Considerations for Intelligent Power Management within High-Density Deployments

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Considerations for Intelligent Power Management within High-Density deployments.

Summary

As data centers deploy virtualization and consolidate equipment for more efficient computing, the average rack power density is constantly rising. While an average cabinet supported 3 - 4 kW a few years ago, today that power load is considered in low-density environments. It is certainly not uncommon to have cabinets drawing 9 - 15 kW and in several cases, even higher than that.

Data Center Density		
Density Metric	**Per Rack**	**Compute Space**
Extreme	**>= 16 kW**	**>= 16 kW**
High	**9 - 15 kW**	**9 - 15 kW**
Medium	**5 - 8 kW**	**5 - 8 kW**
Low	**0 - 4 kW**	**0 - 4 kW**

Table 1: Data Center DENSITY Definition: AFCOM's Data Center Institute board document[1].

Introduction

With the rise in processing being done at every cabinet, strong attention needs to be paid to the cabinet power distribution strategy so that the highest levels of availability and efficiency are achieved 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, recent research[2] shows that the rack PDU market is being driven by higher power ratings, desire for more intelligent products, demand for intelligent and security features, need for power provisioning, capacity planning and remote control. This paper discusses the electrical, physical and management considerations for effective cabinet-level power management within such high-density scenarios. It presents six key considerations when deploying intelligent PDUs into high-density cabinets and also covers the management of cost and security associated with the deployment of intelligent PDUs.

Six Key Considerations when Selecting Intelligent Rack PDUs for High-Density Cabinets:

- Appropriate input circuit – to handle required capacity
- Adequate outlet type and density – to plug all equipment
- Branch over-current 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

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, hence with a lower amount of losses. Organizations have a choice to bring three- 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. The table below 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

As shown in the table, for rack densities beyond 4.9 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 would be 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 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 centers also have a choice of the voltage that would be supplied to the equipment in the cabinet. Most modern day IT equipment can handle voltages within a range of 100 – 250V. 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 240/415V three-phase to the cabinets instead of the typical 208V or even 120V.

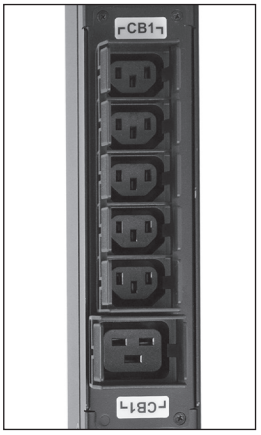
Adequate Outlet Type and Density

In most data centers, high-density cabinets consist of the following configurations:

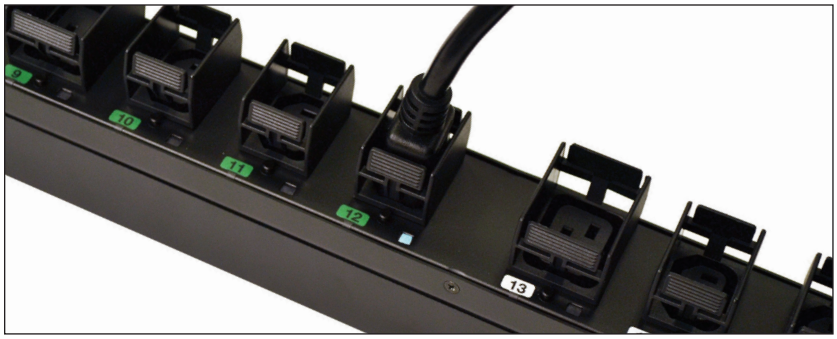
Rack full of 1U/2U servers in taller cabinets – These cabinets would typically have a high number of lower amperage servers that are powered through IEC 320 C14 connectors. For these deployments, the appropriate rack PDU should provide a high quantity of IEC 320 C13 outlets. Today, there are few providers of intelligent PDUs that feature as many as 60 C13 outlets within a standard form factor to support 45U or taller cabinets.

Rack filled with a few blade chassis or data center-level modular network switches – These cabinets would typically have fewer pieces of equipment, all being powered through multiple power supplies, each utilizing one or several C20 connectors. For these deployments, intelligent rack PDUs that have a high number of C19 outlets are required.

