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Will High-Voltage AC Power Prevail in Quest For Data Center Efficiency?

by Ashok Bindra, Technology Writer, Technika

In my last column, the focus was on efforts to reduce power wastage in data centers by using high-voltage dc power distribution. I talked about a 2008 study conducted by Lawrence Berkeley National Labs that highlighted the benefits of the dc approach, which was supported by the Electric Power Research Institute (EPRI) and Emerge Alliance, which is also developing a 380-V dc power standard. Supportive comments from other proponents came from Validus DC Systems, Switzerland's ABB, and power supply giant Delta Electronics.

As I indicated in that column, the ac versus dc power distribution debate continues. And so, this time I will discuss the work being done by proponents of high-voltage ac power distribution.

Recently social networking giant Facebook did something interesting. It created a data center that is very efficient, cheaper to run, and environmentally more sound than the industry standard.

Under an initiative dubbed the Open Compute Project, Facebook released designs for the technology powering its new data center in Prineville, Ore., which the company claims is 38 percent more efficient. Thanks to its custom engineering, it is also 24 percent cheaper to run, according to Facebook.

Now, Facebook wants to give away the blueprint for that data center, hoping that the openness will leverage the expertise of thousands of engineers worldwide to further refine its data center technology, lowering the cost of powering its site. And in doing so, it can squeeze extra dollars out of its ads. To most of the social networking site's 500 million-plus users, Facebook is entirely virtual—an intangible but interactive screen of likes, pokes, chats and status updates that exists only in the ether.

The racks of servers in the Prineville, Oregon data center not only power the online experience that keeps users coming back for more, they also enable Facebook's key moneymaker—its advertising.

According to the Open Compute Project, the Prinville data center design brings 480-V/277-V ac power direct to the server power supply, eliminating up to four power conversion steps that waste up to fifteen percent of power. However, early adopters have to rely on custom power distribution units (PDU) to reap the efficiency benefits of a 480-V/277-V ac system.

Now, leading the first wave in the industry, Eaton Corp. is offering 480-V ac PDUs as part of its ePDU catalog to meet the efficiency needs of server manufacturers.

Utility power in North America typically enters a facility at 480 Vac. Eaton's 480-V ePDU products remove the need for stepdown transformers, reduce distribution costs and power high-efficiency 277-V ac power supplies. A server operating at 277-V ac requires 25 percent less current than a server operating at 208 V ac, according to Eaton.

As shown in Fig. 1, the overall end-to-end efficiency for a traditional 480/208-V ac power distribution system is about 76%.

