



**BEST PRACTICES IN PROTECTING
THE TECHNOLOGY SYSTEMS
REVOLUTIONIZING HEALTHCARE**

Executive Summary

Technology systems such as electronic medical records and digital imaging are revolutionizing healthcare by streamlining processes, eliminating waste, improving accuracy and, most importantly, improving patient outcomes. As these systems become seamlessly woven into the fabric of how healthcare is delivered, their continuous operation becomes increasingly critical. Yet, the explosive growth of healthcare IT applications is making it more difficult to achieve continuous operation both in the data center and throughout the hospital.

While today neither electrical code nor the hospital accreditation standards of the Joint Commission require healthcare organizations to use uninterruptible power supplies (UPS), most have begun doing so to protect vital equipment and systems. Currently it is common practice for healthcare facilities to install UPS backup at the device level, such as an MRI machine or computer server. As the number of UPS units located throughout the facility grows, however, so does the complexity of managing them to keep the devices they protect continuously online. Additionally, device-level protection does not enable the ability to add loads as critical systems spread throughout the hospital, particularly in the operating rooms, patient rooms and nurses stations.

This paper outlines an approach to power protection that addresses the problems that accompany the distributed approach. The centralized approach to power protection presented here enables healthcare organizations to achieve higher availability and scalability for future growth at lower cost and should be considered for all new healthcare facilities and, whenever possible, in retrofit situations. Vertiv™ has developed three centralized UPS configurations specifically for healthcare settings, which we recommend based on the level of protection and seamlessness of operation desired.

Introduction

Information technology is being integrated throughout healthcare operations to improve patient care, service levels and operating costs. Through the use of technologies such as digital diagnostic equipment, electronic medical records and patient RFID, the healthcare industry is benefiting significantly from increased accuracy and efficiency.

Consequently, these innovations have become vital tools on which medical and other staff increasingly rely to perform their roles in the healthcare system.

A walk through an endovascular hybrid operating room, for example, reveals a sophisticated control center incorporating monitors, workstations and communications equipment along with diagnostic and treatment devices. This ability to integrate and comprehensively control equipment, information and environments is being replicated on varying scales throughout healthcare facilities because doing so makes patient care safer and more efficient, which improves outcomes.

Healthcare Technology Trends

The desire to improve patient care, as well as factors such as federal government initiatives and physician attraction and retention strategies, are driving the deployment of new technologies throughout healthcare information systems. Among the most important of these technologies are:

- **Electronic medical records**
Implementing electronic medical records (EMR) makes healthcare workflows more efficient, improves the quality of patient care and reduces costs. The use of EMRs is expected to grow 14 percent annually through 2011.¹
- **Picture archiving and communications systems**
Picture archiving and communications systems (PACS) provide faster access to diagnostic information, reduce the need for film and film storage, virtually eliminate the problem of lost films, and increase radiologist and physician satisfaction and productivity. Because of the efficiencies and cost saving associated with their use, the size of the U.S. market for PACS should reach \$8.6 billion by 2011, which represents 76 percent growth over its size in 2007.²
- **Wireless communications**
While healthcare is often behind other industries in adopting new technologies, it has been a leader in the use of wireless technology. Clinicians are ready users of mobile devices, and hospitals have moved quickly to deploy IP telephony and wireless LANs to save money and more effectively provide connectivity in older buildings. As a result, wireless healthcare applications have become key to optimizing the benefits of EMR.

- **Pharmaceutical barcode/RFID technology**

Pharmaceutical barcode/RFID technology is designed to ensure the right patient gets the right dose of the right medication at the right time. It aids compliance with state and federal regulations requiring additional product tracking to curb drug counterfeiting and improve patient safety and integrity. According to a 2008 study of RFID trends, 76 percent of larger healthcare organizations have invested in RFID-based solutions.³

Within the new digital healthcare environment, IT is the link connecting the facility's medical staff (whether they are located in the OR or a patient's room) with patient data stored on servers in the data center. This link can be broken when problems in the data center, such as brownouts, shut down the system; or when the power supply inside the hospital is disrupted because of weather disturbances, voltage surges or other abnormalities.

The tremendous growth in the use of technology is having an impact both in the data center, where technology systems have traditionally been housed, and in the facility itself, which now must support a complex, interrelated network of technology systems that extend from the data center to the bedside.

Supporting IT Growth in the Data Center

Reliance on IT to diagnose and treat patients and improve organizational efficiency brings a new set of concerns for healthcare IT management in meeting rising expectations from surgeons, doctors, nurses and patients. The required increase in computing capacity, file storage and performance creates a corresponding need to have greater control over the IT infrastructure in order to assure the continuous operation of technology systems.

