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INTELLIGENT POWER MANAGEMENT WITHIN HIGH-DENSITY DEPLOYMENTS

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WITH THE RISE IN THE AMOUNT OF PROCESSING BEING DONE AT EVERY CABINET, ATTENTION MUST BE PAID TO THE CABINET POWER DISTRIBUTION STRATEGY REQUIRED TO ACHIEVE THE HIGHEST LEVELS OF AVAILABILITY AND EFFICIENCY WITH MINIMUM MANAGEMENT OVERHEAD.

To ensure highly available power to IT equipment, all power components in the power chain need to have monitoring capabilities.

Rack power distribution units (PDUs) represent the last leg of the power chain. Therefore, it is critical that organizations choose rack PDUs with monitoring capabilities for high-density deployments. In fact, a recent study showed that the rack PDU market is being driven by higher power ratings, desire for more intelligent products, demand for security features, need for power provisioning, capacity planning and remote control. This article discusses the electrical, physical and management considerations for effective cabinet-level power management within such high-density scenarios. It presents six key considerations for deploying intelligent PDUs into high-density cabinets:

- Appropriate input circuit—to handle required capacity.
- Adequate outlet type and density—to plug all equipment.
- Branch overcurrent protection type—to minimize nuisance tripping and downtime.
- High ambient temperature rating—for reliable operation within hot aisles.
- Appropriate functionality level—to monitor at the rack- or device level.
- Continual monitoring—to enable proactive notification of impending issues.

The article also discussed the management of cost and security associated with the deployment of intelligent PDUs.

APPROPRIATE INPUT CIRCUIT

Incoming power from the utility within data centers is typically three-phase. Bringing three-phase power into the data center allows required power capacity to be delivered at a lower amperage, resulting in lower losses. Organizations have a choice of bringing three-phase or one-phase power to the cabinets. Within high-density cabinet environments, bringing three-phase power to the cabinet provides the same benefit as that of a three-phase incoming supply to the data center. Table 1 provides the maximum capacity that can be handled by the most common one- and three-phase circuits found in North America and international regions.

REGION	TYPICAL CIRCUIT	TYPICAL PLUG TYPE	MAX. CAPACITY (kW)
NORTH AMERICA	THREE-PHASE, 60A, 208V	IEC 60309 3P+G	17.3
	THREE-PHASE, 30A, 415V	L22-30P	17.3
	THREE-PHASE, 50A, 208V	CS8365C	14.4
	THREE-PHASE, 30A, 208V	L21-30P, L15-30P	8.6
	THREE-PHASE, 20A, 208V	L21-20P, L15-20P	5.7
	SINGLE-PHASE, 30A, 208V	L6-30P	4.9
	SINGLE-PHASE, 20A, 208V	L6-20P	3.3
	SINGLE-PHASE, 30A, 120V	L5-30P	2.8
	SINGLE-PHASE, 20A, 120V	L5-20P	1.9
INTERNATIONAL	THREE-PHASE, 32A, 380/400/415V	IEC 60309 32A 3P+N+G	21 – 23
	THREE-PHASE, 16A, 380/400/415V	IEC 60309 16A 3P+N+G	10.5 – 11.5
	THREE-PHASE, 32A, 220/230/240V	IEC 60309 32A 1P+N+G	7.0 – 7.7
	THREE-PHASE, 16A, 220/230/240V	IEC 60309 16A 1P+N+G	3.5 – 3.8

(kW= KILOWATTS; A = AMPERES; V=VOLTS)

TABLE 1: Maximum capacity that can be handled by the most common one- and three-phase circuits found in North America and international regions.

For rack densities beyond 4.9 kilowatts (kW) in North America and 7.3 kW in international regions, it makes the most sense to bring three-phase power to the cabinets. The appropriate three-phase circuit to the rack is determined by the total rack capacity required. Generally, two power feeds are used for each cabinet to support redundancy, and each PDU should be able to support the full load of the cabinet. For example, if the cabinet has a 5 kW (5 volt-ampere [VA]) load, each PDU and supporting circuit would be sized to 10 kW (10 VA).

Three-phase power at the cabinet level not only helps minimize losses, but also simplifies load balancing across all three phases of the incoming power into the data center. Balanced loads result in optimum utilization of the upstream electrical infrastructure by keeping neutral currents and harmonics low.

