

# 24V, 15A Step-Down Regulator in Sub-1 mm Height Package Pushes Monolithic Performance Limits

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Monolithic switching regulators and switching controllers together dominate the DC/DC converter market. Generally, there is little overlap in their respective applications. Controller-based solutions are favored for high performance, higher power applications where minimal power loss and top thermal performance are priorities. In contrast, monolithic regulators are favored in lower power applications where compact size is the main requirement. Controllers typically offer more features than monolithic solutions, but are at a significant solution-size disadvantage. The light footprint of monolithic regulators usually comes at a cost of features and increased power loss, and their reliance on integrated MOSFETs places practical limits on power.

The LTC3613 monolithic regulator blurs the line drawn between applications for controllers and monolithic regulators by combining a high performance fully featured controller with onboard low  $R_{DS(ON)}$  MOSFETs.

## FEATURES

The LTC3613 can accept an input voltage between 4.5V to 24V and supports output voltages between 0.6V to 5.5V. The onboard top and bottom MOSFETs feature low  $R_{DS(ON)}$ , around 7m $\Omega$  and 5m $\Omega$ , respectively, keeping power dissipation low and allowing the LTC3613 to deliver up to 15A of adjustable load current.

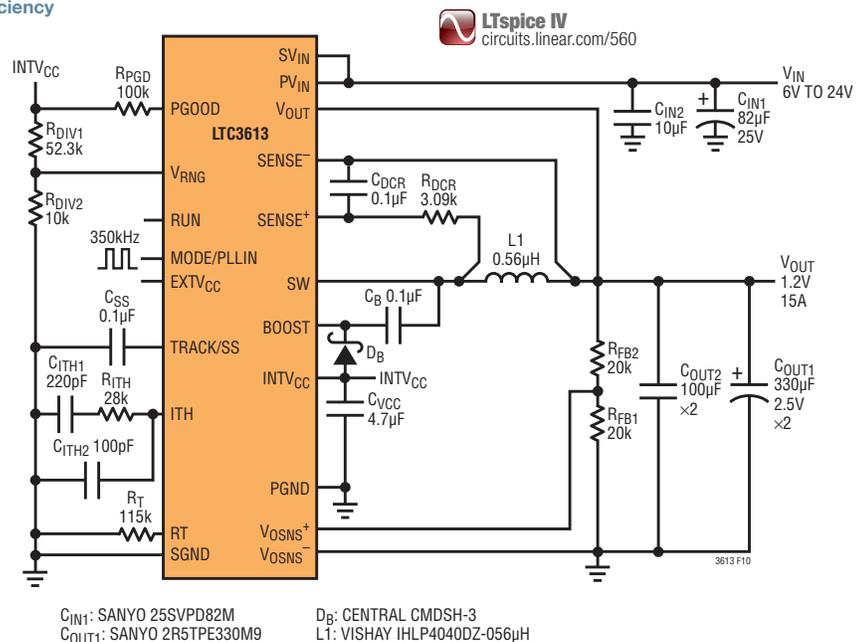
The LTC3613 features true remote differential output voltage sensing. This allows for accurate regulation of the output with maximum load currents and shared ground planes. This feature is critical for low output voltage applications, where even small voltage offsets caused by parasitic IR drops on board traces can cost several percentage points in regulation accuracy. Remote differential output sensing and the LTC3613's accurate internal reference combine to offer excellent output regulation accuracy over line, load and

temperature:  $\pm 0.25\%$  at 25°C,  $\pm 0.67\%$  from 0°C to 85°C and 1% from -40°C to 125°C.

