Front-end technology takes on data center power

Front ends are now achieving operational efficiencies of 90% starting at 20% load without sacrificing full-load operation

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Today's front-end power supplies are using innovative designs and enhanced thermal management techniques to bring power density and efficiency levels to new highs and form factors to new lows. As a result, data centers are experiencing significant cost benefits by saving on rack space, reducing heat dissipation and lowering their overall energy consumption.

Leading-edge ac/dc front ends are packing power densities of 27 W/in.3 and providing up to 2,500 W of output power in a 1U package. Used in a four bay, 1U power shelf, parallel units can supply scalable power up to an astonishing 10,000 or 7,500 W in n+1 redundant architecture — figures unheard of just a few short years ago.

Even more impressive is their ability to provide high-efficiency operation under light-load conditions. Front ends now achieve efficiencies of 90% starting at 20% load without sacrificing full-load operation.

Advanced models provide hot-swap capability, active load sharing, and many other features with built-in intelligence and flexibility. On-board MCUs and supported interface protocols such as I²C, PM Bus, and Ethernet offer real-time monitoring and dynamic digital control based on load levels or other set parameters.

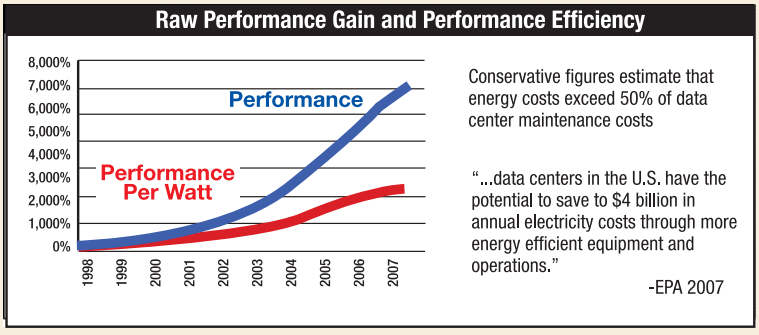
Standard power platforms can be easily modified to optimize performance or footprint for targeted applications where enhanced operation is needed. This allows data center providers to quickly and cost effectively implement custom designs, saving on development time and reducing time to market.

The growing power problem in data centers

The data centers growing appetite for power is creating cost of ownership and available resource issues which are boxing companies into a tight corner. Increased energy consumption coupled with rising energy prices are forcing IT managers to address mounting expenditures as energy costs are starting to dominate their operational budgets.

In many cases, these reoccurring costs are exceeding the price of the IT equipment inside the data center. To make matters worse, the growing power demands are exceeding the available electrical supply and are constrained by minimal real estate in many facilities, threatening future growth and deployment.

The primary cause of these crises is the explosive growth of data servers. Fueled by market demand for better and faster processing capacities, data servers are packing more punch in increasingly smaller form factors. As data center racks fill up with high-density servers, their raw computing performance is increasing in leaps and bounds while their performance per watt is increasing at a significantly slower rate. This growing disparity is taxing power and cooling systems as never before.



The most viable and cost-effective way to attack this problem is to improve system power efficiency in the data center. Inefficient systems not only consume more energy to power the IT equipment, their cooling systems must work harder to remove the wasted energy manifested as excess heat.

In recent studies, when power efficiency and cooling are taken into account, actual work done by IT equipment can be less than 50% of the total draw of the system. That's an enormous amount of wasted energy and expenditure with no return benefits.

Some design changes

One key area where system efficiency has shown vast improvement is the ac/dc front-end power supply. This fundamental system component has historically been the

most wasteful converter in the data center power train, providing only 70% to 80% efficiency on average.

Surprisingly, a significant portion of their losses are simply due to the way they are used in the data center. Standard, parallel-redundant architecture, which is necessary for system availability, creates load sharing among power supplies limiting full load operation.

As a result, data server front ends typically operate at only 20% to 30% rated load. This is a weak area of operation for supplies traditionally designed for peak efficiency at 80% load. In fact, their efficiency drop can be as much as 15% to 20%.

