# Highly Integrated, Scalable, Current-Sharing Hot-Swap Solution for 48V Datacenter Applications

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## Introduction

Servers and racks used in datacenters have undergone a considerable increase in power, going from a few hundred watts to multiple kilowatts. The distribution of these higher power levels on multiple servers inevitably generates greater power losses and hinders efficiency. This aspect can be mitigated by transiting from a traditional 12V distribution voltage to 48V.

The increase in distribution voltage poses challenges for implementing the protection circuit, which is a crucial design requirement in datacenter severs, telecoms systems, and networking equipment applications, since components must be able to withstand the voltage stress and current demand. 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.

To solve space-constraint issues, solutions with a minimal number of components are implemented. In addition to the ever-shrinking time-to-market schedule, engineers must now consider solutions that minimize design effort. These solutions can provide an elegant way for engineers to solve critical design challenges. This article will use the MP5048 solution from Monolithic Power Systems (MPS) as an example, which is the industry's first 60V, 15A, integrated hot-swap solution.

## Design Challenges

Like many communications infrastructures, high availability and reliability are key elements of the system design in datacenters. Modules and PCBs that can be plugged into applications such as servers and storage require a protection/control circuit at the power entry point, commonly referred to as a hot-swap control circuit.

Solutions with hot-swap capabilities allow boards to be inserted and removed from a live backplane without disturbing the power distributed to other boards. One of the major expectations for these systems is minimal system downtime during any abnormal transient event, such as over-voltage, overload or short-circuit conditions. To overcome such scenarios, today's system engineers use protection circuits to manage inrush, overload, short-circuit, and over-voltage events while guarding the sensitive loads for reliable system operation. The key requirement is to bring down the faults to within the application's operating limits, and bring the system back to an active state once the faults are cleared — all without any manual intervention.

The best way to prevent system downtime is to detect, respond to, and correct potentially damaging conditions as quickly as possible. With the new 48V distribution voltage system, conventional wisdom in designing the hot-swap protection circuit says to use discrete components. A typical, discrete hot-swap solution combines a high-voltage controller IC, MOSFET, and sense resistor. These components manage the flow of power between the backplane and the main board to prevent glitches and faults from disrupting power to the rest of the system. However, discrete solutions have well-known drawbacks, including:

- They require more components and occupy more board space. More components also raise concerns regarding solution robustness and reliability.
- They do not incorporate thermal protections for the MOSFET. The thermal design is often larger than the safe operating area (SOA) limits, which ensure that the device is protected under extreme cases.
- They require careful PCB layout. Engineers must understand Kelvin current-sensing techniques to correctly and accurately monitor and limit the current.

Design resources have been stretched thin by increasing system complexity and shortening the design cycle. This often means that the related power scheme must be put aside until later in the development cycle. With little time and sometimes limited power design expertise to address the design drawbacks described above, there is pressure to develop a 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

Integrated solutions present a number of advantages over conventional discrete solutions. For example, the MP5048 from MPS is a monolithic, 60V, hot-swap solution with an integrated MOSFET and sense resistor. The device can handle 15A of current all on a single silicon die, and is available in a small QFN (5mmx5mm) package.

The MP5048 requires a minimal number of external components to simplify the system and PCB layout design (see Figure 1). The base design of the hot-swap solution can be completed in 2 steps:

1. Set the current limit and the current monitoring features by placing a resistor at the CLREF and CS pins to ground.
2. Select the appropriate number of capacitors to adjust the soft start (as well as other timer features). When key components are integrated in a solution, there are fewer concerns regarding robustness and reliability.

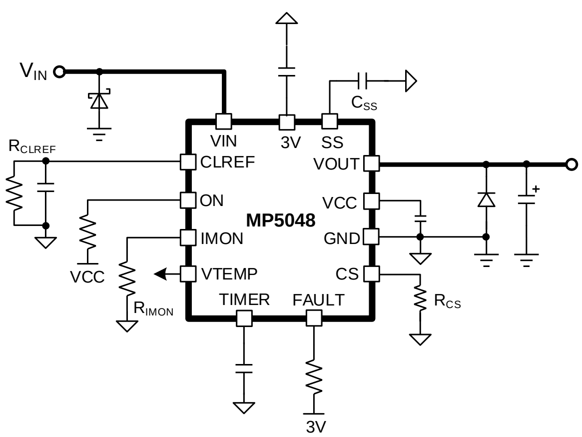


**Figure 1: MP5048 Typical Application Circuit**

One significant advantage of using an integrated solution like the MP5048 over discrete solutions is that the current monitor and current limit accuracy are well under control due to the advanced monolithic process. This particular device can achieve current monitoring within 3% between 0A to 15A with various temperature ranges (see Figure 2).

