Digital Power-Converter Architecture and Applications

Complex and power-hungry computing applications used in manufacturing, Cloud services and telecoms to name a few, must continue to improve energy efficiency to meet customer demands cost effectively and minimise environmental impact. Digital power converters are an important part of the solution, and the latest generation of devise deliver extra advantages such as higher current density, enhanced thermal performance and improved reliability. **Bob Cantrell, Senior Applications Engineer, Ericsson Power Modules, Plano, USA**

The general rising trend of energy prices continues to drive demands for more energy-efficient computing in applications such as industrial control, cloud services, enterprise computing, and telecom. Among responses to these demands, digital power conversion effectively minimizes the energy lost throughout the power supply architecture, from the AC/DC front end to point-of-load converters on the server boards.

Digital power concepts

Traditional analogue power converters, such as point-of-load modules, are designed according to a fixed set of parameters. They can only deliver "best-fit" performance as the computing load and therefore power demand varies from minimum to maximum. Today's digital converters, on the other hand, sense and digitize the output voltage, and feed the digitized value to an algorithm executed in a microcontroller that generates the necessary control signals. The control strategy can be changed dynamically to optimize performance depending on the operating conditions at any given time.

A number of valuable advantages arise from this extra adaptability of digital power converters. Converter efficiency can be much more consistent across the load range, particularly at light loads where analog converters are often less efficient. In addition, the output voltage can be adjusted to optimize system efficiency. Moreover, for an application with a specific input voltage, output voltage, and capacitive load, the control loop of a digital converter can be optimized for a robust and stable operation and with an improved load transient response. This optimization will minimize the amount of required output decoupling capacitors for a given load transient requirement yielding an optimized cost and minimized board space.

Dynamic Loop Compensation (DLC) featured in PoL converters such as the new 60-A BMR466 converter (Figure 1), measures the characteristics of the power train and calculates the proper compensator PID coefficients. Once the output voltage ramp up has completed, the DLC algorithm will begin and a new optimized compensator solution (PID setting) will be found and implemented.

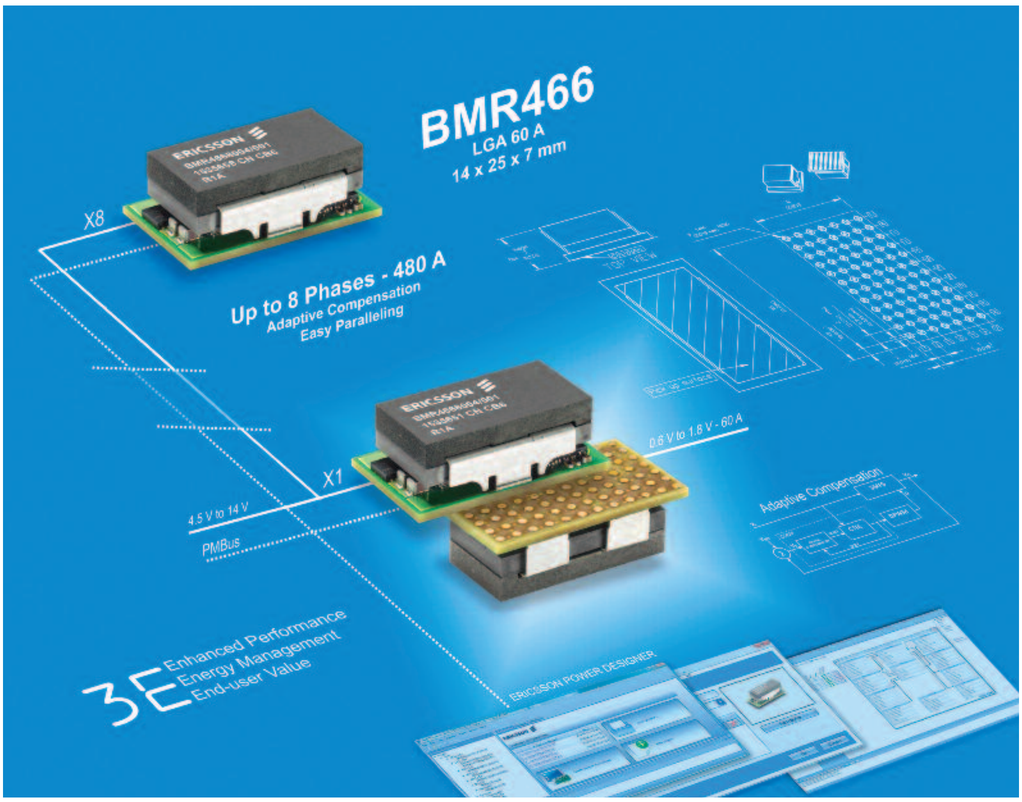

Figure 1: Digital converters measures the characteristics of the power train and calculates the proper compensator PID coefficients

DLC eliminates any need to design circuitry to stabilise the converter, and minimizes demand for filtering capacitors.

