Use of 208 Volt verses 120 Volt Inputs for Servers

White Paper #27

Revision 1

Executive Summary

This note explores the voltage connection options of 208 Volt (V) and 120V for servers in North America. This same discussion applies to the use of 200V vs. 100V in Japan.

Introduction

This white paper explains why and when 208V is used instead of 120V for servers in North America. This same discussion applies to the use of 200V vs. 100V in Japan.

Background

Most entry level and mid-range servers for office use are configured and shipped with 120V plugs but are designed to accept any voltage worldwide, including 120V and 208V. Larger pedestal servers and rack-mount servers tend to be configured with 208V plugs.

There are fundamental reasons why one voltage is sometimes preferred over the other. The reasons are explained in the following sections

Why 120V?

Convenience is the overwhelming reason to use 120V and why virtually all small and departmental servers are installed with 120V plugs. Electrical codes require that habitable space be wired with 120V receptacles with a receptacle for every 10 feet of exposed wall. Therefore, 120V is virtually always available at any office site. However, typical 120V building wiring has a serious and fundamental limitation: the majority of wall receptacles are rated at 15 Amps (15A) and a growing number rated at 20 Amps (20A).

The 15A rating of 120V office power is very important and a significant limitation. Underwriters Laboratory (UL) specifies that a single piece of electronic equipment is not permitted to draw more than 80% of a receptacle's rating, or 12 Amps for a 15A circuit. This places a limit of about 1440 Volt-Amps (Volts x Amps) on a standard 15A receptacle.

Most new servers have power factor corrected supplies with nearly a 1 to 1 correlation to Volt Amps and Watts. This puts the maximum corresponding Watts available through a receptacle also at 1440 Watts - which is the maximum power that a server can draw from a single 15A plug. Due to the losses of the Server power supply, this corresponds to about 1250 Watts of power supply output rating in the server.

Therefore, the maximum power supply configuration typically seen for a server operating from 120V with a single 15A power plug is a server with a 1250W power supply system. Services with a rating of 20A 120V are becoming more popular in commercial environments. For 20A 120V service, 16A or 1920 Volt-Amps or Watts is the maximum of power supply output rating in the server due to losses.

Server power supplies can offer redundancy based on adding additional power supplies. Multiple power cords are also used for redundancy. When a server has 2 power cords, each power cord and power supply must be sized to support the entire server.

It is possible to wire special 120V receptacles for 30 Amp service, but this is very unusual and requires very large wire. Therefore, it is impractical and typically not used for large servers.

It should be noted that a server configured for the maximum power draw described above would use the entire capacity of the 120V circuit. If additional devices like a monitor, PC, Backup device, or RAID subsystem were required then the user would need to supply these from a second circuit which in many cases may require that an additional wire be installed from the AC power distribution panel.

Why 208V?

Power Capacity is the primary reason to use 208V and why many enterprise servers are designed to accept 208V. The most common ratings for 208V receptacles are 20 Amp and 30 Amp, corresponding to about 3600 and 5400 Watts, respectively, of power supply output rating in a server. There very few servers made that require power greater than this level but large enterprise class severs do; for these servers the input power is either hard-wired or multiple 30A 208V cords are provided.

Based on the previous discussion regarding 120V, any server that draws more than the power supply output level of 1920W(20A 120V service), will naturally need to use 208V. Therefore, users should expect this and understand that the use of the higher voltage is driven by fundamental electrical principles.

In addition to the fundamental need to use 208V at higher power, there are other practical reasons why 208V is advantageous.

Rack systems frequently combine a heterogeneous mix of equipment. It happens to be the case that typical rack configurations draw in the range of 1600 to 5000 Watts. This is a poor match to the 120V limitation of 1440W available, but an excellent match to 208V service at either 20Amps or 30Amps. Therefore a single power connection per rack is all that is required at 208V where as many as three connections might be required at 120V.

A given server will draw less current at 208V than at 120V. Therefore its wiring devices, fusing, and switches will run cooler which will reduce their long-term risk of degradation or failure.

An advantage of using 208V is that usually each 208V wall receptacle has its own circuit breaker. This means that the malfunction of a different load cannot trip the server's breaker. In 120V installation, it is very common for a number of receptacles to be fed from a single breaker. This means that in a 120V installation there are often a number of unexpected points where an overload can trip the server's breaker. Most MIS professionals have heard of a case where cleaning personnel have tripped the breaker feeding critical computer loads.

Another advantage of 208V is that the common power receptacles are locking using the twist-lock type plug, which reduces the chance of dislodging them. Furthermore, the quality of the contacts in 208V receptacles is generally higher than 120V receptacles, which greatly reduces the chance of intermittent connections.

What is 240V?

In residential installations in North America and in some limited business installations, 240V is available instead of 208V. Virtually all equipment that operates from single-phase 208V will also operate from 240V. All of the same advantages relative to 120V apply.

What about 3-phase?

Very few servers today require 3-phase power. There is no fundamental advantage to 3-phase for IT equipment, and there are many sites, which simply do not have 3-phase power available. Also, the 3-phase voltage in the rest of the world is much different than that in the USA, making it more difficult to design global products. However, both 120V and 208V single phase can be easily derived from North American 3-phase voltage by simple wire connections; 120V single phase is just the voltage from one of the three phases to neutral, while 208V single phase is the voltage between two of the three phases.

UPS systems for 208V

Users must take the server operating voltage into account when selecting a UPS. There are no "universal" UPS that operate with all combinations of voltage. There are basically four voltage options:

Facility Voltage (UPS Input)	Equipment Voltage (UPS Output)	Example UPS (www.apcc.com)	UPS Power Range
120V	120V	Smart-UPS	420VA - 3000VA
208V	208V (with 400VA of 120V for aux equipment)	Smart-UPS "T" Series	2200VA - 5000VA
208V	208V, 120V	Symmetra, Matrix	3000VA - 16 kVA
208V 3-phase	208V 3-phase, 208V, 120V	Silcon	10 kVA - 2,000 kVA

For servers requiring 208V, the appropriate UPS is selected based on the level of power required. Where multiple product lines provide the power level required, the choice can be based on product features.

Conclusion

208 Volts offers various technical advantages and is the only choice for higher power servers to be pluggable into standard NEMA outlets. Technically, 208V is a superior choice for powering computing equipment when compared with 120V due to lower current draw. However the ubiquitous nature of 120V wiring in North America and 100V in Japan make these lower voltages preferred by users. This has given rise to the situation where lower powered small business or departmental servers are powered by 120V, while larger and enterprise class servers are powered by 208V.