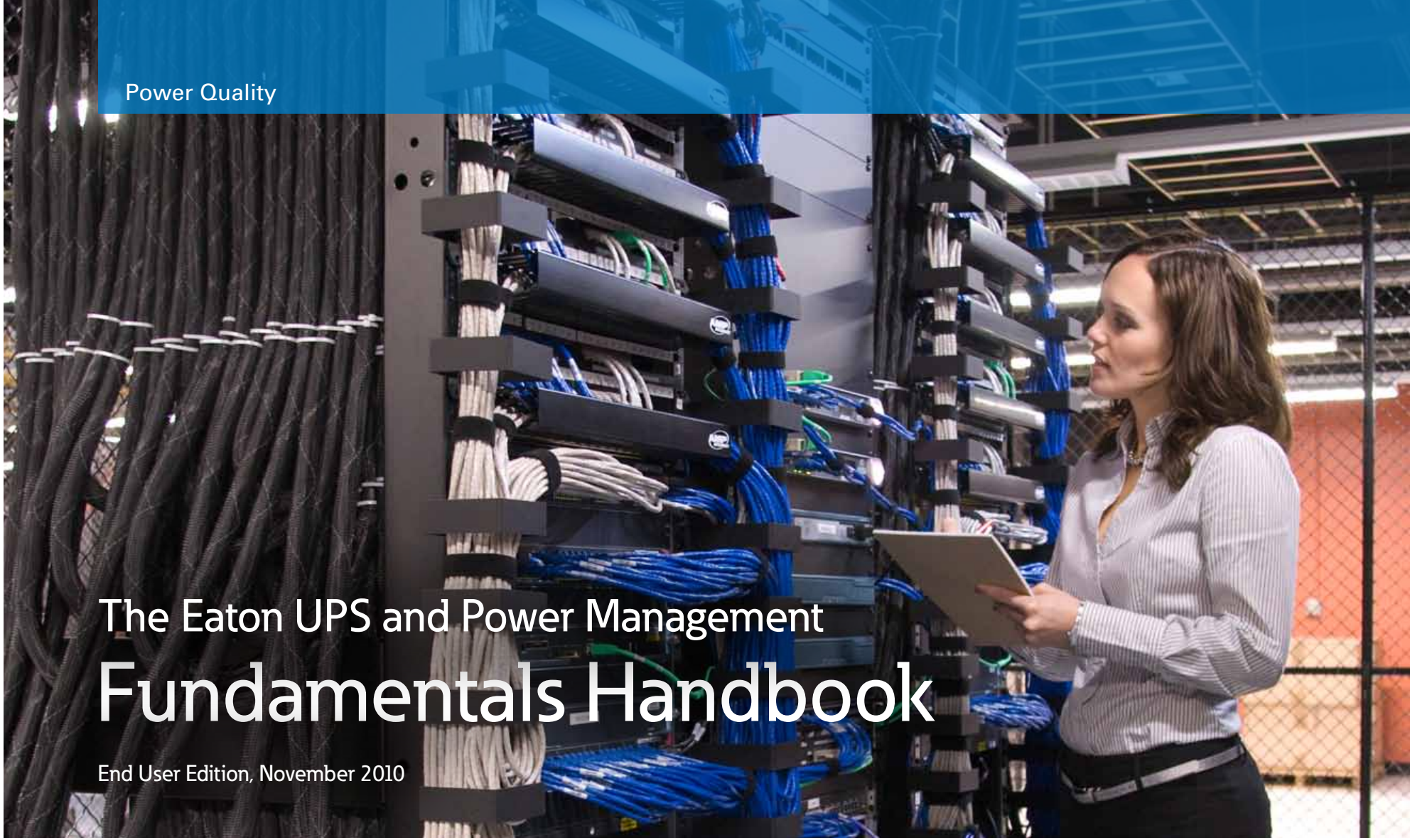

The Eaton UPS and Power Management Fundamentals Handbook

End User Edition, November 2010

EATON
AUTHORIZED
Power Specialist

TITAN POWER
DATA CENTER • DESIGN • BUILD • MAINTAIN

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Introduction

Welcome to the Eaton UPS and Power Management Fundamentals Handbook.

This comprehensive guide includes everything you need to understand about industry-leading power protection solutions from Eaton®.

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. We have also included valuable, real-world case studies that showcase exactly how Eaton can help you to develop the best power protection solution.

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, the Eaton UPS and Power Management Fundamentals Handbook is your one-stop source for essential information.

Why a UPS?

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

1. It prevents hardware damage typically caused by surges and spikes. Many UPS models continually condition incoming power as well.
2. It prevents 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. It provides availability for networks and other applications while preventing downtime. In some cases, UPSs provide enough battery runtime to ride through brief outages. In other cases, it provides hours of runtime to ride through extend power outages. UPSs are also paired with generators to provide enough time for the generator to power up.

Top UPS design considerations

The following factors outline the key design considerations to take into account when analyzing your needs. By assessing the information that they provide, you can make important trade-off decisions during the selection and purchase process. To see how to use these design considerations, please see the sample case studies starting on page 36.

1. Power environment: single and three phase

Understanding your existing power infrastructure is a crucial step in the selection process. Many existing computer rooms and small to mid-sized data centers have single-phase loads at the rack level. While ground-up designs are increasingly moving three-phase power to the point of utilization in order to gain efficiencies and reduce costs, creating great opportunity for three-phase solutions in new construction.

2. Installation environment

It is 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 load is one of the most important factors in identifying the right UPS. After identifying the power environment (if the UPS needs to be single-phase or three-phase), the size of the UPS further narrows down 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

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 can help contribution to the development of an end-to-end solution.

Generally, the amount of runtime required can significantly affect the cost of a solution. However, many Eaton solutions are actually more cost effective in extended runtime applications.

5. Scalability

It's always important to consider your future expansion needs when evaluating a solution. Eaton's scalable UPS solutions provide a competitive advantage by offering you 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.

If you have budget constraints, a UPS with inherent scalability often proves to be the best value in the long run, allowing you to increase capacity without having to purchase additional hardware. A simple kVA upgrade is all that's needed to enable a UPS with inherent scalability to operate at full capacity.

If you have an internal IT or facilities staff and service your own equipment, you may prefer to add capacity by purchasing additional modules that can be added in an expandable chassis or rack as your power load increases.

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 specific needs, a larger, centralized, non-modular system with inherent scalability might ultimately be the most cost-effective solution.

6. 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 other cases, you may need large PDUs to distribute power. Rack-based power strips or ePDU units may also be incorporated.

7. 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 e-mails, 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

8. 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. You should also look at the various UPS product designs to gauge how easy it is to swap out battery and power modules.

9. Budget

Although the latest performance features of a UPS products 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.

Other UPS design considerations

The following design guidelines should be reviewed and followed prior to ordering the appropriate UPS solution.

1. Check to see if there is 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). The site may have its own electrical contractors.

2. Find out the dimensions of the UPS and include any battery cabinets.

Make sure that the installation site has enough space available.

3. Ensure that the UPS can be placed in its final position.

Will the UPS components fit through doors? Are there any stairs? Please consult Eaton's website for detailed UPS dimensions and specifications: **www.eaton.com/power-quality.**

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 the UPS. You should not 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 are not waiting for this to be done after all of their equipment has arrived. Most small computers and rackmounted computers run on normal 120 volt, 15-amp electrical service. Some computers have a power cord that requires a higher voltage of 208V or 240V. In such cases, you will need a 3000 VA or larger UPS.

7. Hardwired connections.

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

8. Installing small UPS models behind larger UPS models.

If you are 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 are plugging a 1500 VA UPS into a 10,000 VA UPS, you must consider the 1500 VA load of the smaller UPS rather than just the load that is 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. Similar to a UPS, a generator provides backup power. However, auxiliary generators typically take 10-15 seconds to start up, depending upon generator type. For long term backup servers and IT equipment, this is not an optimal situation, so during this time the UPS kicks in. Basically, the UPS bridges the power gap between loss of power and when the generator comes on-line.

When designing your UPS solution, it is 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% efficient and second, generators need to account for step loads. In addition to accounting for step load, 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 20 kVA and below should be two times. Also, it is important to note that gas powered generators should be sized a bit larger.

10. Verify that the final UPS solution meets local building codes.

The facility manager is often the best contact to understand local building codes.

UPS form factors

With applications spanning from desktop to large data centers, UPSs come in a variety of form factors.

1

a b

2

3

4

5

a b

6

1. Desktop and tower UPS

a. The Eaton 3105 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 5115 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-post and 4-post racks)

4. Two-in-one rackmount/tower UPS

The Eaton 5130 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

6. Large tower UPS

The Eaton 9390 UPS is designed to be a central backup for multiple loads, including data centers

Input plugs and output receptacles

When you receive a UPS, you should be able to plug it in right away. If you receive a UPS and can't plug it into the wall socket, or can't plug your equipment into the UPS, 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 cannot 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. This procedure should only be done 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 have included the following chart to help you visually confirm input and output plug/receptacle options.

Input Plug and Output Receptacle Chart

5-15R	5-15P	5-20R	5-20P
			
L5-30R	L5-30P	6-15R	6-15P
			
L6-20R	L6-20P	L5-20R	L5-20P
			
IEC-320-C13 (female)	IEC-320-C14 (male)	IEC-320-C19 (female)	IEC-320-C20 (male)
			
L14-30R	L14-30P	IEC-309, 16A	IEC-309, 32A
			
L6-30R	L6-30P	Terminal Block (Hardwired)	
			

*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.

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 9390 are hardwired to incoming utility power

4. Additional Receptacles

Eaton ePDU products mount easily into racks and provide additional receptacles

1

2

3

4

UPS startup

Self startup

UPSs equipped with a standard input plug (units 1500 VA and below) that fit 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. Once it is in place, you should have little problem installing the UPS.

Assisted startup

Many end users do not feel comfortable installing electrical equipment. And 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. End users can also hire a systems integrator, electrician or third-party service organization to install and setup the UPS.

Manufacturer-required startup

Many three-phase UPS models (typically >40 kVA) must be started up by the UPS manufacturer to ensure that the UPS is installed and calibrated properly. In general, electricians and contractors do not have the required in-depth knowledge of the UPS. These manufacturer-trained field technicians provide and overview of the equipment and a tutorial of how to operate the UPS.

The basics of voltage, amperes and frequency

When discussing and dealing with electricity and electrical products, several terms are used to specify electrical characteristics. Three of the most common are voltage, amperes and frequency.

In layman's terms, volts (V) is a measure of the "pressure" with which electricity moves through a wire/circuit, while amperes or amps (A) is a measure of the "volume." Volts and amps are often compared to water in a hose, with volts representing the amount of pressure there is and amps representing the volume of water. When you turn on a garden hose without a nozzle, there is a lot of water (amps) but not much pressure (volts). But by placing your thumb over the end of the hose, you reduce the quantity (amps) but increase the pressure (volts), so it squirts farther.

Applying this analogy to electricity, the number of amps signifies how many electrons are flowing in the wire, while the number of volts characterizes how hard those electrons are being pushed. For an equivalent voltage, a wire carrying more amps needs to be a larger diameter, similar to a fire hose operating at the same pressure as a garden hose would obviously deliver a greater amount of water.

Frequency, on the other hand, is the number of times per second (Hz) that the electrical signal oscillates. Frequency in household voltages may vary based on geographic location, while industrial voltages can often be customized to meet specific site requirements.

Ensuring that the volts, amps and frequency of connected equipment are compatible with the supply of electricity is much like filling up a car with the appropriate type of fuel. Just as diesel fuel would not power a gasoline-driven car, a 120V, 15A, 60 Hz device cannot be connected to a 240V, 15A, 50 Hz outlet.

Decentralized or central UPS?

Decentralized or central UPS?

Is a single, larger UPS better? Or is it better to have multiple, smaller UPSs? Naturally, the answer is that it depends. The appropriate selection 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 encompass a number of factors to consider when making a decision between a decentralized UPS and a central UPS.