Digital technology not only simplifies design but also reduces the converter component count, which can accelerate time to market and save space on server boards. This real-estate is at a premium on expensive, multi-layer main boards, particularly in some of the more complex systems that may have 10, 15 or more PoL converters supplying multiple power domains and multi-rail devices like processors, FPGAs or ASICs. The BMR466 can run at up to up to 94.4 % efficiency with a 5V input and a 1.8V output, at half load.

The reduced component count of a digital converter also helps boost reliability. The MTBF of the BMR466 is calculated at 50 million hours based on the industry-standard Telcordia method. In addition, the BMR466 has an advanced thermal design that ensures the module can maintain extremely high reliability without temperature derating.

PoL construction

The LGA package platform enable to dissipate heat very efficiently. The internal layout has been optimized to promote dissipation from the power FETs, which are a major heat source in any PoL.

The PoL has a compact footprint so it can easily be placed near its load, which is helps to improve transient performance at the load. For systems that require power in excess of 60 A, up to eight BMR466s can be connected in parallel to supply up to 480 A to the load. Where multiple modules are used, two or more of the single-phase BMR466 PoL converters can be synchronized with an external clock to enable phase spreading, which reduces input ripple current and corresponding capacitance requirements and efficiency losses.

In addition to greater efficiency, enhanced simplicity and increased reliability, digital point-of-load power converters like the BMR466 also allow input and output voltage and current, internal temperature, duty cycle, and switching frequency to be monitored more easily than conventional analog converters can allow. This not only facilitates fast and accurate adjustment of converter settings, but also allows the supervising host system to identify any problems with the power supply or the board and determine any maintenance requirements.

The BMR466 is supported in the Power Designer software toolchain. These tools address the requirements both of development and prototyping and configuration of modules in a production environment. Engineers can build systems offline before buying any hardware, and can also use the tools in conjunction with an evaluation board.

Power Designer simplifies setup and initialization of digital power modules, for example by allowing access to the converter's control loop to optimize load transient response and stability, and by optimizing the input and output filters using the minimum possible number of capacitors to ensure the lowest BOM cost. Simple systems or multi-module/multi-phase systems can be configured, and the designer can take control of current sharing, sequencing and tracking, synchronization and phase spreading. In addition, real-time status monitoring of key parameters such as temperature, current and voltage helps identify and fix any faults. Once the design is complete, users can generate configuration files that can be applied directly to units on the production line.

Software-defined power

The BMR466 excels in applications that require increased power delivery within a reduced footprint without compromising reliability, without demanding significant extra provisions for cooling, such as fan or cold plate. The enhanced thermal performance allows these devices to operate reliably at high current for extended periods. The BMR466 has been shown to be capable of delivering 60 A to a 1.8V load, with ambient air temperature of 70°C and airflow of 1.0 m/s. The derating graph of Figure 2 shows that this part will be able to deliver improved thermal performance and reliability compared to conventional digital PoLs for the same amount of airflow.

The BMR466 is compliant with PMBus commands, making the device ready for the coming generation of software-defined power architectures. These will take advantage of the adaptability of digital converters to introduce new and versatile operating modes, under software control to achieve levels of adaptability and responsiveness never seen before.

