

# DESIGN NOTES

## 80 $\mu$ A Quiescent Current Synchronous Step-Down Controller Extends Battery Life in Automotive Applications – Design Note 1014

Julian Zhu

### Introduction

Battery powered applications that have a significant amount of time in standby mode, require electrical circuits to operate with a low quiescent current to preserve battery life. The LTC3835 synchronous step-down controller is an excellent solution with its ultralow quiescent current (80 $\mu$ A). Other features make it uniquely qualified to satisfy the needs of automotive applications. A wide 4V to 36V input voltage range protects the supply against high input voltage transients and is compatible with low voltage cold crank conditions. The constant frequency current-mode architecture with high-side inductor current sensing provides excellent line and load regulation and reliable current limiting and sharing. The 0.8V to 10V output voltage range provides flexibility for a variety of applications. Solution size is small due to the 650kHz switching frequency, which reduces external component sizes, and the integrated synchronous FET driver, which keeps component count low. Furthermore, the LTC3835 provides high efficiency over a wide load range up to 20A. Other important features include:

- The output voltage can be ramped during start-up with an adjustable soft-start or it can track an external ramp signal.
- The controller can be synchronized to an external clock via a phase-locked loop.
- The CLKOUT pin and current mode control allow interleaved operation of multiple parallel controllers for delivery of high output current with accurate current sharing.

The LTC3835 has overvoltage and overcurrent (short-circuit) protection, a power good monitor and an EXTV<sub>CC</sub> option for improved efficiency when V<sub>OUT</sub> > 4.7V. All these are packed in a small 20-pin exposed pad TSSOP or 4mm × 5mm QFN package. The LTC3835-1 fits in a smaller 16-pin SSOP package or 5mm × 3mm DFN package, by eliminating CLKOUT, EXTV<sub>CC</sub> and the power good indicator.

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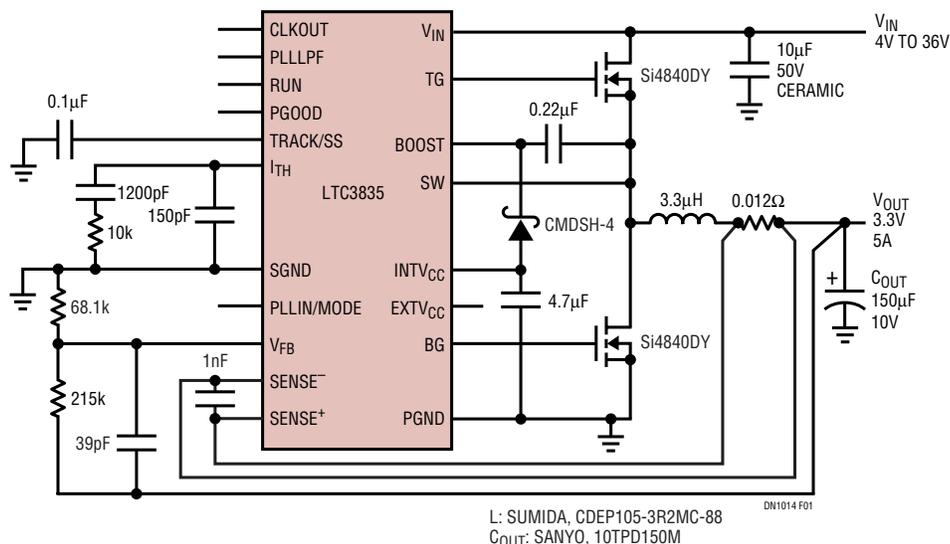


Figure 1. High Efficiency Synchronous Step-Down Converter Consumes only 80 $\mu$ A in Standby Mode

## High Efficiency at Standby

The LTC3835 uses synchronous rectification and N-channel MOSFETs to achieve high efficiency over a wide load range. At light load it minimizes the IC supply current with Burst Mode<sup>®</sup> operation, where the controller switches in fixed duty cycle bursts, as needed, to reduce the IC supply current. When the load current is extremely low, the controller enters sleep mode by turning off both external MOSFETs and most of its internal circuitry, further reduc-

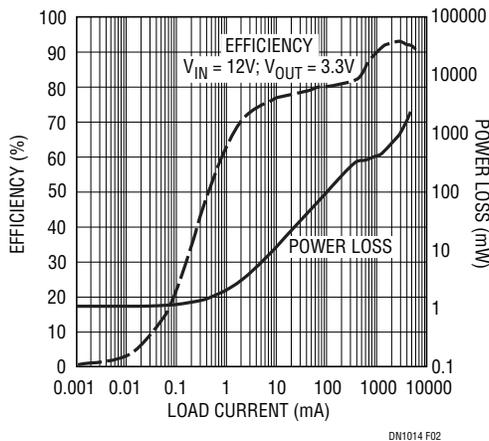


Figure 2. Efficiency and Power Loss vs Load Current for the Circuit in Figure 1.

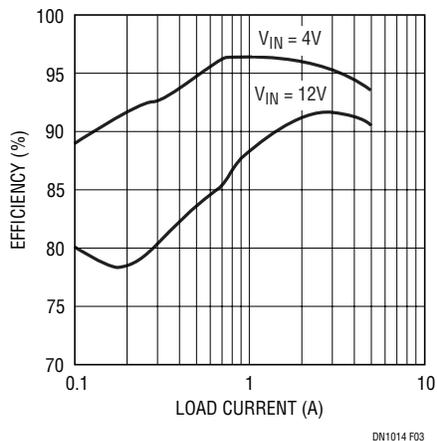


Figure 3. Efficiency vs Load Current at  $V_{IN} = 4V$  and  $V_{IN} = 12V$  for the Circuit in Figure 1.

ing quiescent current. To maximize efficiency during Burst Mode operation the bottom MOSFET is turned off when the instantaneous inductor current is close to zero. The IC is also designed with an  $EXTV_{CC}$  pin to further increase conversion efficiency.

## 3.3V/5A Synchronous DC/DC Converter

Figure 1 shows an automotive application that converts a 4V to 36V input to a 3.3V/5A output. As Figure 2 shows, the converter achieves high efficiency, up to 92%, at 12V input and maintains light-load efficiency, above 65%, down to 1mA load current. The no-load IC supply quiescent current is kept below 80 $\mu$ A. For low dropout operation the efficiency can reach 96.5% at 4V input as illustrated in Figure 3.

The controller uses OPTI-LOOP compensation to optimize the transient response and thus minimize the output capacitance. Figure 4 shows the transient response for the circuit in Figure 1.

## Conclusion

The LTC3835 controller is especially well suited to automotive and other battery-powered applications that demand low quiescent current and light-load efficiency—important for preserving battery life in applications that spend significant time in standby. The LTC3835 also offers a wide input and output voltage range and many other advanced features in either leaded or leadless thermally efficient packages.

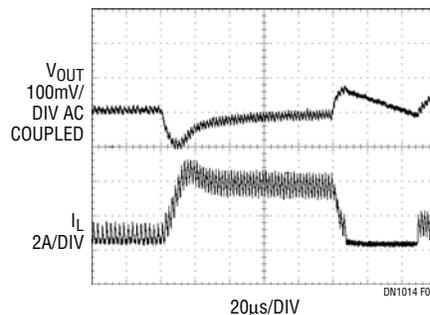


Figure 4. Load Step Transient with 12V Input for the Circuit in Figure 1.

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Linear Technology Corporation  
1630 McCarthy Blvd., Milpitas, CA 95035-7417  
(408) 432-1900 • FAX: (408) 434-0507 • [www.linear.com](http://www.linear.com)

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