In the data center this means transitioning to an infrastructure that can support "always on" operations while scaling to support continued growth in server and storage capacity as well as changing with new technologies and methods. The key areas of the IT infrastructure that hospital IT executives must consider as they retrofit existing data centers or plan for new data centers are:

Power

The data center needs disturbance-free, uninterrupted power to do its job. An online double conversion uninterruptible power supply (UPS) is the only such system that protects against the full range of power disturbances and is the best practice for mission-critical applications.

When implementing a UPS system it's important to understand future requirements and ensure a growth plan is in place to cost-effectively meet those requirements. Providing just the capacity required today – with no growth plan – can constrain future growth and increase the cost and disruption of future technology. As availability requirements rise, power system redundancy is often implemented to reduce single points of failure, enable future growth and increase operating flexibility.

For more information on high-availability data center power protection, refer to the Vertiv white paper, *Power Management Strategies for High-Density IT Systems and Facilities*, available at www.liebert.com.

Cooling

Proper environmental control – temperature, humidity and air quality – plays a key role in overall continuity. As more servers and storage systems are added to the data center, the existing cooling system may be unable to keep temperatures in safe operating range. When sensitive electronics operate at higher than normal temperatures, their short-term reliability is compromised and long-term viability is significantly decreased.

Cooling system scalability can be accomplished via supplemental refrigerant or chilled water cooling systems, such as the Liebert® XD™ system, that bring cooling closer to the source of heat. This allows cooling to be focused where it is needed most and can be added to, rather than displace, the existing cooling system.

For more information on data center cooling, refer to the Vertiv white paper, *Blade Servers and Beyond: Adaptive Cooling for the Next Generation of IT Systems*, available at www.liebert.com.

Monitoring

The third line of defense in keeping a data center up and running is effective monitoring and automated data analysis. A centralized approach to monitoring power and cooling systems can increase visibility into system performance, enable more effective preventive maintenance and speed response to equipment problems.

For more information on data center monitoring, refer to the Vertiv™ white paper, *Managing Critical Systems for Higher Availability and Reliability*, available at www.liebert.com.

Supporting IT Growth in the Hospital

While the changes that are occurring in the data center are evolutionary, the changes occurring on the facility side are revolutionary and may dictate a completely new approach to healthcare power protection. With the increased dependence on technology, a power disruption inside the hospital or healthcare facility can lead to:

- Lost patient data
- Corrupted diagnostic images
- Patients and staff waiting for IT reboot
- Comprised patient safety
- Hospital staff dissatisfaction and reluctance to use IT
- Damage to expensive equipment
- Lost revenue because equipment is unavailable (e.g., during MRI recharge)

Article 517 of NFPA 70, National Electrical Code, requires hospitals to have a power transfer switch and a quick-start backup generator that will be available to carry load in 10 seconds. Recognizing the risks to patient safety posed by power outages within the environment of care and under emergency management situations, the Joint Commission has established standards for power continuity that augment what is required by code.⁴

The Joint Commission 2009 chapter on Emergency Management establishes standards to ensure that healthcare organizations have documented response procedures to be without utility power for 96 hours. The chapter on Environment of Care includes several standards impacting power continuity, including:

- EC 02.05.01: The [organization] manages all risks associated with its utility systems. Elements of Performance include mapping the power distribution systems, documenting procedures for responding to outages and documenting procedures to perform clinical interventions during disruptions.
- EC 02.05.03: The [organization] has a reliable emergency power source. This standard recommends the essential electrical distribution system complies with National Fire Protection Association (NFPA) 99.
- EC 02.05.07: The [organization] inspects, tests and maintains emergency power systems. The testing procedure must conform with NFPA 110.
 - Test the generator 12 times a year for 30 minutes at 30 percent of load
 - Test all automatic transfer switches 12 time a year
 - Test the generator once every 36 months for 4 hours on 30 percent load

Depending on transfer equipment design, complying with the monthly testing standards could cause hospitals to have outages 24 times a year (once when switching to generator and once when switching back to utility for each generator test). While the tests are conducted at the least critical times, every outage at minimum causes unprotected IT systems to reboot and electronic equipment throughout the hospital will need to be reset.

While the Institute of Electrical and Electronics Engineers is not an accrediting agency, it does recommend as a best practice the use of transient voltage surge suppressor products (TVSS)⁵ and uninterruptible power supply systems in healthcare facilities.⁶ Typical applications recommended for backup support include sensitive laboratory and diagnostic equipment, life-support equipment in intensive care units, data processing systems, and for illumination in life-support areas.