Central UPS

Why you would choose a central UPS solution	Why you would not
Typically the sales and service life of the UPS is longer.	A single UPS can mean single point of failure. You can overcome this concern with a N+1 or N+X UPS for redundancy.
A single UPS is easier to monitor, service and maintain than lots of smaller UPSs.	The single UPS may not be in close physical proximity to the equipment that it will protect. All of the equipment may not be fed by a single electrical distribution panel.
Larger UPS will be three-phase and/or 208V and often result in more efficient operation and lower operating costs.	There is no space for a large UPS.
A central UPS is often housed away from high traffic areas. As a result, it is less easily disrupted, accidentally damaged or maliciously interfered with.	Generally requires trained service technician or electrician to service, maintain or install.
A central UPS can be located where cooling is more tightly controlled. Remember, heat is the enemy of the batteries inside a UPS.	A central UPS may incur higher installation and wiring costs.
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 twenty UPSs?	

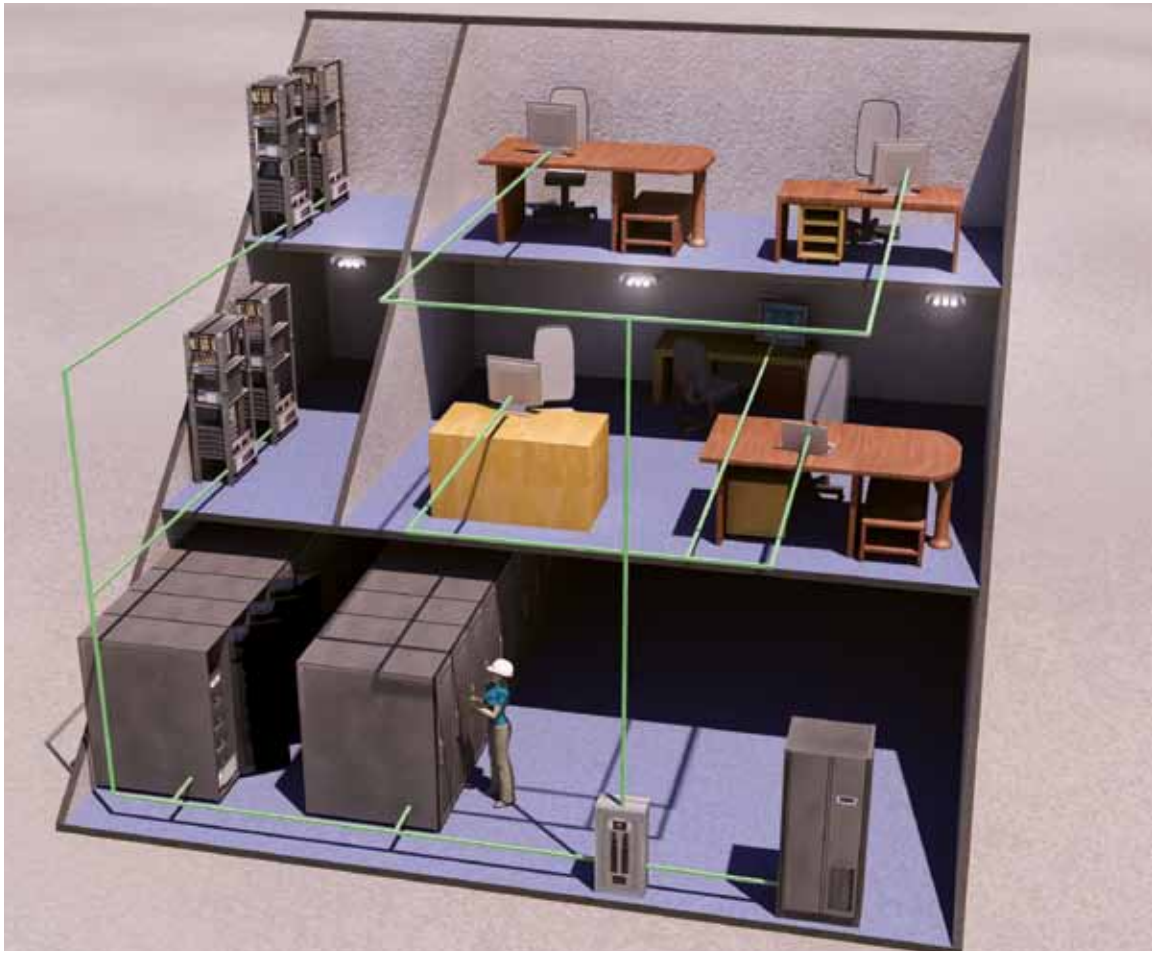


Figure 1

Combining the configurations

It is important to keep in mind that decentralized and centralized power protection deployment strategies are not 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

Why you would choose a decentralized UPS configuration	Why you would not
No rewiring is required. Use existing wall sockets.	If the building is supported by a generator, smaller standby and line-interactive UPSs may not be able to function while the generator is running.
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.	No central panelboard exists or there's no room for the UPS.
If you have no idea how much your company will grow and do not want to get locked into a particular UPS.	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.
You already have a number of smaller UPS units that are fairly new and you do not want to discard them. (Most UPS manufactures offer a trade-in program.)	If 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.
Power conditioning is implemented at the point of use, which mitigates any electrical disturbances that may be coupled into the distribution wiring of centralized system.	Adding redundancy, extended runtime or maintenance bypass functionality to multiple UPSs can be costly.
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 add additional battery modules for less critical equipment.	Multiple audible alarms/alerts may be irritating.

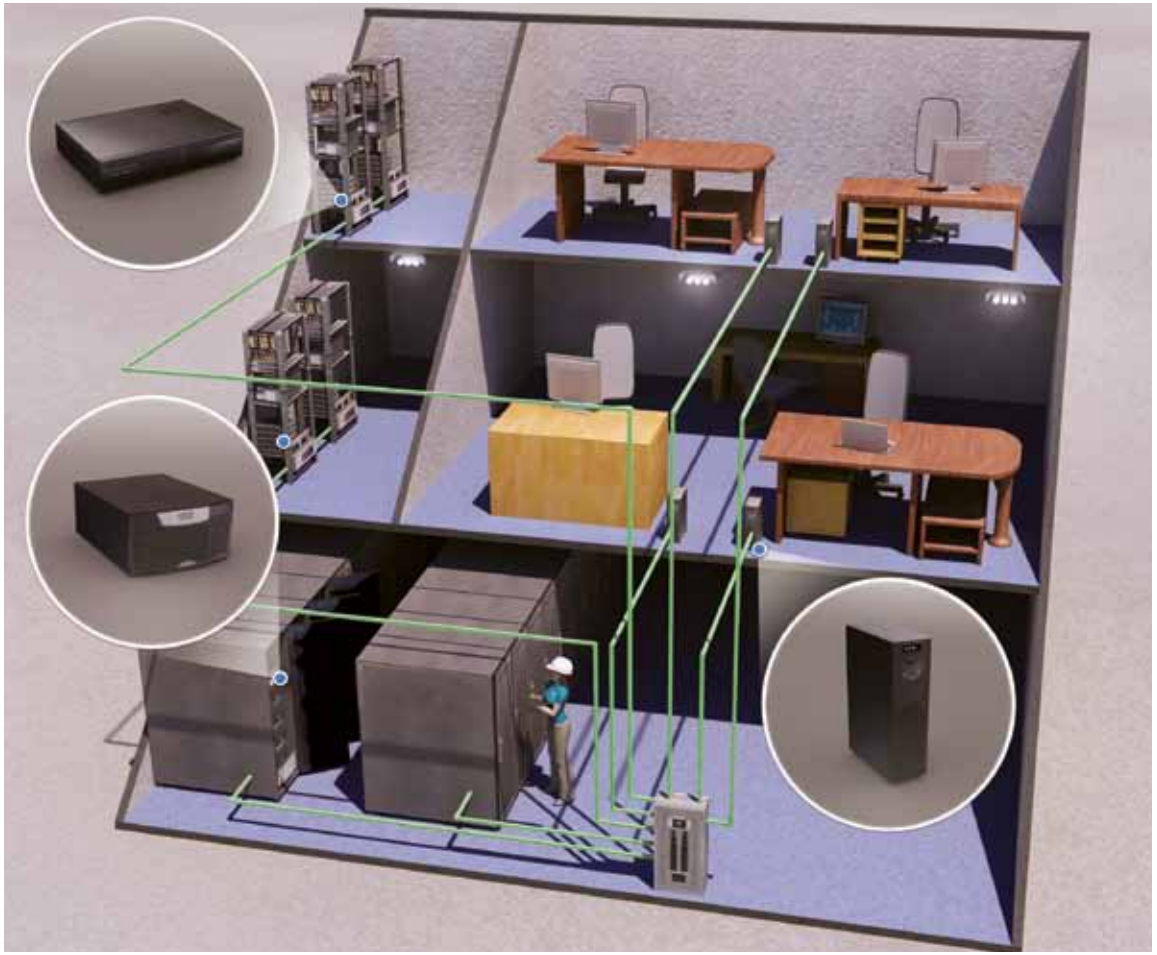


Figure 2

What is three-phase power?

Three-phase power is the most efficient way to distribute power over long distances and allows for large industrial equipment to operate more efficiently. Three-phase power is characterized by three single-phase waves which are offset in their phase angel 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 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 the single-phase outlet as illustrated in Figure 2, there is 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).

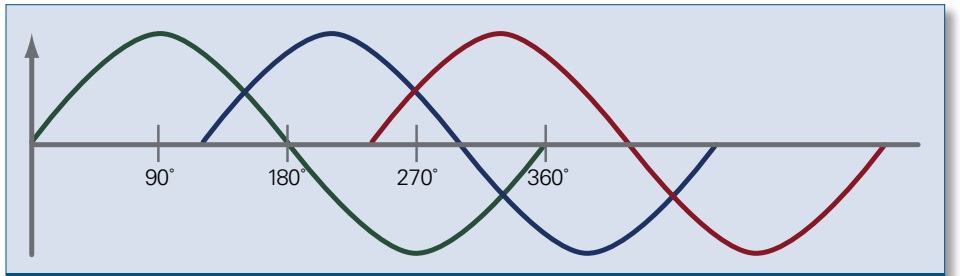


Figure 1. Three-phase power

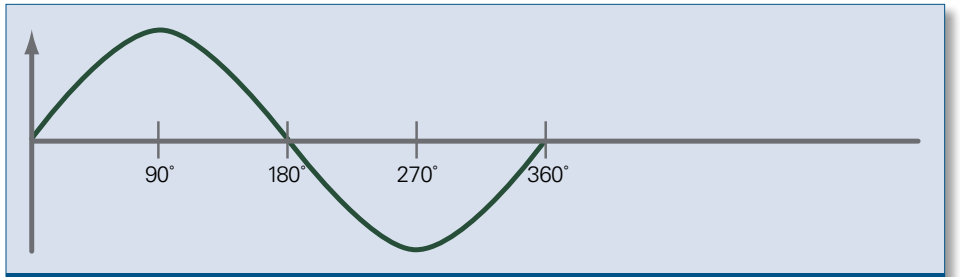


Figure 2. Single-phase power

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 utilize 208V UPSs, which maximizes energy efficiency and uptime, as well as saves money. IT devices that are 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.

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

When operating at 208 volts, a 1.0 to 2.0 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 in, there is an additional 1.5 to 2.0 percent savings. Factor in cooling efficiencies and the savings can add up to between 4 and 8 percent, which translates to about $70 per power supply. When multiplied by the number of power supplies in the server rack, the savings certainly justifies making the switch to 208 volts, especially when expanding or moving into a new location.