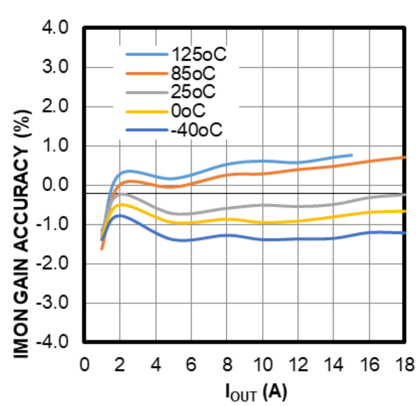


**Figure 2: IMON Gain Accuracy vs. Output Current and Temperature**

An integrated MOSFET provides the ability to monitor the on-die temperature to shut down the device. Once the MP5048 enters thermal shutdown, it either remains off (latch-off mode) or attempts to restart (auto-retry) after the junction temperature falls below the over-temperature protection threshold. This means that engineers do not need to over-design the MOSFET or thermal design to keep the device in SOA limits under extreme fault conditions.

The MP5048 is a versatile hot-swap solution that can be scaled to support any current range needed for the application. Even though the MP5048 is not equipped with PMBus capability, it can pair up with a hot-swap controller, such as the MP5920 from MPS, to add telemetry features to the application (see Figure 3).

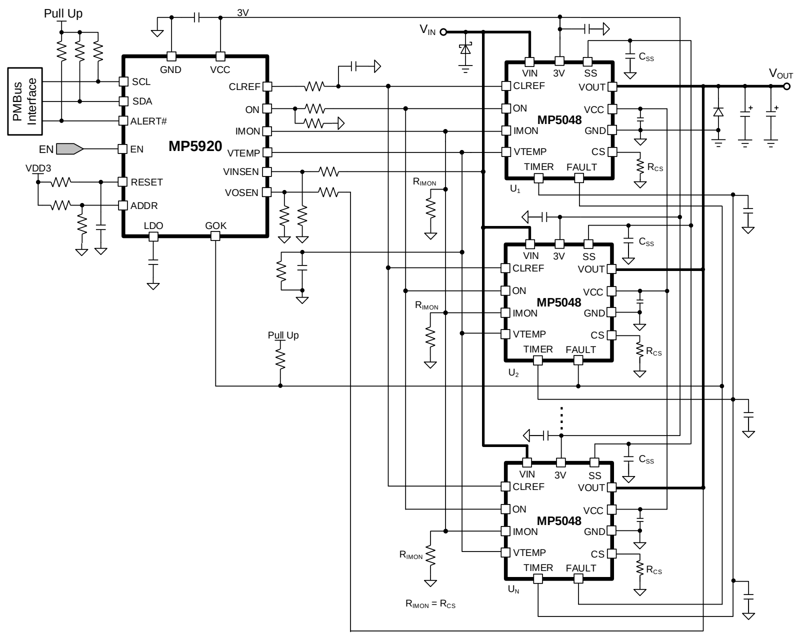


**Figure 3: The MP5048 Can Be Controlled by a Hot-Swap Controller in Parallel Operation**

With telemetry, the ability to read and report real-time information (e.g. voltage, current, temperature, and faults) enables comprehensive visibility into the performance of the entire hot-swap solution. This is useful during the testing and debugging phase, or even during system deployment, as it gives engineers the ability to optimize the system runtime through predictive analysis while minimizing downtime by having more data when a repair becomes necessary.

With the ability to monitor current through the internal MOSFET, multiple MP5048 devices connected in parallel actively balance the current flowing through each device during soft start. This ensures that each device carries the soft-start current equally, and that no one device carries the full soft-start load current (see Figure 4). With the soft-start current equally balanced among the devices connected in parallel, the risk of violating the SOA of the MOSFET is greatly reduced, and the thermal energy is more evenly distributed across the PCB.

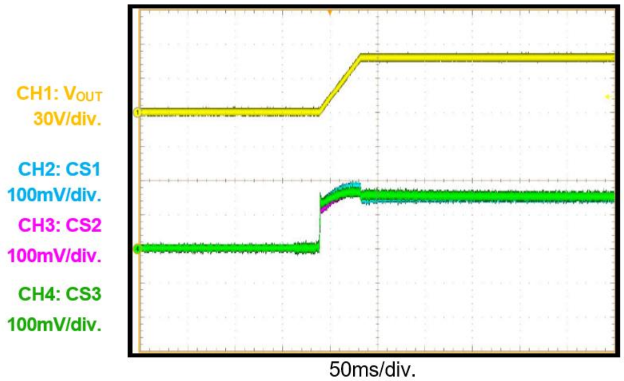


**Figure 4: Current Sharing of Three MP5048 Devices Operating in Parallel During Soft Start**

## Conclusion

Incorporating these elements into an integrated hot-swap solution such as the MP5048 provides a simple, user-friendly and robust solution that is greatly suitable for space-constrained 48V datacenter applications. A monolithic system 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.

 