While the IEEE recognizes using UPS backup in healthcare facilities as a best practice, there also are best practices in how to deploy a UPS system.

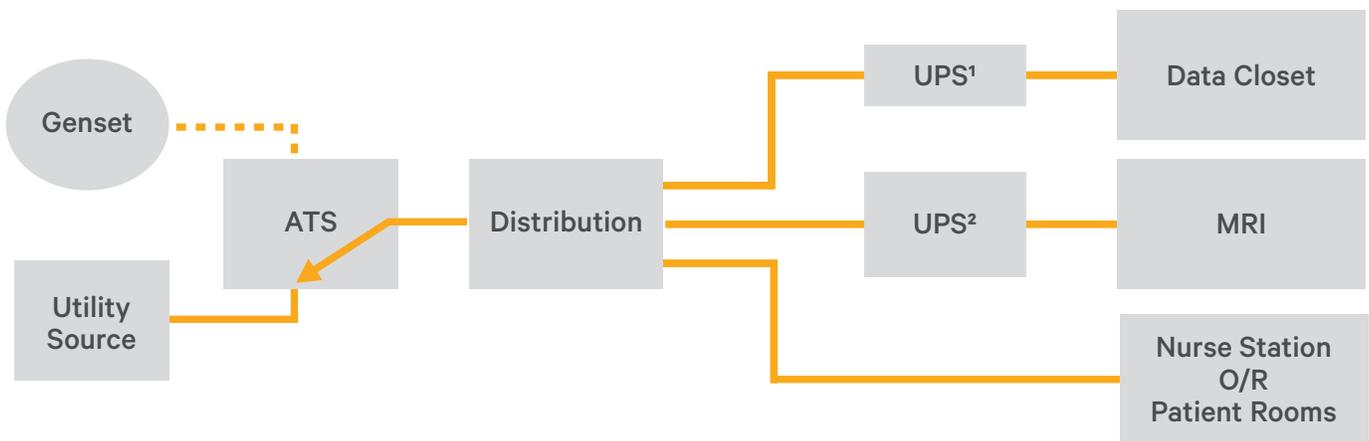
The Move to Centralized Power Protection

The changes in healthcare IT are mirroring changes that occurred in the data center 10 to 15 years ago. When servers were first being deployed in data centers it was common for each server or server rack to be configured with its own UPS. As servers continued to proliferate, that approach became less practical. Besides the growing cost of adding multiple UPS systems, maintaining multiple small servers is a management nightmare and reduces power system reliability and scalability (each new device requires an additional UPS). As a result, virtually all data centers now employ a centralized UPS system, because that is the only way to achieve the high availability required.

Hospitals have been deploying UPS units to protect individual diagnostic devices for years. A typical deployment of UPS systems on the critical branch is shown in Figure 1. The telephony system and the MRI machine each is protected by its own UPS (likely purchased with the equipment the UPS is protecting), but the nurses stations and operating rooms are left unprotected and susceptible to power surges, voltage sags and interruptions. With the proliferation of technology that is occurring today, this approach has become less practical, less economical and more risky.

Instead of providing protection at the device level, hospitals will find they can achieve much higher power availability and simpler management by moving power protection upstream. For smaller facilities this may mean providing a single, large UPS directly downstream of the Automatic Transfer Switch to the facility; larger facilities may require multiple critical branches with a single large UPS on each branch. In either case, a centralized UPS which resides upstream of power distribution can provide protection for multiple devices in the facility, creating a power protection system that is more reliable, more scalable and more manageable than the distributed approach.

As illustrated in Figure 2, the centralized approach provides UPS backup to all loads inside the hospital and supports the ability to add loads for future operating rooms and other critical spaces and equipment. This ability to add/grow loads enables hospitals to implement redundant operating rooms where surgery suites are being powered by different critical branches of the hospital's power system.



ATS = Automatic Transfer Switch
 UPS¹ = Small Uninterruptible Power Supply
 UPS² = Midsize Uninterruptible Power Supply

Figure 1: A typical critical branch with a distributed UPS configuration that provides UPS backup for devices such as the MRI and the wireless telephony system, but leaves the nurses stations and operating rooms unprotected.

