High Efficiency, High Density PSM µModule Regulator with Programmable Compensation

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FPGA boards, as well as prototype, testing, and measurement applications demand versatile and high density power solutions. The LTM4678 is a dual 25 A or single 50 A µModule® regulator with digital power system management (PSM) in a small 16 mm × 16 mm footprint. It features:

- Dual digitally adjustable analog loops with a digital interface for control and monitoring
- Wide input voltage range: 4.5 V to 16 V
- Wide output voltage range: 0.5 V to 3.3 V
- ±0.5% maximum dc output error over temperature
- ±5% current readback accuracy
- Sub-mΩ DCR current sensing
- Integrated input current sense amplifier
- 400 kHz PMBus-compliant I²C serial interface
- Telemetry polling rates up to 125 Hz
- An integrated 16-bit Σ-Δ ADC
- Constant frequency current mode control
- Parallel operation with balanced current sharing
- 16 mm × 16 mm × 5.86 mm CoP-BGA

I²C-Based PMBUS Interface and Programmable Loop Compensation

The LTM4678 is a member of ADI's power system management (PSM) µModule family, so it can be configured and monitored through a PMBus/SMBus/I²C digital interface. The PC-based LTpowerPlay® tool enables visual monitoring and control of power supply voltage, current, power use, sequencing, margining, and fault log data. The LTM4678 is the first µModule regulator with programmable loop compensation: g_m and R_{TH}, which greatly reduces design time, since dynamic performance tuning is done without the hassle of iterative PCB board builds or modifications.

CoP-BGA Package for Enhanced Thermal Performance, Small Size and High Power Density

A thermally enhanced component on package (CoP) BGA package enables the high power LTM4678 to fit a small 16 mm × 16 mm PCB footprint. Inductors are stacked and used as a heat sink to enable efficient cooling.

Easily Scale to Higher Current with Current Mode Control

The LTM4678 uses peak current-mode control. Current is monitored and controlled cycle by cycle. This enables equal current sharing among phases.

Other Unique Features

- Dual remote output sensing compensates for the voltage drop on traces in high current application
- ±0.5% maximum dc output error over temperature provides additional regulation margin
- Direct input current sense measures the precise input current and power
- Dedicated PGOOD pins provide signal for downstream systems when output voltage is in regulation range
- $EXTV_{CC}$ pin maximizes efficiency at high V_{IN} conditions

