on your panelboard or load center; sometimes larger UPS models may have some level of this, but typically not a great amount. Clamps voltage down two even lower tolerances (~1 kV or less).
C. Local outlet level surge protector. A simple surge strip; small plug-and-play UPSs often have this as well. Brings voltage down to levels that will not permanently damage connected equipment (typically ~380V). Lightning strikes have such an incredible amount of energy that only an expensive lightning arrester would protect you from a direct hit and they often don’t guarantee complete protection. For the best protection against lightning strikes, you want to develop a two-stage defense with something at your panel and something at the outlet level. Visit Eaton.com/spd for some informative videos and additional information.

14. What happens if the UPS is overloaded, for example, if the protected equipment and/or load draws more current than it can provide?
The UPS transfers the load to bypass (for a few minutes) until the overload condition is reversed. If the overload condition continues, some UPS models automatically shut down. Some models can run at 110V indefinitely in bypass.

15. What causes a UPS to be overloaded?
There are two possible answers: (1) the UPS was undersized (e.g., the load is rated at 1200 VA, but a 1000 VA UPS was provided), or (2) you plugged more equipment into the UPS than it was designed to handle.

16. I have a 3000 VA UPS. Can I just plug the unit into a standard 15A wall outlet?
Only UPSs with power ratings up to 1500 VA plug into a standard 15A wall outlet. All others require a larger receptacle, which must be installed by an electrician.

17. Why is power management software important?
Although UPSs are typically rugged and reliable, they do require ongoing monitoring and support. Power management software continuously monitors and diagnoses the state of the grid, batteries and power sources, together with the condition of the UPS’s internal electronics. Eaton UPS software and connectivity cards enable remote monitoring and management capability, including graceful shutdown and load segment control.

18. Will my current UPS software monitor my new Eaton UPS?
Yes, you can monitor your Eaton UPS with any UPS or facility management software that supports the industry standard Management Information Base (MIB, RFC 1628) as long as you install the optional connectivity card. Most UPS vendors support this MIB and all good facility management software, including OpenManage, OpenView and Tivoli also support it. Extended Eaton Advanced MIBs are available for greater levels of detail.

You can remotely control your Eaton UPS using the Eaton UPS management software or through a secure web interface if you choose the optional connectivity card, which also allows for automated email alerts for power events without needing to install any software.

19. My data center only went down for a couple of minutes. What’s the big deal?
When a data center goes down and then back up during a power outage without a managed shut down, it doesn’t come up nicely. Storage arrays initialize after servers that try to mount their shares, while some servers boot without access to DNS servers that are also booting and thus have other problems. Although the outage was short, it can take hours to get everything back online. In addition, data corruption is a serious concern.

20. Where can I get technical help?
Contact your territory representative or call the Eaton UPS hotline at 1-800-356-5794 for pre-sales support and 1-800-356-5737 for technical support. You can also visit www.powerquality.eaton.com.

A GENERATOR? I ALREADY HAVE MY OWN!
Electric transmission distribution system

The flow of electricity begins at the utility company, where it’s created at the generating station. A generator transformer at the station switchyard then steps up the voltage to minimize cable size and electrical losses.

The transmission substation then increases the voltage, which depends on the distance the power needs to travel and the amount desired. Electricity then enters the transmission system, traveling at nearly the speed of light, over heavy cables strung between tall towers. A step-down transformer located at a substation near the final destination reduces the voltage to between 22,000 and 69,000 volts, so the electricity can be carried on smaller distribution lines that carry it to the end user. Transformers that adjust the voltages down to the proper level for use are located at or near each end user facility. For commercial use, the load can range from 416 volts to 480 volts, while residential use is typically 208/120 volts in the U.S. and Canada.
Threats to the system

At each stage, there are a number of threats that can interrupt the flow and distribution of electricity. Everything from lightning strikes to failed equipment can severely affect the end user and disrupt important and vital processes.