Recommended UPS Configurations

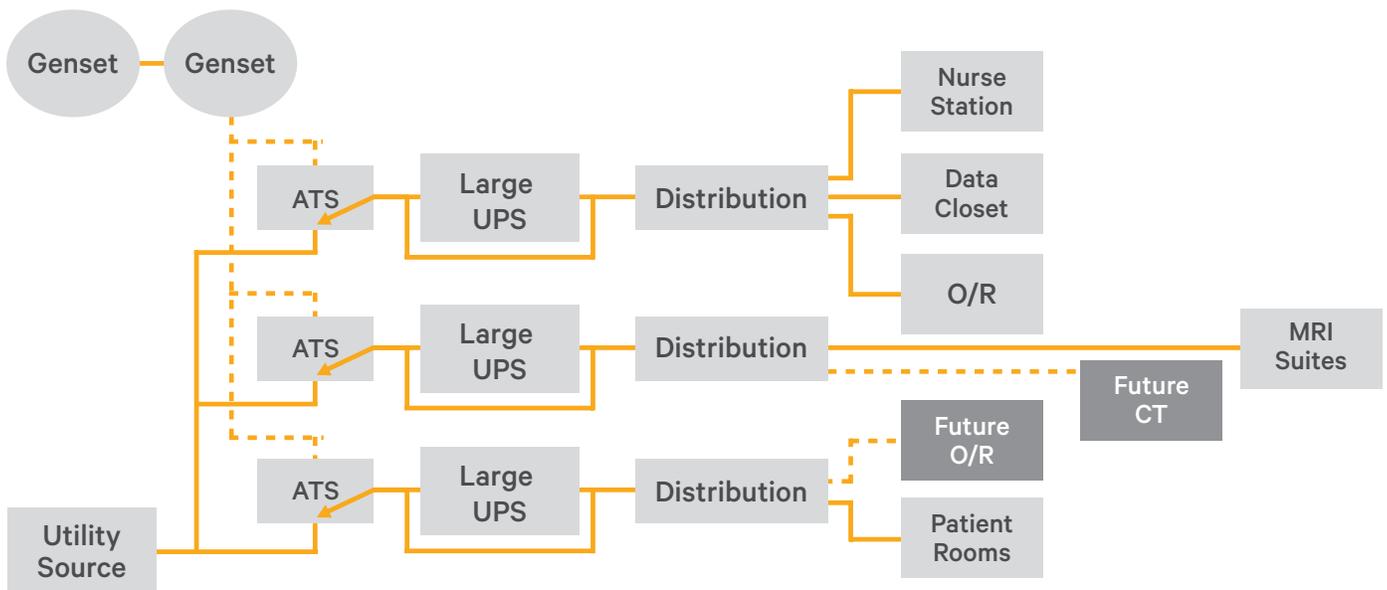
Vertiv™ has defined three levels of UPS configuration suitable in life-critical applications for healthcare facilities that are in compliance with Joint Commission standards regarding backup power. These configurations are presented for reference purposes only and a professional engineer should always be involved when configuring power protection for any life-critical application for which our equipment is installed.

Each configuration is based on an online double-conversion, three-phase UPS, such as the Liebert® NX™ or Liebert NXL™ product families. Online double conversion UPS systems provide the highest degree of protection of any UPS system. By converting incoming power to DC and then creating a clean AC waveform from the DC power, online double conversion systems remove every type of power disturbance, effectively isolating downstream equipment from the incoming power source and are less dependent on the alternate AC power source (typically a diesel genset) for power conditioning.

Three-phase UPS systems provide greater flexibility in distributing power downstream and generally support higher capacities, deliver greater reliability and enable more advanced monitoring than single-phase systems.

In each case, UPS backup power can be delivered by either a battery system, as is typically used in data center applications, or a flywheel system. The flywheel system provides energy efficient, short-term backup power and is ideal for use in applications with fast-start generators. According to the Electric Power Research Institute (EPRI), 98 percent of all outages last less than 10 seconds. Flywheel units can provide instant ride-through power and voltage stabilization for up to 13 seconds (or other combinations of power and time) — more than enough time to switch to generator. Flywheel units are parallelable for additional capacity and/or redundancy.

Compared to batteries, flywheels have a low installation cost, take up minimal floor space and have a design life of 20+ years. Flywheels also have a smaller environmental footprint than batteries. They do not need special ventilation or air conditioning, and have no special disposal requirements because they do not contain hazardous materials.



ATS = Automatic Transfer Switch

Large UPS = Large Uninterruptible Power Supply with a maintenance bypass

Figure 2: The centralized approach to UPS installation utilizes a large UPS system at each critical branch to provide protection for all loads inside the hospital.