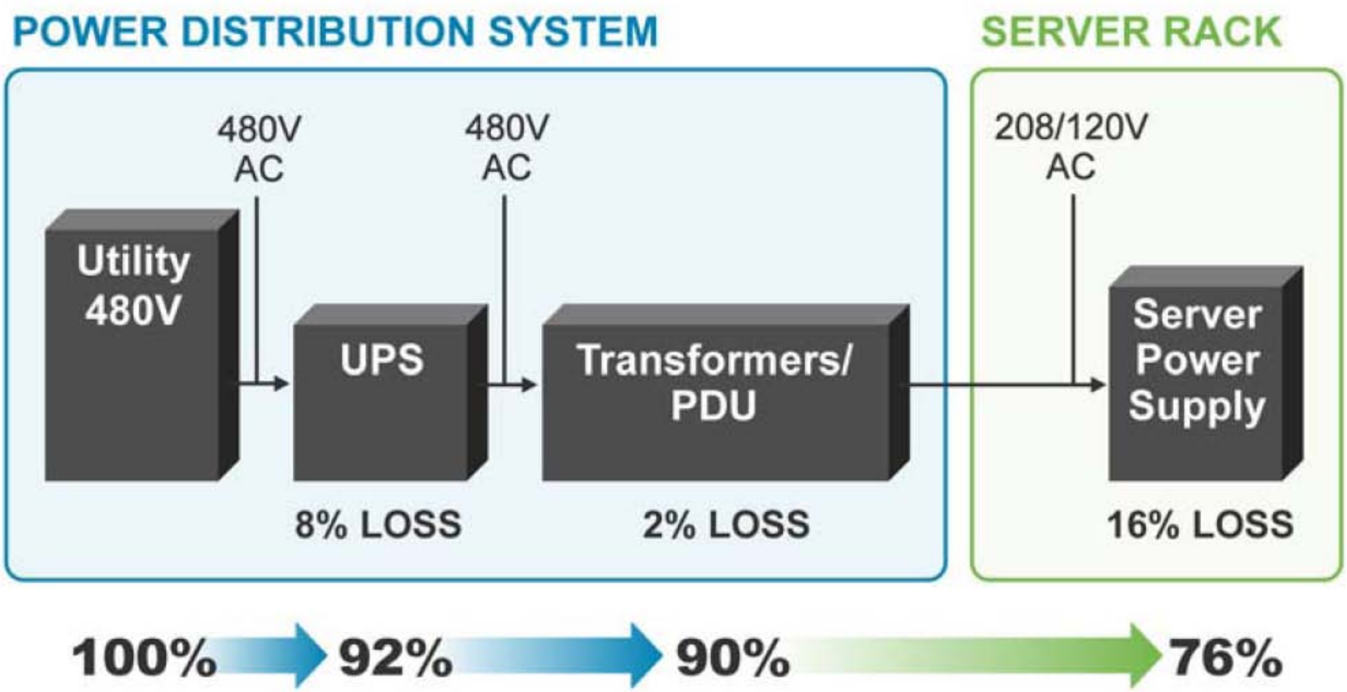

Fig. 1. End-to-end efficiency in the 480-V ac power distribution system.

"We've noticed a trend with many of the new, cutting-edge data centers choosing a 480-V power scheme and 277-V custom power supplies that are extremely efficient," said Joe Skorjanec, ePDU product manager, Eaton Distributed Power Solutions. "Power distribution units at this voltage are usually only available as custom solutions. Eaton is among the first in the industry to offer 480 V as part of our ePDU catalog offering in order to better meet the needs of server manufacturers."

According to the supplier, the majority of its three-phase uninterruptible power supplies (UPSs) are designed to work seamlessly with a 480-V ePDU solution.

Meanwhile, reports indicate that the 400-V ac power distribution model, commonly used across Europe, Asia and South America, offers several advantages in terms of efficiency, reliability and cost, when compared to the 480-V ac approach.

In the 400-V ac system, the neutral is distributed throughout the building, eliminating the need for PDU isolation transformers and delivering 230-V phase-neutral power directly to the load. This not only enables the system to perform more efficiently and reliably, but significantly lowers the overall cost of the system by omitting the multiple isolation transformers and branch circuit conductors required in 480-V ac and 600-V ac power systems.

Losses through the autotransformer, the UPS and the server equipment produce an overall end-to-end efficiency of approximately 80% (Fig. 2.) However, the higher-efficiency UPS can further improve that number. So, unlike a traditional UPS that operates at about 93% or 94% efficiency, Eaton has developed new UPSs that operate at 99% efficiency under normal utility conditions. Using the latest UPS in the 400/230-V ac distribution, the overall efficiency of the power system can be further improved to 84%.

