Simple, Compact, Elegant Hot-Swap Solution for Server Design

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The need to implement protections and control circuits is a crucial design requirement in datacenter severs, telecoms systems, and networking equipment applications. At the same time, engineers designing power-related schemes are expected to minimize board space while reducing the development time between the initial concept and final product.

Solutions with a minimal number of components are implemented to address space-constraint issues. In the face of an ever-shrinking time-to-market schedule, engineers must now consider solutions that minimize design effort. The MP5023, a hot-swap solution with PMBus integration from Monolithic Power Systems (MPS), provides an innovative way for engineers to solve these design challenges.

Understanding Hot-Swap Insertion/Removal Events

As with many communications infrastructures, high availability and reliability are critical elements of system design in a datacenter. Pluggable modules and PCBs, such as servers and storage, require a protection and control circuit at the power entry point. This is commonly referred to as a hot-swap control circuit.

To appreciate what a hot-swap control circuit does to the system, it is important to understand the status of the system before and after the hot-swap event. Figure 1 shows that the host system's backplane is fully powered at the outset. In a live system, all bulk and bypass capacitors are fully charged. Inserting an uncharged card into the live system quickly charges the card and discharges the live system. Uncontrolled card charging demands a large inrush current, and uncontrolled system discharging significantly reduces the backplane voltage.

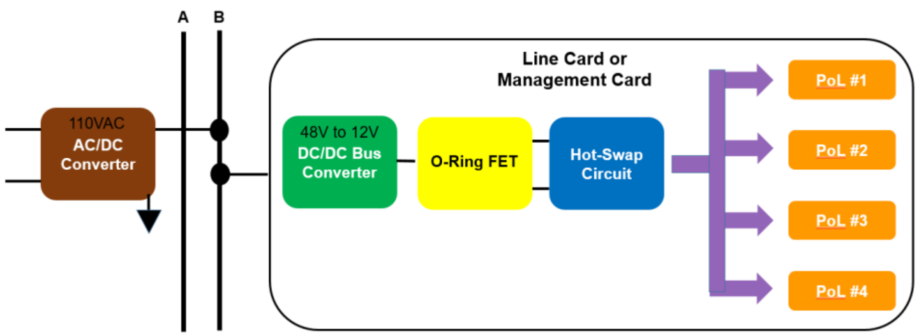

Figure 1: Example of Distributed Power Architecture in a Telecommunications System

Hot-swap solutions control the power-up of uncharged cards and manage system response. Cards mating into a live system connector will connect and disconnect power (bounce power on and off) as the card is rocked into the connector. It can take several milliseconds for the card to mate properly. As the card is inserted, the capacitors on the card start to charge and draw current from the live system. As the capacitors initially charge, the card appears as a short and instantaneously draws a large amount of current. This inrush current produces a large demand on the system, and can cause the system capacitors to discharge and the system voltage to droop. Hot-swap solutions therefore allow cards/boards to be inserted and removed from a live backplane without disturbing the power distributed to other boards.

Design Challenges

The hallmarks of hot-swap solution in applications such as servers and storage generally include safe control of live board inrush current control during insertions and removals, fault monitoring diagnostic and protection, and high accuracy electrical (voltage, current, power) and environmental (temperature) parameters to provide real-time system telemetry in analog or digital domains. In particular, if a fault occurs in one line card/board in a server rack, that fault should remain isolated to that particular line card/board, and impact neither the system backplane nor the other line cards/boards powered from that live backplane.

The best way to prevent system downtime is to detect, respond, and correct potentially damaging conditions as quickly as possible.

Conventional wisdom in designing the hot-swap protection control circuits is to use discrete components. A typical discrete hot-swap solution combines a controller IC, a pass device like a MOSFET, and a sense resistor to manage the flow of power between the backplane and the main board for preventing glitches and faults from disrupting power to the rest of the system. This method fulfills the fundamental protection requirements. However, discrete solutions have well-known shortcomings, including:

- They need more components and occupy more board space. More components also raise concerns regarding solution robustness and reliability.
- They do not incorporate thermal protection for the MOSFET. The thermal design often exceeds the safe operating area (SOA) limits for device protection under extreme cases.
- They require careful PCB layout. Engineers must understand Kelvin current-sensing technique in order for current monitoring and current limiting to be correctly and accurately implemented.

Design resources have been stretched thin by increasing system complexity and shortening design cycles, with resources primarily being allocated to developing the key intellectual property of the system. This often means that the power scheme related circuits are ignored until later in the development cycle.

With little time, and perhaps limited power design expertise to address the drawbacks described above, there is a growing need to develop reliable hot-swap solution. The ideal hot-swap solution would have a small form factor, be cost-effective and reliable, and require minimal design effort.

An Innovative Approach

Unlike conventional discrete solutions, MPS implements a monolithic solution. The MP5023 is a 16V hot-swap solution with an integrated MOSFET and sense resistor, as well as a PMBus interface that can handle 50A of current — all on a single silicon die (see Figure 2). It is available in a small QFN (4mmx5mm) package.