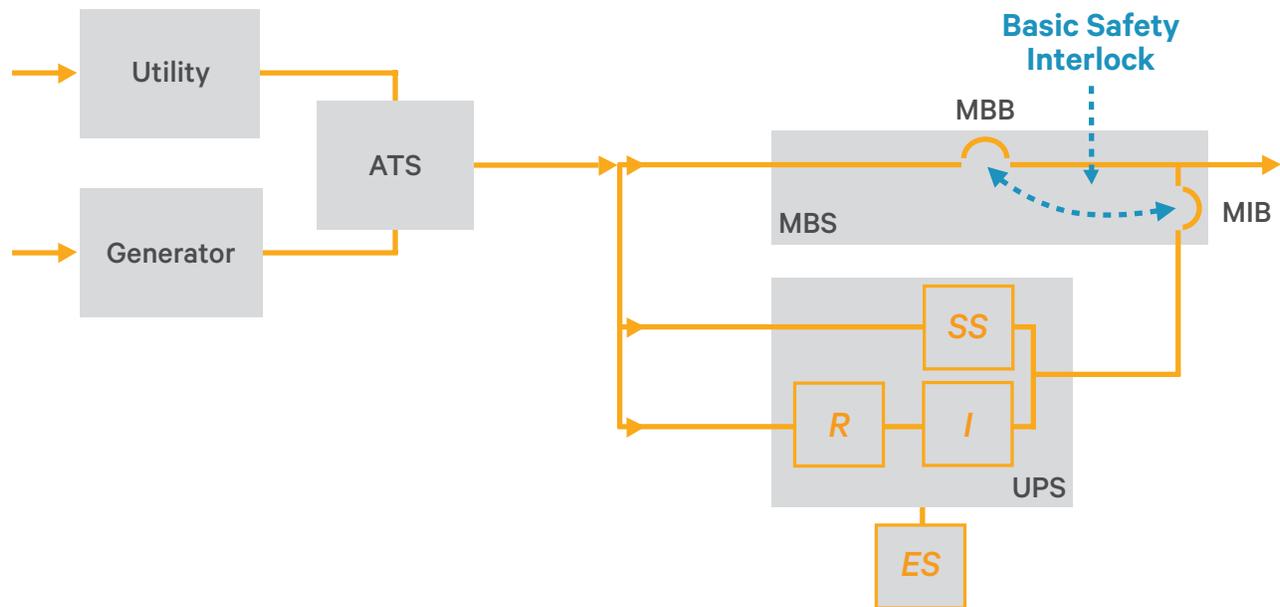
Lastly, regularly scheduled preventive maintenance is required for all UPS systems operating in healthcare facilities. The recommended schedule is every three months for systems with batteries, once a year without batteries.

Basic Configuration for a Hospital’s Centralized UPS

The minimal configuration for centralized power protection in a life-critical healthcare environment is shown in Figure 3. The UPS is connected downstream from the Automatic Transfer Switch that transfers utility power between the utility and generator. As noted previously, this switchover has traditionally created a 10-second interruption in power availability as the generator starts up; however, the UPS allows power availability to be maintained continuously during the transition from utility to generator power and from generator back to utility. By deploying a UPS, power

availability can be elevated from the 98.8 percent provided by the utility to approximately 99.999 percent for the total power system.

The UPS does represent a single point of failure between the utility/generator and downstream equipment. Therefore, it is imperative to have at least a manual bypass, provided by the maintenance bypass switchboard (MBS) – including a safety interlock to prevent both breakers being manually closed at the wrong time – connected to the UPS to route utility power around the UPS during UPS maintenance. A maintenance bypass also provides a basic level of protection in the unlikely event of a UPS failure. Should that occur, the length of the outage will depend on how quickly someone can get to the MBS and transfer power. However, without a redundant UPS, the UPS still represents a single point of failure.



ATS = Automatic Transfer Switch
 UPS = Uninterruptible Power Supply
 R = Rectifier
 I = Inverter
 SS = Static Switch

ES = Energy Storage
 MBS = Maintenance Bypass Switchboard
 MBB = Maintenance Bypass Breaker
 MIB = Maintenance Isolation Breaker

Figure 3: With the basic centralized configuration, the UPS is connected downstream from the Automatic Transfer Switch that transfers utility power between the utility and generator, and maintains power availability during this process. Diagram is for reference purposes only; not all inputs, breakers and TVSS products are shown.