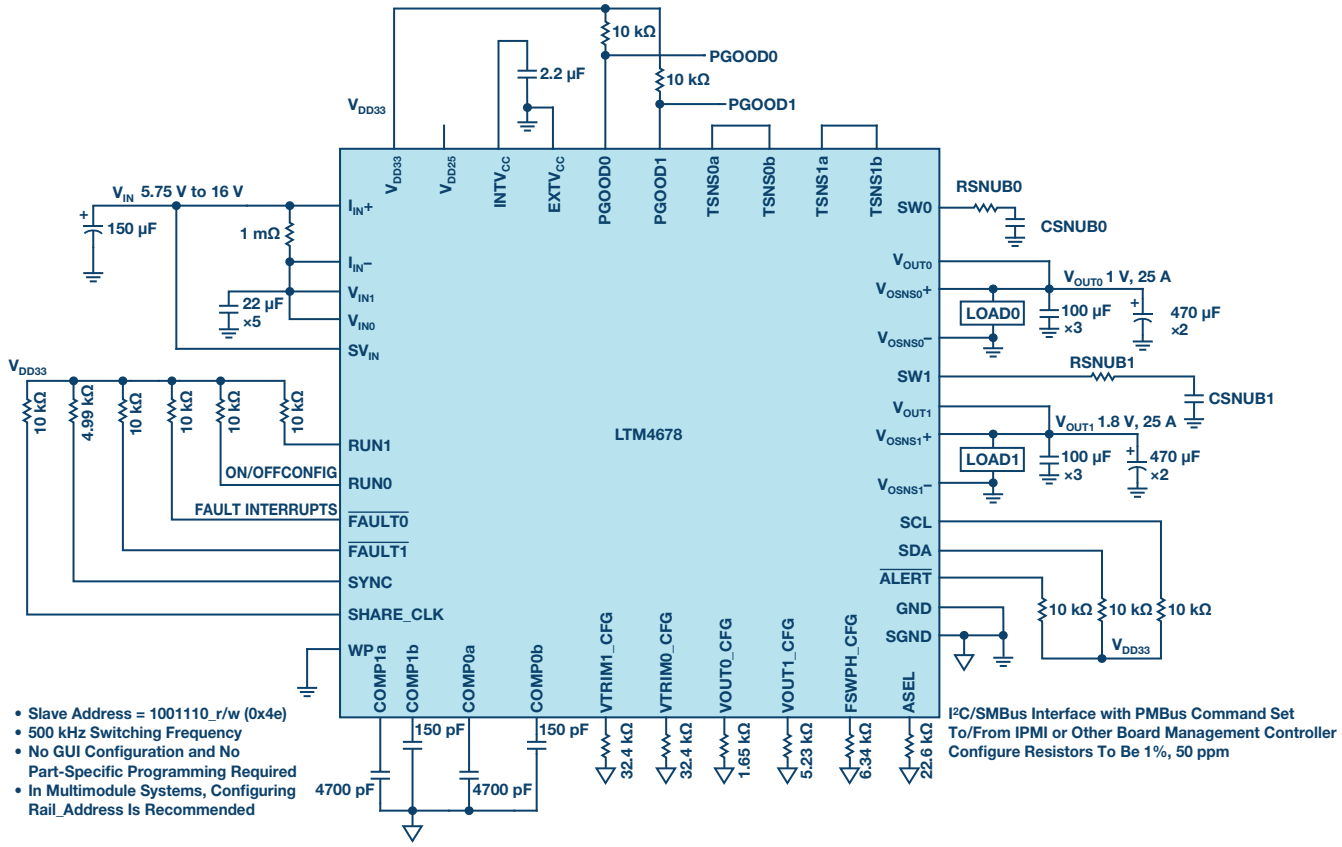

Figure 1. 1V and 1.8 V outputs at 25 A with I²C serial control and monitoring interface.

Dual-Output Converter (1 V at 25 A and 1.8 V at 25 A)

Figure 1 shows a typical 5.75 V to 16 V input, dual-output solution. The LTM4678's two channels run with a 180° relative phase shift, reducing the input rms current ripple and capacitor size.

As shown in Figure 2, the total solution efficiency in forced continuous current mode (CCM) is 85.8% at 1.0 V/25 A output, and 90.4% at 1.8 V/25 A.

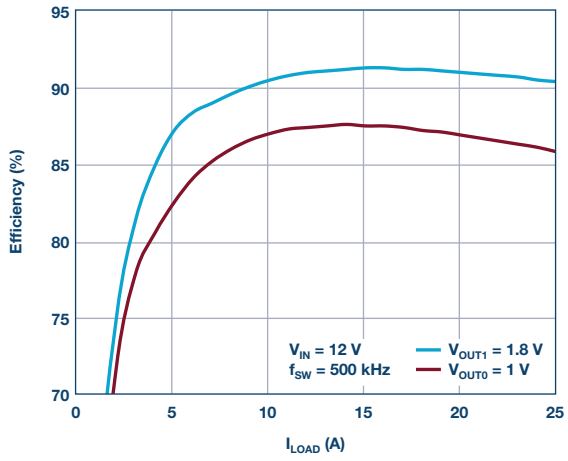

Figure 2. Efficiency of the two outputs.

Figure 3 shows the thermal performance of the LTM4678 running at V_{IN} = 12 V, V_{OUT0} = 1.0 V/25 A, and V_{OUT1} = 1.8 V/25 A with 200 LFM. The hot spot (inductor on CH1) temperature rise is 63°C, where the ambient temperature is about 24°C.

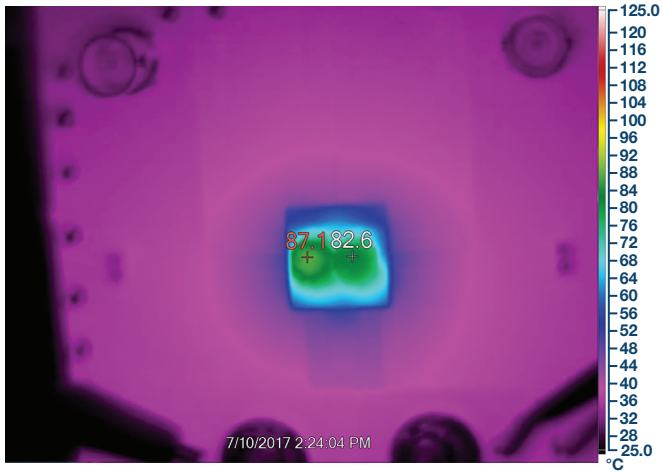

Figure 3. Thermal performance of the dual output converter.

