Simple, Intelligent, High-Density Power:
PMBus Compatible, Monolithic 30A DC/DC Regulator can Parallel up to Eight Phases and Output more than 240A

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Introduction

The need to optimize efficiency and address complex power requirements of high-end processors, FPGAs, and ASICs are making active power management a critical design requirement in datacenter servers, telecoms systems, and networking equipment applications. At the same time, engineers designing power schemes are expected to minimize board space while reducing the development time between the initial concept and the final product. To address the challenges of active power management, engineers must now consider solutions built around the PMBus specification, which offers a platform for monitoring and controlling power management devices. To address space-constraint issues, solutions with a minimal number of components must be implemented. The MPQ8645P, the latest point-of-load (PoL) regulator with PMBus integration from Monolithic Power Systems (MPS), provides a way for engineers to meet both sets of system design challenges.

System Design Challenges

Typical power architecture used in servers, telecom, and networking infrastructure consists of an AC/DC front-end, which is responsible for generating a DC voltage of 48V. This 48V voltage is fed into a DC/DC converter that supplies a 12V intermediate bus architecture (IBA). This 12V voltage is then distributed to multiple point-of-load (PoL) converters on the board to provide power to ICs or sub-circuits. Most of these ICs or sub-circuits are required to operate at voltages ranging from sub-1V to 3.3V at currents ranging from tens of milliamps to hundreds of amps. These power rails often have strict design requirements for sequencing, voltage accuracy, margining and supervision (see Figure 1).

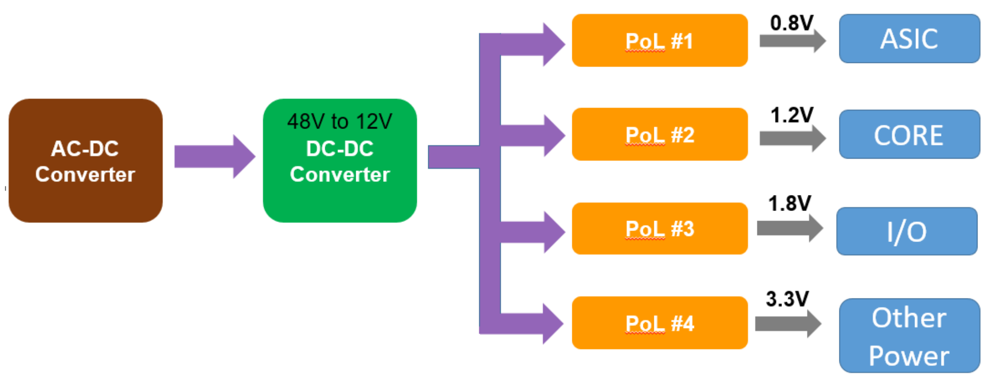

Figure 1: Example of Distributed Power Architecture

In a complex system, there can be as many as 50 PoL voltage rails. System architects and engineers need a simple way to manage these rails with respect to their output voltage, sequencing, and maximum allowable current. Certain processors demand that the I/O voltage power up before the core voltage. Alternatively, certain ASICs require the core voltage to power up before the I/O voltage. Power-up and power-down sequencing is also necessary. There must be an easy way to implement changes to optimize system performance and to store a specific configuration for each DC/DC converter in order to simplify the design effort.

To satisfy the growing demand for active power management, many new system designs have shifted to adopt PMBus technology, since it permits greater flexibility on the power supply. The PMBus simplifies the configuration, sequencing, and monitoring of power supplies while determining and reacting to warnings and faults. The latest PMBus specification (version 1.3) introduces adaptive voltage scaling (AVS), which supports the processor's ability to slow down its clock frequency and reduce the supply voltage autonomously. This minimizes its own power consumption when the output load is light to achieve significant power savings. PMBus version 1.3 offers a number of further improvements, such as faster PMBus speeds to allow increased data throughput, enhanced output voltage tracking to inform warning thresholds, fast zone read/write for high-speed communication with high-priority devices, and a revised data format that allows for higher precision over a wider range.

Design resources have become stretched thin by increasing system complexity and shortening design cycle, with resource allocation falls primarily on developing the key intellectual property of the system. This often means that the power supply must be put aside until later in the development cycle. With little time and perhaps limited power design expertise, there is pressure to develop a highly efficient solution with the smallest possible footprint. The ever-shrinking board area demands leads to the utilization of the PCB's underside to maximize the board's real estate, but this may not be an option in some cases. The ideal solution is a complete power supply in a small form factor.