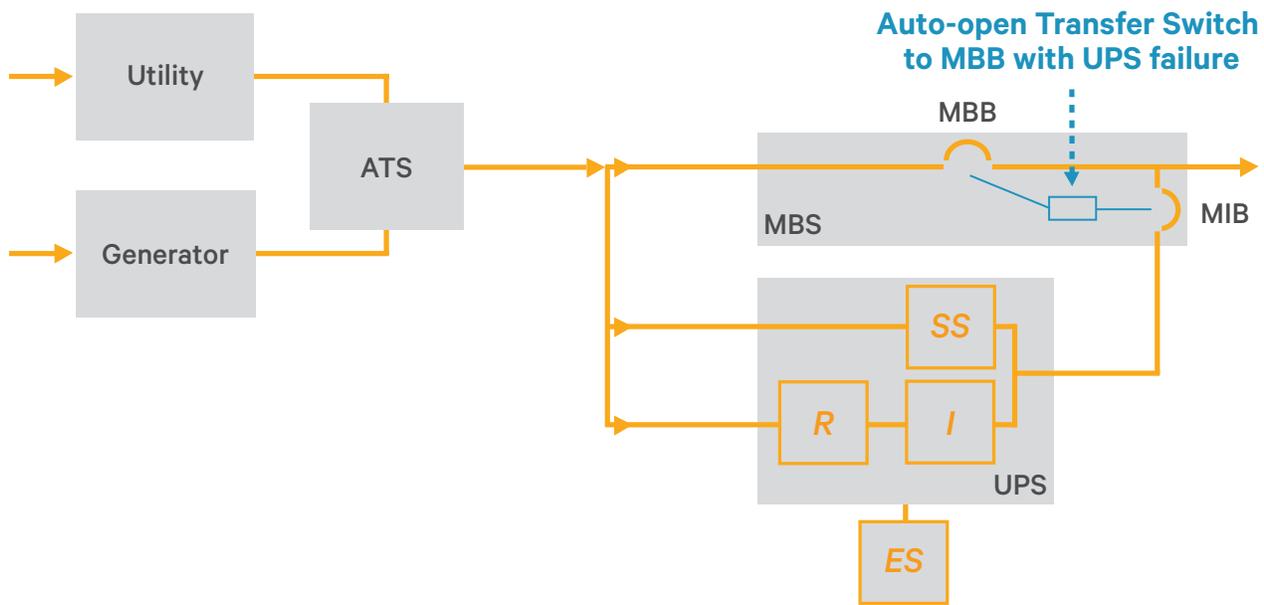
Intermediate Configuration for a Hospital's Centralized UPS

The intermediate configuration, shown in Figure 4, replaces the manual bypass with a combined automatic open transfer function and manual bypass, separate from the upstream automatic transfer switch (ATS). This MBS can also detect an interruption in UPS output power and automatically switch to utility (or genset) power through ATS. Unlike the high-speed Static Transfer Switch used in the High Availability Configuration discussed next, this MBS switchover takes about 0.5 seconds to automatically transfer power, so downstream equipment will experience a momentary interruption in power that will cause electronic systems to shut down and restart. This configuration delivers the same projected availability as the basic

configuration, but eliminates the risk that a catastrophic UPS failure could cause an outage of greater than 10 seconds. Return to UPS output power is by a manual switchover of the MIB and MBB breakers.

High Availability Configuration for a Hospital's Centralized UPS

The high availability configuration (Figure 5) uses a Static Transfer Switch (STS) in place of the MBS automatic function used in the intermediate configuration. The STS switches power seamlessly between the UPS and utility to enable even the most sensitive downstream equipment to continue operating without interruption in the event of UPS failure.



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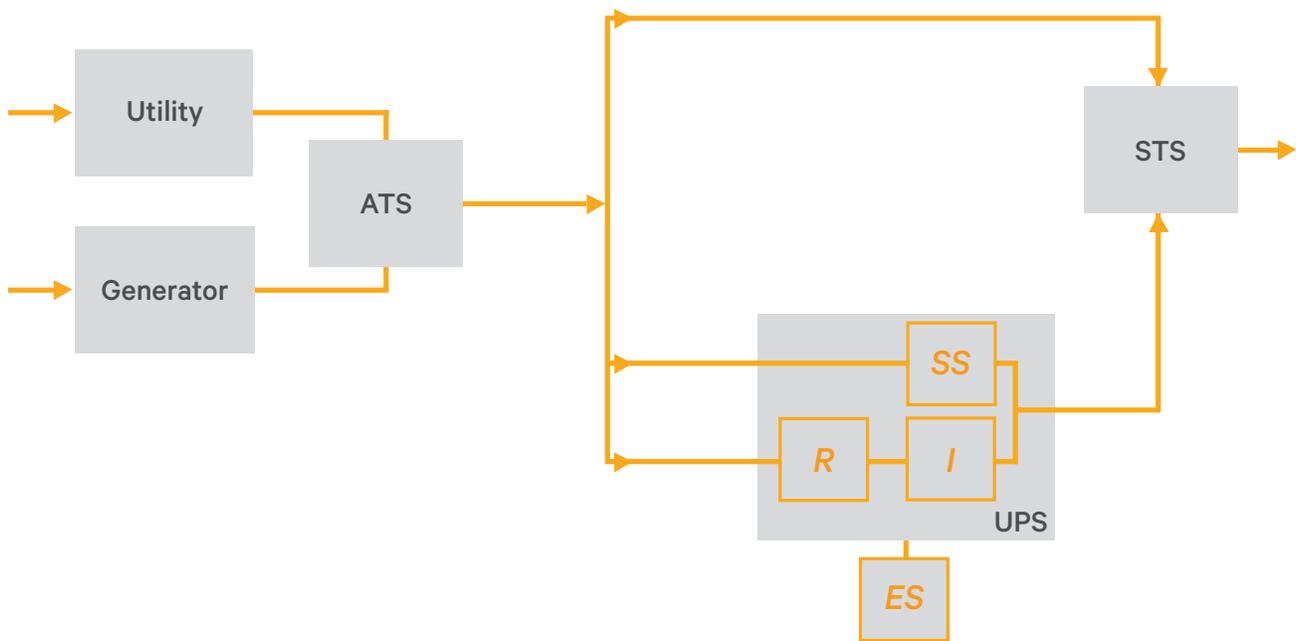
Figure 4: The intermediate configuration delivers the same projected availability as the basic configuration, but substantially reduces the risk that a catastrophic UPS failure could cause an outage of greater than 10 seconds. Diagram is for reference purposes only; not all inputs, breakers and TVSS products are shown.