In an ideal scenario, the decision about the types of outlets and densities to be supported on an intelligent PDU should be made after the IT equipment to be deployed has been selected. However, in the event the decision about the PDU has to be made earlier, it is advised to select an intelligent PDU that provides a good mix of C13 and C19 outlets. Having a higher count of C19 outlets will always be beneficial because these types of outlets can power both equipment with 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 1U/2U 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.



When you do not know what equipment will be placed in the cabinet, select a PDU with a mix of C13 and C19 outlets.



Select an intelligent PDU with locking outlets that work with standard power cords.

Irrespective of the outlet type being C13, C19 or the 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. If you select a model that uses proprietary power cords, you will have the added expense of sourcing a proprietary power cord(s) for each powered device.

Branch Over-current Protection

All intelligent PDUs that draw greater than 20A of current, typically have two or more branch circuits protected by an over-current 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 MTTR.

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

A. Slim profile breakers to ensure minimal interference with airflow

B. UL 489 listed breakers for safety and reliability

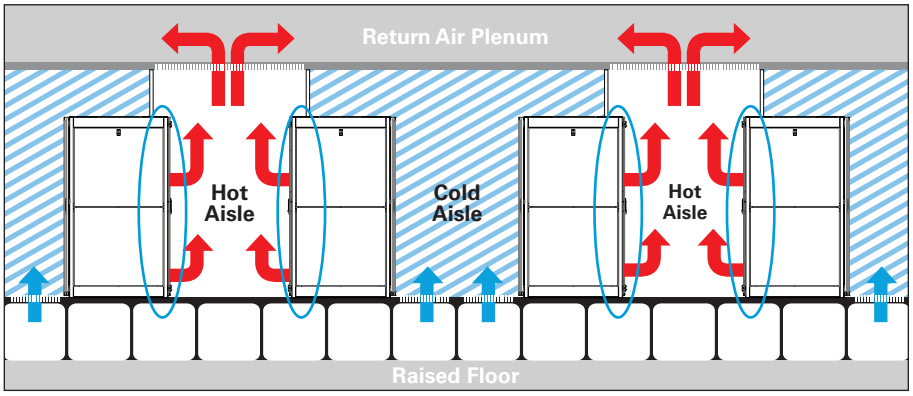
C. Ability to constantly monitor the status of the circuit breaker or fuse irrespective of the type of PDU selected

Low-profile, UL 489 listed, magnetic-hydraulic breakers handle higher temperatures, prevent nuisance tripping and do not block airflow through the cabinet.

Higher 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. 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.



PDUs are exposed to the highest ambient air temperatures. Choose a PDU with the highest temperature rating possible.

Appropriate Functionality Levels of Intelligent PDUs.

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

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

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

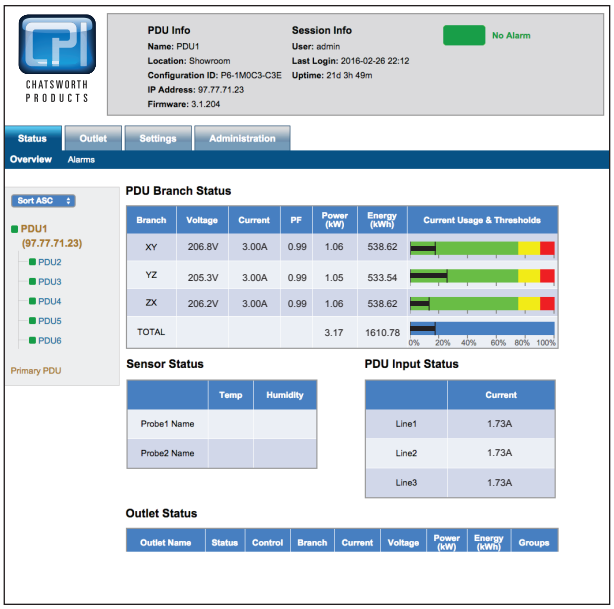
Ensures proper provisioning by providing administrators the ability to control what equipment gets powered from the PDU. As a best practice, all unused outlets should be maintained in the "off" position until an administrator allows the connection of new equipment. This capability also provides the ability to turn equipment on in sequence at the initial startup and for identifying underutilized equipment, or after a power outage to minimize high inrush currents. It also provides the ability to cycle power to hung IT equipment remotely.

