250 A Output Current DC/DC Modules Powering FPGAs and ASICs

The growing number of high-performance FPGA and ASIC applications that are driven by the increased bandwidth of wireless networks and data centers require power regulators with high power density, fast load transient response, and intelligent power-management features. The MPM3695 series of power modules with integrated inductors from Monolithic Power Systems (MPS) offers a versatile solution for powering FPGAs and ASICs by offering up to 60 % higher power density compared to discrete point-of-load (POL) solutions, simplified PCB layout and power stage design, minimal external components, and minimal expertise requirement for the power converter and compensation network design. **Heng Yang, Sr. Applications Engineer, Monolithic Power Systems, San Jose, California**

The trend of higher power density for FPGA and ASIC applications poses challenges to power module designs. A compact power module inherently requires both highly efficient operation and good thermal management. The MPM3695 series optimizes the package size and current-handling capability by adopting lead-frame packaging technology that enables direct and efficient heat dissipation from the power module to the PCB. With the monolithic structure of the power IC and customized integrated inductor design with advanced packaging technology, the MPM3695 series power modules achieve up to 40 % footprint reduction.

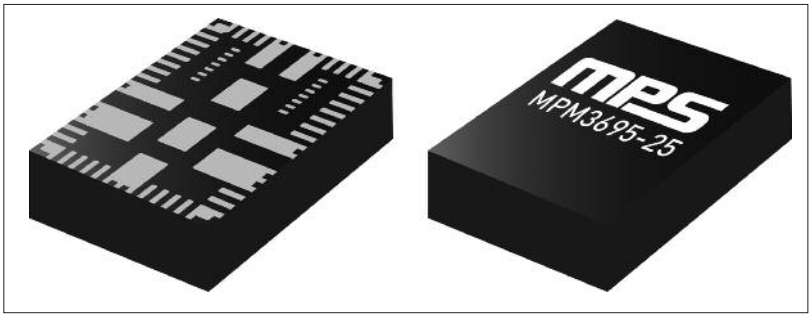


Figure 1: **MPM3695-25, 25A power module**

Achieving high power density

The MPM3695 series offers four power modules that are tailored for different output voltage and current ranges.

The MPM3695-25 is a step-down, 25 A power module with a 3.3 – 16 V input range and 0.5 - 5.5V output range. The output current is scalable for up to 250 A by stacking multiple modules. The top and bottom sides of the MPM3695-25 are shown in Figure 1. Residing in a 10 mm x 12 mm x4 mm QFN package, it integrates one monolithic buck converter and one inductor with up to 25 A of current-handling capability. The power density is 2.25 kW/inch? due by its highly efficient operation. The efficiency of the MPM3695-25 peaks at 94 % with a 3.3 V output voltage and above 80 % for the main operation range (Figure 2).

The MPM3695-10 is a thin, 10 A, step-down power module with output current scalable for up to 60 A. Its 1.6 mm height enables the power module to be placed on the bottom-side of a PCB, saving board space for high-density designs (Figure 3). The input voltage range is 3.3 – 14 V, and the output voltage range is 0.5 – 3.3 V. Residing in a compact 8 mm x 8 mm x 1.6 mm QFN package, the MPM3695-10 offers power density of 3.7kW/inch^3. Additionally, the MPM3695 series offers two enhanced-efficiency versions: the MPM3695A-25 and MPM3695A-10 with an output voltage range between 0.5 – 1.8 V

The dynamic load of FPGAs and ASICs inherently demands fast transient response from the power regulators to satisfy the voltage requirement of the core power. The output capacitors required to maintain the output voltage during a load transient occupy significant board area. The MPM3695 series