Now that modules such as the BMR466 have raised efficiency to yet higher levels, software-defined power takes the search for further gains up to the system level. Features such as dynamic bus-voltage adjustment and phase spreading are a couple of techniques that can be applied by manipulating converters in real-time

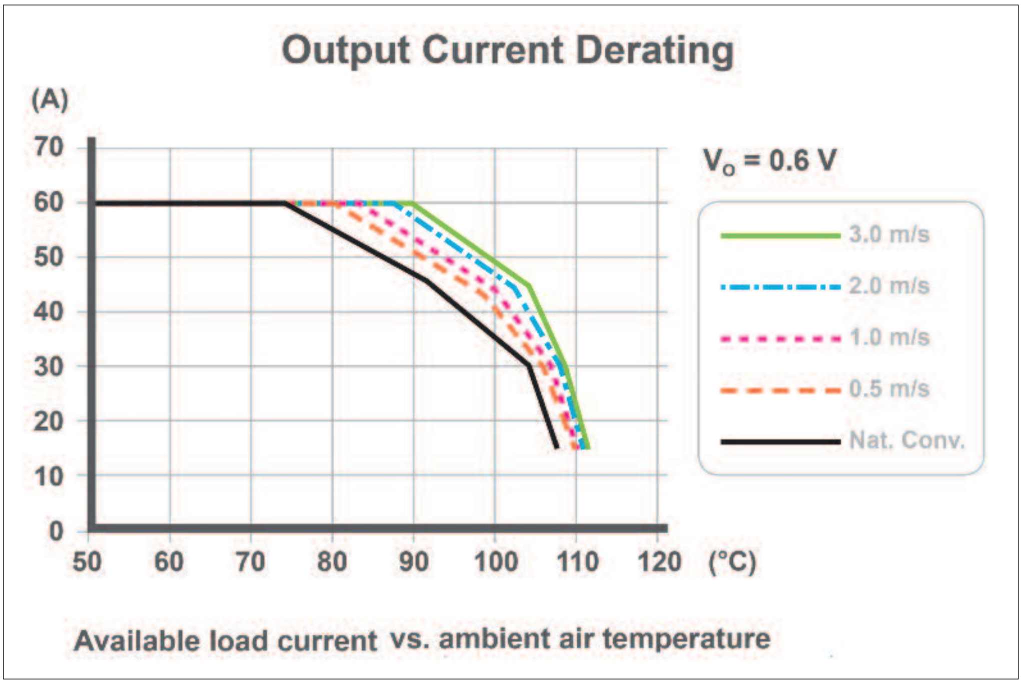

Figure 2: Enhanced thermal performance helps enhance reliability compared to conventional converters, without increasing cooling demands

using PMBus commands, to further increase the efficiency, reliability and controllability of tomorrow's distributed power architectures.

The most recent PKB4313D is a low-profile, 12 V-output, digital DC/DC converter module that offers up to 25 A current handling and 300 W of power to deliver tightly regulated voltages to point-of-load DC/DC regulators. Compatible with the DOSA (Distributed-power Open Standards Alliance) 5-pin eighth-brick footprint standard and offering an input range from 36 V to 75 V, this bus converter is suited for intermediate bus conversion in ICT (Information and Communication Technologies) applications.

PMBus Enables Standardized Digital Power

The PMBus protocol has enabled the electronics industry to standardize communications to their power conversion circuits. Controlling, configuring, and monitoring of AC/DC power supplies, isolated DC converters ("bricks"), and non-isolated point-of-load (PoL) converters has proliferated across the power supply industry.

The original idea of a standardized digital power management protocol, soon deemed PMBus, was conceived in 2004. Several power supply manufacturers and IC suppliers collaborated together as the original promoters of PMBus. With business and technical persons from these contributors, the Special Interest Group (SIG) was created, and the original PMBus specification was developed and released in March 2005. The specification continues to be driven by the System Management Interface Forum (SMIF). The new AVSBus addition in Part III of the latest PMBus revision is creating a lot of interest with board-level system designers. It enables real-time, dynamic control of high-power, high-speed, complex digital logic devices like ASICs, FPGAs, memory and processors with multi-rail voltage requirements. These capabilities will gain support in data center and other computing applications, and certainly spread to other industry segments. This will serve to accelerate broader adoption of PMBus 1.3, which will in turn increase demand for PMBus-compliant power conversion solutions.

At APEC 2016 PMBus support options for the Linux platform (in particular Ubuntu on the Raspberry hardware platform) has been presented within an industry session. This session addressed the needs of power engineers from the perspective of design, debug and manufacturing, mainly the tradeoffs when choosing between Linux sysfs, /dev/i2c, and kernel drivers. According to presenter Michael Jones the Raspberry and Linux platform are open and SMBus is built-in into the Ubuntu kernel, thus PMBus will be supported across various Linux versions and might enable the path towards software defined power.

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