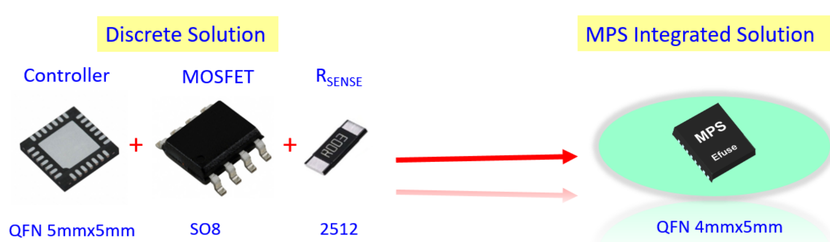

Figure 2: The MP5023 vs. Discrete Hot-Swap Solution

The MP5023 requires a minimal number of external components, which helps simplify system design (see Figure 3). Engineers only need to select the correct values of resistors for setting the current monitoring, current limit and PMBus address, and correct values of capacitors for soft-start and other timer features. The MP5023 also simplifies PCB layout issues by optimizing MOSFET and sense resistor connections inside the IC package. It can compensate internally for an incomplete or improper implementation of Kelvin-sensing, requiring less time and effort from engineers.

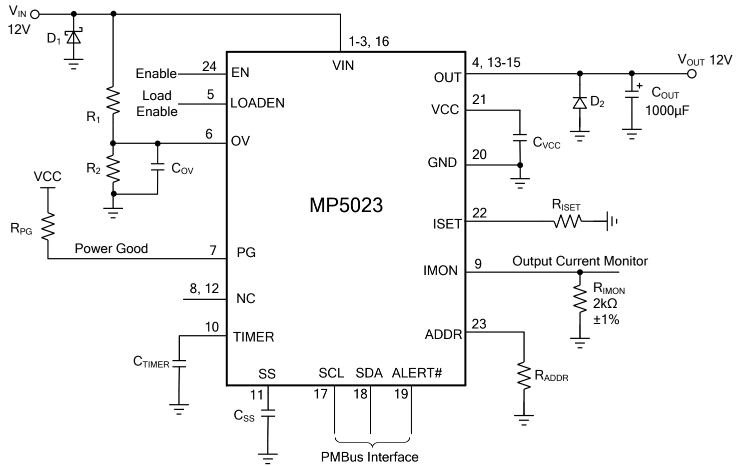

Figure 3: Typical Application Circuit of the MP5023

One significant advantage of the MP5023 over discrete solutions is that the current monitor and current limit accuracy are well under control due to the advanced monolithic process. It can achieve ±1.5% current monitoring between 10A and 50A in various temperature ranges (see Figure 4).

An integrated MOSFET provides the ability to monitor the on-die temperature to shut down the MP5023. Once the device enters thermal shutdown, it either remains off (latch-off) or attempts to restart (auto-retry) after the junction temperature falls below the over-temperature protection threshold. The on-die temperature can be monitored and read via the PMBus. Therefore, engineers do not need to over-design the MOSFET or thermal design to keep the device in SOA limits under extreme fault conditions.

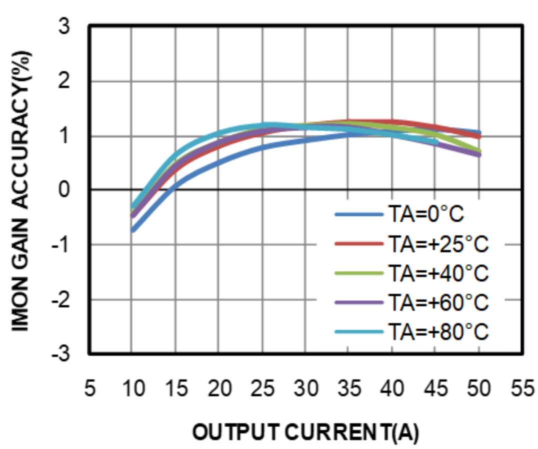

Figure 4: IMON Gain Accuracy vs. Output Current and Temperature

The MP5023 has a PMBus interface and is PMBus 1.3 compliant, which offers ease and flexibility of configuration, broad and accurate system control, as well as detailed, precise monitoring and telemetry. Parameters such as the voltage, current, temperature, and faults are programmable via the PMBus, which can read and report real-time information. The adjustment of these parameters can be changed dynamically. Real-time monitoring enables comprehensive visibility into solution performance, which gives engineers the ability to optimize the system run-time through predictive analysis and minimize downtime by having more data available when repairs become necessary.

Conclusion

Incorporating these elements into a hot-swap solution such as the MP5023 makes it possible to adapt the operation of the system to the needs at hand, eliminates repetitive and labor-intensive activities, and allows engineers to address shrinking space constraints and tight project turnaround times.