
Wye 415V to the Rack in North America

Recognizing Efficiencies
and Increased Power Capacities

Introduction

The growing need to increase energy savings while decreasing physical infrastructure is driven primarily from the exponential growth of digitization. As the digital world evolves, everything around us is hyper-connected and is expected to operate seamlessly. Without the proper power distribution, these connections would not be possible.

As a result, more and more new construction data centers in North America are bringing high voltages (415 V) directly to the rack. The Rack Power Distribution Unit market report published by IHS2 (see Figure 1) further supports this observation.



Wye 415V to the Rack – in North America

According to the report, IHS predicts that the 415 V rack Power Distribution Unit (PDU) will experience an average CAGR of ~40% YOY through 2021.

Below is a list of the top reasons data center owners, builders, and managers are opting to bring 415 V to the rack:

1. Increased power capacity
2. Streamlining the supply chain by standardizing the input plug (globalization)
3. Energy savings caused by increases in power efficiency
4. Decrease in physical infrastructure costs (enabling smaller AWG wire)
5. Quality, reliability, and safety

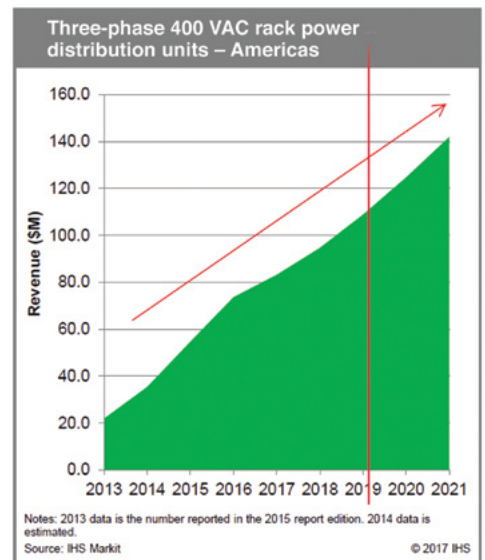


Figure 1. IHS 415V Projection 40% Growth by Volume Year Over Year through 2021.

Increased Power Capacity

Digitization, IOT, hyperscale, cloud computing, mobile computing, smart phones, tablets, social media, video streaming, and professional services are driving the need for maximizing the amount of IT equipment that can be placed in the physical floor print of a cabinet or rack. For this reason, a major trend occurring in the data center cabinet and rack space is the use of taller racks to accommodate the market need of housing even more IT equipment in the same floor print. Although 42 U racks were once the majority, 47 U, 48 U, and 51 U racks have been experiencing strong growth since 2016 and this growth is expected to continue to 2022¹⁰.

This trend presents a unique challenge for the rack power designers because they are tasked to find the capacity to power all the equipment. To resolve this challenge many electrical designers are considering options to bringing 415 V to the rack. To understand how this works (and the respective benefits) we can explore restive load and frequencies under 400 Hz. With that assumption the familiar Ohm’s Law can demonstrate how this works:

$$P = V * I * \sqrt{3}$$

As shown in the above equation, if we double the voltage while keeping the same current, we effectively double the available power capacity. Simple calculations are as follows:

$$P = V * I * \sqrt{3}$$

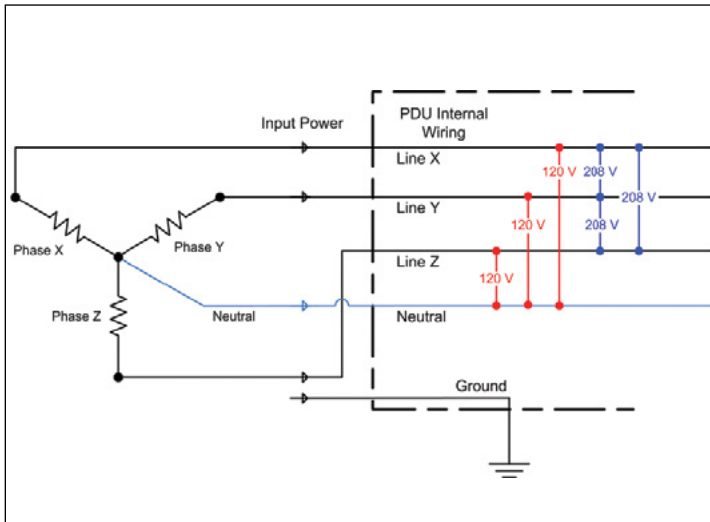
$$P = 208V * 24A * \sqrt{3} = 8.6KW$$

Next, if we consider the same equation and replace 208 V with 415 V we get the following result:

$$P = 415V * 24A * \sqrt{3} = 17.3KW$$

Note: We de-rated the 30 A to 80% (24 A) to follow UL / good design practices in North America. It does not affect the outcome because it applies to both voltage levels.