This configuration delivers the high availability power protection offered in the basic and intermediate configurations while protecting against the possibility that UPS failure will cause an outage. For that reason, this configuration is recommended for most healthcare facilities employing technology-based diagnostic or patient-care systems. If the STS is located close to the UPS, because it has the needed circuit breakers built in, it can also serve as the maintenance bypass. If the STS is physically separated from the UPS, a separate maintenance bypass (MBS) should be configured with the UPS.

Table 1 summarizes, in the unlikely event of a total UPS failure, whether the load would be dropped or maintained depending on which power protection configuration is deployed.

Benefits of Centralizing Healthcare Power Protection

The benefits of a centralized UPS are significant and make it an easy choice for new facilities. Existing facilities that are already well down the distributed UPS path face a tougher decision, as their current approach may remain feasible for the short term. However, these organizations should look for opportunities to push power protection upstream. Anytime new technology initiatives are being deployed, or facility upgrades or expansions are being planned, is a good time to evaluate the power (and cooling) infrastructure.



ATS = Automatic Transfer Switch
 UPS = Uninterruptible Power Supply
 R = Rectifier
 I = Inverter

SS = Static Switch
 ES = Energy Storage
 STS = Static Transfer Switch

Figure 5: The high availability configuration uses a Static Transfer Switch to switch power seamlessly between the UPS and utility, enabling all downstream equipment to continue operating without interruption in the event of a total UPS failure. Diagram is for reference purposes only; not all inputs, breakers and TVSS products are shown.

Following are some questions to help determine whether an existing facility has reached the limits of the protection a distributed approach can provide and may be putting patient care at risk:

1. Can the facility, especially critical-life areas such as operating rooms and catheterization labs, be without power for 10 seconds while waiting for the generator to power up during a utility outage? What is the impact of the 10-second outage on patient safety and confidence, and surgeon satisfaction?
2. Does a maintenance plan with clear lines of responsibility exist to keep multiple UPS units spread throughout the facility in good working order through monitoring and battery maintenance?
3. Will equipment and systems that require UPS protection continue to be added, rendering a device level approach more costly than a distributed strategy without creating benefits such as the ability to protect all loads inside the hospital?

In summary, the advantages of a centralized power protection strategy compared to the distributed approach include:

Higher Availability

- All loads inside the hospital are on uninterruptible power, so critical medical equipment and information systems do not go down for 10 seconds when the power goes out. Loads are protected from transients as well as outages.
- Depending on the chosen centralized configuration, availability ranges from 99.99964 percent to 99.99979 percent – throughout the hospital.

Scalability

- New technology is protected simply by plugging it into the protected outlet.

- With today's large, scalable UPS systems, loads can be added without having to add more UPS modules, thereby protecting the initial investment in power protection.
- And, when significant additional power is needed, modern UPS systems can be configured to be easily expanded with minimal or no interruption to UPS power.

Greater Reliability

- Reliability is increased when UPS monitoring, testing and battery replacement are centralized.
- With everything inside the hospital protected by UPS systems, the monthly generator test can be conducted at 100 percent load instead of only 30 percent load and will not cause outages.

Simpler Management and Maintenance

- With far fewer, larger UPS modules, there is less to monitor and maintain.
- While a large UPS creates a bigger footprint, it is in an out-of-the way electrical room instead of in prime real estate, as is often the case with device level UPS protection.
- If flywheel technology is used instead of batteries, maintenance needs are dramatically reduced. Flywheels also take up less floor space.

