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1.5-PetaFLOPS/m³ Super Computer Is Powered by High-Performance Power Modules

At the recent Super Computing conference (SC16), ExaScaler and PEZY Computing unveiled ZettaScaler-1.8, the first super computer with a performance density of 1.5 petaFLOPS/m^3 (Rpeak). The ZettaScaler-1.8 is an advanced prototype of an even more advanced super computer, the ZettaScaler-2.0. The '2.0 version, which is due to be released in 2017, will feature a performance density three times higher than the ZettaScaler-1.8. However, from a power design perspective, the ZettaScaler-1.8 is notable in two ways. First, it is cooled by ExaScaler immersion liquid cooling technology. Secondly, it is powered by Vicor's 380-V to 48-V and 48-V to 1-V power modules.

At SC16, Vicor announced its supporting role in ExaScaler and PEZY Computing's development of its supercomputing platforms. Powered from 380 V dc, ExaScaler's ZettaScaler-1.8 uses Vicor converters to provide 48 V to high-density, high-efficiency direct-to-PoL current multipliers feeding PEZY Computing's low-voltage, high-current processors (Figs. 1 and 2.)

"ExaScaler and PEZY Computing have achieved substantial improvements in efficiency and density with 380-V to 48-V converters and 48-V direct-to-PoL VTM current multipliers from Vicor," said Motoaki Saito, founder/CEO of ExaScaler and PEZY Computing.

"A Vicor modular power system supports the unprecedented performance of ExaScaler and PEZY Computing's new super-computing platforms," said Patrizio Vinciarelli, founder and CEO of Vicor.

Vicor's high-voltage power architecture enables a higher-density power solution overall and higher power density in particular close to the point-of-load—i.e. the CPU. That's higher density in comparison with mult-phase buck converters, which represent the conventional solution for powering the CPU. It's also higher density versus solutions that are not using 380-V and 48-V power buses.

As Robert Gendron, Vicor's VP of marketing and business development at Vicor, explains, the higher power density is needed in the supercomputing application for several reasons. First, the application contains many parallel processors communicating with each other. "In order to get the speed, you have to get the processors as close together as possible." This leads to the requirement for a dense power solution at the point of load. Gendron adds that there are economic reasons for higher density as well. For example, more-dense, more-efficient power conversion solutions help to reduce the hardware required for cooling.

The multi-phase buck converter approach to powering CPUs was developed in part to overcome inductor shortcomings. It reduces the inductor size required for the required level of energy storage by using multiple small inductors across multiple power phases rather than attempting a single-phase buck with a single inductor. To achieve greater power delivery to the CPU, more phases are added. Over time, improvements in the converter's performance have been achieved by incremental improvements in the MOSFET power switches and the associated PWM controller.

The problem with the multiphase approach, is that it can require many phases per CPU and the power stage components associated with each phase occupy precious real estate near the CPU. What's more, they complicate the PCB layout and create noise problems. In a high end computing application, a typical multiphase approach may use multiple DrMOS power stages and inductors along with the associated output capacitors. If the multiphase buck converter operates from a 12-V bus, then large amounts of input capacitance will also be required for energy storage. On the other hand, if the input voltage is increased (to 48 V for example), input capacitance will be decreased, but two buck converter stages will usually be needed to step 48 V down to the CPU voltage if reasonable efficiency is to be obtained.

Vicor's 48-V direct to CPU power solution, overcomes these issues. Rather than requiring two buck converter stages, it uses a regulator stage (a pre-regulator or PRM) to tightly regulate the 48-V supply followed by a voltage transformation module (VTM) to step down that 48 V to the 1 V needed to power the CPU. In the case of the ZetaScaler, two VTMs replace multiple DrMOS stages, which saves board space. And because of its fast transient response, the VTM requires much less capacitance at the point of load than the multiphase solution. Fig. 3 illustrates how Vicor's 48-V to CPU power solution saves space versus a multiphase buck converter in the general case by reducing the number of power semiconductor components, inductors and capacitors.

For more about Vicor's 48-V direct to CPU power solutions, see http://www.vicorpower.com/industries-computing/48v-direct-to-cpu. For more about high-voltage dc (HVDC) distribution and power conversion, see http://www.vicorpower.com/innovations-in-power/hvdc.