For greenfield opportunities, data center managers also have a choice of the voltage supplied to the equipment in the cabinet. Most IT equipment can handle voltages within a range of 100–250 volts (V). Choosing a higher voltage for the IT equipment leads to lower current draw and, hence, lower losses. This is why many new data centers in North America are being set up with 240/415 V three-phase to the cabinets instead of the typical 208 V or even 120 V.

ADEQUATE OUTLET TYPE AND DENSITY

In most data centers, high-density cabinets consist of the following configurations of rack units (RUs):

- ***Rack full of 1RU/2RU servers installer cabinets:*** These cabinets typically have a high number of lower amperage servers that are powered through IEC 320 C14 connectors. For these deployments, the appropriate rack PDU should provide a high quantity of IEC 320 C13 outlets. Today, there are a few providers of intelligent PDUs that feature as many as 60 C13 outlets within a standard form factor to support 45RU or taller cabinets.
- ***Rack filled with a few blade chassis or data center level modular network switches:*** These cabinets typically have fewer pieces of equipment, all powered through multiple power supplies, each utilizing one or several C20 connectors. These deployments require intelligent rack PDUs that have a high number of C19 outlets.

In an ideal scenario, the decision about the types of outlets and densities to be supported on an intelligent PDU should be made after selecting the IT equipment to be deployed. However, in the event the decision about the PDU has to be made earlier, it is advisable to select

FIGURE 1: When it is not known what equipment will be placed in the cabinet, a PDU with a mix of C13 and C19 outlets should be selected.

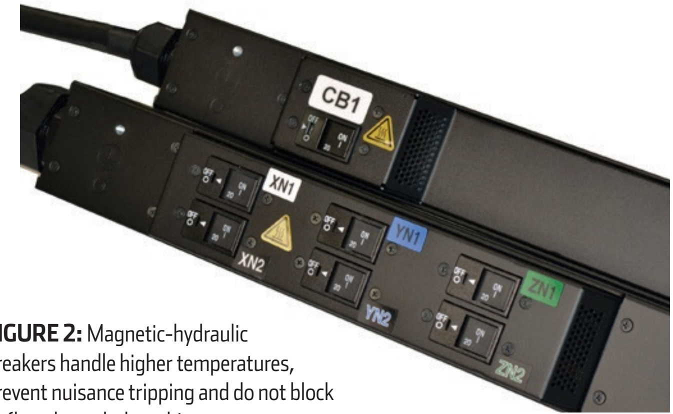

FIGURE 2: Magnetic-hydraulic breakers handle higher temperatures, prevent nuisance tripping and do not block airflow through the cabinet.

an intelligent PDU that provides a good mix of C13 and C19 outlets (Figure 1). Having a higher count of C19 outlets will always be beneficial because these types of outlets can power equipment with either a C14 or C20 connector. On the other hand, a C13 outlet cannot be used to power a higher amperage C20 connector. Again, the power supplies in smaller rack-mount equipment, such as 1RU/2RU servers, typically use the C14/C13 connection, and the power supplies in larger blade and modular switch equipment typically use the higher amperage C19/C20 connection.

Regardless of whether the outlet type is C13, C19 or a mix of both, the outlets should provide a locking feature that prevents accidental disconnection of IT equipment. To save on overall upfront costs of the entire solution, locking outlets should be able to support standard power cords. Selecting a model that uses proprietary power cords will require the added expense of sourcing a proprietary power cord for each powered device.

BRANCH OVERCURRENT PROTECTION

All intelligent PDUs that draw greater than 20 amperes (A) of current typically have two or more branch circuits protected by an overcurrent protection fuse or breaker. It is highly recommended that a breaker is chosen over a fuse. A breaker can be easily reset when tripped, whereas a fuse must be replaced, and power remains out until the fuse is replaced. Replacement activity requires the entire PDU to be turned off, as well as the intervention of a licensed electrician, ultimately leading to a higher mean time to repair.

Breaker type is another important consideration. Breakers can be thermal, magnetic or a magnetic-hydraulic. Magnetic-hydraulic breakers are the least susceptible to thermal changes and minimize nuisance tripping, making them the best choice for high-density deployments (Figure 2).

To handle minor overload situations, opt for magnetic-hydraulic breakers with a 100-percent rating. Other important capabilities related to branch overcurrent protection include:

- Slim profile breakers to ensure minimal interference with airflow.
- UL 489-listed breakers for safety and reliability.
- Ability to constantly monitor the status of the circuit breaker or fuse regardless of the type of PDU selected.

