The mission critical role that data centers play in supporting global business operations cannot be overstated. Rapid adoption of hybrid IT and cloud services, the growth of AI, and an ability to support a remote workforce have made data centers essential for storing and transmitting the "1s and 0s" the world economy runs on. The connectivity of home automation devices, as well as the dramatic increase in e-commerce shopping and virtual conferencing during the COVID-19 pandemic, have also bolstered data centers' significance in everyday life.

To give a sense of the volume of information being processed by data centers, consider eBay. It processes 300 billion data queries each day, with a data footprint exceeding 500 petabytes (4e+9 GB). That is enough to backup the American Library of Congress more than 300 times.

While the economy depends on data centers for a variety of reasons, the more than seven million data centers operating around the world depend on one common factor for their 24/7/365 availability: the reliable supply of electrical power.

Downtime Costs

Data centers that are experiencing regular power outages risk their temperature control systems shutting down, potentially leaving the estimated 18 million servers deployed worldwide in data centers vulnerable to the dangers of overheating and condensation changes. Both can limit a server's ability to safely store data and may permanently damage it. According to a 2018 survey by Uptime Institute, 31% of data centers experienced a power-related downtime incident or severe degradation in the last year and 48% reported at least one outage at their site or at a service provider in the last three years.

Downtime due to a power outage has grave consequences for data centers. Gartner reports that data center downtime costs $5,600 per minute or between $140,000 and $540,000 per hour depending on the organization. Based on an average reported incident length of 90 minutes, the typical cost of a single downtime event was approximately $505,500.

These costs are calculated applying such things as data loss or corruption, employee and equipment productivity reductions, equipment replacement, root-cause detection and recovery actions, legal and regulatory repercussions, revenue loss, and the long-term repercussions on reputation and trust among key stakeholders. While business disruption and lost revenue are cited as the most significant cost consequences of downtime, other less obvious costs also have a significant impact on an average downtime event. For example, every second a data center experiences downtime, their clients experience downtime as well, creating a cascading effect of losses.

UPS Battery Related Failures

A survey conducted by Emerson showed that more than 39 percent of data center outages were attributed directly to vulnerabilities in the facility's power. Among the many general root causes of data center downtime related to power, UPS (uninterruptible power supply) battery failures proved to be the most costly ($687,700) and accounted for one-quarter of all such events. Time after time, the battery in a UPS proved to be the most vulnerable part of the system.

Having a system of UPS is essential in any data center, large or small, to ensure service continuity. UPS provide critical backup power if the primary power source goes offline due to a disruption or a catastrophic emergency. It bridges the short-term loss between utility power failure and backup generator operation. In addition to backup power, a UPS provides protection against surges, sags and other disruptions that can severely damage connected devices, reduce their lifespan, or affect their overall performance.

Why Do UPS Batteries Fail?

Like every battery, UPS batteries have a built-in lifespan (approximately 3-6 years) and require replacing when they can no longer supply 80 percent of rated capacity in ampere-hours. However, UPS battery life may be compromised by several factors other than time. For instance, if ambient temperatures are too warm or if the battery is subjected to wide temperature variances, it is put at serious risk of degrading. In general, if the temperature drops below 22 °C (71.6 °F), UPS batteries will underperform or sustain damage. Operating above 25 °C (77 °F) will result in increased battery capacity but reduced battery life. As a guideline, every 8 °C (14.4 °F) rise in temperature above 25 °C (77 °F) cuts the battery life in half.

Over-cycling is another culprit. "Cycling" refers to when a battery is discharged and recharged. If this happens too often it reduces the capacity of a battery and causes deterioration of the battery contacts. Constant discharging of batteries will send them to a premature end-of-life.

In addition, UPS batteries may fail due to incorrect float voltage, as well as leaving them in storage too long without re-charging, or as a result of simple human error.