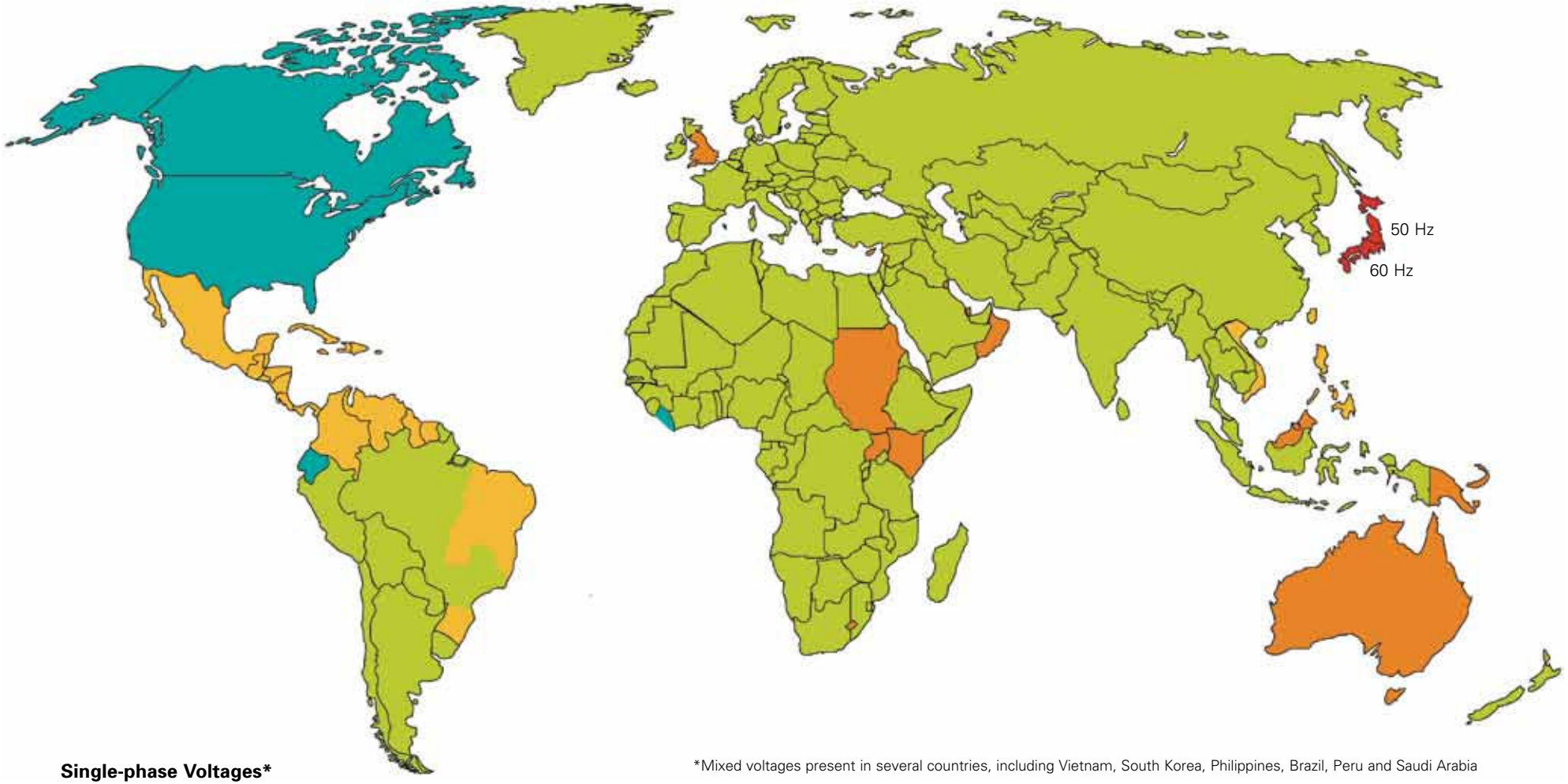
One of the main reasons that customers in the U.S. have been reluctant to switch to high voltage is that high voltage UPSs are typically fitted with IEC outlets (or even inlets) and customers do not know how to connect them to IT equipment with a traditional NEMA plug. However, all IT power supplies 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.

To read the complete white paper on this subject, please visit **www.eaton.com/pq/whitepapers.**

Making the connections

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

Worldwide voltage map



Single-phase Voltages*

- 110-127V; 60 Hz (also 208V; 60 Hz)
- 110-127V; 60 Hz
- 100V
- 220/230V; 50 Hz
- 240V; 50 Hz

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

Worldwide voltages

Country	Single-phase voltage (V)	Three-phase voltage (V)	Frequency (Hz)
Afghanistan	220	380	50
Albania	230	400	50
Algeria	127/220	400	50
American Samoa	120/240	208	60
Andorra	230	400	50
Angola	220	380	50
Antigua	230	400	60
Armenia	230	380	50
Argentina	220	380	50
Aruba	115/127	220	60
Australia	240	415	50
Austria	220-230	400	50
Azerbaijan	220	380	50
Azores (Portugal)	220	400	50
Bahamas	120	208	60
Bahrain	220	400	50
Balearic Islands	230	400	50
Bangladesh	220	380	50
Barbados	115	200	50
Belarus	220	380	50
Belgium	220-230	400	50
Belize	110	190/380	60
Benin	220	380	50
Bermuda	120	208	60
Bhutan	230	400	50
Bolivia	110-115/220	400	50
Bosnia-Herzegovina	220	400	50
Botswana	220	400	50
Brazil	110-127 220	220/380/ 440	60 60
Brunei	240	415	50
Bulgaria	220	400	50
BurkinaFaso	220	380	50
Burundi	220	380	50
Cambodia	120/220	400	50
Cameroon	220-230	380	50
Canada	120	208/240/600	60
Canary Islands (Spain)	220	400	50
Cape Verde	220	400	50
Cayman Islands	120	208	60
Central African Republic	220	380	50
Chad	220	380	50
Channel Islands	240	400	50
Chile	220	380	50
China	220	380	50
Colombia	110-220	440	60
Congo	220	400	50
Congo, Dem. Rep. of (formerly Zaire)	220	380	50
Cook Islands	240	415	50
Costa Rica	120	240	60
Croatia	220	400	50
Cuba	120	190	60
Cyprus	240	400	50
Czech Republic	220	400	50
Denmark	220-230	400	50
Djibouti	220	380	50
Dominica	230	400	50
Dominican Republic	110	120/208/ 227/480	60
Ecuador	120	190	60
Egypt	220	380	50
El Salvador	115	200	60
England	240	400	50
Estonia	220	400	50
Ethiopia	220	380	50
Faeroe Islands	230	400	50
Falkland Islands	240	415	50
Fiji	240	415	50
Finland	220-230	400	50
France	220-230	400	50
French Guiana	220	380	50
French Guyana	220	380	50
Gabon	220	380	50
Gambia	220	400	50
Gaza	230	400	50
Georgia	220	380	50
Germany	220-230	400	50
Ghana	220	400	50
Gibraltar	240	400	50
Greece	220-230	400	50
Greenland	220	400	50
Grenada	230	400	50
Guadeloupe	220	400	50
Guam	110-120	190	60
Guatemala	120	208	60
Guinea	220	208	50
Guinea-Bissau	220	380	50
Guyana	110	190	50-60
Haiti	110-120	190	50-60
Honduras	110	190	060
Hong Kong	200	380	50
Hungary	220	400	50
Iceland	220	400	50
India	220-250	400	50
Indonesia	220	400	50
Iran	220	400	50
Iraq	220	400	50
Ireland	220	400	50
Isle of Man	240	400	50
Israel	230	400	50
Italy	220-230	400	50
Ivory Coast	220	380	50
Jamaica	110	190	50
Japan	100	200	50&60
Jordan	220	400	50
Kazakhstan	220	380	50
Kenya	240	415	50
Korea, South	220	380	50&60
Kuwait	240	415	50
Kyrgystan	220	380	50
Laos	220	400	50
Latvia	220	400	50
Lebanon	110-220	400	50
Lesotho	240	380	50
Liberia	120	208	60
Libya	127-230	220/400	50
Liechtenstein	220	400	50
Lithuania	220	400	50
Luxembourg	220-230	400	50
Macau	220	380	50
Macedonia	230	400	50
Madagascar	220	220/380	50
Madeir (Portugal)	220	400	50
Malawi	230	400	50
Malaysia	240	415	50
Maldives	230	400	50
Mali	220	380	50
Malta	240	400	50
Martinique	220	380	60
Mauritania	220	220	50
Mauritius	230	400	50
Mexico	127	220/480	50
Moldova	220	380	50
Monaco	220	400	50
Mongolia	220	400	50
Montseurrat	230	400	60
Morocco	220	380	50
Mozambique	220	380	50
Myanmar	230	400	50
Namibia	220-250	380	50
Nauru	240	415	50
Nepal	220	400	50
Netherlands Antilles	120-127/220	220/380	50/60
Netherlands	220-230	400	50
New Caledonia	220	380	50
New Zealand	230	415	50
Nicaragua	120	208	60
Niger	220	380	50
Nigeria	230	400	50
Northern Ireland	240	400	50
Norway	220-230	400	50
Okinawa	110-120	200/230	60
Oman	240	415	50
Pakistan	230	400	50
Palau	120	208	60
Panama	110-120	190	60
Papua New Guinea	240	415	50
Paraguay	220	380	50
Peru	110/220	220	50/60
Philippines	115	380	60
Poland	240	400	50
Portugal	220	400	50
Puerto Rico	220-230	208	50
Qatar	240	415	50
Réunion Island	230	400	50
Romania	220	400	50
Russia	220	400	50
Rwanda	220	400	50
Saudi Arabia	127/220	190/380	50/60
Scotland	220	400	50
Senegal	220	400	50
Serbia	230	400	50
Seychelles	240	240	50
Sierra Leone	230	400	50
Singapore	230	400	50
Slovakia	220	400	50
Slovenia	230	400	50
Somalia	110/220	380	50
South Africa	220-230	400	50
Spain	220-230	400	50
Sri Lanka	230	400	50
St. Kitts & Nevis	230	400	60
St. Lucia	240	400	50
St. Vincent	230	400	50
Sudan	240	400	50
Surinam	115	220	60
Swaziland	230	400	50
Sweden	220-230	400	50
Switzerland	220-230	400	50
Syria	220	380	50
Tahiti	220	380	50
Taiwan	110	190	60
Tajikistan	220	380	50
Tanzania	230	400	50
Thailand	220/230	380	50
Togo	220	380	50
Tonga	115	415	60
Trinidad & Tobago	115/23	200	60
Tunisia	220	400	50
Turkey	220	400	50
Turkmenistan	220	380	50
Uganda	240	415	50
Ukraine	220	380	50
United Arab Emirates	220/230	415	50
United Kingdom	240	400	50
United States	120	277/480	60
Uruguay	220	220	50
Uzbekistan	220	380	50
Venezuela	120	240	60
Vietnam	120/220	380	50
Virgin Islands	120	190	60
Wales	220	400	50
Western Samoa	230	400	50
Yemen	220	400	50
Zambia	220	400	50
Zimbabwe	220	415	50

Nine power problems

And their UPS solutions

Eaton UPSs address any of the nine power protection problems to fulfill power protection, distribution and management needs in the office, computer networking, data center, telecommunications, healthcare and industrial markets. Low-cost products such as the Eaton 3105, 5110 and EX UPSs protect general desktop systems for small office/home office (SOHO) applications. The line-interactive and online UPSs such as the Eaton 5125, Evolution, EX, MX, MX Frame and BladeUPS are designed to safeguard a myriad of mission-critical systems including network servers and power hungry blade servers.

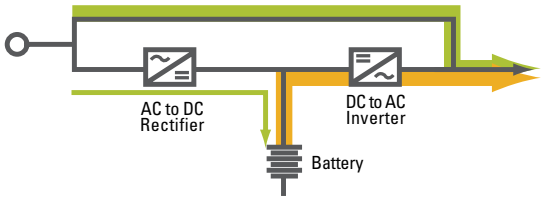
Power Problem		Definition*	Cause*	Solution
1 Power Failure		**A total loss of utility power**	Can be caused by a number of events: lightning strikes, downed power lines, grid over-demands, accidents and natural disasters.	Single-phase Series 3 UPS; Single-phase Series 5 UPS; Single- and Three-phase Series 9 UPS
2 Power Sag		**Short-term low voltage**	Triggered by the startup of large loads, utility switching, utility equipment failure, lightning and power service that's too small for the demand. In addition to crashes, sags can damage hardware.	
3 Power Surge (Spike)		**Short-term high voltage above 110% of nominal**	Can be caused by a lightning strike and can send line voltages to levels in excess of 6,000 volts. A spike almost always results in data loss or hardware damage.	
4 Under-voltage (Brownout)		**Reduced line voltage extended periods few minutes to days**	Can be caused by an intentional utility voltage reduction to conserve power during peak demand periods or other heavy loads that exceed supply capacity.	
5 Over-voltage		**Increased line voltage for extended periods of a few minutes to a few days**	Triggered by a rapid reduction in power loads, heavy equipment being turned off, or by utility switching. The results can potentially damage hardware.	
6 Electrical Line Noise		**High frequency waveform caused by EMI interference**	Can be caused by either RFI or EMI interference generated by transmitters, welding devices, SCR driven printers, lightning, etc.	
7 Frequency Variation		**A change in frequency stability**	Resulting from generator or small co-generation sites being loaded and unloaded. Frequency variation can cause erratic operation, data loss, system crashes and equipment damage.	
8 Switching Transient		**Instantaneous under-voltage (notch) in the range of nanoseconds**	Normal duration is shorter than a spike and generally falls in the range of nanoseconds.	
9 Harmonic Distortion		**Distortion of the normal line waveform, generally transmitted by nonlinear loads**	Switch mode power supplies, variable speed motors and drives, copiers and fax machines are examples of non-linear loads. Can cause communication errors, overheating and hardware damage.	