HIGH AMBIENT TEMPERATURE RATING

To maintain high levels of efficiency and lower energy consumption costs, high-density deployments are featuring higher server inlet temperatures that ultimately translate into higher server exhaust temperatures. Some data centers also deploy containment solutions for higher efficiency. All of these steps lead to higher temperatures in the hot aisles, which is where most vertical PDUs are installed.

To ensure that the PDUs continue to operate reliably through this trend of rising temperatures, consider a PDU with a high temperature rating (Figure 3). To have the highest levels of availability, the PDU must also support full load capacity at the rated temperature. Therefore, it is important to select a manufacturer that provides PDUs with a high temperature rating to meet current practices and future needs.

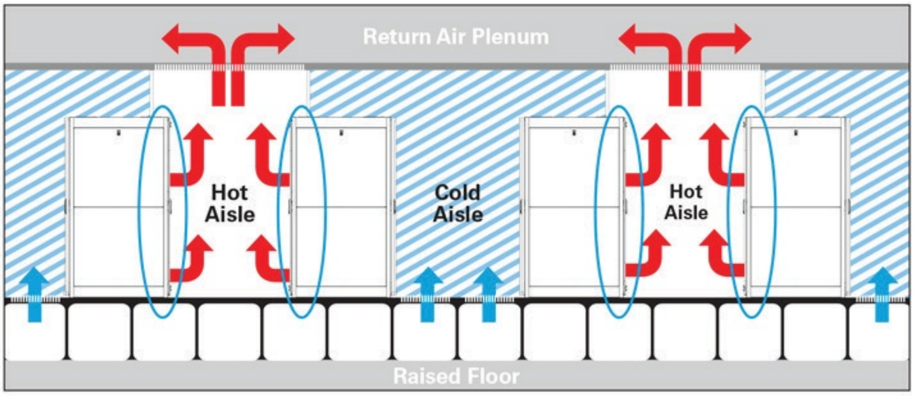

FIGURE 3: PDUs are exposed to the highest ambient air temperatures.

APPROPRIATE FUNCTIONALITY LEVELS OF INTELLIGENT PDUS

Intelligent PDUs feature various levels of functionalities. The benefits associated with each functionality within high-density deployments are:

- ***Branch circuit & phase-level monitoring:*** Continual monitoring of these parameters, along with the ability to set thresholds with notifications, ensures that the connected loads stay within capacities at all times. Phase-level monitoring also ensures that the loads stay balanced for efficiency and optimum utilization.
- ***Outlet-level metering:*** This provides information about energy consumption of individual IT equipment that ultimately enables charge back reports and higher accountability. In addition, it helps set baseline energy consumption for individual equipment, which can be useful when choosing new equipment to be added to the cabinets.
- ***Outlet-level switching:*** This ensures proper provisioning by giving administrators the ability to control what equipment gets powered from the PDU.As a best practice, all unused outlets should be maintained in the off position until an administrator allows the connection of new equipment. This capability also provides the ability to turn equipment on in sequence at the initial startup, to identify under-utilized equipment, and to remotely cycle power to hung IT equipment.
- ***Integrated environmental monitoring:*** Continual monitoring of ambient temperature and humidity parameters at the cabinet level, provided by sensors that are integrated into or attached to the rack PDU, ensures availability of IT equipment by providing early notification of any impending issues.

CONTINUAL MONITORING

For high-density environments, it is critical that intelligent PDUs have the capability to provide circuit-breaker status at all times. For all the electrical parameters being monitored, PDUs must be able to set thresholds. As warning or critical thresholds are exceeded, the PDU should have the capability to generate notifications. The intelligent PDU selected should provide flexibility with notifications. Preferred notification methods include email, simple network management protocol (SNMP) traps or syslog. For troubleshooting and auditing purposes, intelligent PDUs should provide an exportable event log with a time and date stamp for each logged entry.