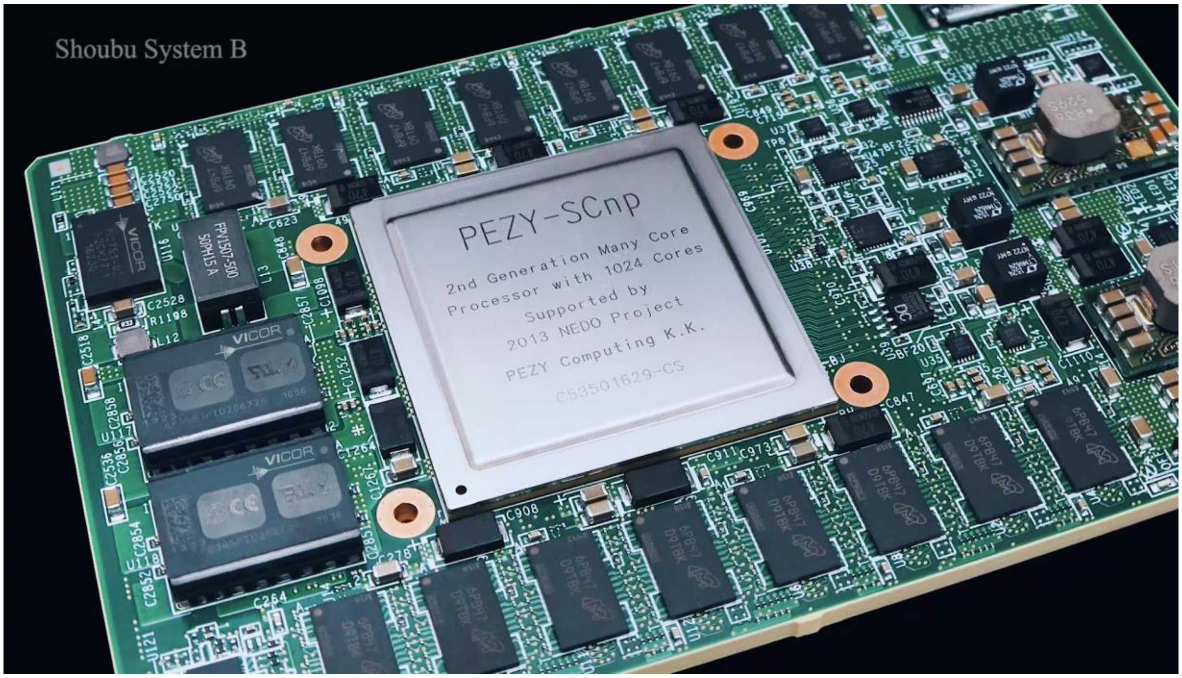

Fig. 1. The ExaScaler/PEZY ZettaScaler-1.8 Super Computer pushes the limits in computing performance with a performance density of 1.5 PetaFLOPS/m^3. Powered by Vicor modules, the ZettaScaler leverages high-voltage dc (380-V) power distribution and a 48-V direct-to-CPU architecture.

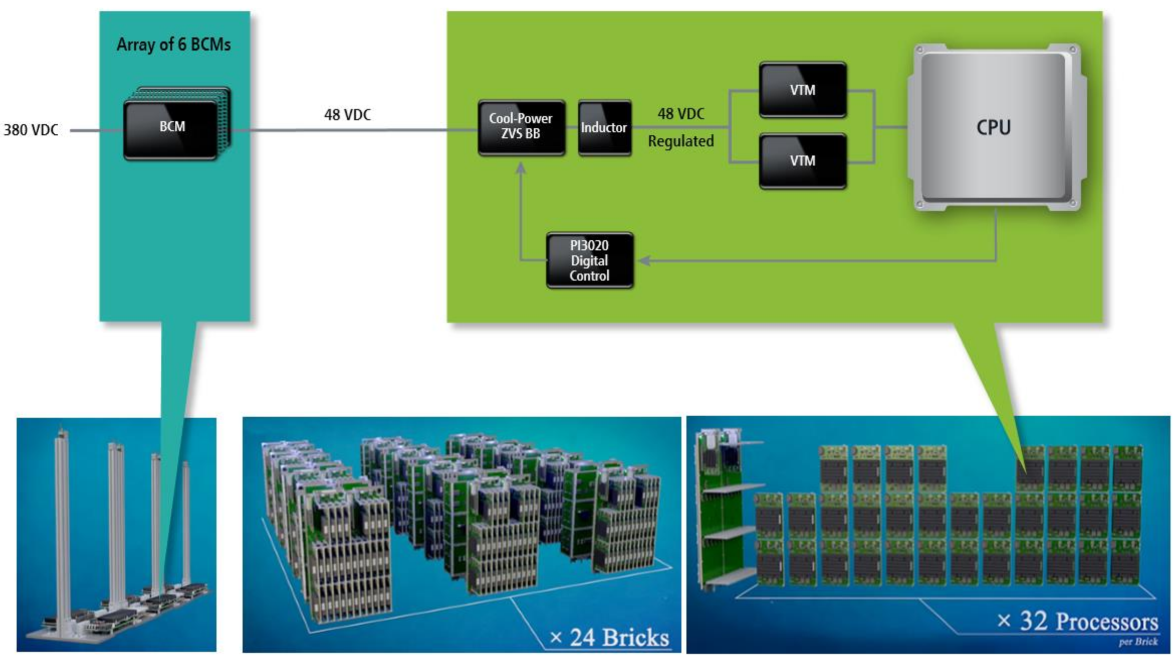

Fig. 2. Vicor BCM modules convert 380 V to 48 V at each of its 24 Brick CPU clusters. (In this context, a Brick is a stack of CPUs.) Within each PEZY Brick CPU cluster, 48 V is distributed to 32 PEZY-SCnp48 module cards. Each PEZY module card uses a PRM and two VTMs for 48-V direct to CPU power.

