UPS Design, Specification Considerations

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This month's panel of electrical experts offer advice on specifying the most suitable UPS system for a given application.

CSE: What is driving the demand for uninterruptible power supply (UPS) systems these days?

CARLINI: UPS systems are in more demand than ever—primarily in the data center. Even though the new servers are much faster and require less power to operate, the demand for computational capacity is much higher than increased server efficiencies. This drives incremental servers and storage, which translates to the need for more UPS.

Another driver is integration of telecom and IT. As the industry switches to Voice over Internet Protocol (VoIP), it creates a greater need for UPS because this network technology is AC-power based. The expectation for voice transmission reliability is much higher than data transmission reliability, so UPS systems with higher built-in redundancy levels for deploying UPS in redundant configurations is now being required.

PANFIL: I agree that the demand for UPS units is strong and is being driven by several factors. First, organizations are continuing to add technologies, such as servers, network switches and storage systems, that have higher power requirements than previous generation equipment, as mentioned. In addition, many organizations are adding redundancy to their critical power systems to support high availability for networks and data centers. Finally, a wave of large data center development activity, driven by data center consolidation and web-based content and software delivery, has created spikes in demand for large UPS and power distribution systems.

YANKE: Other applications include hospitals, which depend on their servers for everything from medical records to PACS [picture archiving and communication system] to pharmaceutical dispensing and corporate data centers. These servers support nearly every aspect of day-to-day operations for most corporations. Also, trading floors also have been transformed from the "open outcry" floor to the electronic trading floor.

CSE: Are certain facility types and applications ideal for specific types of UPS?

CARLINI: Regarding application, standby UPS offers the best value for personal workstations, although line-interactive is the most popular due to high reliability. Line-interactive UPS is ideal for rack or distributed servers and/or harsh power environments. Alternatively, double-conversion on-line models are suited for N+1 designs, and the efficiency of delta conversion on-line reduces the substantial life-cycle cost of energy in large installations.

PANFIL: Most facilities that are business-critical will use online double-conversion systems based on reverse transfer topology. Today, that includes most data center and server room applications. Businesses with zero tolerance for downtime may choose dual-bus configurations because they provide opportunities to eliminate single-points-of-failure along critical power paths. Less critical applications may opt for some redundancy by deploying an N+1 UPS configuration, which balances availability and flexibility.

YANKE: Battery systems with runtimes of more than 30 minutes let users shut down small systems for utility power failures, while larger systems with somewhat lower battery runtimes are common for large data centers with sufficient engine/generator availability.

A newer application of UPS is to support imaging equipment as part of medical procedures such as cath lab equipment and other interventional radiology equipment. Some medical equipment manufacturers are now furnishing their equipment with small battery systems. Rotary UPS also is an option for this application, because all that is required is 10 seconds or less to ride through until the diesel engine/generators come online.

CSE: How does one determine to go with an offline or online UPS?

PANFIL: Offline UPS provides little power conditioning and typically is limited to desktop applications. Line-interactive units provide partial power conditioning and might be suitable for small networks and wiring closets. Online double-conversion/reverse-transfer UPS systems provide the most complete power conditioning and are recommended for mission-critical applications. They correct for certain types of sags and frequency variations that pass through a line-interactive system. They also eliminate generator compatibility problems common with line-interactive systems and isolate connected equipment from the power source.

LANE: Online UPS continually provides power quality protection for critical loads, as mentioned, whereas offline systems use a transfer switch for a system bypass. The system normally runs in bypass mode, which doesn't run current through the rectifier, battery or inverter. Because critical loads and systems typically have direct connections to the utility or generator source of power, protection from power quality anomalies is available only when the serving voltage dips to a predetermined level and the transfer switch changes its position and draws current through the UPS system.

Offline UPS also provides protection from electrical line noise, power brownouts and voltage sags, but only when the battery is delivering power to the critical loads. In a surge event, a standby UPS will pass the overvoltage directly to the critical load until the voltage reaches a predetermined level, typically at 115% to 120% of the nominal voltage.

> "It is tempting to size the UPS system to the initial load and add modules as load increases, but this may create problems if you have to add too many modules."

CSE: If online is the appropriate choice for a given application, what are the advantages and disadvantages of static, rotary and hybrid?

YANKE: Static UPS is relatively inexpensive and available in a wide range of capacities. Single-phase units are available to support single pieces of equipment or small IDF [intermediate distribution facility] rooms, and large three-phase units can be used to support large server rooms and data centers. Battery technology has improved and equipment is readily available with power factors of 90% or better.

Rotary UPS is well suited for large loads, generally 500 kVA or larger, with the need for seconds vs. minutes of backup.

LANE: Most of the flywheel UPS will supply 15 seconds of full-load power and can actually serve up to several minutes at less than full load. In addition, most of the utility disturbances will last for 5 seconds or less. For these reasons, a rotary or flywheel UPS can be a viable option over conventional battery backup UPS.

The advantage to the "static" or conventional UPS system with batteries is that the owner can get significantly more backup time than with a rotary UPS. The disadvantage is that these battery systems require significant space, maintenance and need to be replaced every five to 20 years depending on the type of battery systems.

CARLINI: For static and hybrid UPS, input PFC [power factor correction] is important. Many times users are sold an inexpensive UPS that claims high efficiency. Once the UPS is installed, the reflected harmonics can have an adverse effect on the operating environment and result in penalties from the utility. An input filter is then required that adds to the cost and greatly reduces the efficiency.

PANFIL: While everyone would like to reduce their dependence on batteries, because they are the weak link in UPS systems, batteries are more versatile than rotary systems. They can be packaged in a form factor that works with UPS systems of various sizes, and can be configured to provide runtimes from minutes to hours or more. Plus, recent advances in battery monitoring can eliminate most of the reliability problems associated with batteries.