CHALLENGES ASSOCIATED WITH INTELLIGENT PDU DEPLOYMENT

In addition to the key considerations, there are several important deployment considerations related to how the intelligent PDU integrates into the network:

- Minimizing network connectivity costs of all PDUs
- Ensuring high levels of network security
- Comprehensive management of all PDUs

MINIMIZING NETWORK CONNECTIVITY COSTS OF ALL PDUS

Network connectivity of intelligent PDUs typically requires the installation of additional network switches and cabling from each PDU back to the switches. Internet

	100	200	400
NUMBER OF CABINETS	100	200	400
NUMBER OF PDUs (2 PER CABINET)	200	400	800
Cost of ports @ $500 per port			
DEDICATED IP ADDRESS PER PDU	$100,000	$200,000	$400,000
SECURE ARRAY	$3,500-$7,000	$6,400-$13,000	$12,500-$25,000
Number of IP Addresses Used			
DEDICATED IP ADDRESS PER PDU	200	400	800
SECURE ARRAY	7-14	13-26	25-50

TABLE 2: Estimated total savings an organization can expect with the deployment of intelligent PDUs within a secure array.

protocol (IP) consolidation technology minimizes the network connectivity costs by consolidating up to 32 PDUs under one single IP address and physical network connection.

This reduces the total number of IP ports used, which ultimately translates to deployment of fewer network switches. The total installation time and the Ethernet cable length also decreases significantly. Table 2 provides an estimate of the total savings an organization can expect with the deployment of intelligent PDUs within a secure array, compared to the cost using an individual network connection to each PDU.

A secure array also allows for another PDU within the array to be set up as an alternate primary for network redundancy. This ensures continued communications across the array, even in the event that one of the enrolled PDUs loses its network connection or its intelligence gets compromised. Other benefits of a secure array include the ability to mass-configure all PDUs, as well as grouping of all PDUs and outlets within the entire array.

ENSURING HIGH LEVELS OF SECURITY

With the ability to turn outlets on and off and set thresholds remotely, network security is of paramount importance when considering intelligent PDUs. The key items to consider in order to ensure high levels of security include:

- Ensure security is built into all interfaces available for the monitoring and management of the PDUs. The web interface should support HTTPS protocol; SNMP compatibility should include v3 support that has built in SHA and DES encryption; and the Command Line Interface, if supported, should include SSH capability.
- The intelligent PDU should support remote authentication protocols such as LDAP and RADIUS to minimize the need to maintain passwords and user logins at each and every individual PDU.
- All interfaces should provide separate permissions at the user and administrator levels.
- Functionality of the local interface should be limited as much as possible for monitoring items only. The ability to change settings and outlet control should not be available through the local interface.

COMPREHENSIVE MANAGEMENT OF PDUS

A typical data center has two PDUs within each cabinet. With any mid-size to large data center with tens to hundreds of cabinets, managing each PDU individually can be a cumbersome proposition. A comprehensive software solution simplifies management of all PDUs within a data center or multiple sites through a single interface that provides access, administration and auditing capabilities. Key management capabilities of a comprehensive software solution include:

- Visual health map status of all PDUs.
- Consolidated event log and alarming/notification capabilities.
- Embedded database with reporting capabilities that helps data center managers take steps to reduce energy consumption, utilize stranded capacity and better plan for the future.
- Grouping of all PDUs and outlets for energy consumption charge back reports, power control and setting permissions.
- Configuration changes to all PDUs.

The software solution selected to manage PDUs should have the capability to autodiscover all of the supported devices. Dynamic plug-in capability that allows quick development of support for new equipment is a big benefit, as it truly makes it a vendor-agnostic software. Open database and provision of web application programming interfaces allow data center operators to customize the software solution to their own needs. The software solution should also be constantly synchronized with the PDUs themselves to ensure consistency within the common data model.

CONCLUSION

Intelligent power management at the cabinet level is critical to a successful high-density deployment, and it requires proper planning. The first step is to look at all the electrical input options available, and choose a compatible one that would also support the required cabinet density. The next step is selecting the appropriate type and number of outlets required to support the high-density environment. Proper care should be taken to ensure that the PDU selected will support the idiosyncrasies of high-density deployments such as higher rack temperatures and branch circuit currents.

Intelligent PDU deployments provide significant benefits but also pose some challenges. Utilizing PDUs with secure array technology and secure interfaces addresses issues around network connectivity and costs. Deploying centralized management software makes management of all PDUs seamless and makes the investment in intelligent PDUs really meaningful. The modern data center requires intelligent products that not only meet the minimum market requirements, but also exceed expectations in reliability, capability and quality. ◀

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