1. Fire sparked by weak wire burns through line
2. Lightning strike damages transmission line
3. Bird flies in causing short circuit
4. Thieves steal copper
5. Blown fuse at substation transformer
6. Squirrels and raccoons chew through a wire or wander into the wrong area
7. Underground explosion causes cable failure
8. Storm blows branches and limbs down that crash into power lines
9. Equipment malfunction
10. Mylar balloons drift into power lines
11. Three-car collision strikes utility pole
12. Failure of underground cable
13. Equipment failure
14. The power goes out and no one knows why
15. Utilities conduct a planned outage for repairs or upgrades

TREES, ROADS, GRASS AND POWER LINES. WHERE AM I SUPPOSED TO LAND?
Eaton’s Blackout Tracker monitors power outages across the U.S. and Canada to provide a snapshot of reported power outages. The Blackout Tracker is an interactive and educational way to share information about the causes, frequencies and impact of power outages. You can view a region or individual state or province to see specific information about power outages, including their cause, duration and number of people affected. Visit Eaton.com/blackouttracker to see this interactive tool and order the latest Blackout Tracker annual report.

Impact of power outages

Every day, an interruption to electrical service in homes, businesses and public sector organizations occurs, and the losses from these power outages can be extensive and of great consequence. For a business, the recovery time is significant and the costs are high. According to Price Waterhouse research, after a power outage disrupts IT systems:

- >33 percent of companies take more than a day to recover
- 10 percent of companies take more than a week
- It can take up to 48 hours to reconfigure a network
- It can take days or weeks to re-enter lost data
- 90 percent of companies that experience a computer disaster and don’t have a survival plan go out of business within 18 months

Power outages can cause substantial losses for the companies affected. According to the U.S. Department of Energy, when a power failure disrupts IT systems:

- 33 percent of companies lose $20,000-$500,000
- 20 percent lose $500,000 to $2 million
- 15 percent lose more than $2 million
Overview
of 2014
US national
power outage
data

The following data was compiled by Eaton based on reported power outages during 2014.

<table>
<thead>
<tr>
<th>Table Title</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total number of people affected by outages</strong></td>
<td>14,268,989</td>
</tr>
<tr>
<td>(This is the sum of the number of people affected by reported power outages in the U.S. for 2014.)</td>
<td></td>
</tr>
<tr>
<td><strong>Total duration of outages</strong></td>
<td>151,366 minutes (approximately 2,522 hours or 105 days)</td>
</tr>
<tr>
<td>(This is the sum of the durations of the reported power outages.)</td>
<td></td>
</tr>
<tr>
<td><strong>Total number of outages</strong></td>
<td>3,634</td>
</tr>
<tr>
<td>(This is the sum of the number of reported power outages.)</td>
<td></td>
</tr>
<tr>
<td><strong>Average number of people affected per outage</strong></td>
<td>3,996</td>
</tr>
<tr>
<td>(This number is determined by dividing the “Total number of people affected by outages” by the number of outages that reported the number of people affected. The number of outages used for this calculation can be found in the note following this table.)</td>
<td></td>
</tr>
<tr>
<td><strong>Average duration of outage</strong></td>
<td>43 minutes</td>
</tr>
<tr>
<td>(This number is determined by dividing the “Total duration of outages” by the number of outages that reported durations. Not all reports of outages included the duration. The number of outages used for this calculation can be found in the note following this table.)</td>
<td></td>
</tr>
</tbody>
</table>

Notes:

A. Note: Total number of people affected (and average) is based on 2,404 (66%) of the total reported outages. Total duration of outages (and average) is based on 671 (18%) of the total reported outages. These are the number of outages that had reports that included data for number of people affected and duration, respectively.

B. Reports from news services, newspapers, websites, etc. used as sources, sometimes give statistics using different terms. For example, some reports may be based on “people” while others may be based on “addresses,” “homes and businesses” or “utility customers.” For purposes of this report, all of these are assumed to be and counted as people.
Reported power outages by cause in 2014

- Animal (150)
- Faulty Equipment/Human Error (1,026)
- Planned (194)
- Unknown (753)
- Vehicle Accident (356)
- Weather/Trees (1,081)
- Overdemand (14)

Note: Each power outage was grouped into one of seven possible causes. The outages by cause were totaled and the results displayed in the chart above. The number adjacent to the pie piece is the number of outages attributable to that cause.