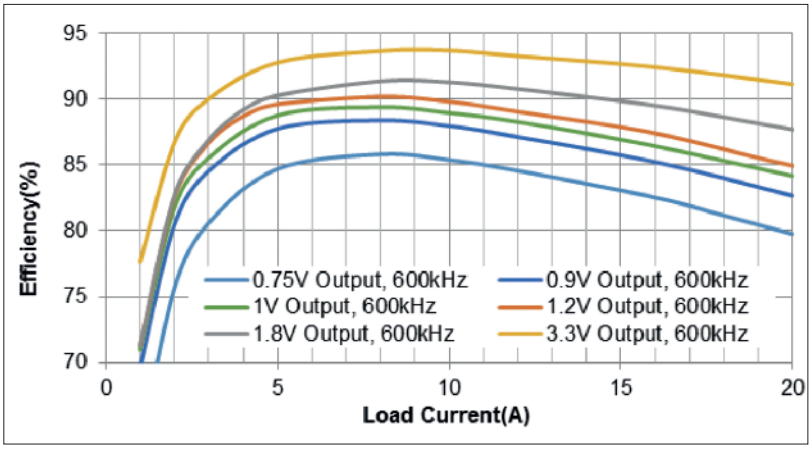


Figure 2: **Efficiency curve of MPM3695-25 at 12 V input**

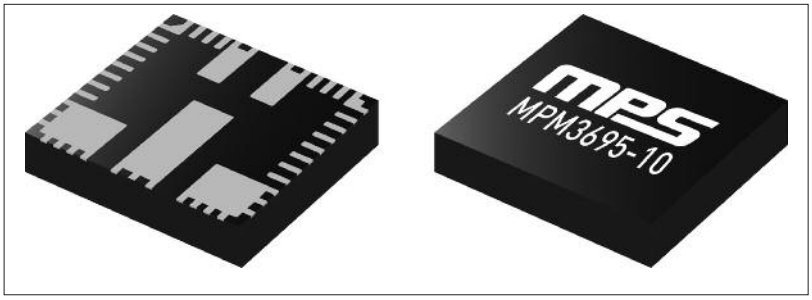


Figure 3: **Ultra-thin MPM3695-10 power module**

minimizes the output capacitor requirement by adapting the patented multiphase constant-on-time (MCOT) control scheme. MCOT control enables the power modules to adjust the switching frequency dynamically during a transient event, minimizing the energy demand from the output capacitors. Under steady-state operation, MCOT control guarantees interleaved operation for multi-phase configurations and leads to minimize input and output current ripple.

Additionally, the MCOT control scheme simplifies the converter design by eliminating the need for complex compensation networks used in traditional current- and voltage-mode control schemes. Figure 4 shows the experimental waveform of an MPM3695-10 module under a 25 % load current step at a 200 A/µs slew rate. The converter operates at an output voltage of 1.2 V. Two 47 µF output capacitors are installed on the evaluation board. As shown in the waveform results, only two 47µF output capacitors are required to maintain ±3 % or better output voltage deviation during a load current transient.