*Reference IEEE E-050R & old FIPS PUB 94

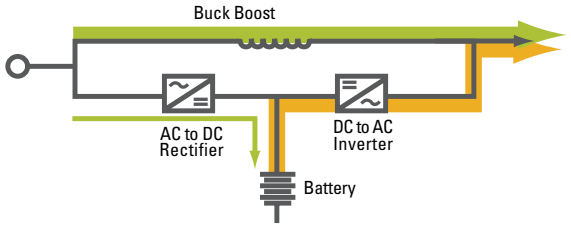
UPS topologies

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 you require, 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 the UPS switches to battery power to protect against sags, surges or outages. Because the band of normal operation is typically narrow, the UPS must resort to batteries frequently, which can reduce battery runtime and service life.



Line-interactive UPSs 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 typically switch to battery mode with a transfer time of 3-8 ms, which is within acceptable limits for most power supplies. Battery usage is lower than a standby UPS, but still higher than an online model.

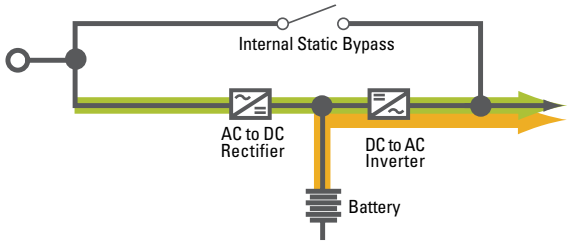


Normal Operation
Battery Power

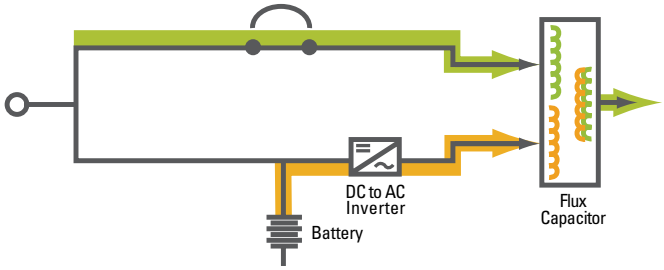
Online UPSs provide the highest level of protection by isolating equipment from raw utility power—converting power from AC to DC and back to AC again. When input voltage is within preset UPS tolerances, the output is regulated without going to battery. In this manner, the UPS uses the batteries less often and for less time than either standby or line-interactive designs. Many online UPSs allow an even wider input acceptance window when the UPS is below 100% load.

High-efficiency mode UPSs are among the latest generation of UPS models, successfully combining the benefits of both single- and double-conversion technologies. Under normal conditions when power falls within acceptable limits, the multi-mode UPS operates as a high-efficiency, energy-saving system, regulating voltage and resolving common utility power anomalies.

During erratic power or fleeting disturbances when AC input power falls outside of preset tolerances for line-interactive mode, the UPS switches to online double-conversion mode, completely isolating equipment from incoming power. If power is lost altogether, or the input power exceeds the tolerances of the double-conversion rectifier, the UPS relies on the battery to keep loads operating, converting back to high-efficiency mode when it is safe.



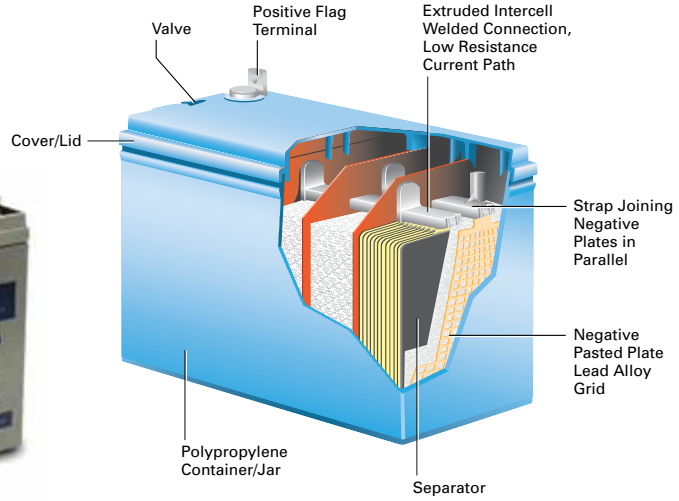
Ferroresonant UPSs operate similarly to line-interactive models with the exception that a ferroresonant transformer is used to condition the output and hold energy long enough to cover the time between switching from line power to battery power which effectively means a no-break transfer. Many ferroresonant 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 oil and gas, petrochemical, chemical, utility and heavy industry markets.



UPS battery overview

It's well known that the battery is the most vulnerable part of a UPS. In fact, battery failure is a leading cause of load loss. Yet understanding how to properly maintain and manage UPS batteries can not only extend battery service life, but can also help prevent costly downtime.

VRLA batteries are frequently used in UPS or other high-rate applications.



Internal and external components of a valve-regulated lead acid (VRLA) battery.

The most common type of battery used in UPSs is valve-regulated lead acid (VRLA) batteries, also known as sealed or maintenance free. 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 cannot 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 the life of the battery.

Frequently asked questions: batteries

1. What is the "end of useful life?"

The IEEE defines "end of useful life" for a UPS battery as being 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, remains the same regardless of UPS size, there are some inherent differences between large and small applications. First, 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 battery 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 allow the batteries to 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.

UPS models like the Eaton 9130 feature hot-swappable batteries for maximum uptime

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 does not increase the UPS capacity. Be sure your UPS is adequately sized for your load, then add batteries to fit your runtime needs.

Adding extended battery modules increases runtime but does not increase the power rating or capacity of the UPS

7. 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.

8. 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% longer than with standard models.

9. Why are batteries disconnected on small, single-phase UPSs when they are shipped?

This is done to ensure that they are in compliance with Department of Transportation regulations.

10. Does the UPS need to have a load on it to charge its batteries?

The UPS should have a minimum of 10% 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

11. 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 batteries. While this type of battery is sealed and you do not need to check the fluid level in the battery, 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 of the UPS.

12. 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 is important to note that the load is fully protected while the batteries are recharging. However, if the batteries are needed during the recharge time, the holdover time available will be less than it would have been if the batteries were fully charged.

13. 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.

14. What is thermal runaway?

Thermal runaway occurs when the heat generated in a lead-acid cell exceeds its ability to dissipate that heat, 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 overcharging, excessive charging, internal physical damage, internal short circuit or a hot environment.

15. 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

16. How is battery performance generally measured?

Batteries are generally rated for 100+ discharges and recharges, but many batteries 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.

Because the rated capacity of a battery is based on an ambient temperature of 25°C (77°F), any variation from this can affect performance and reduce battery life. For every 8.3°C (15°F) average annual temperature above 25°C (77°F), the life of the battery is reduced by 50 percent.

2. Battery chemistry.

UPS batteries are electro-chemical devices whose ability to store and deliver power slowly decreases over time. Even if all guidelines for storage, maintenance and usage are followed, batteries will still require replacement after a certain period of time.

3. Cycling.

After a UPS operates on battery power during a power failure, the battery is recharged for future use, which is called the discharge cycle. At installation, the battery is at 100 percent of its rated capacity, but each discharge and subsequent recharge slightly reduces the relative capacity of the battery. Once the chemistry is depleted, the cells fail and the battery must be replaced.

4. Maintenance.

For larger UPS models, service and maintenance of batteries are critical to the reliability of the UPS. Periodic preventive maintenance not only extends battery string life by preventing loose connections and removing corrosion, but can help identify ailing batteries before they fail. Even though sealed batteries are sometimes referred to as "maintenance free," they still require scheduled service, as "maintenance free" refers only to the fact that they do not require replacement fluid.

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 **www.eaton.com/upsbatteries.**

UPS software overview

Operating a UPS without power management software is kind of like driving in the rain without windshield wipers — you may be protected from the downpour, but your visibility only lasts for so long.

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 facilitating automatic, orderly shutdown of all connected devices during an extended outage, power management software delivers a broad spectrum of other advantages. The perfect complement to any UPS solution, management software keeps a constant pulse on network health through its monitoring and management capabilities.

Most power management software is shipped with the UPS and is usually available as a free download online as well. Power event notifications are available as audible alarms, pop-up alerts on a monitor, e-mails to pre-designated recipients based on the condition, text messages, phone calls from our remote monitoring center, and triggers for a multitude of network and building management systems to initiate the orderly shutdown of equipment.

Some software offerings are capable of delivering a global view across the network — often from any PC with an Internet browser. Software can also provide a complete log of events and of UPS utility data, which is invaluable when debugging a power anomaly. Many power management products have the ability to centralize alarms, organize data by customized views and maintain event logs for preventive maintenance of the entire installed equipment base.

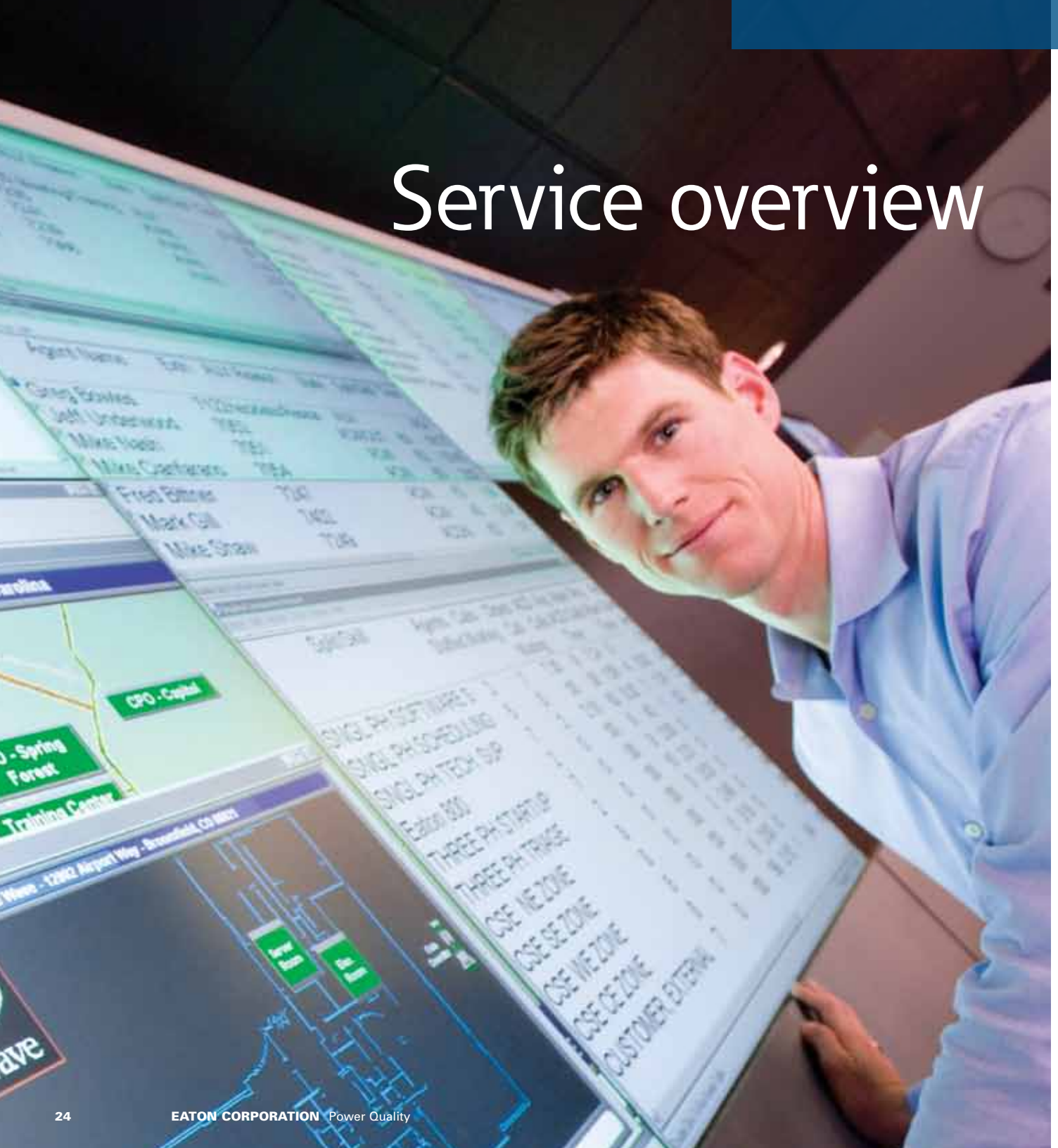
The more robust and versatile software offerings are compatible with devices that support a network interface, including all manufacturers' UPSs, environmental sensors, ePDUs and other devices. Furthermore, power management software enables load segment control for UPS models that support that feature.