Reported power outages by month/year

Note: Data collection began February 16, 2008.
Commonly used acronyms

**UPS and electrical acronyms**

A  Ampere
AC  Alternating Current
AFCI  Arc Fault Circuit Interrupter
AH  Ampere Hour
ANSI  American National Standards Institute
ASCII  American Standard Code for Information Interchange
AVR  Automatic Voltage Regulation
BBM  Break-Before-Make (Bypass Switch)
BDM  Bypass Distribution Module
BTU  British Thermal Unit
CRAC  Computer Room Air Conditioning
CRAH  Computer Room Air Handler
CSA  Canadian Standards Association
DC  Direct Current
DCIE  Data Center Infrastructure Efficiency
EBC  Extended Battery Cabinet
EBM  Extended Battery Module
EMC  Electromagnetic Compatibility
EMF  Electromagnetic Force
EMI  Electromagnetic Interference
FCC  Federal Communications Commission
GFCI  Ground-Fault Circuit Interrupter
GND  Ground
HV  High Voltage
HVAC  Heating, Ventilating and Air Conditioning
HW  Hardwired
Hz  Hertz
IEC  International Electrotechnical Commission (IEC)
IEEE  Institute of Electrical And Electronics Engineers
IGBT  Insulated Gate Bi-polar Transistor
ISO  International Standards Organization
ITIC  Information Technology Industry Council
kAIC  Kilampere Interrupting Capacity
kVA  Kilovolt ampere
LAN  Local Area Network
LCD  Liquid Crystal Display
LED  Light-Emitting Diode
LV  Low Voltage
MBB  Make-Before-Break (bypass switch)
MIB  Management Information Base
MOV  Metal Oxide Varistor
MTBF  Mean Time Between Failure
MTTR  Mean Time To Repair
NEC  National Electrical Code
NEMA  National Electrical Manufacturers Association
NIC  Network Interface Card
PDM  Power Distribution Module
PE  Protective Earth (also Physical Education)
PF  Power Factor
PFC  Power Factor Correction
PM  Preventive maintenance
PoE  Power over Ethernet
PPDM  PowerPass Distribution Module
PPE  Personal Protective Equipment
PUE  Power Usage Effectiveness
REPO  Remote Emergency Power Off
RFI  Radio Frequency Interference
RM  Rackmount (also Rectifier Magazine)
RoHS  Restriction of Hazardous Substances
SCR  Silicon-Controlled Rectifier
SLA  Service Level Agreement
SNMP  Simple Network Management Protocol
SPD  Surge Protection Device
THD  Total Harmonic Distortion
TVSS  Transient Voltage Surge Suppressor
UL  Underwriters Laboratory
UPS  Uninterruptible Power System (or Supply)
USB  Universal Serial Bus
V  Volt

**Eaton acronyms**

ABM  Advanced Battery Management
AFC  American Football Conference
AM  Advanced Monitored (ePDU)
ARG  Amphibious Ready Group
BA  Basic (ePDU)
CSE  Customer Service Engineer
EOSL  End of Service Life
EMS  Energy Management System
ESS  Energy Saver System
ME  Metered (ePDU)
MI  Ethernet Monitored (ePDU)
NFC  National Football Conference
PDR  Power Distribution Rack
RMA  Return Material Authorization
RPM  Rack Power Module
ROO  Remote On/Off
RPO  Remote Power Off
RPP  Remote Power Panel
SEAL  Sea Air Land
SW  Switched (ePDU)
T&M  Time and Material
VMMS  Variable Module Management System
Other acronyms