MPS's Latest Approach

A conventional approach to handle applications that range from tens of milliamps to hundreds of amps would be a discrete analog solution. The building blocks for discrete analog solutions consist of a controller IC and either a pair of external MOSFETs or a driver-MOSFET (DrMOS) IC. These components implemented with the appropriate amount of input and output capacitors and a proper inductor would fulfill the fundamental power conversion requirement. However, most sophisticated modern system designs require the ability to monitor, control, and obtain real-time information for system reporting. These features can be achieved by adding more external components, such as a voltage supervisor, temperature sensor, analog-to-digital converter (ADC) and digital-to-analog converter (DAC). This not only adds cost, but it also requires a great deal of board space that most modern systems do not have.

Unlike conventional discrete analog solutions, MPS implements a monolithic solution. The MPQ8645P is a 16V, step-down regulator with PMBus interface that can deliver 30A of current in a single-phase operation, taking advantage of synchronous rectification for optimum efficiency, all on a single silicon die. It is available in a thermally enhanced TQFN (4mmx5mm) package. The MPQ8645P is about 20 - 50% smaller than discrete analog solutions using a separate controller IC and power stage (not including external components) (see Table 1).

Table 1: IC Area of MPS vs Discrete Analog Solutions

	MPS PMBus Solution	Discrete Analog Solution #1	Discrete Analog Solution #2
Controller	-	3mm x 3mm package	3mm x 3mm package
External MOSFETs (Dual-Channel)	-	5mm x 6mm package	-
DrMOS	-	-	3.5mm x 4.5mm package
One-Chip Solution	4mm x 5mm package	-	-
Total ICs Area (mm^2)	20	39	24.75

The MPQ8645P requires minimal number of external components to simplify the schematic and PCB layout (see Figure 2). The base design of the power supply can be completed in three steps. First, choose the appropriate amount of input and output capacitors to satisfy voltage and current ripple requirement for the application. Second, select the proper inductor to fulfill the total load current demand for the application. Third, program the current limit and PMBus address by placing a resistor from their respective pins to ground. The rest of the functionalities and operation can be addressed via the PMBus. Because of its high integration and simple design, the MPQ8645P can achieve a typical efficiency of 85 - 95%. For example, the MPQ8645P's peak efficiency is as high as 95% for 12Vin to 2.5Vout in 1MHz switching frequency applications.

