Compact and Versatile Monolithic Synchronous Buck Regulators Deliver 1.25A in Tiny TSOT23, DFN and MS10 Packages

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Introduction

To meet industry demands to squeeze more power from smaller packages the LTC3564 monolithic synchronous buck regulator provides 1.25A from a tiny TSOT23-5 package. Its siblings, the LTC3565 and LTC3411A, also 1.25A monolithic synchronous bucks, come in 10-lead 3mm × 3mm DFN and MS10 packages. The LTC3564's internal switching frequency is set at a fixed 2.25Mhz to allow the use of tiny inductors and ceramic output capacitors. Switching at this high frequency does not compromise efficiency. In Burst Mode operation, the LTC3564 only needs 20µA of quiescent current and <1µA in shutdown. The internal 150mΩ power MOSFETs keep the power dissipation low and efficiencies as high as 94% at maximum load current.

DESIGN IDEAS

Adding More Options

The additional pins of the LTC3565 and LTC3411A give them a versatility edge over the LTC3564. Both parts can program their internal frequency, synchronize to an external clock, select the mode of operation among Burst Mode operation, pulse-skipping, or forced continuous mode, and provide a PGOOD indicator output. For noise-sensitive applications, pulse-skipping mode decreases the output ripple noise at low currents. Although not as efficient as Burst Mode operation at light load, pulse-skipping mode still provides high efficiency for moderate loads. In forced continuous mode a steady operating frequency is maintained at all load conditions, making it easier to reduce noise and RF interference—important for some applications. In order to squeeze into a TSOT23-5 package, the LTC3564 forgoes a few features such as PGOOD, the ability to adjust the switching frequency and the mode select. The frequency and mode of operation are internally set at 2.25MHz and Burst Mode operation respectively.

All three devices employ a constant frequency, current mode architecture that operates from an input voltage range of 2.5V to 5.5V and provides an

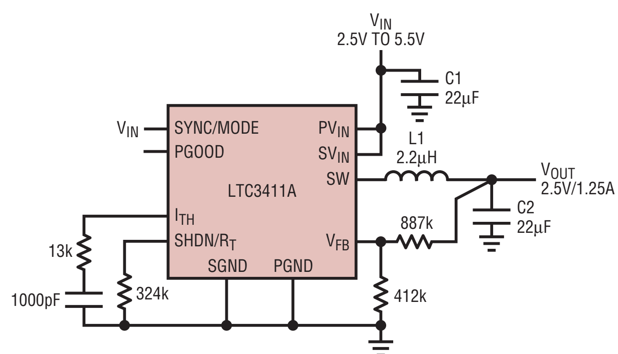

Figure 1. Battery to 2.5V at 1.2A application of the LTC3411A

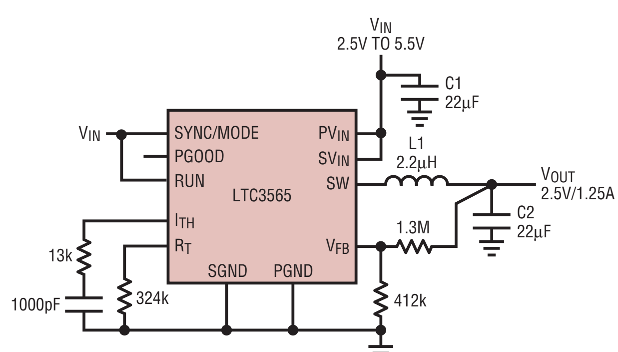

Figure 2. Battery to 1.2V at 1.2A application of the LTC3565

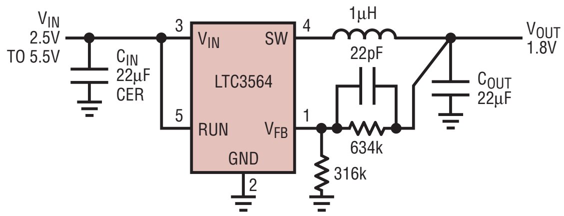

Figure 3. Battery to 1.2V at 1.2A application of the LTC3564

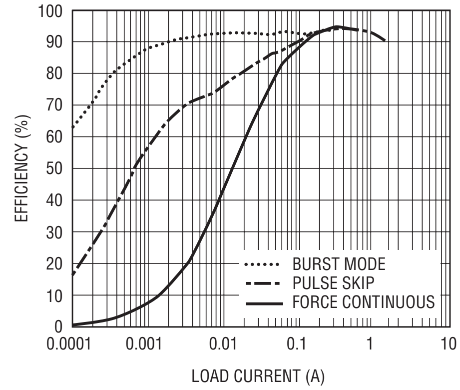

Figure 4. Efficiency vs load current for the circuit of Figure 1 in various operating modes

