32V_{IN} Synchronous Buck Regulators with Integrated FETs Deliver up to 12A from Sub-1mm Height Packages

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Introduction

Monolithic buck regulators are easy to hook up and they make it possible to squeeze an entire DC/DC converter into very tight spaces. Although monolithics are an easy fit, they aren't the perfect fit for every application. For instance, they typically lack the capability to efficiently convert high input voltages (>12V) to low voltages at high output currents (>4A), thus leaving the job to a traditional controller IC and external MOSFETs.

A new family of devices, though, offers the advantages of monolithics with the low duty cycle and high efficiency of discrete components. The LTC3608, LTC3609, LTC3610 and LTC3611 are synchronous buck converters that bring high power density and simplified design to point-of-load applications. With a maximum input of 32V they utilize current-mode control up to a 2MHz switching frequency, deliver up to 12A of load current, and are packaged in thermally enhanced packages less than 1mm in height. A typical application of the LTC3608 is shown in Figure 1.

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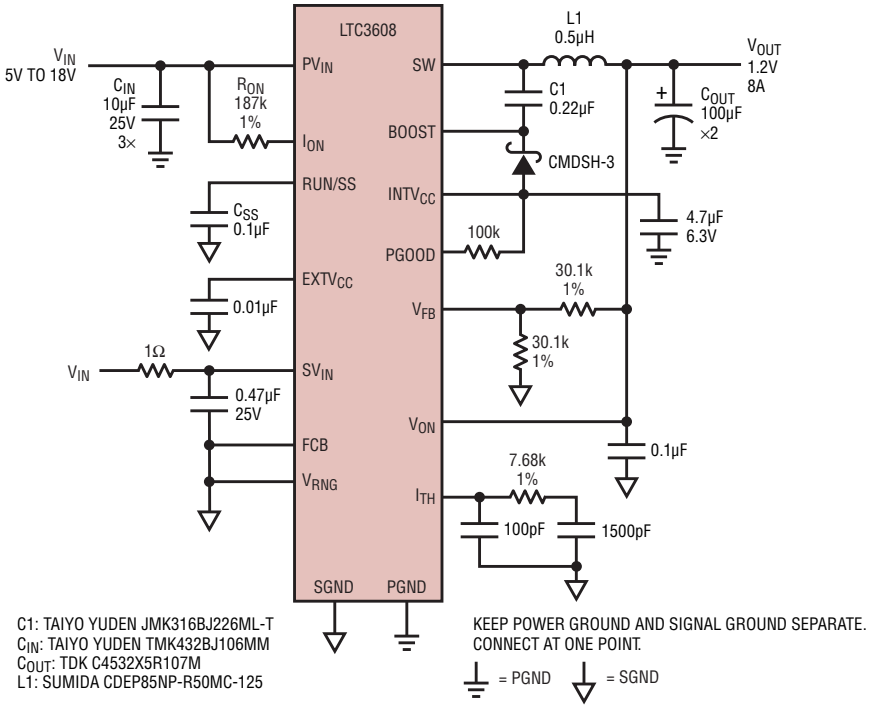

Figure 1. Typical application of the LTC3608

Features

The LTC3608, LTC3609, LTC3610 and LTC3611 integrate high performance synchronous buck controllers with super-low $R_{DS(ON)}$ DMOS MOSFETs to produce compact high efficiency converters (Figure 2). Two package sizes are available, each having a high voltage or high current option (Table 1). Each device features a sub-100ns on-time, allowing very low duty cycle operation and high switching frequency. The current-mode control architecture of these parts simplifies tuning of loop stability and allows excellent transient response with a variety of output capacitor types, including all-ceramic output capacitor applications.

The LTC3610 can operate in forced continuous mode, which provides the lowest possible output ripple and EMI, or discontinuous mode, which has better light load efficiency because inductor current is not allowed to reverse.

Current into the I_{ON} pin sets the on-time—a resistor R_{ON} from V_{IN} to the I_{ON} pin reduces on-time as V_{IN} rises, thus limiting changes in switching frequency. Furthermore, response to a load step can be very fast since the loop does not have to wait for an oscillator pulse before the top switch is turned on and current begins increasing.