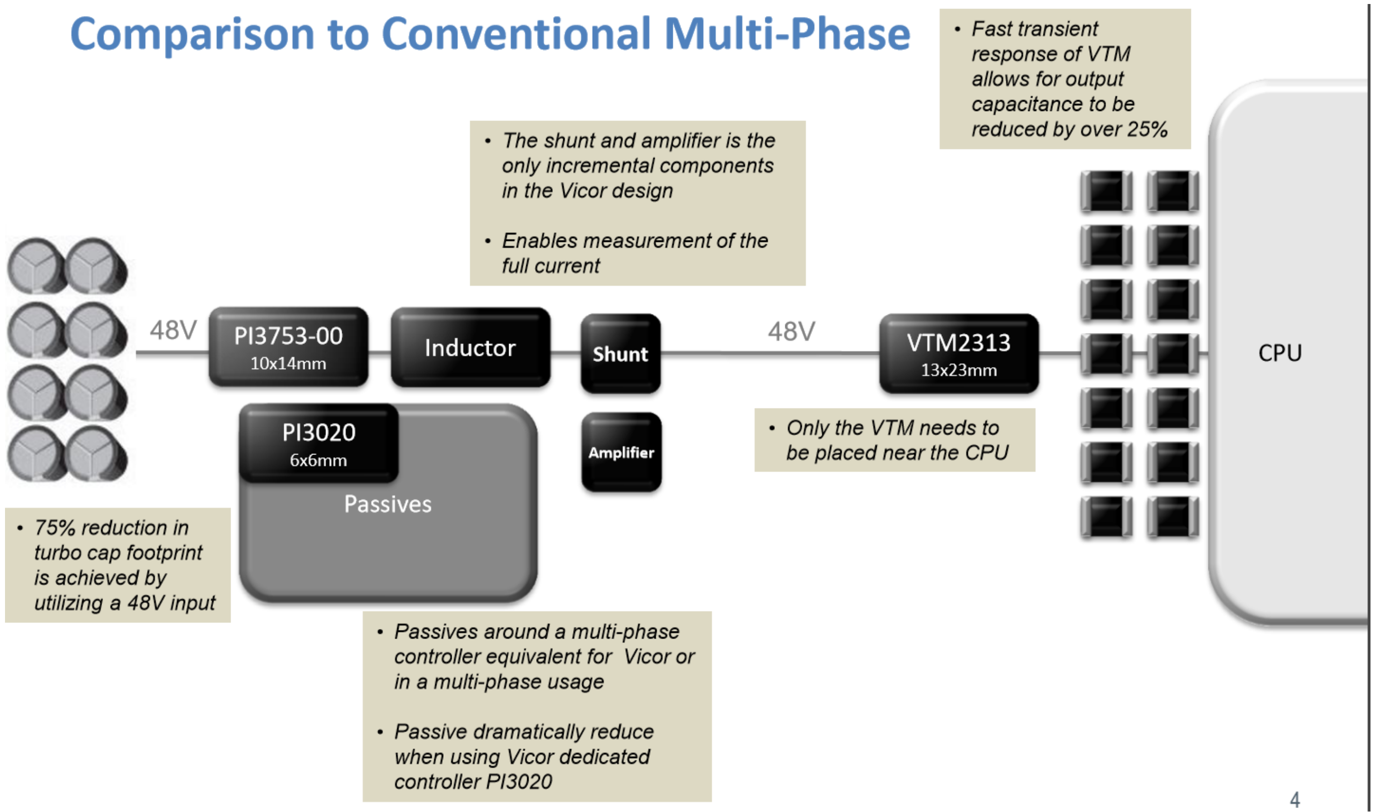

Fig. 3. Vicor's 48-V direct to CPU power conversion solution saves space versus a conventional multi-phase buck converter power solution. It replaces multiple DrMOS power stages and inductors close to the CPU with a single VTM. It also reduces the amount of capacitance needed close to the CPU because the VTM has faster transient response than the multi-phase buck. On the input side, the PRM (model PI3753 shown here) can be located away from the CPU, but here too it saves space by operating from a 48-V bus, which slashes the capacitance required on the input versus a 12-V bus, as might be used with the multiphase buck converter. (If the multiphase buck is powered from 48 V, a second buck converter stage may be required.)