UPS Battery Overheating

Overheating is by far the most frequent cause of UPS battery failure and the leading accelerator of UPS battery aging. Even batteries designed for high-temperature chemical reactions are not immune to heat induced failures due to parasitic reaction within the cell. Overheating will happen in a data center due to:

- Air conditioning not producing a sufficient volume of chilled air. This event commonly happens when an older UPS is replaced with a larger capacity UPS. Hot summer days can also lead to air conditioning not providing the needed amount of cooling. Air conditioning units must be serviced regularly to ensure the proper cooling of each UPS system.
- Dust build-up inside the UPS is an unseen villain that causes overheating. Internal dust build-up leads to degradation of not just the battery, but of all the components of the UPS.
- Fans used to cool the UPS may fail. In a multi-fan system, a single fan failure may go unnoticed resulting in less than adequate cooling.
- An overloaded UPS continuously operating at 100% or higher will overheat.
- A UPS that is installed in an area without proper ventilation will overheat.

Three-phase and Single-phase UPS

Three-phase UPS are commonly installed in data centers for larger equipment with higher power requirements distributed over longer distances. A single-phase UPS is generally used for smaller loads within the data center, for instance: HVAC and control equipment, network workstations, VoIP, rack or distributed servers, and safety/security systems. Smaller remote IT centers and edge data centers may rely entirely on single-phase UPS to keep infrastructure operational.

For the purpose of this whitepaper, we are only reviewing issues regarding single-phase units in data centers. Until recently it was thought that only loads less than 20kVA could safely use a single-phase UPS. Yet most quality industrial-grade single-phase UPS are now fully capable of handling

much higher kVA applications in a broader range of VDC without failure. For low- to mid-power requirements, single-phase UPS are more efficient than three-phase UPS, striking the right balance of price, energy density, power, and resiliency. In the event that the commercial power source is down, a correctly specified and installed industrial single-phase UPS will intercept virtually any potential power disruption the data center may experience, while maintaining electricity at a consistent rate, and providing critical power.

Emerson's Solution
The SolaHD™ SDU AC-B UPS by Emerson combines a very compact footprint with a wide operational temperature range [0 to 50 °C (32 to 122 °F)], plus offers a network communications option supporting all major industrial protocols. Built rugged for long-term reliability, this single-phase UPS helps data centers by bridging power failures during outages to allow for safe shutdowns of machinery, and by mitigating power quality issues that adversely affect critical loads; therefore minimizing work interruptions, long restart cycles and loss of data at the point of use.

An Emerson customer who works as a Design Engineer for a large data center explained: "We have a hard time selling our products when we can't keep our data center up and running all the time. A single outage can be a multi-million-dollar loss, which also damages our brand. The SolaHD SDU B-Series ensures we avoid these significant losses while reducing our total cost of ownership through advanced battery health checks and user replaceable batteries. Our data center allows production as well as sales, ensuring our customers receive the product they ordered, when they need it.

Types of Single-phase UPS

In general, classifying single-phase UPS comes down to three basic characteristics.

1. Topology:From a simplified perspective, UPS topology comes down to a choice between standby (basic), line interactive, and on-line. Each has their advantages and disadvantages. In single-phase applications involving a control system, standby or line-interactive UPS models with Simulated Sine Wave in battery mode, a technology based on approximated sine wave output waveform, are recommended. This type of UPS delivers a combination of low cost, light weight, and a small footprint for non-sensitive loads. A UPS that utilizes heat-sinks in place of prone-to-failure fans will further increase reliability, especially in dusty environments

2. Form Factor: When choosing a form factor, the main consideration is where the UPS is going to be installed. Standard UPS form factors are desktop, tower, rack/tower, rackmount and DIN- rail. In data centers it is best practice to install small single-phase UPS on a DIN rail, which is a metal rail of a standard type widely used for mounting circuit breakers and industrial control equipment inside equipment racks. The lighter the UPS, and the smaller its footprint, directly translates into more space for additional equipment on the DIN rail with the proper ventilation needed to keep mounted equipment cool.