adjustable regulated output voltage down to 0.6V (0.8V for LTC3411A), which make them ideal for single-cell Li-Ion or 3-cell NiCd and NiMH applications. The 100% duty cycle capability for low dropout allows maximum energy to be extracted from the battery. In dropout, the output voltage is determined by the input voltage minus the voltage drop across the internal P-channel MOSFET and the inductor resistance.

The switching frequency of the LTC3565 and LTC3411A can be set between 400kHz and 4MHz with an external resistor or synchronized to an external clock. The LTC3411A is a drop-in replacement for the popular LTC3411, but with improved efficiency at higher V_{IN} and improved response to fault conditions.

Adaptive Current Reversal Comparator

In each of the parts, a patent pending adaptive current reversal comparator monitors the current reversal across the synchronous switch. In discontinuous mode, to emulate the behavior of an ideal diode, the synchronous switch turns on when the inductor current is positive and turns off when the inductor current is negative. Because the comparator has a finite propagation delay, the inductor current trip point is offset before zero. This offset depends on the output voltage of the regulator and the inductor value used on the board. In the LTC3564, LTC3565 and LTC3411A, the offset of the current reversal comparator is automatically adjusted for any output voltage and inductor value to ensure the synchronous switch is always turned off at the right inductor current value.

The LTC3564, LTC3565 and LTC3411A employ a constant frequency, current mode architecture that operates from an input voltage range of 2.5V to 5.5V and provides an adjustable regulated output voltage down to 0.6V (0.8V for LTC3411A), which make them ideal for single cell Li-Ion or 3-cell NiCd and NiMH applications.

Fault Protection

All three parts are protected against output short-circuit and output over-dissipation conditions. The output can be shorted to ground or V_{IN} in any mode without fear of damage. When a V_{OUT} short to V_{IN} is removed the output returns immediately to its regulated output voltage if forced continuous mode is selected. This allows the use in a pre-biased application where the output is held at higher than the regulated output when the part is shutdown. When there is a power over-dissipation condition and the junction temperature reaches 160°C, the thermal protection circuit turns off the power switches. Normal operation does not resume until the part cools off and the junction temperature drops back to 150°C.

Conclusion

Three monolithic synchronous step-down voltage regulators provide up to 1.25A of output current in a tiny footprint. The LTC3564, LTC3565 and LTC3411A also offer high switching frequency, high efficiency and a number of versatile features that make them an excellent choice for portable applications.

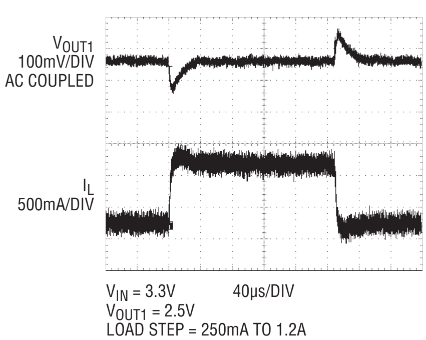

Figure 5. Load step response

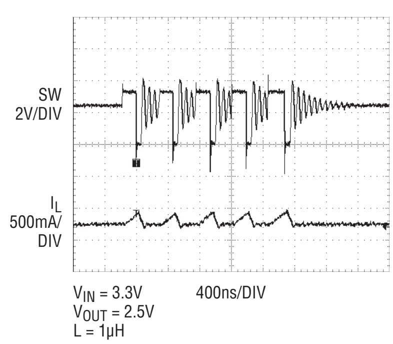

Figure 6. Operating waveforms

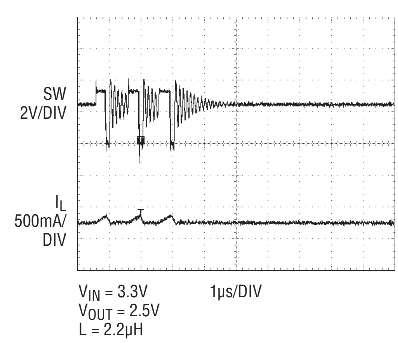

Figure 7. Operating waveforms