

# DESIGN NOTES

## 10A High Performance Point-of-Load DC/DC $\mu$ Module Regulator 4.5V to 28V Input, 0.6V to 5V Output in a 15mm $\times$ 15mm $\times$ 2.8mm Package

Design Note 385

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### Introduction

Advancements in board assembly, PCB layout and digital IC integration have produced a new generation of densely populated, high performance systems. The board-mounted point-of-load (POL) DC/DC power supplies in these systems are subject to the same demanding size, high power and performance requirements as other subsystems. The rigorous new POL demands are difficult to meet with traditional controller or regulator ICs, or power modules.

For such demanding applications, an ideal POL power supply must meet high performance specifications while simplifying board assembly—mounting similar to other surface mount ICs on the board without requiring special tooling. Such POL DC/DC regulators must also demonstrate exceptional thermal performance with innovative packaging technology. Power density increases without the danger of overheating and shortened device life. The LTM<sup>®</sup>4600  $\mu$ Module<sup>®</sup> regulator does all of these things.

### 10A DC/DC $\mu$ Module Regulator in IC Form Factor

The LTM4600  $\mu$ Module regulator is a complete power supply point-of-load DC/DC regulator with a low profile IC form-factor. The controller, onboard inductor, MOSFETs and compensation circuitry are all housed in a 15mm  $\times$  15mm  $\times$  2.8mm LGA surface mount package which weighs only 1.73g (Figure 1). These size parameters allow the

LTM4600 to be mounted on the back side of a system board, taking advantage of the otherwise unused space. The  $\mu$ Module regulator switches at a nominal 800kHz in a synchronous topology to offer very high efficiency in a small form factor and low profile.

The  $\mu$ Module regulator is offered in two versions. The LTM4600EV operates from an input supply range of 4.5V to 20V; the LTM4600HVEV operates from 4.5V to 28V. Both offer adjustable output voltages from 0.6V to 5V and output currents of 14A peak and 10A continuous. Fault protection features include overvoltage protection and overcurrent protection.

### Quick and Easy Design

Figure 2 shows a typical LTM4600EV design for a 2.5V output and Figure 3 shows the efficiency of the circuit. Although bulk capacitors on the input and output suffice in most applications, this design uses two low ESR 10 $\mu$ F 25V ceramic capacitors to reduce input RMS ripple. The output voltage is set with an external resistor from the V<sub>OSET</sub> pin to ground. The output capacitors are selected for low ESR to maintain an initial voltage droop of the output voltage to approximately  $\Delta V_{OUT} = I_{LOADSTEP} \cdot R_{ESR}$  in a transient step.

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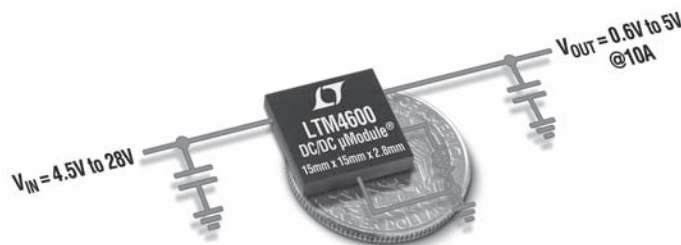
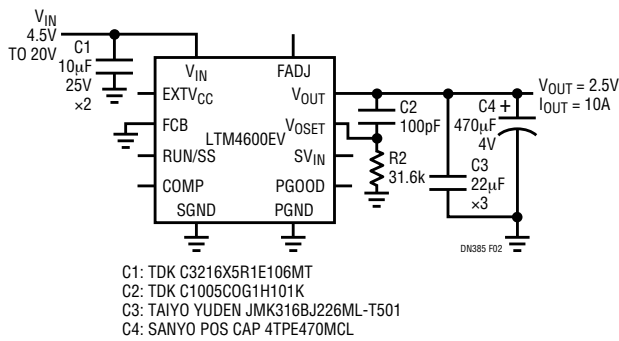
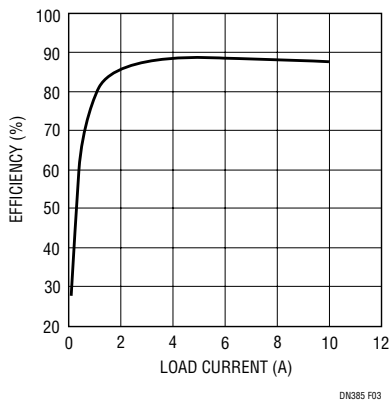


Figure 1. The LTM4600 Offers Unprecedented Power Density in a Small Package



**Figure 2. Few Components Are Required in this 2.5V/10A Application**



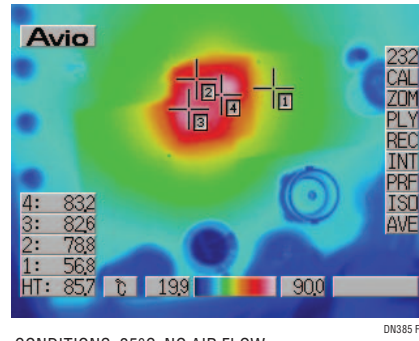
**Figure 3. Efficiency of the Application in Figure 2**

### Thermally Enhanced Packaging

The  $\mu$ Module regulator package has extremely low thermal resistance of 6°C/W and 15°C/W junction-to-case and junction-to-ambient, respectively. It allows heat-sinking from both the top and bottom of the device. Figure 4 shows the top view thermal imaging of the LTM4600 at full throttle with no airflow and heat sink. Refer to Application Note 103 for detailed thermal analysis and measurements.

### Fast Transient Response

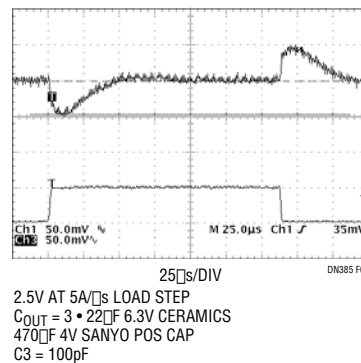
A unique feature of the LTM4600 is its no-clock-latency valley current mode architecture. This feature allows very fast loop response to rapid load transients with minimum output capacitance. Typically, the output voltage turns around in 4 to 6 microseconds and fully recovers in 20 to



CONDITIONS: 25°C, NO AIR FLOW, NO HEATSINK, NO EXTVCC

**Figure 4. The LTM4600 Exhibits Impressive Thermal Performance, Even Without Air Flow and Heat Sink (24V to 3.3V at 10A, Top View). For a Color Representation, Download the File at [www.linear.com](http://www.linear.com)**

25 microseconds. Figure 5 shows the transient deviation of only 55mV on a 2.5V output with a 5A load step. The 6 $\mu$ s of turnaround is achieved with only a 470 $\mu$ F POS cap and the three 22 $\mu$ F ceramics.



**Figure 5. Load Transient Response for the Application in Figure 2**

### Paralleling the $\mu$ Module Regulator for 20A Output

Two LTM4600  $\mu$ Module regulators can be used in parallel to double the output current. The current mode architecture and precision current limiting allow two modules to equally share the output current, thus maximizing efficiency and equally distributing the heat.

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