Because power protection and management are just as vital for virtual machines as they are for physical servers, new software technologies have been specifically designed to provide monitoring and management capabilities in virtualized environments. Shutdown software is now compatible with VMware's ESXi and vSphere and Microsoft's Hyper-V, enabling graceful shutdown of multiple virtual machines.

To view an online demonstration of Eaton's power management software capabilities, please visit **www.eaton.com/intelligentpowermanager.**

Eaton's Intelligent Power Manager facilitates easy and versatile remote monitoring and management of multiple devices, keeping you apprised of power and environmental conditions.

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.

In fact, research indicates that regular preventive maintenance is crucial in order to achieve maximum performance from equipment. Studies show that routine preventive maintenance appreciably reduces the likelihood that a UPS will succumb to downtime. The 2007 Study of Root Causes of Load Losses compiled by Eaton revealed that customers without preventive maintenance visits were almost four times more likely to experience a UPS failure than those who complete the recommended two preventive maintenance visits per year.

All manufacturers' UPSs are complex devices that perform several critical power conditioning and backup supply functions and are subject to failure. Without proper maintenance, all UPSs will eventually fail over their useful life since critical components like batteries and capacitors will wear out from normal use. A good maintenance plan delivered by trained and experienced personnel can greatly minimize this risk of failure.

Types of UPS service

There are several UPS service delivery methods, designed to meet a variety of needs. These include:

- **Depot exchange repair or replace.** You contact the UPS service provider and ship the UPS to a repair facility. The service provider returns the repaired unit or a refurbished unit.
- **Advance swap depot exchange.** You contact the UPS service provider, who ships a refurbished unit to you and the original UPS unit is returned to a repair facility.
- **On-site repair.** You contact the UPS service provider and a factory-trained field technician arrives at 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 15 kVA can either be repaired at a depot or serviced on-site. Larger UPSs that are either hardwired (cannot be unplugged) or too heavy to ship can only be serviced via on-site field technicians.

Smaller UPS models are usually sent to a repair facility

Larger UPS models require on-site preventive maintenance visits for optimal performance

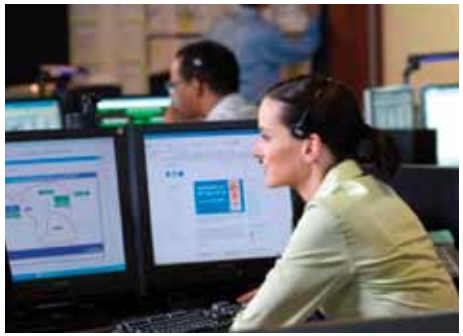
Types of service agreements

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), at least 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.
- **Extended warranty (or basic warranty)** may also be purchased for many UPS products. A warranty commonly covers specified parts and labor such as electronic components for a fixed period of time, but will not include 7x24 coverage or arrival response times. Nor will warranties include preventive maintenance, although extra services can be purchased in addition to a warranty extension. The more services that are added to a warranty, the closer it becomes to a support agreement.
- **Time and Material (T&M) service** is a pay-as-you-go approach in which the service provider makes a repair only when something breaks. T&M can be done either via depot repair or on-site, depending on the UPS. This method can be an unacceptable service solution, since it is often expensive, and there is the uncertainty of not knowing when a field technician will arrive. Because support agreement (contract) customers always take priority, T&M response times can require up to five days, based on the product and location for non-contract customers.

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.



Some UPS companies, such as Eaton, provide remote monitoring services

For more information on UPS service, and to access service-related white papers, please visit **www.eaton.com/upsservices.**

Frequently asked questions

We have compiled the following set of questions based on our extensive experience. For frequently asked questions about UPS batteries, please the UPS battery overview section on page 20.

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% capacity. In addition, the batteries degrade over time; by oversizing, you provide room for error. In the online Eaton UPS sizing tool **(www.eaton.com/powerquality)** we have 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 from downtime. 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 United States provides "three nines" of reliability—the power is available for 99.9% 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.

Reliability average	Non-availability per year
99%	88 hours
99.9%	8.8 hours
99.99%	53 minutes
99.999%	5.3 minutes
99.9999%	32 seconds
99.99999%+	3.2 seconds

9. How are phone systems and IT equipment affected by inconsistent power?

Fluctuating power is a waste of valuable time and money. If you expose your telephone systems (and any other electronic equipment) to inconsistent utility power, they are 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 your bottom line.

10. 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—which often requires several minutes to stabilize.

11. How much UPS capacity do I need?

Determine the total load (in watts) of the equipment you want to protect. Add 10–20% for future growth and decide the minimum amount of runtime you need. Use the online sizer at **(www.eaton.com/powerquality)** to identify the right solution for your application.

12. I already have surge protection. Why do I need a UPS?

Surge protection will not keep your business and phones operational during a blackout. In addition, surge protectors do nothing to improve the quality of power feeding your sensitive and expensive telecom equipment. The Eaton UPS provides perfect, clean power to your equipment at all times. Over time, poor quality power will degrade your equipment.

13. What happens if the UPS is overloaded? For example, if the protected equipment and/or load draws more current than the UPS can provide.

The UPS transfers the load to bypass (for a few minutes) until the overload condition is reversed. If the overload condition continues, the UPS automatically shuts down.

14. What causes a UPS to be overloaded?

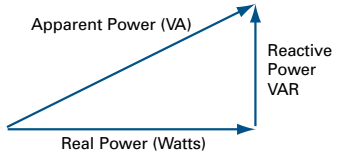
There are two possible answers: (1) the UPS was undersized (e.g. the load is was rated at 1200 VA but a 1000 VA UPS was provided), or (2) you plugged more equipment into the UPS than it was designed to handle.

15. What's the difference between VA and watts?

The engineering answer: In order to correctly size a UPS, it is important to understand the relationship between watts and VA. However, we must have a brief discussion about power terminology first. 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-amps 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 these 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:

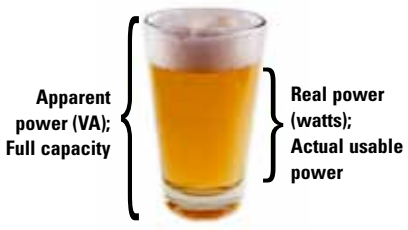
Watts = VA * Power Factor or VA = Watts / Power Factor

Since many types of equipment are rated in watts, it is 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 is rated at 525 watts and has a power factor of 0.7 results in a 750 VA load.

750 VA = 525 Watts / 0.7 PF

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

The answer for the rest of us:



16. How do you convert amps to VA?

Single phase: Multiply amps by voltage (120 volts in the U.S.). 10A x 120V = 1200 VA
Three phase: Amps x volts x 1.732 = VA

17. What is the difference between a centralized and a decentralized UPS solution?

In a centralized configuration, a larger UPS supports multiple loads from a single point. Centralized UPSs are often hardwired into an electrical panelboard. A decentralized configuration allows multiple UPSs to protect a handful of devices. Decentralized UPSs generally utilize plugs and receptacles for the input and output connections.

18. I have a 3000 VA UPS. Can I just plug the unit into a standard 15A-amp wall outlet?

Only UPSs with power ratings up to 1500 VA plug into a standard 15A-amp wall outlet. All others require a larger receptacle, which must be installed by an electrician.

19. 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' internal electronics. Eaton UPS software and connectivity cards enable remote monitoring and management capability, including graceful shutdown and load segment control.

20. 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 such as OpenManage, OpenView, Tivoli also support this. Extended Eaton Advanced MIBs are also available for greater levels of detail for the UPS. You can also remotely control your Eaton UPS using both the Eaton UPS Management software, and if you choose the optional connectivity card to go with your Eaton UPS, you can also control your UPS through a secure Web interface. The cards also allow for automated e-mail alerts for power events without needing to install any software at all.

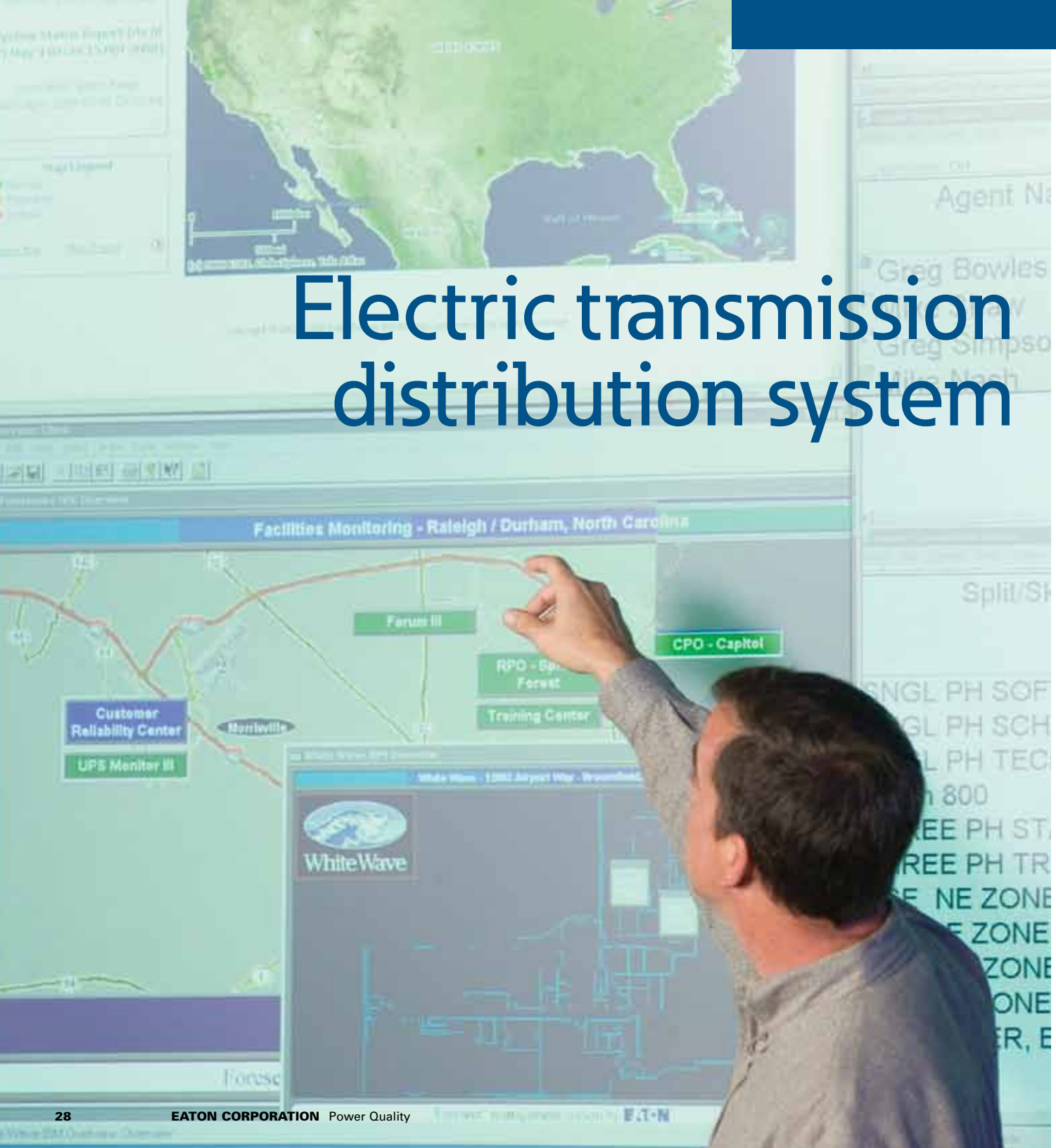
21. My data center only went down for a couple of minutes. What's the big deal?