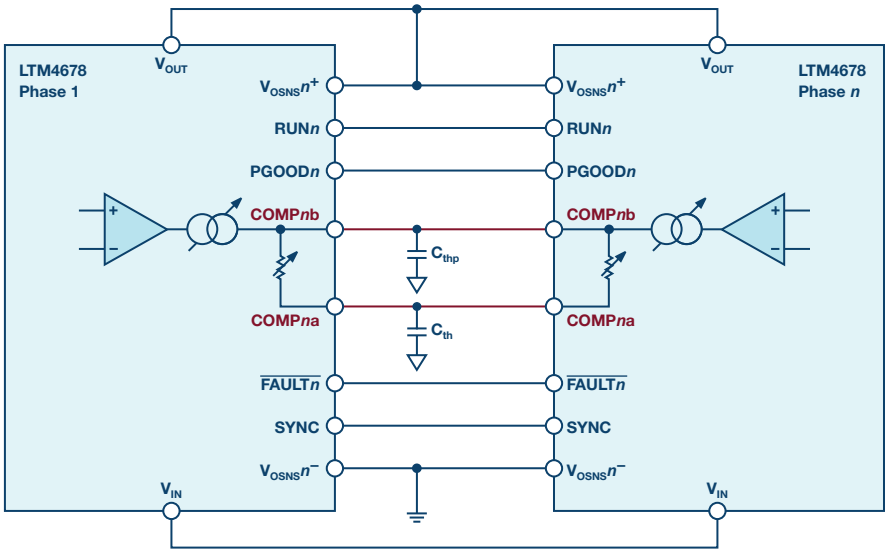

Figure 4. Block diagram showing the simplicity of multiphase operation.

Polyphase, Single-Output High Current (12 V to 1 V at 250 A)

The LTM4678 can be configured as a polyphase single-output converter for higher current solutions. Figure 4 shows a block diagram for connecting multiple LTM4678s. To increase output current, just add additional LTM4678s and connect the respective V_{IN}, V_{OUT}, V_{OSNS}+, V_{OSNS}–, PGOODs, COMPa/b, RUN, $\overline{FAULT}$, SYNC, and GND pins together.

Figure 5 shows the current from each phase when five LTM4678 (10 phases) are paralleled. The maximum current difference among 10 phases is 0.75 A (3% based on 25 A), representing balanced current sharing.

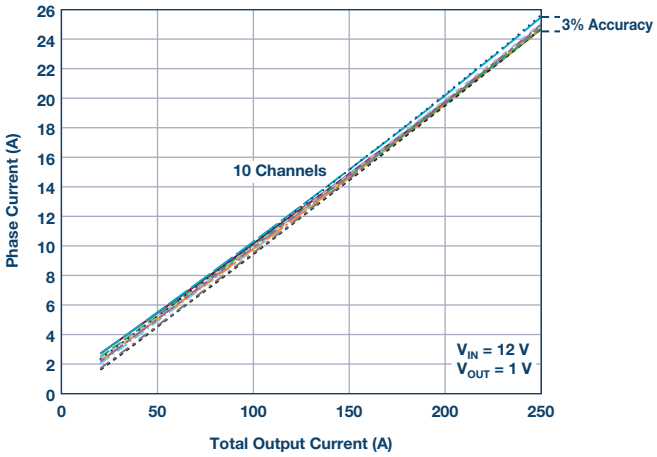

Figure 5. Current sharing among 5 LTM4678 devices with 10 phases in parallel.

Figure 6 shows the thermal image for the five parallel LTM4678s at 220 A output with 450 LFM air flow applied. Maximum thermal difference between the five µModule regulators is 10°C. Figure 7 shows the full schematic for an 8-phase solution.

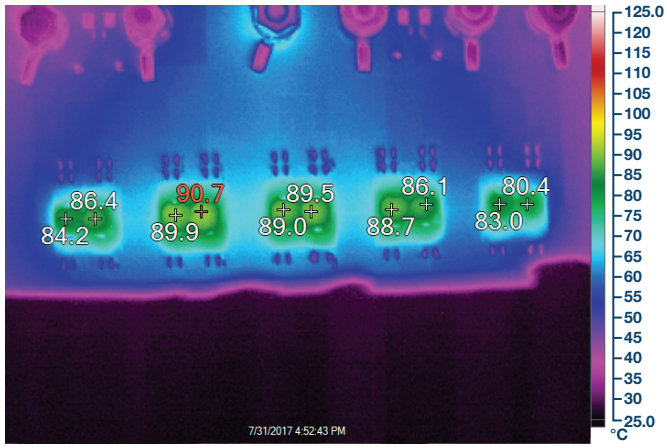

Figure 6. Thermal performance of multiphase converter.