We are also seeing a surge in demand for rotary flywheel systems, as noted. These systems provide ride-through times of 30 seconds or less, so they need to be coupled with a fast-start generator to provide extended outage protection. However, newer generation systems are moving up the power density curve and can support UPS systems as large as 200 kVA with a single module. These systems are attractive because they are highly reliable, efficient and environmentally friendly. The newer generation systems also also reduce operating costs.

A hybrid solution can be effective for high-availability applications. In this case, the flywheel provides power during the brief interruptions that can drain battery life. Batteries are reserved for outages of more than 10 seconds, extending battery life and increasing overall system reliability.

Before, the high end of rack-mount UPS ranges was 3 kVA. Now, it is 10 kVA with higher capacities on the horizon.

CSE: What are the most common mistakes when designing UPS?

PANFIL: The one mistake we see is in how these designs are sometimes applied. It is tempting to size the UPS system to the initial load and add modules as load increases, but this may create problems if you have to add too many modules —reliability suffers, the system is hard to manage and costs skyrocket. We advocate sizing the initial UPS module to half the projected capacity, if possible, and no less than one-third of projected capacity. This allows up to 300% growth without compromising reliability.

YANKE: The most common mistake, in our experience, is not providing adequate distribution downstream to access full capacity of UPS.

LANE: Some other common design mistakes are undersizing the UPS system for future loads or for the harmonic profile of the load to be served, and failing to look at the UPS and generator systems as a complete package. It's important to be aware that the size and harmonic profile of the UPS system will affect the generator systems. Consequently, sometimes the generator will have to be oversized when UPS systems are used.

Additionally, much thought has to be given to the battery systems. The choice of batteries—VRLA or wet cell—and the number of backup minutes will determine the location of the batteries—within the UPS or in a separate room—and the other requirements such as spill containment, ventilation, CO_2 monitoring and eye wash requirements.

CSE: What are the latest advances in UPS technology?

CARLINI: Building UPS out of modular black box components—power, battery, intelligence—into an integrated system that can easily and quickly be repaired and scaled in response to customer needs.

PANFIL: On our end, we are continuing to design compact, rack-based UPS modules to meet the requirements of higher density racks and rooms. Not long ago, the high end of our rack-mount UPS range was 3 kVA. Now, it is 10 kVA with even higher capacities on the horizon. In larger units we are moving toward rack form factor UPS modules to provide greater application flexibility. We will also be introducing new ways to dynamically adjust UPS capacity without adding hardware.

> If there is no emergency standby generator in the electrical distribution system, a fluorescent light fixture with an integral battery fed from a "fast transfer" UPS would be required.

CSE: Are any recent or anticipated code changes affecting UPS specifications?

PANFIL: The European Union's Restriction of Hazardous Substances (RoHS) directive issued in 2006 is an effort to ensure that hardware is free of toxic substances. This directive does not currently cover UPS technology, but it eventually will and we are getting out in front of this regulation by evaluating alternates to those materials that contain restricted substances.

LANE: A significant portion of the International Building Code that differs from the Uniform Building Code and impacts the electrical distribution system is section 1006, "Means of Egress Illumination." That, combined with the way the 2003 edition of the Life Safety Code defines a public right of way, creates a requirement for emergency lighting from an exit discharge to the public right of way. The typical wall-mounted egress light over an exit doorway will now have to provide emergency illumination to the public right of way, which could be a significant distance away from the building. This light is typically metal halide. In this situation, if a generator is installed in the building, an arc maintenance device would be required to ensure proper light levels within the 10 seconds, as prescribed by Section 700 of the National Electrical Code. If there is no emergency standby generator in the electrical distribution system, a fluorescent light fixture with an integral battery or a metal-halide light fixture fed from a "fast transfer" centralized lighting inverter—UPS—would be required. In either case, per Section 700 of the National Electrical Code, 90 minutes of backup would be mandatory.

Another issue with this section of the International Building Code is that the public right of way could potentially be quite some distance away from the building. If this is the case, additional light fixtures on the exterior of the building and/or along walkways with emergency lighting provisions may be required to obtain the minimum average foot candles and uniformity ratios from the building to the public right of way. |cse|

UPS Technology Update

Headlining the latest in UPS technology are superconducting magnetic energy storage (SMES) systems, super capacitors and compressed air energy storage (CAES) systems.

SMES circulate direct current in a field of a magnetic coil. A solid-state switch controls the circulation of the current and the large magnetic coil creates a high amount of inductance. This high inductive force pushes current into a capacitor. Control circuits in the system preserve a predetermined voltage level across the capacitor. The current circulates through the closed switch and keeps the magnetic field charged. An internal inverter then converts the direct current source into an alternating current. The capacitor discharges the required voltage during short power quality anomalies, such as utility switching events, and provides protection to the critical loads in the facility. After use, the system recharges within a few minutes. The amount of stored energy can be in the megawatt range.

Ultracapacitors—also known as superconductors—store electrostatic energy within the capacitor. Supercapacitors work with other energy storage devices, such as batteries, to provide power-quality protection. By combining the two systems, the ultracapacitor handles a majority of the power-quality events, leaving the batteries to deal with just the long-term events. This will reduce the duty cycle on the batteries and increases the life of the entire power-quality protection system.

CAES systems use pressurized air as reserve energy. A compressor pressurizes air during off-peak energy usage hours. The air is then released through a turbine at peak hours. This gives lower cost power during high-peak demands and is ideal for use in mines and aquifers.

Compressed air cylinders also are joined with a flywheel to provide both short-term active response to a power quality anomaly and long-term backup from the compressed air supply.

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