The current limit, which is inferred from the maximum allowable sense voltage across the on-resistance of the bottom FET, can be adjusted by applying a voltage to the V_{RNG} pin. Maximum load current limits for each

part are shown in Table 1. Soft-start and latch off functions are controlled by the RUN/SS pin, preventing inrush current and current overshoot during startup, and providing the option of latch-off if an under voltage or short circuit is presented. An open drain power-good pin monitors the output and pulls low if the output voltage is ±10% from the regulation point.

Conclusion

The LTC3608, LTC3609, LTC3610 and LTC3611 buck regulators offer the efficiency and power output capability of separate (controller + discrete) MOSFET solutions with the ease-of-use and space-saving advantages of traditional MOSFET-on-the-die monolithics. These parts also yield higher efficiencies than traditional monolithic solutions. They conserve power, save space, and simplify power designs. They reduce discrete components over controller-based solutions, making them a good fit in everything from low power portable device applications such as notebook and palmtop computers to high-power industrial distributed power systems.

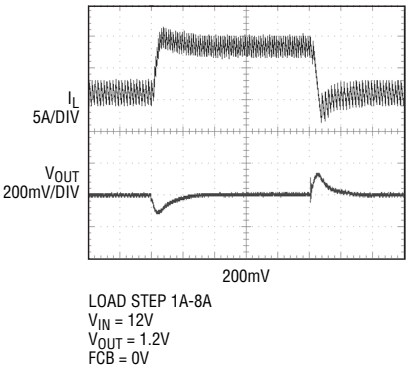

Figure 3. Transient response for the typical LTC3608 application represented in Figure 1 with a load step of 1A to 8A

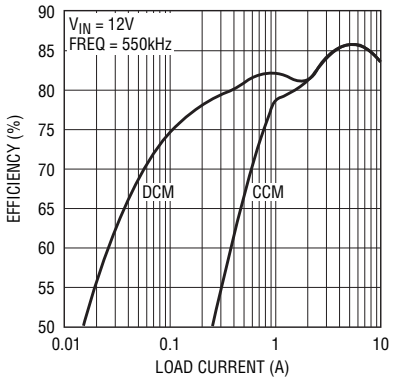

Figure 2. Efficiencies for a typical LTC3608 application in discontinuous conduction mode (DCM) and continuous conduction mode (CCM)

Table 1. Integrated MOSFET buck regulators

	LTC3610	LTC3611	LTC3608	LTC3609
PV_{IN} Max	24V	32V	18V	32V
I_{LOAD} Max	12A	10A	8A	6A
Package	9mm × 9mm × 0.9mm 64-pin	9mm × 9mm × 0.9mm 64-pin	7mm × 8mm × 0.9mm 52-pin	7mm × 8mm × 0.9mm 52-pin
$R_{DS(ON)}$ Top FET	12mΩ	15mΩ	14mΩ	19mΩ
$R_{DS(ON)}$ Bottom FET	6.5mΩ	9mΩ	8mΩ	12mΩ

LTC4009, continued from page 20

LTC4009 family monitors the voltage across the input blocking diode for unexpected voltage reversal. Initial startup, restarts from fault conditions, and charge current reduction during input current limit are also carefully controlled to avoid producing reverse current.

All members of the family provide an input current limit flag to tell the system when the adapter is running at over 95% of its current capacity. Finally, each IC features internal over-temperature protection to prevent silicon damage during elevated thermal operation.

Recovery from all fault conditions is under full control of the analog feedback loops, which guarantees charging remains suspended until the internal feedback loops respond coherently and report the need to supply current to the load to maintain proper voltage or current regulation.

Conclusion

The LTC4009 family integrates a full set of charger building blocks in a small PCB footprint. The result is a high power battery charger IC with high precision and a full set of monitoring and fault handling features.

The LTC4009 provides adjustable output voltage control with a simple, external, user-programmed resistive voltage divider. As such, it is suitable as a general purpose charger that works with multiple battery chemistries and supercaps. It offers direct control over the entire charge process, facilitating implementation of a wide range of charge termination algorithms with an external microprocessor.

The LTC4009-1 and LTC4009-2 feature pin-programmable output voltage for common lithium-ion or lithium-polymer battery pack configurations with one to four series cells. For these chemistries, the number of precision external application components is reduced without sacrificing accuracy. Both 4.1V/cell (LTC4009-1) and 4.2V/cell (LTC4009-2) options are available, allowing the user to balance capacity and safety per the demands of the application.