Improved Efficiency

- Large UPS systems such as the Liebert® NXL™, can be up to 94 percent efficient, while smaller UPS units may have efficiencies under 90 percent.
- If the centralized system uses flywheels, they are significantly more energy efficient than batteries, and have a much better overall environmental profile.

CONFIGURATION	CATASTROPHIC UPS FAILURE?			
	MANUAL BYPASSING	AUTOMATIC BYPASSING	LOAD DROPPED	LOAD MAINTAINED
No UPS (ATS only)	Yes	No	Yes	No
UPS + MBS	Yes	No	Yes	Manual xfer with break
UPS + MBS xfer	Yes	Yes	Yes (0.5 seconds only)	Auto xfer with break
UPS + STS	Yes	Yes	No	Yes

Table 1: The UPS with automatic bypass to STS maintains the load in the unlikely event of a total UPS failure.

Lower Cost

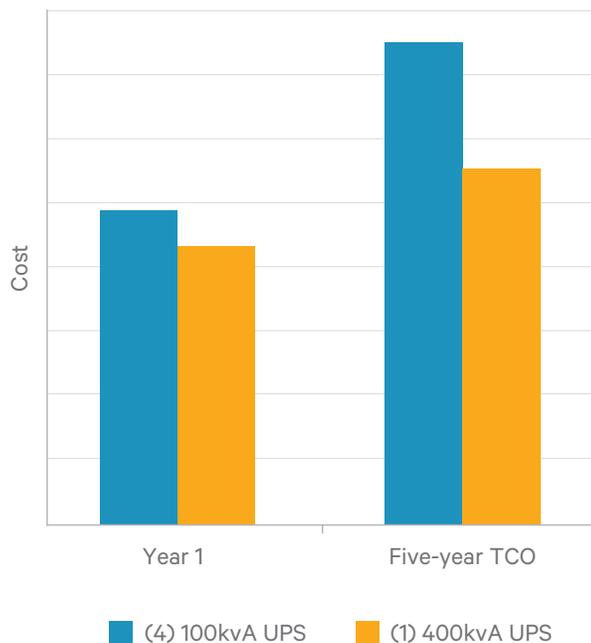
- The initial cost of deploying a large UPS is lower than deploying a few small UPS units; and as small UPS deployments grow, the total cost of ownership will be significantly higher than a large UPS system, as illustrated in the example in Figure 6.
- Higher costs are incurred for monitoring, testing and replacing batteries for multiple small UPS units.
- Increased local heating where small UPS units are deployed requires investment in more comfort cooling.
- If flywheel technology is used, it pays for itself soon after the first battery replacement and provides savings over batteries for the rest of the UPS systems life.

Conclusion

Hospitals and other healthcare facilities are turning into data centers, with increasing reliance on digital technologies to help improve patient care, increase efficiency and lower costs. To ensure continuous availability of life-critical information and equipment, hospitals can turn to proven power protection strategies used in 24/7 data centers delivering high 9s availability. When compared to the device level approach, deploying a centralized UPS system allows hospital IT management to maximize power protection at the best cost, while enabling future growth.

Note: Materials sold hereunder cannot be used in the patient vicinity (e.g., use where UL, cUL or IEC 60601-1 is required). Medical Applications such as invasive procedures and electrical life support equipment are subject to additional terms and conditions.

Initial Purchase and Five-year TCO



References

1. Kalamora Information, 2007. *U.S. Market for EMR Technologies*.
2. Datamonitor, 2007. *Digital Imaging: Reducing Medical Error and Improving Diagnostics*.
3. Spyglass Consulting Group, 2008. *Trends in RFID 2008*.
4. The Joint Commission, 2009. *Hospital Accreditation Program*.
5. Institute of Electrical and Electronics Engineers. IEEE Std 1100-2005. *IEEE Recommended Practice for Powering and Grounding Electronic Equipment (Emerald Book)*.
6. Institute of Electrical and Electronics Engineers. IEEE Std 602-2007. *IEEE Recommended Practice for Electric Systems in Health Care Facilities (White Book)*.

Figure 6: The initial cost of four 100kVA UPS units is twelve percent more than the cost of one 400kVA UPS. The five-year TCO on the 400kVA module is 26 percent less than the TCO for the four smaller units. (Unit price, battery, battery cabinet, shipping, start-up, unit maintenance and battery maintenance are included in the cost calculation. Costs related to cooling, real estate and battery replacement are not included; however, each of these would increase the five-year TCO for the four 100kVA UPS installation.)



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