



APPLICATION NOTE 3519

Integrated DC-DC Converters Save Space and Design Time in Distributed-Power Systems

Abstract: Traditional distributed-power architectures employ several isolated DC-DC power modules to convert a 48V bus voltage to system supply-voltage rails such as 5V, 3.3V, and 2.5V. That configuration, however, poses difficulties in meeting the load requirements of fast, low-voltage processors, DSPs, ASICs, and DDR memories. Such devices impose stringent requirements on the power supply: very fast transient response, high efficiency, lower voltage rails, and a reduced footprint area.

Introduction

Improved performance can be obtained by using a single isolated, high-power DC-DC module to convert 48V to an intermediate supply rail of 12V or less. The intermediate voltage is then converted to the system voltages required for specific loads. Such voltage conversions can be achieved with nonisolated, point-of-load power supplies as shown on the right side of **Figure 1**. Integrated switching regulators are excellent candidates for this second power-conversion stage, because the required input voltage ($\leq 12V$) and output current ($< 10A$) are both relatively low.

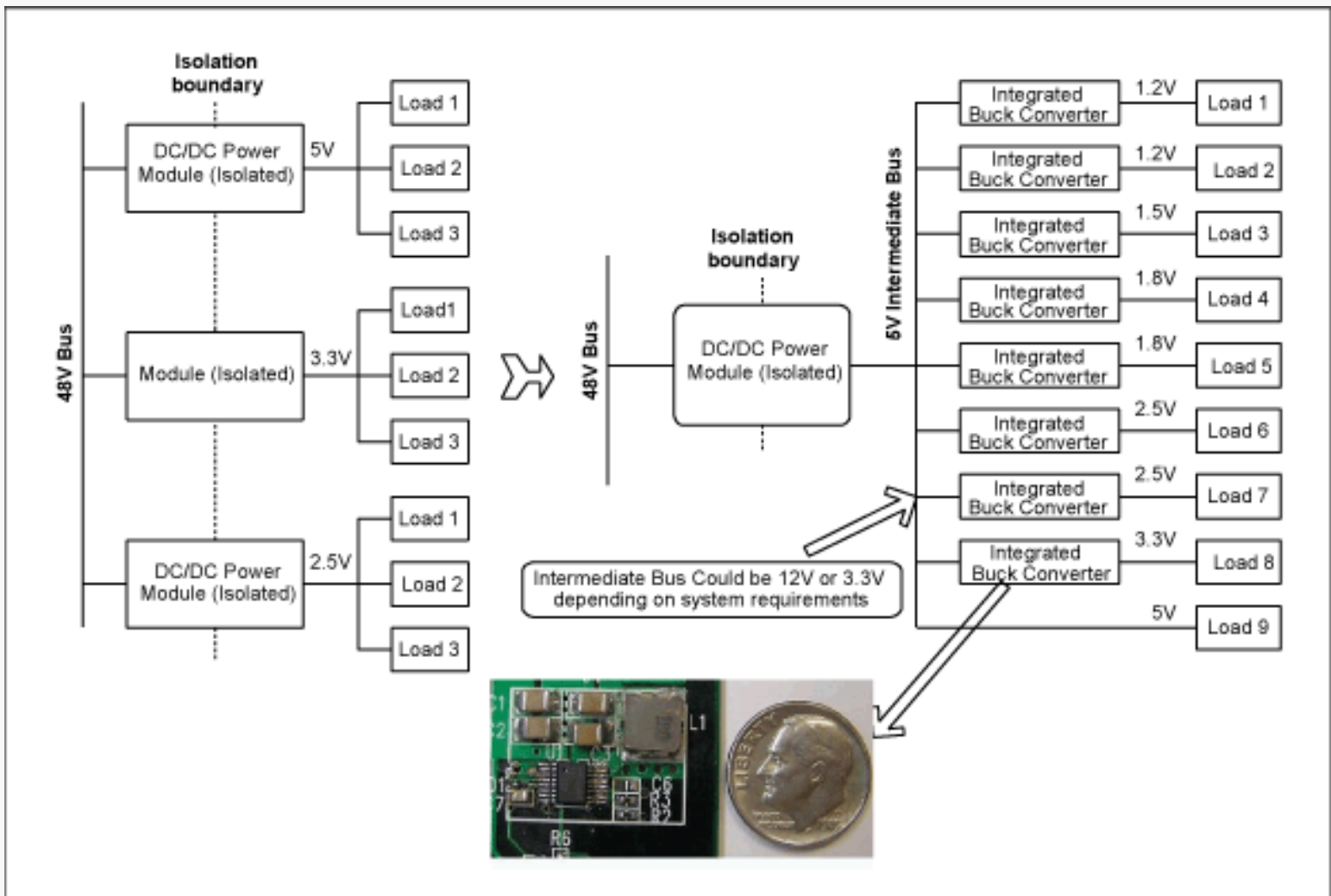


Figure 1. Compared with the conventional power-distribution architecture for telecom boards (left side), the integrated switching-regulator architecture (right side) offers better efficiency and reliability, faster design, and a smaller footprint.