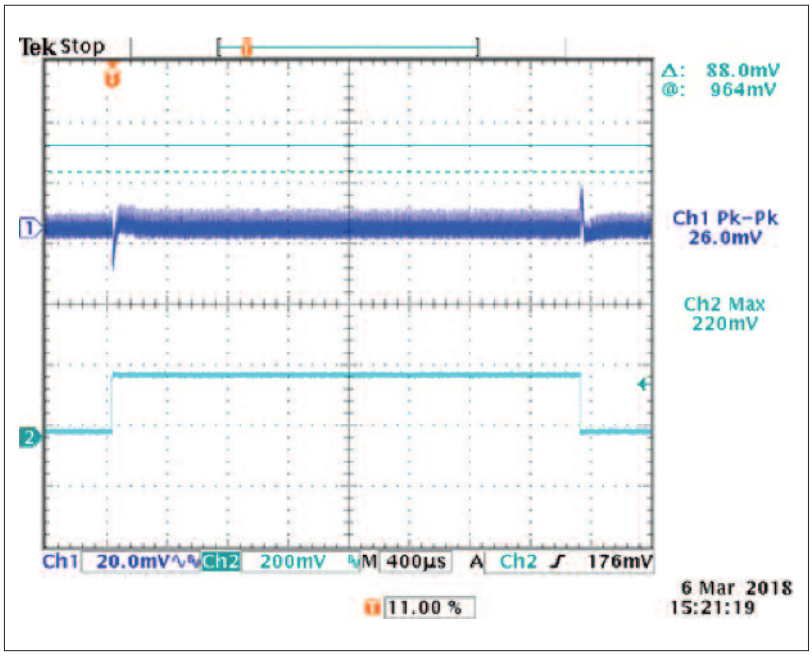
Scalable and smart power modules

The MPM3695 series adopts the concept of modular and scalable design, by which each module is a standalone power converter block with integrated inductors and can be easily stacked up to handle higher current. The parallel connection is conceptualized in Figure 5. The modular feature of the MPM3695 series simplifies PCB layout and power stage design, which leads to minimized development lead-time. A design engineer can easily copy and paste the same layout design for a variety of voltage rails with different current requirements. Additionally, the modular design minimizes the number of parts that must be maintained.

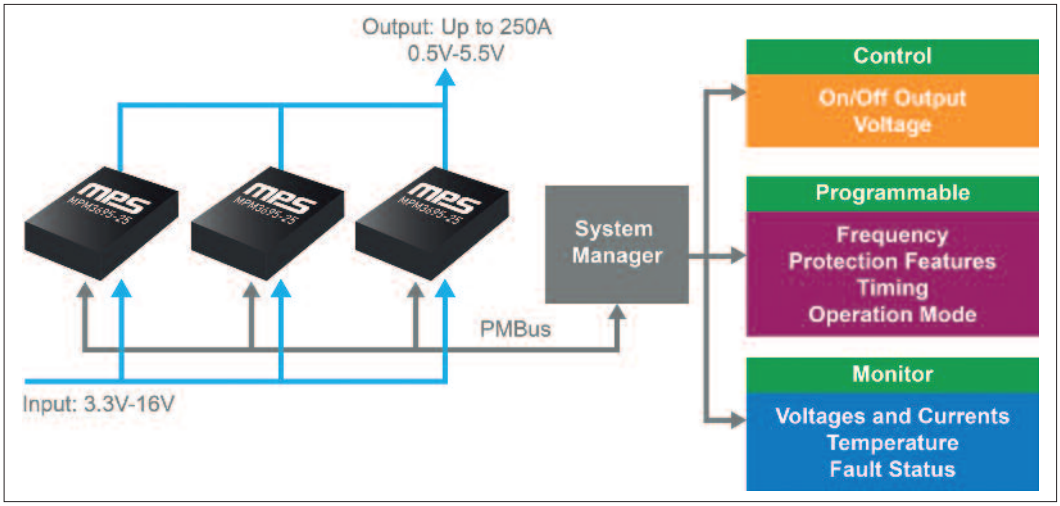
The smart features of the MPM3695 series enable the power modules to cooperate with intelligent power management systems. As shown in Figure 5, the series features PMBus 1.3, which allows the power module to report its operating condition and state of health (including voltages, currents, temperatures, and a variety of fault alerts) and to receive commands from a host. Programmability is offered over many important functions, such as faults threshold, switching frequency, timing, and conduction modes. The MPM3695 series also supports real-time on/off control and the output voltage setting. Paired with the graphical user interface (GUI) Virtual Bench Pro the series offers a customizable performance that fits the need for various applications.

Conclusion

The MPM3695 series of power modules is the power solution for today's FPGA and telecom applications requiring a short time-to-market, high power density, and intelligent power management. The modular feature of the MPM3695 series minimizes schematic and layout design effort. The innovative MCOT control scheme eliminates the expertise required for designing complex compensation networks. The programmable and power management features enables the power modules to fit every application.



ABOVE Figure 4: **Experimental waveform of a 25 % load step on MPM3695-10 with 1.2 V output**



LEFT: Figure 5: **MPM3695 series offers scalability and programmability**