BCDR  Business Continuity and Disaster Recovery  
BYOD  Bring Your Own Device 
CI  Converged Infrastructure 
CPU  Central Processing Unit 
DCIM  Data Center Infrastructure Management 
DISA  Defense Information Systems Agency 
DNS  Domain Name System 
DR  Disaster Recovery 
DSL  Digital Subscriber Line 
DV  Data, Voice, Video 
E911  Enhanced 911 
ELT  Emergency Locator Transmitter 
EMEA  Europe, Middle East, Africa 
FMC  Fixed/Mobile Convergence 
FTP  File Transfer Protocol 
GUI  Graphical User Interface 
GoT  Game of Thrones 
HDD  Hard Disk Drive 
HP  High-Performance Computer 
HTML  HyperText Markup Language 
HTTP  HyperText Transfer Protocol 
IOT  Internet of Things 
MDF  Main Distribution Frame 
NNM  Network Node Manager 
IaaS  Infrastructure as a Service 
IDF  Intermediate Distribution Frame 
IP  Internet Protocol 
ISP  Internet Service Provider 
KVM  Keyboard, Video, Mouse 
LEED  Leadership in Energy and Environmental Design 
MSP  Managed Service Platform 
MTDC  Multi-Tenant Data Center 
M2MI  Machine-to-Machine Interface 
NAS  Network Attached Storage 
NIC  Network Interface Card 
NOC  Network Operations Center 
PABX  Private Automatic Branch Exchange 
PaaS  Platform as a Service 
PBX  Private Branch Exchange 
PC  Personal Computer 
PEBKAC  Problem Exists Between Keyboard and Computer 
PHI  Personal Health Information 
PICNIC  Problem in chair not in computer 
PMDC  Portable Modular Data Center 
POTS  Plain Old Telephone System 
PSAP  Public Safety Answering Point 
PSTN  Public Switched Telephone Network 
P2V  Physical to Virtual 
RAM  Random Access Memory 
ROBO  Remote Office/Branch Office 
SaaS  Software as a Solution 
SAN  Storage Area Network 
SATA  Serial Advanced Technology Attachment 
SOA  Service-Oriented Architecture 
SQL  Structured Query Language 
SSL  Secure Socket Layer 
SVGA  Super Video Graphics Array 
TCP/IP  Transmission Control Protocol/Internet Protocol 
TDM  Time-division Multiplexing 
UC  Unified Communications 
URL  Uniform Resource Locator 
VDI  Virtual Desktop Infrastructure 
VGA  Video Graphics Array 
VDN  Virtual LAN 
VoIP  Voice over Internet Protocol 
VM  Virtual Machine 
VPN  Virtual Private Network 
WAN  Wide Area Network

AT OUR OFFICE, WE ALLOW BYOD. MY IT PRO BROUGHT ME.
Glossary of power terms

In the following glossary, we’ve attempted to capture the common terms related to UPS and power distribution products. If you look closely, you might see us trying to have a little fun!

Advanced Battery Management
A three-stage charging technique that automatically tests battery health. Provides advance notification when preventive maintenance is needed, allowing ample time to hot-swap batteries without ever having to shut down connected equipment significantly extending the life of your UPS’s battery (and, quite possibly, your contract).

Alternating Current (AC)
An electric current that reverses its direction at regularly recurring intervals, as opposed to direct current, which is constant. Usually in a sine wave pattern, for optimal transmission of energy.

Ampere (A or Amp)
The unit of measure for the rate of flow of electricity, analogous to gallons per minute. VA x 0.7 (power factor) = watts

Apparent Power
Applied voltage multiplied by current in an AC circuit which doesn’t take the power factor into account. Unit is volt amperes (VA).

Arc
Sparking that results when undesirable current flows between two points of differing potential due to leakage through the intermediate insulation or a leakage path due to contamination. In astronomy, an arc is the part of a circle representing the apparent course of a heavenly body.

Audible Noise
A measure of the noise emanating from a device at audible frequencies.

Backup Time
The amount of time the battery in a UPS is designed to support the load.

Balanced Load
(1) AC power system using more than two wires, where the current and voltage are of equal value in each energized conductor. (2) Laundry with equal parts of light and dark clothes.

Battery String
A group of batteries connected together in a series.

Blackout
A zero-voltage condition lasting for more than two cycles. Also known as a power outage or failure.

British Thermal Unit (BTU)
Used to measure heat dissipation and is the amount of energy required to raise one pound of water one degree Fahrenheit. One pound of water at 32°F requires the transfer of 144 BTUs to freeze into solid ice.

Brown Field
An existing data center—often with capabilities.

Crest Factor
Usually refers to current. It’s the mathematical relationship between RMS and peak current. A normal resistive load will have a crest factor of 1.4142, which is the normal relationship between peak and RMS current. A typical PC will have a crest factor of 3. Unrelated to toothpaste.

Critical Equipment
Equipment such as computers, communications systems or electronic process controls, which must be continuously available.