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.

22. Where can I get technical help?

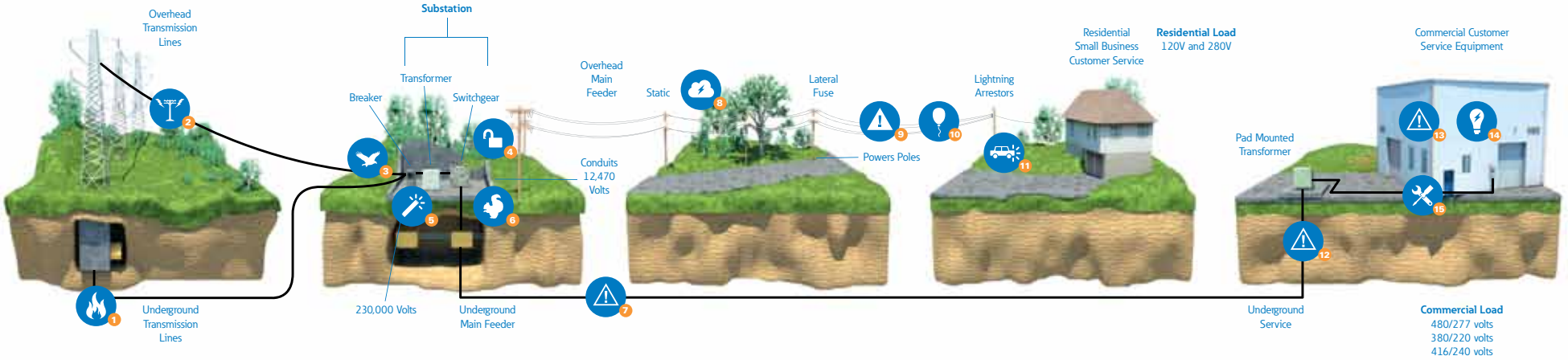
Contact your territory representative or call the Eaton UPS hotline at 1-800-356-5794 for pre-sales support and 1-800-356-5737 for technical support. You can also visit www.eaton.com/powerquality

Electric transmission distribution system



The flow of electricity begins at the utility company where it is created at the generating station. The voltage is then stepped up by a generator transformer at the station switchyard. This is done to minimize the cable size and electrical losses.

The transmission substation then increases the voltage. The voltage depends upon 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 cables. Distribution lines then carry the electricity to the end user. At or near each end user facility are transformers that adjust the voltages down to the proper level for use. For commercial use, the load can range from 416 volts to 480 volts, while residential use is typically 208/120 volts in the United States and Canada.

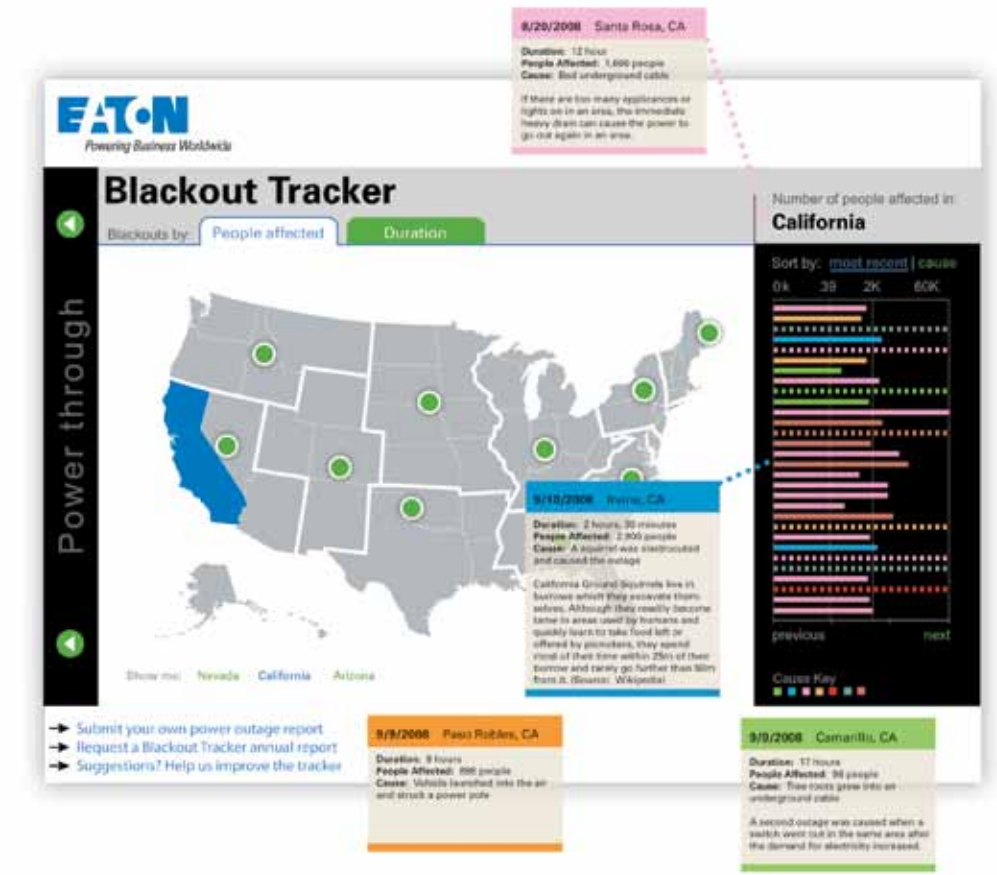


Threats to the system

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

1. Fire sparked by weak wire burns through line
2. Lighting strike damages transmission line
3. Bird flies in causing short circuit
4. Thieves stealing 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 which 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

Eaton's Blackout Tracker



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 **www.eaton.com/blackouttracker** to see this interactive tool and to 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. The losses from a power outage 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 company affected. According to the US 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 2009 U.S. national power

The following data was compiled by Eaton based on reported power outages during 2009.

Total number of people affected by outages	**13,566,778**
(This is the sum of the number of people affected by reported power outages in the USA for 2009.)	
Total duration of outages	**196,212 minutes** (approximately 3,270 hours or 136 days)
(This is the sum of the durations of the reported power outages for 2009.)	
Total number of outages	**2,840**
(The sum of the number of reported power outages for 2009.)	
Average number of people affected per outage	**7,483**
(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. Not all reports of outages included number of people affected. The number of outages used for this calculation can be found in the note following this table.)	
Average duration of outage	**194 minutes** (nearly 3.25 hours)
(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.)	

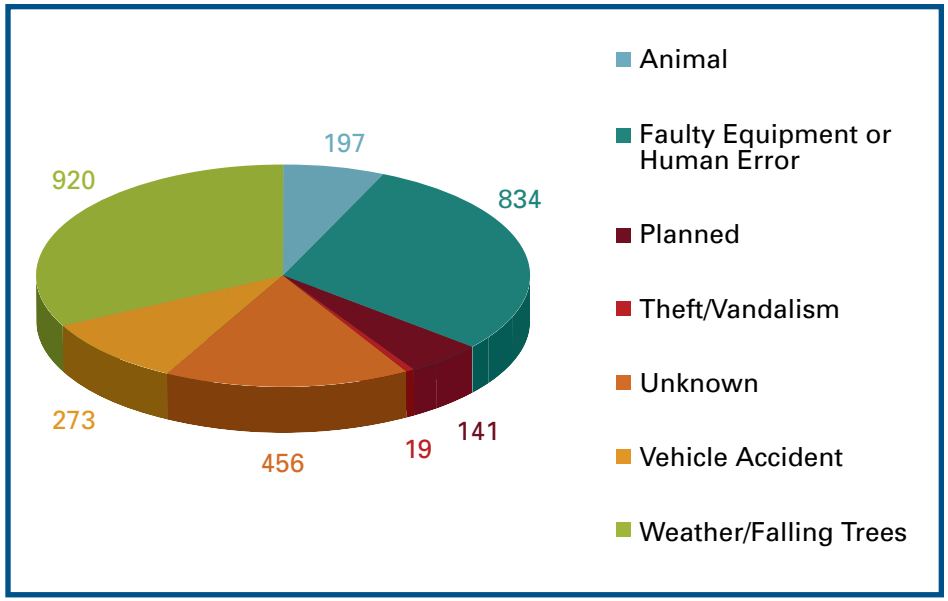
Notes:

a. Total number of people affected (and average) is based on 1,813 (64%) of the total reported outages. Total duration of outages (and average) is based on 1011 (36%) 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, Web sites, etc. that are 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 are counted as people.

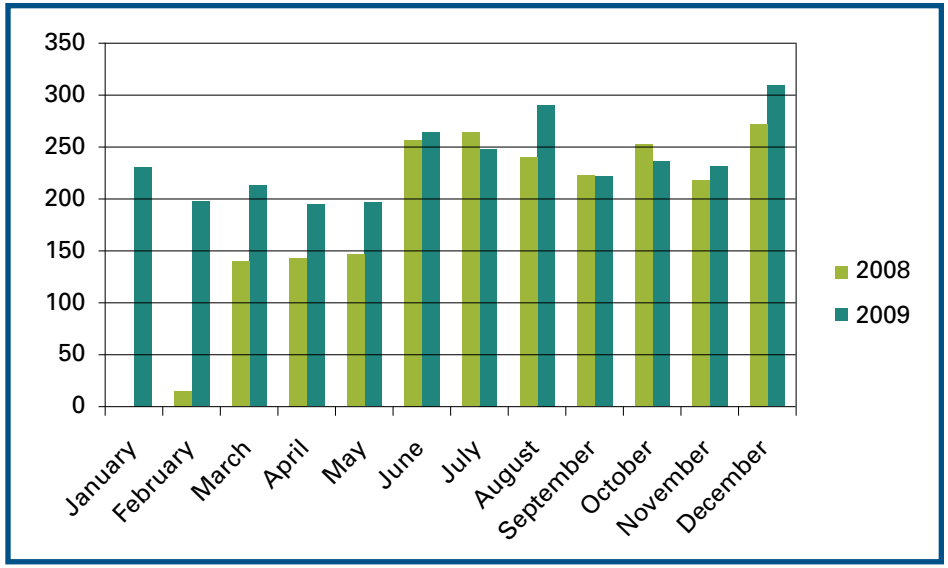
outage data

Reported power outages by cause in 2009



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: 2008 and 2009



Note: Data collection began February 16, 2008.

Eaton product overview

Eaton's power quality portfolio encompasses a comprehensive offering of power management solutions from a single-source provider. This includes UPSs, surge protective devices, power distribution units (PDUs), remote monitoring, meters, software, connectivity, enclosures and services. Our power quality portfolio was designed to fulfill specific requirements, complement a new or pre-existing solution, and to deliver a comprehensive solution.

With all our products, Eaton strives for continued success in lever¬aging technical innovation to develop next-generation solutions. The products and services listed below are just a sampling of our comprehensive solution set. To view the complete offering or to request a product catalog, please visit **www.eaton.com/powerquality.**

PC/workstation and home A/V UPS

Power range: 500 VA–1500 VA

These Eaton UPSs provide the perfect level of protection for small office/home office (SOHO) applications. These essential, cost-effective products prevent damage such as data loss, file corruption, flickering lights, hardware damage and equipment shutoff, and they are most commonly used to protect single workstations, telephone systems and point-of-sale (POS) equipment.