The LTC3613 has a low minimum on-time of 60ns, allowing for high step-down ratios at high switching frequencies. Because of its sophisticated controlled on-time, valley current mode architecture, the on-time is controlled so that the switching

frequency is constant over steady state conditions under line and load. It also allows the LTC3613 to recover from a large load step in only a few short cycles. This architecture yields well balanced current sharing among multiple LTC3613s, which can be easily paralleled for high power applications. It also includes a phase-lock loop (PLL) for synchronization to an

Figure 1. 24V input to 1.2V output using inductor DCR sensing to minimize solution size and cost and to maximize efficiency



	LTC3608	LTC3609	LTC3610	LTC3611	LTC3613
$PV_{IN(MAX)}$	18V	32V	24V	32V	24V
$I_{LOAD(MAX)}$	8A	6A	12A	10A	15A
Frequency Sync					✓
Precise Differential Output Sensing	±1%	±1%	±1%	±1%	±0.67%
Accurate Current Sensing	Bottom FET $R_{DS(ON)}$	Bottom FET $R_{DS(ON)}$	Bottom FET $R_{DS(ON)}$	Bottom FET $R_{DS(ON)}$	$R_{SENSE}$ or DCR sensing
MOSFET $R_{DS(ON)}$ Top/Bottom	10mΩ/8mΩ	18mΩ/13mΩ	12mΩ/6.5mΩ	15mΩ/9mΩ	7.5mΩ/5.5mΩ
Package	7mm × 8mm × 0.9mm 64-pin	7mm × 8mm × 0.9mm 64-pin	9mm × 9mm × 0.9mm 52-pin	9mm × 9mm × 0.9mm 52-pin	7mm × 9mm × 0.9mm 56-pin

**Table 1. High power monolithic regulator family**

external clock, especially beneficial for high current, low output voltage applications where interleaving of paralleled phases can minimize output voltage ripple.

The LTC3613 includes several safety and protection features including overvoltage protection and current-limit foldback. If the output exceeds 7.5% of the programmed value, then it is considered an overvoltage (OV) condition, the top MOSFET is immediately turned off and the bottom MOSFET is turned on indefinitely until the OV condition is cleared. A power good output monitor is also available which flags if the part is outside a ±7.5% window of the 0.6V reference voltage. In the case of an output short circuit, if the output fails by more than

50%, then the maximum sense voltage is reduced to about one-fourth of its full value, limiting the inductor current level to one-fourth of its maximum value.

The LTC3613 offers precise control of the output during start-up and shut-down sequencing through its output voltage tracking and soft-start features. An external  $V_{CC}$  input pin is also available, allowing for bypassing of its internal LDO for an efficiency benefit in high power applications.

The LTC3613 can be configured to sense the inductor current through a series sense resistor,  $R_{SENSE}$ , or via an inductor DCR sensing network. The trade-offs between the two current sensing schemes are largely matters of cost, power

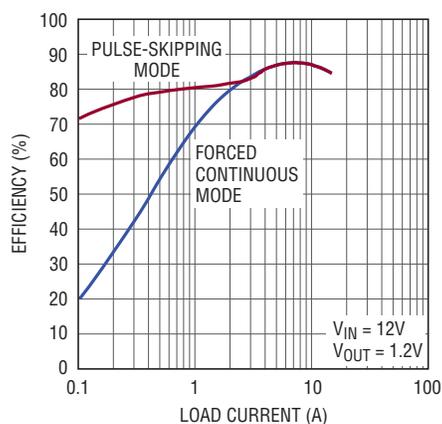
consumption and accuracy. DCR sensing owes its increasing popularity to its lower expense and power loss compared to a sense resistor scheme. Even so, the tight tolerances of current-sensing resistors provide the most accurate current limit.

Figure 1 shows a typical application of the LTC3613, configured for DCR sensing in a high step-down solution, 24V to 1.2V, and synchronized to a 350kHz external clock. Figure 2 shows the efficiency and Figure 3 shows transient performance.

## CONCLUSION

The LTC3613 offers far more design flexibility than a typical monolithic switching regulator by including a variety of user-programmable features such as soft-start, programmable frequency, external clock synchronization, adjustable current limit and selectable light load operating modes. Its critical safety features such as overvoltage protection and programmable current limit with foldback current limiting further improve the robustness of the part. An external  $V_{CC}$  input is provided for high power applications. Its compact solution size, extensive feature set and high performance capabilities extend its range of use compared to traditional monolithics, making it suitable for an expanding range of applications. ■

**Figure 2. Efficiency of the regulator in Figure 1**



**Figure 3. Load transient response of the circuit in Figure 1**