Conclusion

The LTM4678 µModule regulator is a versatile high performance power solution that delivers high efficiency and high power in a small 16 mm × 16 mm footprint. The small form factor and ease of use make the LTM4678 ideal for space-constrained designs, such as FPGA boards. Multiple LTM4678s can be operated in parallel polyphase operation for higher current applications, such as those required in telecom and datacom systems, as well as industrial and computer system applications.

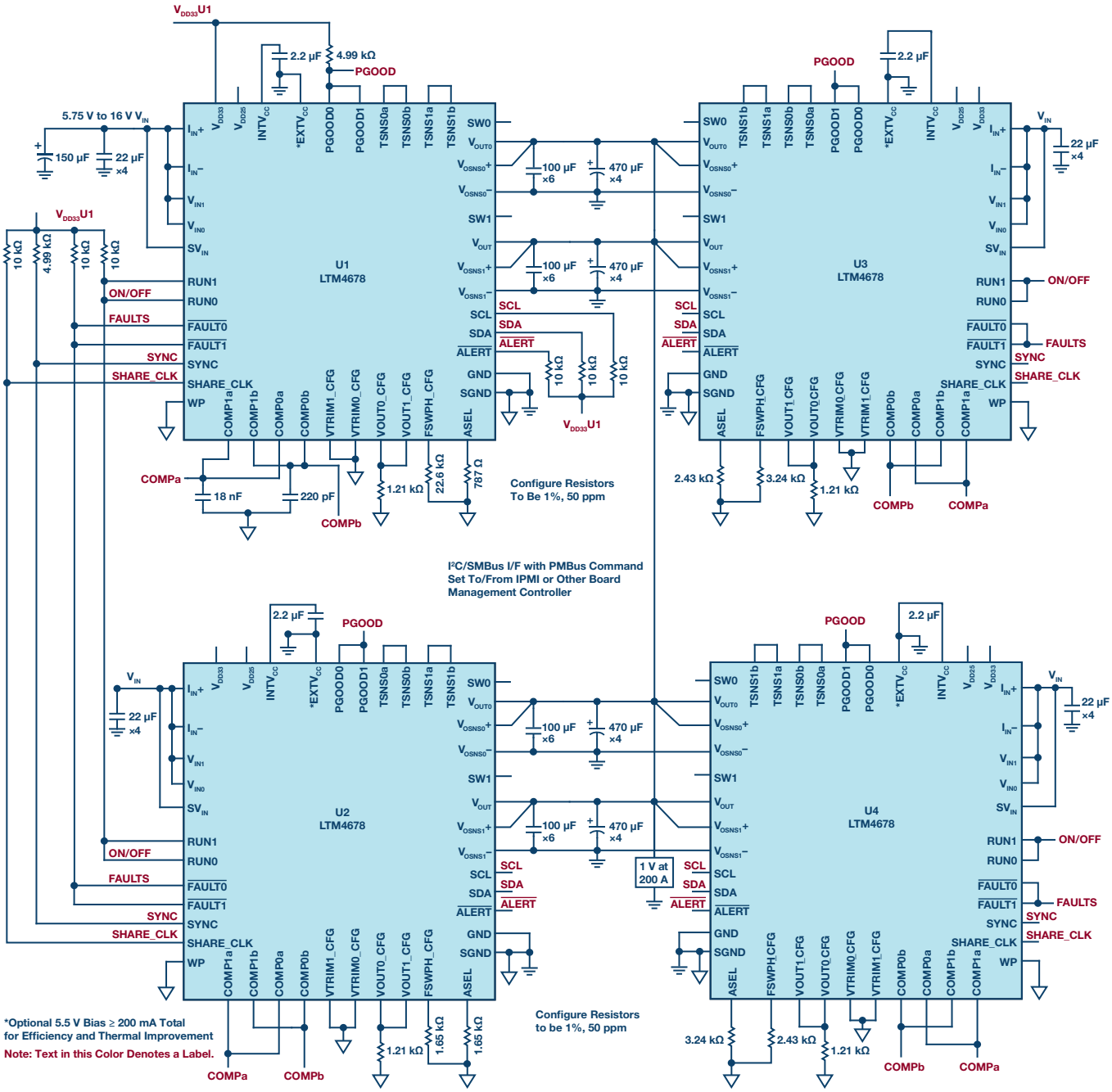

Figure 7. 8-phase operation with four LTM4678s producing 1 V at 200 A.

About the Authors

Haihua Zhou is a senior applications engineer at ADI. Her work covers µModule buck regulator and step-down regulator IC applications. Before joining ADI, she worked with Infineon/ International Rectifier on GaN applications. She has a Ph.D. from the National University of Singapore. She can be reached at *haihua.zhou@analog.com*.

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