Power supply manufacturers have aggressively targeted this area of operation, using multiple design strategies to significantly boost efficiency levels. Key approaches include optimizing the switching frequency for the full-bridge and PFC circuits, optimizing dead time as a function of load, eliminating preload losses at the point of no-load and using better materials in the main transformer and output choke to reduce core losses. Additional techniques save power by shutting down synch FETs not needed at light load and improving the internal bias and fan usage actively optimized for a specific operating point.

Projected Savings: CAR2548 vs. Industry-Standard Front End

		Energy Savings		Cost Savings (@8.9¢/kw-hr)	
# of Servers	Configuration (full n+ 1 shelf)	Annual kW-h	6 Yr Life kW-h	Annual $	6-Year Life $
1	Single	6,929	41,574	$617	$3,700
1	Dual	13,858	183,148	$1,233	$7,400
100	Single	692,900	4,157,400	$61,700	$370,000
100	Dual	1,385,800	8,314,800	$123,300	$740,000
1000	Single	6,929,000	41,574,000	$617,000	$3,700,000
1000	Dual	13,858,000	83,148,000	$1,233,000	$7,400,000

Baseline efficiency levels have also shown considerable improvement by the resourceful use of recycled energy in the system and the innovative application of zero-voltage switching techniques by maximizing performance of primary and secondary topologies. The cumulative result of these design changes is a high-performance front end delivering efficiencies of 90% or better over the entire operating range starting at light loads.

Case Study: Saving with front-end power

The Project: A fortune 500 datacom company needed to spec an ac/dc front-end power supply for its next-generation switch application. The intended project was positioned as a high-end switch targeting the LAN switching market. It was a Tier 2 level program expecting significant volume on the platform. The projection was 10,000 units per year.

The Challenge: The front-end power supply needed to have a 1U form factor with the ability to integrate into a custom power shelf housing up to eight units. The platform configuration would offer single and dual power shelves, each containing four power bays.

The power solution had to lend itself to scalable architecture. Every installation would be unique so actual power requirements would be dependent upon features selected by the end user. Each power shelf needed to be able to implement scalable 48-Vdc power up to 7,500 watts in a redundant (n+1) architecture.

Units had to be high performance with the best available power densities. Operation would primarily be at light loads (20% to 40%) so high efficiency was mandatory. The targeted requirements were 92% efficiency at full load and 80% efficiency at 20% load. The line input was 230 Vac.

The Solution: The front-end power supply chosen was the CAR2548 from Cherokee International. The 48-Vdc front end was a high-input operating switch-mode power supply providing a maximum output power of 2,500 W in a 1U package.

The supply was designed for parallel redundant operation and active load sharing so multiple units could be mounted together to meet scaling and maximum power requirements for each shelve. Its building block platform was designed to be easily modified so it could be quickly adapted to the custom power shelf.

The key factor in choosing the CAR 2548 was the high overall power density and efficiency performance it could deliver in one package. The unit was able to provide an industry-leading power density of 27 W/in.^{3} and baseline efficiencies of 92% at full load and 90% efficiency at 20% load. These values surpassing the 80Plus Gold level efficiency standard.

The Savings: With the load draw for each front-end unit expected to be 20% on average, efficiencies of 82.2% could normally be anticipated using current industry standards. However, by using the CAR2548, front-end efficiency jumps to 90%, an efficiency gain of 8.8%! 24/7 operation with this operational model translates to significant energy and cost savings for the end customer.

The figures speak for themselves. As IT managers reinvent their architectures around energy efficient technologies, the new generation of front-end power supplies are leading the way. Data centers are reaping the benefits by reducing energy waste and saving money.

Visit http://frontends.electronicproducts.com to see full coverage of ac/dc front-end technology. Cherokee International designs, manufactures, and markets high-reliability custom and standard switch-mode power supplies for datacom, telecom, medical, and process-control applications. As the leading provider of custom-designed power sources, Cherokee also delivers a complete range of standard and modified-standard ac/dc power supplies, ac/dc rectifiers and power shelves, and dc/dc converters. Cherokee International is headquartered in Tustin, CA. For more information, visit **http://www.cherokeepwr.com.**

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