Delta Connection
A circuit formed by connecting three electrical devices in series to form a closed loop; most often used in three-phase connections. If you fly Delta Airlines, this most likely takes place in Atlanta, Salt Lake City or Cincinnati.

Derating
A reduction of some operating parameters to compensate for a change in one or more other parameters. In power systems, the output power rating is generally reduced at elevated temperatures.

Direct Current (DC)
An electric current in which the flow of electrons is in one direction, such as supplied by a battery.

Eaton 9130 equipped with a communication bay.
DC Distribution (DCD)  
A module in a DC power system that distributes DC power to the loads. It also provides protection for the load cables.

DC Power System  
An AC to DC power supply with integrated control and monitoring, and standby batteries designed to supply no-break DC power (usually 24V or 48V) to telecommunications and IT network equipment.

Double Conversion  
A UPS design in which the primary power path consists of a rectifier and inverter. It isolates the output power from all input anomalies such as low voltage surges and frequency variations.

Downtime  
The time during which a functional unit can’t be used because of a fault within it or the environment.

Dry Contacts  
Dry contact refers to a contact of a relay that does not make or break a current.

Efficiency  
The ratio of output to input power. Generally measured at full-load and nominal line conditions. If the power efficiency of a device is 90 percent, you get back 90 watts for every 100 you put in, and the rest is mainly dissipated as heat from the filtration process. To think of it another way, this would be equivalent to a bartender pouring off about an ounce and a half of your beer before handing you the remaining 14.5 ounces!

Electrical Line Noise  
Radio frequency interference (RFI), electromagnetic interference (EMI) and other voltage or frequency disturbances.

Electromagnetic Interference (EMI)  
Electrical interference that can cause equipment to work improperly. EMI can be separated into conducted EMI (interference conducted through cables out of the UPS) and radiated EMI (interference conducted through the air).

Energy Saver System (ESS)  
Innovative technology from Eaton that enables select UPS models to operate at 99 percent efficiency without compromising reliability—not to be confused with inferior “eco” modes.

ePDU  
A power distribution unit that mounts to rack enclosures and distributes power to connected devices via a wide variety of output receptacles.

Federal Communications Commission (FCC)  
A U.S. federal regulating body whose new EMI limitations are affecting the design and production of digital electronics systems and their related subassemblies.

Flooded Batteries  
A form of battery where the plates are completely immersed in a liquid electrolyte.

Frequency  
The number of complete cycles of AC voltage that occur during one second (Hz). In North America, electrical current is supplied at 60 Hz, or 60 cycles per second.

Green Field  
A new data center with many possibilities for sustainable and energy-efficient designs.

Ground  
A conducting connection, whether intentional or accidental, by which an electric circuit or equipment is connected to the earth, or to some conducting body of relatively large extent that serves in its place.

Harmonics  
A sinusoidal component of an AC voltage that’s multiple of the fundamental waveform frequency. Certain harmonic patterns may cause equipment problems.

Harmonic Distortion  
Regularly appearing distortion of the sine wave which is converted into a complex waveform at a multiple of the fundamental frequency.

Hertz (Hz)  
A unit of frequency equal to one cycle per second.

High Efficiency Mode  
A mode of UPS operation that cuts energy usage and operating costs.

High Voltage (HV)  
In the context of UPS products, high voltage is anything ≥200V. 200V, 208V, 220V, 230V, 240V, 250V, 480V and 600V.

High Voltage Spike  
Rapid voltage peaks up to 6,000 volts.

Hot Swappable  
The ability to change a module without taking the critical load off the UPS. Also see “user replaceable.”

Insulated Gate Bipolar Transistor (IGBT)  
A three-terminal power semiconductor device, noted for high efficiency and fast switching. It switches electric power in many modern appliances such as electric cars, trains and UPSs.

Impedance  
The total opposition to alternating current flow in an electrical circuit.

Input Voltage Range  
The voltage range within which a UPS operates in “normal” mode and doesn’t require battery power.

Inrush Current  
The maximum, instantaneous input current drawn by an electrical device when first turned on. Some electrical devices draw several times their normal full-load current when initially energized.