3. Battery Type: In industrial and data center areas, a good choice for a single-phase UPS battery is sealed, Valve Regulated Lead Acid (VRLA) technology. VRLA batteries are rechargeable and are considered low maintenance. In recent years, Lithium-ion UPS systems have become available in some UPS designs. Being volatile, Lithium makes certification difficult in an industrial or data center area. Also, Lithium has strict battery management system requirements that measure each individual cell; if one exceeds ~+50 to +55 °C (~+122 to +131 °F) the whole system shuts down without warning. Most commonly, Li-ion is found within three-phase UPS systems deployed to provide resiliency in industrial plants or large data center facilities.

Selecting a Single-phase UPS

Specifying a UPS solution with the optimal power protection is essential for data center availability. To ensure that the UPS matches with your needs, consider these factors during the selection process:

- **Capacity:** UPS capacity is simply how much power a UPS system can provide. To calculate the load, create an equipment list based on the total watts each device

requires to run. The higher the UPS capacity, the more devices it can support. If requirements exceed 16,000 watts, consider a 3-phase UPS, or divide equipment into groups to be supported by several single-phase UPS. When replacing an existing UPS, keep in mind the IT load may have changed since it was originally installed.

- **Runtime:** Backup runtime refers to the duration the UPS can bridge power to the devices it is supporting during an outage.
- **Space:** Data center real estate is always at a premium for IT and facility managers. Specify a UPS with the smallest footprint and lowest weight without compromising protection.
- **Energy Efficiency:** While the efficiency of a typical UPS ranges from 94% to 95%, that rating plunges as the load decreases.
- **LCD Panel:** An LCD displays critical data points at a glance, such as voltage, low battery, frequency, and backup time, permitting easier system management. There are also audible alarms that notify the facility manager of status conditions.
- **Redundancy:** To meet uptime requirements for data centers, UPS are often deployed with redundancy. There are three main UPS redundancy architectures, N+1, 2N and 2(N+1). N is the full UPS capacity required to handle the total load or the same as non-redundant.
- **Connection Ports:** UPS may have several connection ports for your application. Serial ports connect a UPS system to a computer. USB ports are used for communication. An RJ45 port or a network management card can be used to control and configure the UPS remotely via a web browser or network management system.
- **Ratings:** The three major data center design and infrastructure standards developed for the industry are Uptime Institute's Tier Standard, ANSI/TIA 942-A 2014, and EN 50600 (International). There are also operational standards for day-to-day processes. Specifically, for UPS there are IEC 62040, and UL-1778. You should look for a manufacturer that goes beyond these standards for its industrial UPS and offers models that are rated explosionproof (Class I, Div 1), corrosion-resistant and sealed to prevent moisture ingress.
- **Temperature and Humidity:** ASHRAE revised its acceptable operating range for data centers upwards from +18 °C to +27 °C (+64 °F to +81 °F). While this saves power and money, it gives facility managers less time to react to escalating temperatures. ASHRAE's 2016 guidelines for data center humidity is 50% humidity; minimum humidity is set at 20%, while maximum humidity is 80%. Environmental factors should be considered when purchasing a single-phase UPS, as changes can lead to product degradation over time. The UPS you specify must have a wide operating temperature range outside of ASHRAE's recommendations to prepare your data center for a worst-case scenario.

UPS Network Monitoring

Some IT departments manually assess UPS health only if an alarm is sounding or a fault indicator light is on. Upgrading to a network to monitor UPS on a website dashboard is a major

step forward; it minimizes labor costs and, if properly used, can dramatically reduce battery problems.

Warning signs, such as deteriorating performance or an overheating battery, results in the sending of real-time notifications by text or email. Technicians can make repairs or replace batteries before serious breakdowns have a chance to occur.

Is the Future Underground?

