Low-voltage ICs in power-hungry data centers benefit from high-voltage DC supply path

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As rail voltages drop and currents increase, the key to efficient power delivery is use of higher voltages and DC conversion and distribution

There's a "back to the future" aspect to power distribution for datacenters in the 21st century. At the beginning of the 20th century, Thomas Edison was a proponent of distributing power to homes and businesses using higher-voltage DC, while Nikola Tesla’s backer George Westinghouse supported distribution via AC. That rivalry ended with AC as the preferred method, using transformers (an inefficient but reliable, available passive component) for step-up/down conversion.

Either AC or DC, the key to an efficient system is high voltage, of course. The reason is simple: reduced transmission losses. Transmission (I2R) losses are reduced at the lower line currents which correspond to using higher voltages to deliver a given amount of power (V×I). However, the key to an efficient overall system is to also have higher efficiency down-conversion elements.

Today, even as individual ICs operate at ever-lower voltages—approaching and passing under 1V and over 100A—the overall datacenter or other large system is drawing increasingly more current (remember, we're not talking about milliamp-sipping portable devices here). Power engineers know this basic fact: current is needed to do "work", and it is voltage which drives that current to the load.

Fast-forward to the present, and changes in both application needs as well as advances in conversion are making high-voltage DC an even more attractive proposition for efficient power delivery to low-voltage loads. The long-established 48V systems are becoming more expensive to install and operate, with their higher I2R losses, while the need for always-ready UPS/battery backup makes AC distribution more complex and costly. New distribution topologies, conversion technologies, and active components allow designs to both use 400V DC power more efficiently than AC in new designs, and also interface to the vast legacy of installed 48V systems in retrofit situations.

Higher voltage DC is taking an increasing role in distributing power to data processing, routing/switching, lighting, cooling and factory automation applications.400V DC is the preferred choice for new and upgrade designs. No need to use transformers for up-down conversion, as modern electronics allows for low-cost AC/DC and DC/DC conversion, at efficiencies greater than 90%. In addition, 400V DC is easily generated by alternative energy sources such solar and wind to reduce a facility’s environmental footprint.

To address the 48V equipment base, the 400V DC can be dropped to 48V via power-conversion blocks, using backplane distribution adapters at each rack unit. Alternatively, the existing 48/12V bus converters can be replaced by high-voltage, wide-range 32:1 conversion; this change would be "invisible" to the backplane.

For highest efficiency and lowest Total Cost of Ownership (TCO), Factorized Power Architecture offers tangible benefits plus flexibility. The AC mains is rectified to 400V DC, converted down via isolated bus converters to buck or buck-boost

regulators and current multipliers which, in turn, provide very localized rails to the circuitry. By staying with higher voltage further into the supply chain, and developing low voltages/high currents as close to the loads as possible, power distribution and power-conversion costs and losses are minimized. Backup batteries can be connected to critical400V or 48V busses, while the entire system is galvanically isolated from the AC mains, so the need for downstream isolation (and its cost) is eliminated.

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