Inverter  
UPS assembly that converts internal DC power to output AC power to run the user’s equipment. When the inverter is supporting 100 percent of the load at all times, as with an online UPS, there is no break from utility to battery power.

IT Mullet or Business Mullet  
Blazer on the top, jeans on the bottom.

Kilovolt Ampere (kVA)  
A common measurement of equipment capacity equaling 1000 volt-amperes. An approximation of available power in an AC system that does not take the power factor into account.

Kinetic Energy  
The energy an object possesses because of its motion.

Line Conditioner  
A device intended to improve the quality of the power that’s delivered to electrical load equipment. A line conditioner is generally designed to improve power quality (e.g., proper voltage level, noise suppression, transient impulse protection, etc.).

Line Interactive  
An offline UPS topology in which the system interacts with the utility line to regulate the power to the load. Provides better protection than a standby system but isn’t as fully prepared against irregularities as a full double-conversion system, making it the "Goldilocks" of UPS topologies.

Linear Load  
AC electrical loads where the voltage and current waveforms are sinusoidal. The current at any time is proportional to voltage.

Load  
The equipment connected to and protected by a UPS. Pretty rockin’ Metallica album.

Load Segment  
UPS configuration with separate receptacle groups, enabling scheduled shutdowns and maximum backup power time for critical devices.

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Ohm’s Law
The voltage (E) is equal to the current (I) times the resistance (R). The formula is written: E=IR.

Online
(1) A UPS that provides power to the load from its inverter 100 percent of the time, regulating BOTH voltage and frequency, usually using double-conversion topology. (2) The most convenient way to shop, bank, get news, etc.

Orderly Shutdown
The sequenced shutdown of units comprising a computer system to prevent damage to it and subsequent corruption or loss of data.

Output Waveform (UPS)
The shape of the graph of alternating current on the output side of a UPS. The highest quality of an output waveform from a UPS is the sine wave, but, some UPSs provide step waves or modified sine waves.

Sine Wave

Parallel Operation
The ability of UPSs to be connected so the current from corresponding outputs can be combined into a single load.

Partition
A logical division of a hard disk created to have different operating systems on the same hard disk or to create the appearance of having separate hard drives for file management, multiple users, or other purposes.

Peak Demand
The highest 15- or 30-minute demand recorded during a 12-month period.

Phase
The time relationship between current and voltage in AC circuits.

Plenum Cable
Cable that’s laid in the plenum spaces of buildings to facilitate air circulation for heating and air conditioning systems. The plenum space is typically used to house computer and telephone network communication cables. Cable that runs between floors in non-plenum areas is rated as riser cable.

Plug and Play
An electrical device that doesn’t require extensive setup to operate.

Power Factor (PF)
(1) The ratio of real power to apparent power. Watts divided by VA. Most power supplies used in communication and computer equipment have a power factor of 0.9. (PF = 0.9)

Power Surge
Low voltage (below nominal 120 volts).

Power Surge
High voltage (above nominal 120 volts).

Pulse Width Modulation (PWM)
A circuit used in switching regulated power supplies where the switching frequency is held constant and the width of the power pulse is varied, controlling both lines and load changes with minimal dissipation.

Rackmount
Ability to mount an electrical assembly into a standardized rack. Generally stacked up to 42U and 19 inches wide —about the size of a pizza box but not as greasy.

Rack Unit (U)
A unit of height measurement in a rack enclosure. A U is equivalent to 1.75 inches.

Rectifier Magazine (RM)
(1) The standard for serial interfaces (serial refers to the eight bits of each character successively sent down one wire) used by most computers, modems and printers. (2) A little known droid in the Star Wars trilogy.

Redundancy
The ability to connect units in parallel so if one fails the other(s) will provide continual power to the load. This mode is used in systems when power failure can’t be tolerated.

Relay Communication
Communication between a UPS and a computer through the opening and closing of solid-state relays that are pre-defined to indicate UPS status.

Root Mean Square (RMS)
A modified average. Averaging a sine wave would give a zero, so to obtain meaningful values, the wave is first squared (S), then averaged over one period (M) and finally the square root taken (R). In a sine wave, the factor between RMS and peak is the square root of two. If you know what that means, you’re pretty smart!

