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Is DC Power The Optimal Route For Data Centers To Improve Energy Efficiency?

by Ashok Bindra, Technology Writer, Technika

In my February column, the focus was on improving overall data center efficiency because the total power consumption of today's data centers is surging dramatically. The U.S. Environmental Protection Agency (EPA) reported to Congress that data center industry power consumption doubled from 2000 to 2006 and was expected to double again over the next five years. If this trend continues to 2016, then reducing this power consumption becomes very critical because every watt saved translates into savings in dollars. Hence, from component level to data center infrastructure, IT managers and administrators are exploring every possible way to improve overall system efficiency to drastically cut power consumption.

This column will explore dc power distribution as it is a proposal that is gaining support from several agencies, including the EPA, Green Grid, EPRI and Emerge Alliance. While researchers at Lawrence Berkeley National Lab, the Intel Labs, and universities are demonstrating the energy efficiency benefits of using dc power in data centers, vendors such as Validus DC Systems and Delta Electronics are delivering actual dc power solutions to data centers.

In a conventional data center, power is supplied from the grid as ac power and distributed throughout the data center infrastructure as ac power. However, most of the electrical equipment, such as servers, solid-state disks for storage, and other IT gear, within the data center, as well as the batteries storing the backup power in the UPS system, require dc power. As a result, the ac power must go through multiple conversions, resulting in power loss and wasted energy.

Hence, to eliminate these unnecessary conversion steps and, thereby, substantially reduce power wastage, some experts are proposing the use of dc power distribution. A study conducted by Lawrence Berkeley National Labs in 2008 highlighted the benefits of the dc approach. This study compared the use of 380-Vdc power distribution for a datacom facility to a traditional 480-V ac power distribution system. The results showed that the facility using dc power had a 7% reduction in energy consumption compared to the typical facility with ac power distribution.

In another test conducted late last year by the Electric Power Research Institute (EPRI) at a Duke Energy data center in Charlotte, North Carolina, the researchers found that a dc power system uses 15 percent less electricity than the existing ac power system. For this demonstration project, the data center's 480 V ac was converted to 380 Vdc and delivered to the equipment racks via a 380-Vdc bus. According to the researchers, the 15 percent energy savings achieved in this project provides a good benchmark for the industry because the 480-V ac system configuration is typical for data centers across the United States.

Besides the work done by Lawrence Berkeley National Labs and EPRI, industry associations like the EMerge Alliance, backed by some 70+ corporate members, are also pushing the adoption of 380-Vdc power distribution across data centers and beyond. In fact, to address the need for improved reliability and energy efficiency in data centers, the EMerge Alliance is developing a 380-V dc power standard. For that, it has formed a technical standards committee, which is planning to release the 380-Vdc specs next month.

EPRI's Dennis Symanski has been appointed as chairman of the new standards committee, whose focus is on reducing or eliminating inefficient ac-to-dc conversions that occur between power sources and digital devices in data centers. "Since most of the existing power supplies in data centers are running at 380 Vdc, the 380-V dc power distribution across data centers will make it easier for power supply makers, as well as PC manufacturers to adopt the standard," stated Symanski. "The secret to achieving maximum energy efficiency in data centers is to use highest possible voltage with fewer number of conversions," noted Symanski. "By eliminating multiple power conversion stages, dc powered data centers provide the energy savings desired."

In a statement, Duke Energy's Curtis Watkins of Technology Development Group, said, "While this is significant news for any company running a data center today, this could be especially critical for the more than 2.5 million smaller data centers across the United States that rely upon inexpensive yet viable ways to reduce costs." He added, "If this dc technology was implemented in all those data centers the impact could be significant."

Likewise, Validus DC Systems, a supplier of integrated dc power distribution solutions, is a strong proponent of 380-Vdc distribution for data centers (see the figure). "With all things equal, a dc distribution can achieve 10%

more energy efficiency than a comparable ac distribution," said Rudy Kraus, founder and CEO of Validus DC. "Since 380 Vdc is inherent voltage, it is less costly to install, more efficient, takes less space, and is simpler and less costly to maintain," noted Kraus. Plus, he added, "It enhances reliability of the system."

Fig. The energy losses associated with today's ac power systems come from the rectifications and inversions that are required to reliably deliver ac power to dc equipment in data centers. Validus's dc system provides an energy efficient power path that eliminates losses associated with traditional ac systems.

Foreseeing the dc power distribution trend, Switzerland's ABB, the global power and automation technology group, has purchased a controlling interest in the Brookfield, Conn.-based Validus DC Systems. Interestingly, using Validus DC, ABB is developing a dc power distribution solution for Switzerland's green.ch, one of the top information and communications technology (ITC) service providers in Switzerland.

Dc technology is substantially more energy efficient than traditional ac technology for electrical distribution. Dc systems are also less complex, requiring less space and equipment, resulting in considerable additional savings in real estate and capital expenditure. The investment in Validus complements ABB's strong technology platform to bolster its entry into the $24 billion market for telecommunications and data center power infrastructure.

"DC systems provide data centers with a game-changing advantage in both operational and capital cost savings and we believe they will be widely adopted in this energy-intensive industry," said Tarak Mehta, head of ABB's Low Voltage Products division.

Also, putting its weight behind dc power distribution for data centers is the power supply giant Delta Electronics, the world's largest supplier of power supplies. The manufacturer has launched a state-of-the-art Data Center DC Power Solution that includes a complete product portfolio of dc UPS systems, power distribution units (PDUs), and server power supplies for more energy-efficient data center applications. With its advanced power design and fewer power conversion stages, Delta's new solution will provide customers with an estimated 10% increase in energy efficiency to reduce operational costs and lower carbon emissions, and realize the benefits of a more environmentally-friendly green data center.

Meanwhile, the Green Grid Association has published the results of case studies of energy-efficiency initiatives in the Japanese data centers. In the case of one of the member companies using 380-V dc power distribution, the result was an estimated savings of 18% versus a comparable ac system. However, the study notes that this

savings will vary from one implementation to another, and that the 18% figure may or may not be verifiable in other configurations.

However, another white paper (#16) published by the Green Grid, "Quantitative Efficiency Analysis of Power Distribution Configurations for Data Centers,"concludes 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. All components and configurations have undergone great efficiency improvements in the last decade and will likely continue to improve. When evaluating data center power distribution configurations, multiple factors such as reliability, equipment availability, safety and cost must be considered in addition to efficiency. Regardless of the topology, history shows that proper component selection is the dominant factor in delivering high efficiency. Accordingly, when high efficiency is desired, great care should be exercised in the component-selection process.

Similarly, a quantitative comparison of high-efficiency ac versus dc power distribution for data centers by American Power Conversion concludes that the two architectures offer virtually the same efficiency performance, suggesting that the move to a dc-based architecture is unwarranted on the basis of efficiency.

In summary, the debate over the merits of ac and dc power configurations is not new. It has been going on for years and will continue for a long time.

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.