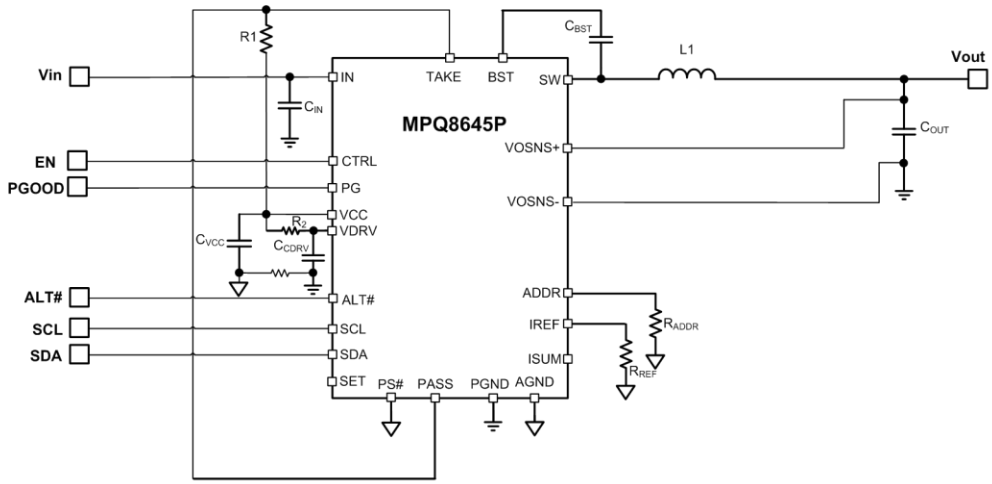

Figure 2: Typical Application Circuit of MPQ8645P in Single-Phase Operation

Parallel Operation and Current-Sharing

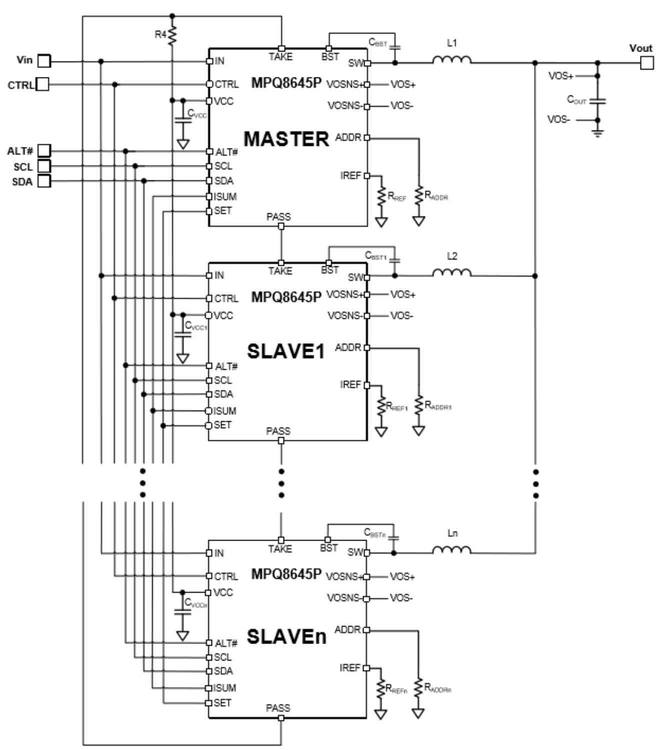

Figure 3: Typical Application of MPQ86459P in Multi-Phase Operation

The MPQ8645P also provides a simple way to handle high-power applications. Figure 3 shows a typical application of the MPQ8645P in a multi-phase operation. It is scalable and can be paralleled for high load-current demands. The constant-on-time (COT) control mode architecture ensures balanced load current sharing and matching. The ISUM pin of all phases are connected together in multi-phase operation. The information on ISUM is collected from each phase and compared with the average current to determine the duration of the T_{ON} pulse. The MP8Q8645P can achieve a precise current matching with <2% error among each phase at room temperature in a 4-phase operation (see Figure 4). This mitigates the potential for hot spots. The MPQ8645P can parallel up to eight ICs, and the maximum number of phases can increase up to 24. The MPQ8645P can support a maximum output current of 720A easily.

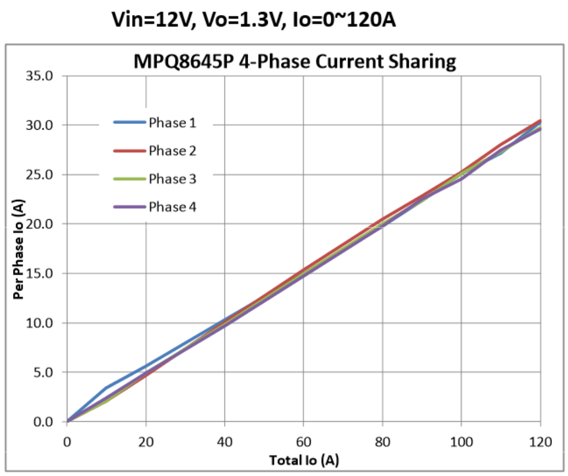

Figure 4: Current-Sharing Measurements of MPQ8645P in 4-Phase Operation

System Monitoring/Controlling and Debugging/Fine-Tuning

Using a PMBus-compatible power IC provides many system benefits over conventional discrete analog solution approach. They offer ease and flexibility of configuration, broad and accurate system control, and detailed and precise monitoring and telemetry.

In a conventional discrete analog solution, parameters such as output voltage, current limit, switching frequency, and the over-current threshold are usually set through one or more resistors. Any changes or updates made on the application requires the rework of actual physical components. This means that each application has a different set of components for engineers to keep track of.

With one bill of materials (BOM), the MPQ8645P can support a variety of applications. Parameters such as the input/output voltage, input/output current (per-phase and total), switching frequency, fault protections, and more are programmable via the PMBus. The adjustment of these parameters can be changed dynamically. The MPQ8645P makes it possible to adapt the operation of the power supply to the needs at hand.

The MPQ8645P also uses built-in multiple-time programming (MTP) cells to store custom configurations. Engineers can save and store all adjusted parameters after each system fine-tuning to specific applications. This allows for rapid modifications and minimizes physical hardware changes. The MPQ8645P eliminates repetitive and potentially intensive labor activities, making system fine-tuning hassle-free.

The MPQ8645P is PMBus 1.3 compliant and has monitoring capability. The ability to read and report real-time information (e.g.: voltage, current, power, temperature, switching frequency, and faults) enables comprehensive visibility into the performance of the power supply. This is useful during the test and debug phase or even system deployment as it gives engineers the ability to optimize the system run time through predictive analysis and minimize downtime by having more data when repair becomes necessary.

Conclusion

Active power management holds the key to achieving the level of in-system adaptability essential for meeting the energy efficiency demands of the growing data communication and networking industries. It is also the way system architects and engineers are able to deliver new designs with space constraints and tight turnaround times. MPS's latest PoL regulator, the MPQ8645P, is a direct solution to these challenges. With the MPQ8645P, the design burden of component selection, optimization, and layout is eliminated, shortening the overall design time, system trouble-shooting, and ultimately improving the time to market.