RS-232
(1) The standard for serial interfaces (serial refers to the eight bits of each character successively sent down one wire) used by most computers, modems and printers. (2) A little known droid in the Star Wars trilogy.
Server room
Dedicated computer room with some power and cooling, typically within an office environment. Minimal redundancy for power and cooling distribution. Singular source of power and cooling. (451 Research)

Server closet
Small room or closet with little to no redundancy power and cooling distribution. Singular source of power and cooling. (451 Research)

Simple Network Management Protocol (SNMP)
A User Datagram Protocol (UDP)-based network protocol. It’s used mostly in network management systems to monitor network-attached devices for conditions that warrant administrative attention.

Sine Wave
A mathematical function that plots three qualities of an electrical signal over time: amplitude, frequency and phase. Clean, uninterrupted power is represented by a sine wave, which can also resemble ocean waves, though they’re rarely perfect.

Single Phase
(1) Power system with one primary waveform. Lower-capacity distribution of power using only one portion of a power source that’s three-phase, like what’s supplied by most electric utilities. Used for heating and lighting, no large motors or other heavy-drain devices. (2) That part of junior high school in which you briefly refer to a neutral connection with a transformer. The capabilities for output are:

- Phase to neutral 100, 110, 120 or 127 Vac
- Phase to phase 200, 208, 220, 230, 240 Vac

Standby
(1) UPS type that “stands by,” waiting for a power problem from the utility company and rapidly switching to UPS battery power to protect equipment against power failures, sags and surges. (2) The person you call after your hot date falls through, and the two of you go out for milkshakes in your sweatpants instead.

Static Switch
An electrical component in a UPS that turns power flow on and off on command without moving or mechanical components.

Step Load
An instantaneous change in the loading conditions presented to the output of a UPS.

Technischer Überwachungs-Verein (TUV)
An independent non-profit organization that tests and certifies electrical equipment for public safety in the U.S. and worldwide.

The Far Side
The greatest cartoon strip ever. Created by Gary Larson.

Thermal Regulation
Monitoring the temperature of the batteries to ensure proper charging.

Three Phase
(1) Power supplied through at least three wires, each carrying power from a common generator but offset in its cycle from the other two. Used for heavy-duty applications. (2) The universal healing parameter, typically associated with input voltage or output loading parameters. (2) Transient killer whale pods are generally comprised of an adult female and two or three of her offspring. Among the differences between residents and transients are that while resident orcas of both sexes stay within shouting distance of their mothers their entire lives, only first-born male transients maintain such intense fidelity to their mothers.

Unbalanced Load
(1) AC power system using more than two wires, where the current is not equal due to an uneven loading of the phases. (2) A load that makes your washing machine go, “whump, whump, whump.”

Underwriters Laboratories (UL)
An independent non-profit organization that tests for public safety in the U.S. UL recognition is required for equipment used in some applications.

Uninterruptible Power System (UPS)
(1) An electrical system designed to provide instant, transient-free backup power during power failure or fault. Some UPSs also filter and/or regulate utility power (line conditioning). (2) A Device whose sole purpose is to save your equipment, your data and your job.

User Replaceable
Capable of being replaced by an end user. Connected equipment may need to be shut down first. Also see “hot swappable.”

Variable Module Management System (VMMS)
Innovative technology from Eaton that minimizes UPS efficiencies at low load levels while supplying the load with continuous double-conversion power.

Virtualization
The creation of a virtual (rather than actual) version of something, such as an operating system, server, storage device or network resource. Operating system virtualization is the use of software to allow a piece of hardware to run multiple operating system images at the same time.

Voltage (V)
Electrical pressure that pushes current through a circuit. High voltage in a computer circuit is represented by 1, while low (or zero) voltage is represented by 0.

Volt Amps (VA)
(1) The voltage applied to a given piece of equipment, multiplied by the current it draws. Not to be confused with watts, which are similar but represent the actual power drawn by the equipment, and can be somewhat lower than the VA rating. (2) Legendary Brigadier General from Planet Zap.

Watts (W)
The measure of real power. It’s the rate of doing electrical work. W x 1.3 = VA.

Wye Connection
A connection of three components made in such a manner that one end of each component is connected. It’s generally used to connect devices to a three-phase power system.