One of the most dramatic trends in data centers is the move away from traditional "clean room" environments to damp, underground sites. Data storage requirements are growing exponentially yet available real estate is not. The massive fleets of hard drives and servers contained within data centers require hundreds, if not thousands, of acres of land. Increasingly, this simply isn't cost-effective, leading companies to shift to new underground facilities. Rather than constructing a building from scratch or occupying space in an existing building on a lease, it is far cheaper to use an abandoned bunker, cave or mine.

Emerson's Solution
SolaHD UPSwatch Monitoring Software by Emerson is a one-to-one application for computers, laptops and workstations used for monitoring UPS systems. When the UPSwatch is operating, it collects messages sent from the UPS in the background. UPSwatch interprets the received messages and makes them available to the UPS. If UPSwatch detects supply voltage variations or even a total power loss, it can execute various command scripts. It allows communication with the SolaHD SDU B, SPS, SLN and/or SSW UPS Series when they are directly connected to a computer. When installed on a local computer, UPSwatch software connects to the UPS using either a USB or serial cable, giving you the ability to monitor the UPS and its loads. The software performs battery checks every month and will notify users of weak battery through the monitoring software or relay card – signaling the maintenance team to prepare for battery replacement.

Besides reducing real estate costs, subterranean data centers have geographical and geological advantages, such as zero solar heat gain, low ambient temperature, natural geothermal cooling, and solid rock surrounded structures. These factors dramatically reduce cooling costs, plus may improve physical security.

The downside to subterranean data centers is moisture. Damp walls and elevated humidity levels can wreak havoc on ordinary location UPS systems. While exposure to moisture might not immediately cause a UPS failure, it facilitates corrosion of the cabinet and its internal components, ultimately leading to UPS failure. Simple dehumidification equipment may not be sufficient where humidity is a problem.

Using an industrial-grade, IEC 60068 rated UPS will provide the optimum backup protection of critical data center infrastructure from moisture. IEC 60068 offers guidance for the environmental testing of electronics, including UPS, such as heat, cold and humidity. Specify UPS models with maximum permissible relative humidity levels of 90 percent or more. Because standard UPS systems may not have been subjected to IEC 60068 testing, they are not appropriate for underground data center use.

Summary

Compared to large three-phase floor UPS systems, single-phase UPS are less visible yet play an equally vital role in maintaining modern data centers. Behind the scenes, single-phase UPS are protecting building systems, such as the controls for the facility's HVAC, workstations, VoIP and safety/security. For low- to mid-power requirements, single-phase UPS are more efficient than three-phase UPS, striking the right balance of price and resiliency. Given the importance of maintaining uptime, single-phase UPS in your data center must be capable of withstanding environmental and mechanical factors that can compromise long-term performance.

Emerson's Solution

The SolaHD brand of power quality products by Emerson has a long history of developing power protection equipment for harsh industrial and hazardous locations, supporting such industries as oil & gas, petrochemical processing and wastewater treatment. Many of the same features that these industries require — higher operating temperatures, robust enclosures, vibration resistance, advanced protection against high inrush loads — are also needed in today's data centers.

Emerson's long-established place in the data center puts it in a unique position of leadership in software, hardware, and services. For decades, Emerson has provided innovative data center infrastructure management solutions that bridge the gap between IT and facility management. Emerson data center brands have included Liebert, Avocent, ASCO, Knurr and Aperture.

Today, Emerson has stepped up as a new powerhouse for data centers through its SolaHD brand. Targeting the single-phase niche within the data center, SolaHD UPS convert, protect and backup mission-critical power. Even if the data center surroundings don't seem to be affecting UPS performance, they can change quickly and lead to deteriorating batteries. SolaHD UPS are designed as industrial-grade products with wide operation temperature ranges. Dirt or dust that can restrict air flow is kept out of SolaHD UPS, and moisture that could corrode connections is prevented from entering the enclosure.

To learn more about how SolaHD UPS by Emerson can help maintain data center availability, visit www.solahd.com.

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