Eaton 5110, 500–1500 VA

— The Eaton 5110 UPS provides cost-effective, line-interactive backup power and voltage regulation. With its compact form factor, the 5110 can be utilized as a standalone tower or under a computer monitor. This UPS is also equipped with eight outlets—four with surge suppression and battery backup and four with surge suppression only.

Network and server UPS

Power range: 500 VA–18000 VA

Eaton offers an extensive and innovative line of network and server UPS solutions to protect rack servers, data storage, storage systems, VoIP equipment, network equipment and other critical devices. Get industry-leading power protection with the highest efficiency for increased energy savings in optimized rack, tower and rack/tower form factors.

Eaton 9130, 700–3000 VA, rack and tower

— The 9130 delivers more real power with a 0.9 power factor and offers a high efficiency mode, performing at a remarkable 95 percent efficiency or higher. This UPS delivers superior power protection for IT and networking environments, medical and manufacturing systems.

Eaton EX RT, 5–11 kVA, rackmount/tower

— Ideal for high-density server environments and harsh industrial applications, the Eaton EX RT UPS is specifically engineered to meet the high availability demands of switches, IT systems, measuring instruments, PLCs, industrial PCs and other sensitive electronic equipment.

Data center and facility UPS

Power range: 10–1100 kVA

Featuring an array of inventive features, Eaton's data center and facility UPS solutions incorporate the design elements essential to protecting the most critical of applications. These groundbreaking solutions address current and future power protection requirements, featuring scalable architecture that grows with you to manage changing needs with the highest levels of efficiency and reliability. And, with Eaton's Energy Saver System technology, an Eaton UPS can run at 99% efficiency, the energy savings from which usually recover the total cost of the UPS in 3-5 years.

Eaton 9390, 20–160 kVA

— The 9390 UPS provides a high-end power quality solution for data centers, banks and other critical computing applications.

Eaton BladeUPS, 12–60 kW

— The scalable and modular BladeUPS expands power protection up to 60 kW in a single 19-inch rack while reducing energy and cooling costs with its energy-efficient UPS design. The BladeUPS packs 12 kW of power into only 6U of rack space.

Power distribution

Eaton's power distribution solutions are designed to help you save money, prevent downtime and use energy more efficiently. Our comprehensive portfolio includes enclosures, rackmount UPSs, ePDUs (rackmount power distribution units) and a host of other power quality equipment

ePDU

— Eaton's line ePDU products distribute 1.4 to 15 kW of power and offer five levels of functionality. From basic, economical power distribution to automatic transfer switch capabilities, Eaton ePDU products satisfy demands of every data center.

Eaton enclosures

— Designed specifically for IT applications, this 42U modern enclosure offers strength, stability and a vendor-neutral environment to house any IT equipment. The enclosure is complemented with a range of cable management, cooling and power distribution accessories to enable you to tailor your enclosures to your specific application.

Surge suppressors

— Eaton's Eclipse surge suppressors offer the best price/performance ratio for home office / small office users looking for a convenient way to combine multiple receptacles and excellent surge suppression capabilities.

Software and connectivity

Eaton's software products deliver the ability to manage all your power devices over your network or the Web, from one or more PCs. With both supervisory and protection capability, our software allows you to monitor your power devices and even gracefully shut them down in the event of an extended power outage.

Eaton's connectivity products are accessory hardware options that link UPS products with external power and communication devices. Our connectivity products provide communication compatibility with a variety of external devices through the Web, serial, relays or SNMP.

Eaton services

Eaton's comprehensive, world-class service solutions for our AC, DC, software and connectivity products are designed to improve costs, uptime, reliability, power quality and safety. We are consistently ranked number one in quality and demonstrate our commitment to strong customer relationships through our technical expertise and expansive support services. With 240 field technicians in North America and 1,200 international authorized service providers, we have more service personnel than any other UPS manufacturer. Eaton also provides extended warranties.

Case study example number one

Here is an example of a customer request that Eaton can help you respond to with a complete solution.

Challenge

A small college with multiple satellite campuses is consolidating data centers to a brand new facility. The branch you are visiting is a small community branch with only single-phase loads left in the data center. This facility supports only small processes and equipment.

The facility does have generator backup, which works for long-term outages, but the IT Manager wants 15 minutes of runtime. When you inquire about the need for that amount of time, you learn that the usual shutdown process takes six to seven minutes, but the IT manager prefers to have 15 minutes for peace of mind. The main IT support and servers will be handled from the main campus, but some of the backup and support processes will be run from this data center and need power protection.

There is no need for scalability as the load at the various branches will most likely decrease over the next several years. With the move to the central data center, the expectation is that over the next five years almost 100 percent of IT equipment will be housed at the main campus.

The IT manager provides you with a list of equipment that shows the majority of the load that needs protection is telecom equipment. There are three 120V telephony racks with an average power draw of 1.5 kW each. There are two 208V racks of servers to handle the support processes that average 2.5 kW each.

Operation and maintenance: With the move to the main data center, the support staff on site will be minimal. The IT manager wants a comprehensive support plan to handle all service and maintenance.

Budget: The budget is a major consideration, since the satellite campus IT budgets have been reduced due to consolidation of IT equipment. The IT manager expects to spend less than $20,000.

Management: The IT manager wants to continue to manage the equipment over the network but only minimal monitoring is needed.

Power distribution: The facility has several rackmount UPSs being fed from an upstream distribution panel. There is a mixture of 5-20R and L6-30R receptacles available on this distribution panel. The IT manager prefers to continue using the existing distribution panel without bringing in an electrician to rewire the facility. Eaton 9130 UPSs are available with these options in both tower and rackmount models. The IT manager can separate racks based on 208V or 120V, due to the limited equipment and ample rack space from the consolidation.

Additional power quality needs: You inquire about the hierarchy in the new centralized data center approach with respect to IT and facilities decisions. You learn that all purchasing decisions in the future will be made at the main campus. You also ask about the power protection of the workstations and computer labs and are given the facility manager's name and contact information for each campus.

Recommended solution

Customer equipment

1. On-site generator
2. Distribution panel
3. Single-phase power
4. Three telephony racks with a total load of 4.5 kW (120V)
5. Two server racks with a total load of 5 kW (208V)

Eaton solution

1. Three Eaton 9130 UPSs and three EBMs provide 1.8 kW of power each and 40 minutes of battery runtime.

   UPS part number: PW9130L2000R-XL2U

   EBM part number: PW9130N3000R-EBM2U
2. Two Eaton 9130 UPSs and two EBMs provide 2.7 kW of power each and 20 minutes of battery runtime.

   UPS part number: PW9130G3000R-XL2U

   EBM part number: PW9130N3000R-EBM2U
3. Six ePDU models. Two in each rack for the A and B feeds. Model PW102BA0U015 with eight 5-20R output receptacles
4. Four ePDU models. Two in each rack for the A and B feeds. Model PW105BA1U163 with twelve C13 output receptacles.
5. Intelligent Power Manager UPS software (free with UPS) for comprehensive monitoring
6. Recommended service contract: Flex On-Site
   - Comprehensive coverage of UPS & batteries
   - Telephone technical support
   - eNotify Remote Monitoring
   - Connectivity support
   - Expedited delivery of replacement parts, modules & batteries
   - On-site startup
   - On-site corrective maintenance
   - Next-day 24-hour response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EATON
Powering Business Worldwide
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Case study example number two

Here is another example of a customer request that Eaton can help you respond to with a complete solution.

Challenge

A data center has 480 Vac three-phase service with dual-mains, feeding an older 300 kVA UPS. There are two wall-mounted panels being fed from the two utility sources feeds the UPS (rectifier and bypass input), which is feeding a switchboard. The switchboard feeds two 150 kVA power distribution units (PDUs). It is a three-phase environment for the main UPS and single-phase UPSs within the racks.

The switchboard, fed by the UPS, is feeding two 150 kVA PDUs; the PDUs are feeding six rows of racks via cabling under the 12-foot raised floor. Each rack has metered ePDU units for in-rack power distribution, which is being fed from the PDU distribution breakers and receptacle junction boxes under the floor. With metered ePDUs in each rack already, this is a nice power distribution scheme. The ePDUs are being fed through receptacle boxes under the floor with L6-30P input plugs for each rack. He also says he has a mixture of C13 and C19 outputs on each ePDU.

One or more UPSs will replace the existing 300 kVA system and be installed in the dedicated facility or power room behind the wall. In total, the facility has 54 racks of IT equipment (~1500 sq ft) with a total load of 214 kW, or 4 kW per rack.

The facility has a backup generator, which suffices for long-term outages. Because he has critical phone switches and other telecom equipment, the IT manager wants 10 minutes of runtime to be safe, should he face generator problems. Also having two 150 kVA PDUs, the IT manager is interested in the possibility of providing two parallel UPSs for N+1 redundancy. With two UPSs providing a total of 300 kVA or more, only half the data center would be impacted in a UPS or mains failure.

In regard to service, the IT manager defers to the facility manager, who prefers complete factory support. With the systems backing up their critical data center, they want to ensure each UPS is under a service contract with ongoing preventive maintenance.

Recommended solution

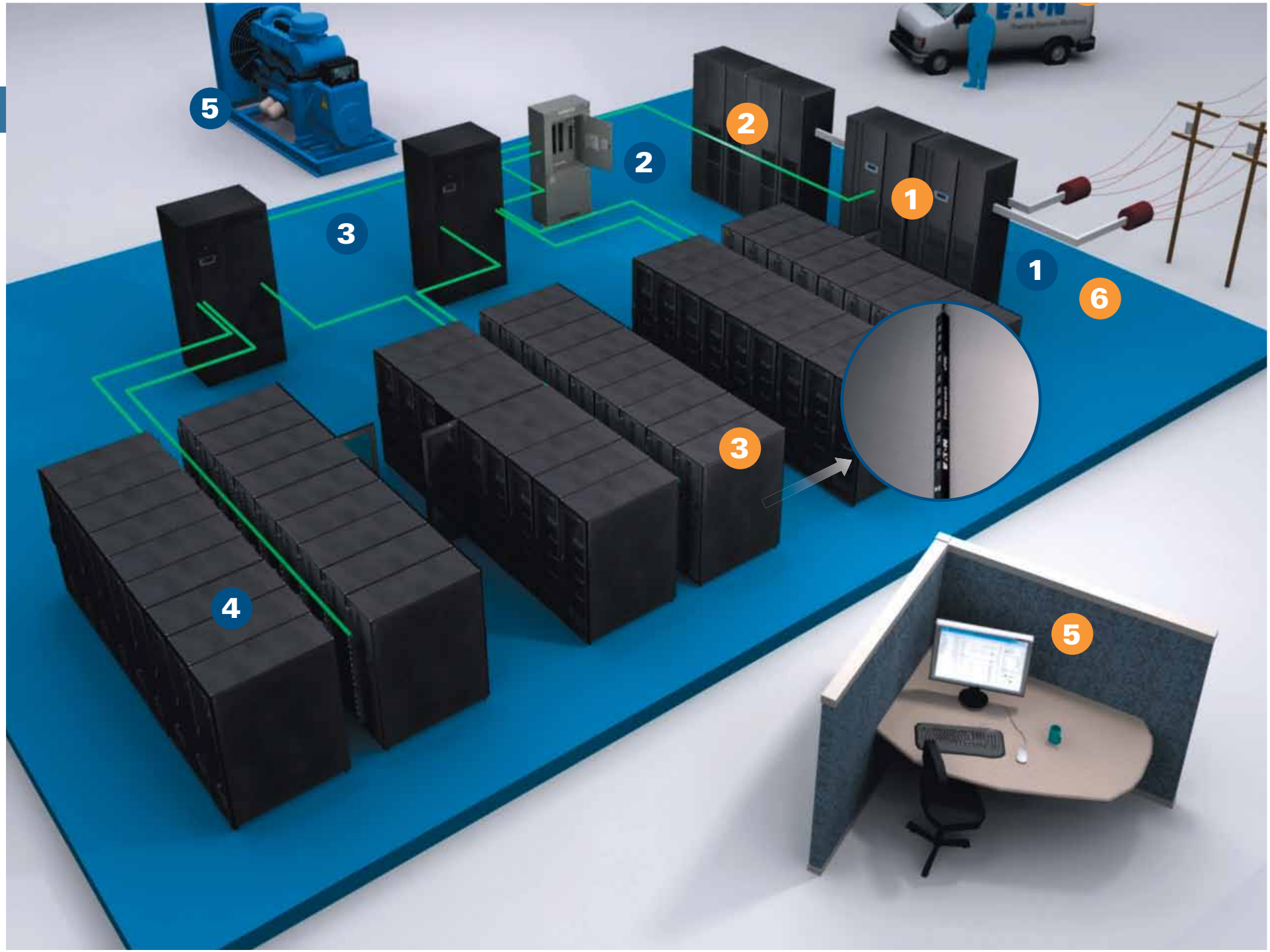
Customer equipment

1. 480 Vac three-phase service with dual-mains
2. Switchboard
3. Pair of 150 kVA PDUs
4. 54 racks of IT equipment (~1500 sq ft).
5. Backup generator

Eaton solution

1. Two Eaton 9390 UPS (160 kVA each) providing 320 kVA of support or 288 kW (34% extra capacity); includes parallel configuration, Web card, side-car tie cabinet and three-breaker MBS (TD1622231129010).
2. Two External battery cabinets (432 Vdc) providing 12 minutes of runtime (TL1602E28211100)
3. 54 Monitored ePDU units with L6-30P input, (24) C13s and (4) C19s (PW105MIOU096)
4. Startup and one year of on-site service included with all 9390 units.