208 V – 5 Wire – 3 Phase



415 V – 5 Wire – 3 Phase

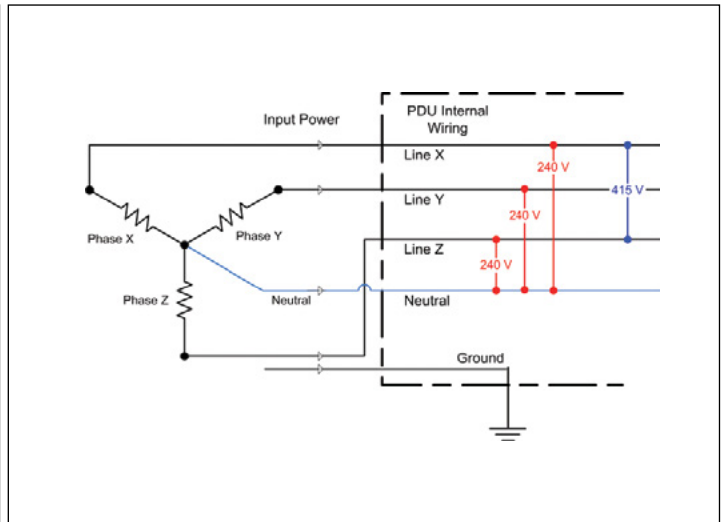


Figure 2. 30 A Circuits – 208 V 8.6kW Capacity; 415 V Circuit 17.3 kW Capacity.

Streamlining the Supply Chain

To accommodate the demand for increased power capacity, IT and computer equipment manufacturers have been streamlining their portion of the supply chain for quite some time by designing IT equipment with switching power supplies capable of accepting 100 – 240 V (voltage levels). Similarly, the demand driven by digitization is being physically realized as rapid growth that hyperscale, colocation, and cloud computing data centers owners/managers are experiencing. This trend is driving the market towards streamlining the supply chain around rack power because not only can they leverage economies of scale but it can decrease the risk of products being available at the speed and scale that data center builders need them. In the process, these global companies have discovered an opportunity to have the same (or similar PDUs) for both North America and Europe (e.g., global PDUs). Traditionally the National Electrical Manufacturers Association (NEMA) input plugs have dominated the North American rack power distribution market while the European rack power market has predominately used IEC 60309 Pin & Sleeve11 input plugs. Understanding the need to standardize across two major continents with recognizing that Europe has been bringing 415 V to the rack for quite some time, input plug manufacturers are providing dual rated input plugs in the IEC 60309 Pin & Sleeve variety (see Figure 3) and data centers in North America are normalizing to the same standard. As an added benefit, the IEC plugs are available in either splash proof IP44, or the more popular watertight IP67 with a locking collar. The locking collar is the preferred option not necessarily for its IP67 waterproof attributes because most of this power is dropped from overhead, but for locking capabilities it provides by screwing together the male and female ends. From a facilities standpoint, this is widely accepted as the safer option to prevent (or almost eliminate) accidental disconnects.



Figure 3. Example of a globally focused dual rated 415 V, 30 A UL is equivalent to 32 A VDE (CE).



Savings (ROI)

Energy Savings

Bringing 415 V to the rack allows for significant energy savings. It is estimated that by using a smaller isolation transfer that goes from 480 V to 415 V, approximately 2% in energy losses can be saved when compared with similar larger isolation transformers which take the incoming voltage of 480 V to 208 V. In addition, when considering IT rack equipment power supply, the end user can realize even more efficiencies. According to an article on arc flash boundary and NFPA-70E requirements, it is estimated that IT equipment switching power supplies run at approximately 80% efficiency at 100 V AC up to 94% efficiency at 240 V AC1. In summary, if 415 V is brought to the rack, the 415 V PDU outlets supply 240 V to the attached IT equipment, which can cause the equipment to run as much as 14% more efficiently when comparing that same piece of equipment running on 120 V.

Infrastructure Costs Savings

415 V also helps to lower infrastructure costs. During the energy savings discussion, we talked about using smaller isolation transformers, which are not only smaller but also approximately \$1500 more cost effective than their larger counterparts (480 V to 208 V) per transformer deployed. In addition, there are significant savings to be had in the power cables themselves. Considering what we learned from the increased power capacity section, we can conclude that a 60 A 208 V (3 Phase) PDU is equivalent in power capacity to a 30 A 415 V (3 Phase) PDU. Leveraging the excerpt for (90°C) THHN cable from National Electrical Code's Allowable Ampacities of Insulated Conductors Rated 0-2000 Volts, we can see that the AWG required to carry 30 A is 12 AWG while the AWG required to carry 60 A is 6 AWG. If we look at the market costs of the two AWG, we can see an approximate savings of \$0.54 per foot when comparing the relative costs at 500 ft increments. Considering the amount of power cable that is installed into a data center this can lead to significant savings to the data center owner.

Voltage	Phase	Current	Load kW	AWG Required	Copper Cost Per Foot
415	3	30	17.3	12	\$0.22*
208	3	60	17.3	6	\$0.76*

*Cost per foot when purchased in 500 feet increments

Figure 4.

Further savings can be realized by using the smaller AWG wire for space savings within the cable raceways.

Quality, Reliability & Safety

As the voltages are increased so is the inherent increased risk for arc flash⁸. Therefore, it's important to select a supplier known for quality, reliability, and safety. To increase the safety level of the PDU, a major safety upgrade in the Panduit 415 V rack PDUs is the 10 KAIC circuit breakers. These breakers are double the rating of a standard 208 V rack PDU which typically has five KAIC breakers. The Panduit 415 V PDUs also are available in the IP67 watertight input plugs, not necessarily for the ingress protection but for the locking collar which offers the highest level of safety. Even with these additional safety components, it is still important to remain vigilant in following standard safety practices such as using Personal Protective Equipment (PPE), adhering to best practices and building and local codes at the installer/technician level. Only licensed professionals trained to deal with electricity should be working with the power chain and the data center environment is no exception. Although 415 V brings a great deal of benefits to capacity and savings in both energy and infrastructure costs, these benefits are only worth it when the solution can be deployed safely with the utmost precautions emphasized around industry best practices.

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