Technical Article

Conversion to Core Voltage in a Single Step

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Abstract

This article describes the possibility of directly converting high voltages, such as 48 V or 54 V, to core voltages (usually below 1 V) in a single step. This conversion not only saves space and enhances efficiency, but also reduces the costs associated with designing input power rails. Compared to using a 12 V intermediate bus carrying the same power, less copper is consumed when routing a high voltage bus.

What do data center digital processors, high end FPGAs, larger artificial intelligence (AI) processors, and supercomputers have in common? A power supply is needed for the core voltage. The core voltage typically falls below 1 V, with current levels ranging from below 100 A to 1 kA and above.

Constructing high current, low voltage power supplies poses challenges. High conversion efficiency is essential to minimize cooling requirements. Additionally, these voltage converters must be compactly built to minimize parasitic trace between the power supply circuit and the load (processors), facilitating quick responses to load transients and better voltage regulation.

Figure 1 shows a common voltage converter architecture, where a 48 V supply voltage is converted to a 12 V DC link voltage, then regulated to the core voltage of less than one volt in a second step.

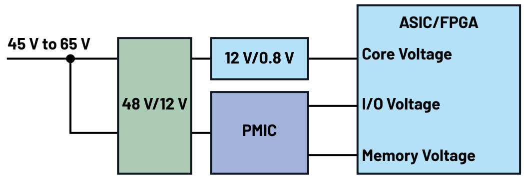

Figure 1. Voltage conversion architecture from 48 V to 0.8 V core voltage in two steps.

These two-step conversion steps suffer from reduced overall efficiency, despite high individual efficiencies. Even if each conversion step achieves 93% efficiency, the total efficiency remains about 87% (0.93 × 0.93 = 0.8649) due to cumulative losses.

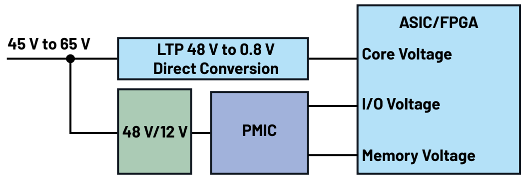

Figure 2. Voltage conversion architecture from 48 V to 0.8 V core voltage in one step.

Figure 2 shows an alternative conversion architecture featuring the μModule® LTP8800-4A, capable of directly converting from 48 V to a core voltage of 0.8 V in a single step. With a load current of 100 A, this solution offers efficiency of over 90%. However, the module can supply up to 200 A of current at the output. Several of these devices can be operated in parallel to generate 1000 A or higher—crucial for some high end processors.

Specialized core voltage converters, such as the LTP8800-4A, can generate a core voltage ranging between 0.5 V and 1.1 V at high currents of up to 200 A in one step. Conventional buck converter circuits struggle with such low duty cycles, typically managing around 1% duty cycle when converting from 48 V to 0.5 V, which proves challenging to implement. The inherent constraints of switching regulators, including minimum switch-on times, limit achieving such low pulse width ratios (duty cycles) at higher switching frequencies, resulting in suboptimal efficiency.

Eliminating the DC link voltage streamlines the system configuration, necessitating only a single power converter stage. This approach not only saves space, but also optimizes cost by reducing copper requirements, as the high supply voltage of 48 V or 54 V is routed directly into the core voltage converter.

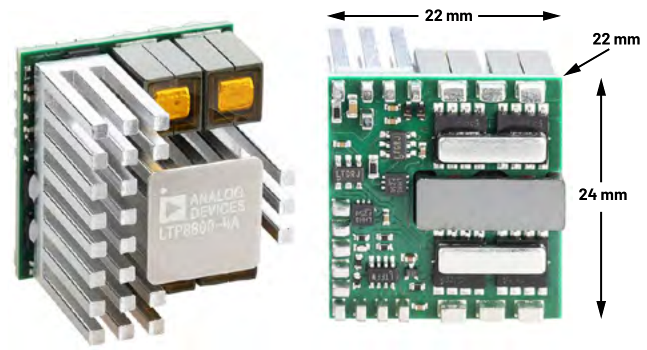

Figure 3. Small form factor with an LTP8800-4A module.

Figure 3 illustrates a compact form factor featuring the LTP8800-4A module. Leveraging a μModule device yields an excellent power supply, bypassing the complexities of conventional circuit design. The resulting circuit is compact, easily integrated onto a circuit board adjacent to the digital load.

Modern core voltage converters, such as the aforementioned μModule device, offer advanced digital control capabilities via PMbus® connectivity, facilitating real-time monitoring of voltages, currents, temperatures, and faults. An internal EEPROM enables the storage of various settings and error logs. Additionally, the digital connection allows for fine-tuning the power converter's control loop.

Conclusion

New modules for direct voltage conversion from 48 V to core voltage enable alternative power supply architectures that are not only compact, but also exceptionally efficient.

About the Author

Frederik Dostal is a power management expert with more than 20 years of experience in this industry. After his studies of microelectronics at the University of Erlangen, Germany, he joined National Semiconductor in 2001, where he worked as a field applications engineer, gaining experience in implementing power management solutions in customer projects. During his time at National, he also spent four years in Phoenix, Arizona (U.S.A.), working on switch-mode power supplies as an applications engineer. In 2009, he joined Analog Devices, where he has since held a variety of positions working for the product line and European technical support, and currently brings his broad design and application knowledge as a power management expert. Frederik works in the ADI office in Munich, Germany.

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