Integrated environmental monitoring

Continual monitoring of ambient temperature and humidity parameters at the cabinet level through 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 need to provide the ability to set thresholds. As warning or critical thresholds get exceeded, the PDU should have the capability to generate notifications. The intelligent PDU that you select should provide flexibility with notifications. For example, some of the preferred notification methods include email, 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.



Branch	High Voltage Threshold (Volts)	Low Voltage Threshold (Volts)	Warning Overload Threshold (Amps)	Critical Overload Threshold (Amps)	Warning Low Load Threshold (Amps)
XY	0	0	0	20	0
YZ	0	0	0	20	0
ZX	0	0	0	0	0

Additional Considerations – Handling Challenges Associated with Intelligent PDU Deployment:

In addition to the key considerations presented above, there are several important deployment considerations related to how the intelligent PDU integrates into your 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 with Secure Array™ IP Consolidation Technology

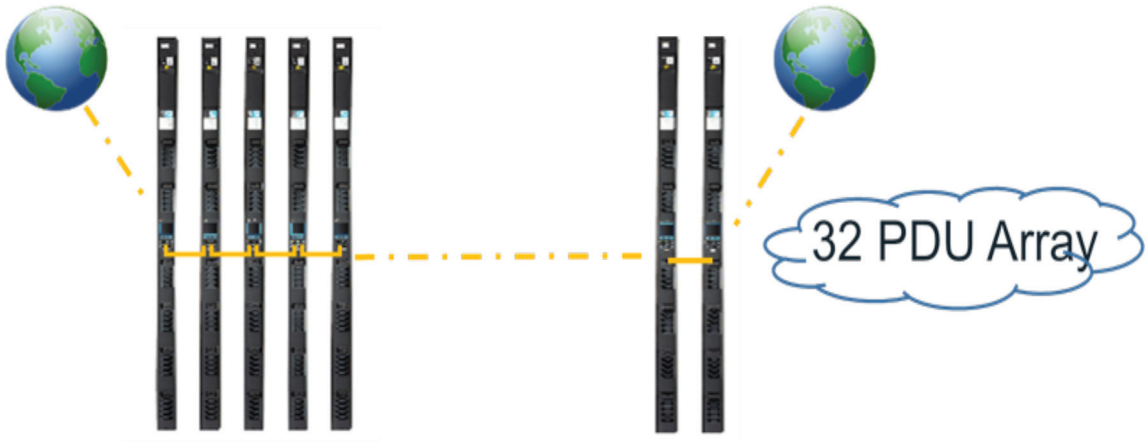
Network connectivity of intelligent PDUs typically requires the installation of additional network switches and cabling from each PDU back to the switches. The costs of this networking infrastructure can run as high as $500 for each networked PDU. Secure Array™ IP Consolidation technology minimizes the 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. The table below 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.

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
eConnect Secure Array	$3,500 – $7,000	$ 6,400 – $13,000	$12,500 – $25,000
	Number of IP Addresses Used		
Dedicated !P Address per PDU	200	400	800
eConnect Secure Array	7–14	13– 26	25–50

Note: Costs are estimates based on networking cost of $500.00 per network connection.

As shown in the diagram below, Secure Array also allows for another PDU within the array to be setup as an "Alternate Primary" for network redundancy. This ensures continued communications across the array, even in the event one of the enrolled PDUs loses its network connection or its intelligence gets compromised. Other benefits of 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 to ensure high levels of security include:

A. Ensure security is built into all interfaces available for the monitoring and management of the PDUs:
   a. The web interface should support HTTPS protocol
   b. SNMP compatibility should include v3 support that has built in SHA and DES encryption
   c. Command Line Interface, if supported, should include SSH capability

B. 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.

C. All interfaces should provide separate permissions at the user and administrator levels.

D. Functionality of the local interface should be limited as much as possible for Monitoring items only. Ability to change settings and outlet control should not be available through the local interface.

Comprehensive Management of all 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 and every PDU individually can be a very 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 but are not limited to:

- 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 to manage PDUs should have the capability to autodiscover all of the supported devices. Dynamic plugin 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 APIs 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 exceed expectations in reliability, capability and quality. That is why it is important to choose a manufacturer that provides a PDU that includes all the features and capabilities described in this paper.

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