   Recommended PowerTrust service plan:
   - Parts and labor for electronics
   - 24x7 On-site corrective maintenance
   - 8-hour field technician response time
   - 8x5 preventive maintenance (1 per year)
   - Battery preventive maintenance (1 per year)
   - eNotify Remote Monitoring service
   - Discounted spare parts and upgrade kits
5. Intelligent Power Software Suite UPS software (free with UPS) for comprehensive monitoring
6. Future LAN drop to UPS for communications and PowerXpert for advanced monitoring and management capabilities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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
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
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	Kiloampere 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
PDU	Power Distribution Unit
PF	Power Factor
PFC	Power Factor Correction
PoE	Power over Ethernet
POTS	Plain Old Telephone System
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)
RMS	Root Mean Square
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	Underwriter's Laboratory
UPS	Uninterruptible Power System (or Supply)
USB	Universal Serial Bus
V	Volt
VA	Volt Ampere
Vac	Volts Alternating Current
Vdc	Volts Direct Current
VRLA	Valve Regulated Lead Acid
W	Watt

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
VMMS	Variable Module Management System
PDR	Power Distribution Rack
ROO	Remote On/Off
RPO	Remote Power Off
RMA	Return Material Authorization
RPM	Rack Power Module
RPP	Remote Power Panel
SEAL	Sea Air Land
SW	Switched (ePDU)
T&M	Time and Material
CPU	Central Processing Unit

Other acronyms

AFCI	Arc Fault Circuit Interrupter
CI	Converged Infrastructure
DNS	Domain Name System
DSL	Digital Subscriber Line
DVV or DV2	Data, Voice, Video
E911	Enhanced 911
EMEA	Europe, Middle East, Africa
FMC	Fixed/Mobile Convergence
FTP	File Transfer Protocol
GUI	Graphical User Interface
HPC	High-Performance Computer
HTML	HyperText Markup Language
HTTP	HyperText Transfer Protocol
IP	Internet Protocol
ISP	Internet Service Provider
KVM	Keyboard, Video, Monitor
LEED	Leadership in Energy and Environmental Design
MSP	Managed Service Platform
NOC	Network Operations Center
PABX	Private Automatic Branch Exchange
PBX	Private Branch Exchange
PC	Personal Computer
PMDC	Portable Modular Data Center
PSAP	Public Safety Answering Point
PSTN	Public Switched Telephone Network
RAM	Random Access Memory
RMA	Returned Merchandise Authorization
SAN	Storage Area Network
SOA	Service-Oriented Architecture
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
VGA	Video Graphics Array
VoIP	Voice over Internet Protocol
VM	Virtual Machine
VPN	Virtual Private Network
WAN	Wide Area Network

Glossary of power terms

In the following glossary, we have 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
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—this value would not 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; this may be 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.

BTU – British Thermal Unit
BTUs are 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.

Brownout
A steady state of low voltage, but not zero voltage. Brownouts often occur during summer months when energy use is high.

Canadian Standards Association (CSA)
An independent Canadian organization that tests for public safety, similar to the function of Underwriter's Laboratories (UL) in the U.S. As far as we know, they don't set the rules for hockey.

Capacitor
An electronic component that can store an electrical charge on conductive plates.

Cloud Computing
(1) Internet- (cloud-) based development and use of computer technology. This is a new supplement, consumption and delivery model for IT services based on the Internet, and it typically involves the provision of dynamically scalable, and often virtualized, resources as a service over the Internet. (2) Work done on a commercial passenger jet.

Common Mode Noise
An undesirable voltage that appears between the power conductors and ground.

Commercial Power
The power supplied by local utility companies. The quality of commercial power in the US varies drastically depending on location, weather and other factors.

Communication Bay
A communication bay or option slot on a UPS enables you to add various connectivity cards for Web, SNMP, Modbus or serial connectivity interface capabilities.

Eaton 9130 equipped with a communication bay.

Converter
A device that delivers DC power when energized by a DC source. It is also a section of a switching power supply that performs the actual power conversion and final rectification.

Crest Factor
Usually refers to current. It is the mathematical relationship between RMS current 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, whose continuous availability is imperative.

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 is something that 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.

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. Double-conversion isolates the output power from all input anomalies such as low voltage surges and frequency variations.

Downtime
The time during which a functional unit cannot be used because of a fault within the functional unit or within the environment.

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

Efficiency
The ratio of output power to input power. It is generally measured at full-load and nominal line conditions. If power efficiency of a device is 90%, you get back ninety watts for every hundred you put in. The rest is mainly dissipated as heat from the filtration process. In other terms, this would be equivalent to the 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% efficiency without compromising reliability. Not to be confused with inferior "eco" modes.

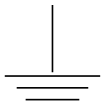
ePDU
A power distribution unit that mounts to rack enclosures and distributes power to connected devices via a wide variety of output receptacles.

Federal Communications Commission (FCC)
A US 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 which occurs during one second (Hz). In North America, electrical current is supplied mainly at 60 Hz, or 60 cycles per second.

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 place of the earth.



Earth ground symbol

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

Harmonic Distortion
Regularly appearing distortion of the sine wave whose frequency is a multiple of the fundamental frequency. Converts the normal sine wave into a complex waveform.

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 peak 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."

The batteries on this Eaton 9130 UPS are hot swappable.

IGBT
Insulated gate bipolar transistor or IGBT is 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 does not 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 first 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% of the load at all times, as with an online UPS, there is no break from utility power to battery power.

System i Server
One of a family of general-purpose systems that supports IBM i5/OS and Operating System 400 and that provides application portability across all models.

Kilovolt Ampere (kVA)
One thousand volt-amperes. Common measurement of equipment capacity. 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 is 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 in order to regulate the power to the load. Provides better protection than a standby system but is not 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.

This Eaton 9130 UPS is equipped with two load segments, each with three 5-15R

Low Voltage (LV)
In the context of UPS products, low voltage is anything <200V (100V and 120V).

Maintenance Bypass
An external wiring path to which the load can be transferred in order to upgrade or perform service on the UPS without powering down the load.

Make Before Break
Operational sequence of a switch or relay where the new connection is made prior to disconnecting the existing connection, also soft-load-transfer switching.

Modbus
Modbus is a serial communications protocol which is now the most commonly available means of connecting industrial electronic devices. Modbus allows for communication between many devices connected to the same network.

Network Transient Protector
UPS feature that isolates networks, modems and cables from power threats including surges and spikes.

Noise
(1) A disturbance that affects a signal; it can distort the information carried by the signal. (2) Random variations of one or more characteristics of any entity such as voltage, current or data. (3) Loosely, any disturbance tending to interfere with normal operation of a device. (4) What parents with children deal with every day.

Nominal Output Voltage
The intended, ideal voltage of any given output.

Non-linear Load
AC electrical loads where the current is not proportional to the voltage. Non-linear loads often generate harmonics in the current waveform which leads to distortion of the voltage waveform.

Offline
Any UPS that does not fit the definition of online. Line-interactive and standby topologies are offline, as are minor skirmishes that take place just outside the boardroom.

Ohm
The unit of measurement for electrical resistance or opposition to current flow.

Online
A UPS that provides power to the load from its inverter 100% of the time, regulating BOTH voltage and frequency, usually double-conversion topology.

Orderly Shutdown
The sequenced shutdown of units comprising a computer system to prevent damage to the system 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. However, some UPSs provide step wave or modified sine waves.

Sine Wave

Parallel Operation
The ability of UPSs to be connected so that 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
Time relationship between current and voltage in AC circuits

Plenum Cable
Cable that is laid in the plenum spaces of buildings that 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 does not 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)

VA x PF = W

W/PF = VA

(2) Why DeNiro can get immediate seating in any restaurant he wants, and you can't.

Power Sag
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.

The Eaton 5130 UPS occupies 2U of rack space and the optional extended battery module also occupies 2U.

Rail Kit
A set of metal brackets that allow you install a UPS or extended battery module in a 2- or 4-post rack.

Four-post rail kit

Eaton 5130 UPS in a two-post rack

Rectifier
UPS component that converts incoming AC power to DC power for feeding the inverter and for charging the battery.

Rectifier Magazine (RM)
A module in the DC power system used to connect the rectifiers in the power system.

Redundancy
The ability to connect units in parallel so that if one fails the other(s) will provide continual power to the load. This mode is used in systems when power failure cannot 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)
RMS is a modified average. Averaging a sine wave would give a zero and therefore, 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.

Sine Wave
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. Can also resemble ocean waves, though they're rarely very perfect.

Single Phase
(1) Power system with one primary waveform. Lower-capacity distribution of power using only one portion of a power source that is 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 but fiercely embrace an unusual hobby or interest, like lawn bowling, never to return to it again.

Sliding Demand
Calculating average demand by averaging the average demand over several successive time intervals, advancing one interval at a time.

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

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.

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

Switching Frequency
The rate at which the source voltage is switched in a switching regulator or chopped in a DC to DC converter.

Thermal Regulation
Monitoring the temperature of the batteries to assure 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 process after buying inferior power protection:

1. Denial
2. Anger
3. Calling Eaton

Topology (UPS)
The core technology of a UPS. Typically, a UPS is either standby, line interactive or online though other hybrid technologies have been introduced.

Total Harmonic Distortion (THD)
(1) How much the circuit voltage deviates from a perfect sine wave. When viewed on a meter, a poor voltage THD is most often manifested in a flat topped waveform that comes from the inability of a power source to respond to the demands of highly nonlinear loads. (2) The parts of a difficult lecture that didn't quite make it into your brain, but rather united in a "blahblahblah" cacophony of scratchy-sounding jargon and esoteric corollaries.

Transfer Time
The length of time it takes a UPS to transfer to battery power. Typically measured in milliseconds (ms).

Transformer
A magnetic device that converts AC voltages to AC voltages at any level. An ideal transformer is a lossless device in which no energy is stored and that requires no magnetic current. A transformer is also an alien robot that can disguise itself by transforming into everyday machinery.

Transient
A temporary and brief change in a given parameter. Typically associated with input voltage or output loading parameters. 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.

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

Unbalanced Load
An AC power system using more that two wires, where the current is not equal in the current-carrying wires due to an uneven loading of the phases. A load that makes your washing machine go "whump, whump, whump."

Underwriters Laboratories (UL)
An independent, not-for-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 back up power during power failure or fault. Some UPSs also filter and/or regulate utility power (line conditioning). (2) 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 maximizes 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, a server, a 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.

Volt/Voltage (V)
Electrical pressure that pushes current through a circuit. High voltage in a computer circuit is represented by 1; 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.

Volts Direct Current (Vdc)

Volts Alternating Current (Vac)

Watts (W)
The measure of real power. It is 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 is generally used to connect devices to a three-phase power system.

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