Benefits of an Integrated Switching Regulator

Many areas of the electronics business, including the power-electronics industry, employ a strategy that integrates system components to reduce overall cost, enhance reliability, and minimize valuable real estate on the PC board. In the past two decades, manufacturers of power-management ICs have done a tremendous job of producing devices that integrate many of the functional blocks required in power supplies for isolated and nonisolated DC-DC conversion applications.

The integrated switcher, which combines the MOSFETs, gate drivers, and PWM controller of a DC-DC switching converter within a single package, is not a new concept. What is new is the increased current capability and enhanced features now provided by such devices. They are well suited to the distributed-power requirements of modern telecom boards, which require compact, multiple, point-of-load power supplies that provide an excellent transient response to dynamic loads.

Design, development, and testing of the power supply for a telecom system board represents a substantial part of that board's development time. Apart from the time required for PCB layout, a major part of power-supply development consists of fixing layout-related problems. Those problems include improper power-stage layout, incorrect grounding schemes, routing of sensitive analog traces near power traces that carry rapidly changing currents and voltages, failure to provide Kelvin connections for voltage and current sensing, excessive EMI, and the location of decoupling capacitors. Most of these problems can be traced to the higher probability of layout mistakes when implementing a power supply containing several discrete external components.

Integrated switching regulators, in contrast, avoid many layout problems by integrating the power stage (MOSFETs and gate drivers) and current sensing within the device to eliminate several PCB interconnects. Moreover, the pin

configuration of an integrated switcher is designed to preclude questions that would otherwise be faced about component location and grounding. Integrated switching regulators often come with compact, optimized, and tested PCB layouts which reduce the design cycle and time to market.

Because the environment of modern telecom systems demands higher performance along with smaller size and less floor space, PCB real estate is increasingly valuable. Apart from the space saved by integrating the power stage and PWM controller, an integrated switcher conserves PCB area by operating at higher frequencies than a discrete-component alternative. Higher switching frequencies allow physically smaller input/output capacitors, inductors, and other filtering components. Higher frequency operation also produces a faster load-transient response by enabling the design of higher bandwidth control loops.

Power-conversion efficiency is an important measure of power-supply performance and a primary motivation to use switching power supplies instead of linear power supplies. This is true in spite of the higher levels of noise and EMI from a switcher. Power dissipation in a switcher consists of conduction losses, which are related to the MOSFETs' ON-state resistance ($R_{DS(ON)}$), and switching losses, which are related to how fast the MOSFETs make transitions between the ON and OFF states. At higher operating frequencies, switching losses dominate because the MOSFET switching transitions occur more times per second. Transition times are determined primarily by impedance in the gate-drive circuitry that turns the MOSFETs ON and OFF. For power supplies with discrete MOSFETs and gate drivers, the gate-drive impedance is larger at high frequency due to parasitic components such as MOSFET lead inductance and PC trace inductance. An integrated switcher, however, minimizes these parasitic components by combining the gate driver and MOSFETs in a single package, thereby delivering faster transition times and better efficiency at high frequencies.

Thermal management is one of the most critical considerations in large-system power design. In point-of-load architectures, the heat generated from power conversion is distributed among the integrated switching regulators instead of being concentrated in one power module. The higher efficiency of integrated switching regulators further reduces heat generation. In addition, integrated switching regulators are often packaged in thermally enhanced packages with exposed metal "paddles" that solder directly to the PCB and allow thermal vias (with 8-to-12 mil diameters) to transfer heat into the internal ground layers. (Ground layers eliminate bulky heat sinks by spreading heat into the board.) Finally, thermal-shutdown circuitry coupled directly to the integrated power switch increases system reliability by protecting the device from catastrophic failure in the event of thermal runaway.

Integrated switching regulators feature a variety of package options and a wide range of input voltages (3V to 12V) and output currents (< 1A to 10A). Low-power versions are available in packages such as SOTs, MSOPs, and TSSOPs. High-power versions use packages such as QFNs and BGAs, which offer higher power-dissipation.

Conclusion

Integrated switching regulators are ideal candidates for the intermediate-bus power-supply architectures of modern telecom systems. When compared with regulators based on discrete MOSFETs, gate drivers, and controllers, their use reduces time to market, saves space, improves efficiency, simplifies thermal management, and yields better reliability.

For a list of our internal-switch, step-down inductor-based DC-DC converters, click [here](#).

A similar article first appeared in EE Times in October, 2004.

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