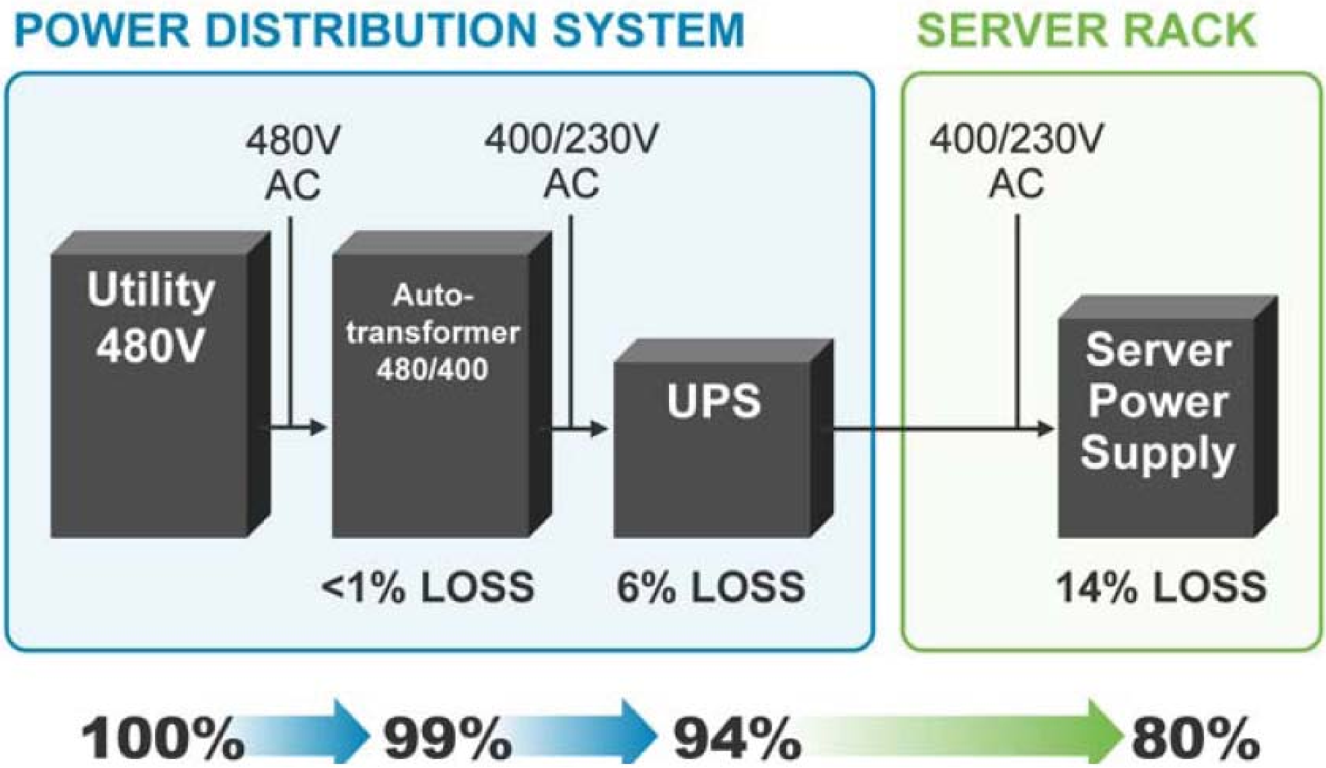

Fig. 2. End-to-end efficiency in the 400-V ac power distribution system.

Last month, while exploring Green Grid's white paper (#16) "Quantitative Efficiency Analysis of Power Distribution Configurations for Data Centers", it was observed that there is no single ac or dc configuration that provides superior efficiency at all loads or in all situations. The efficiency differences among the contemporary implementations are relatively minor.

Similarly, another analysis "AC vs DC Power Distribution for Data Centers" by American Power Conversion, a Schneider Electric company, concludes that the advantages of using dc versus ac are small. And it finds that the most-efficient power distribution architectures are the 380-V dc architecture and the 400/230-V ac distribution scheme. Because their efficiencies are so close to one another, a highly detailed and fact-based quantitative comparison is necessary, according to APC.

In summary, the debate over the merits of ac and dc power distribution will continue because ultimately the overall efficiency of the data center depends on many other factors. The choice of ac or dc power distribution is just one element in the overall efficiency-improvement solution.

About The Author

Ashok Bindra is a veteran writer and editor with more than 25 years of editorial experience covering RF/wireless technologies, semiconductors and power electronics. He has written, both for print and the web, for leading electronics trade publications in the U.S, including Electronics, EETimes, Electronic Design and RF Design. Presently, he has his own technical writing company called Technika through which he does writing projects for different trade publications and vendors. Prior to becoming an editor, Bindra worked in industry as an electronics engineer. He holds an M.S. degree from the Department of Electrical and Computer Engineering, Clarkson College of Technology (now Clarkson University) in Potsdam, NY, and an M.Sc (Physics) from the University of Bombay, India. He can be reached by email at bindra1[at]verizon.net.