

DESIGN NOTES

42V, 2.5A Synchronous Step-Down Regulator with 2.5 μ A Quiescent Current

Design Note 504

Hua (Walker) Bai

Introduction

The LT[®]8610 and LT8611 are 42V, 2.5A synchronous step-down regulators that meet the stringent high input voltage and low output voltage requirements of automotive, industrial and communications applications. To minimize external components and solution size, the top and bottom power switches are integrated in a synchronous regulator topology, including internal compensation. The regulator consumes only 2.5 μ A quiescent current from the input source even while regulating the output.

High Efficiency Synchronous Operation

Replacing an external Schottky diode with an internal synchronous power switch not only minimizes the solution size, but also increases efficiency and reduces power dissipation. The efficiency improvement is significant in low output voltage applications where the voltage drop of the Schottky diode represents a relatively large portion of the output voltage. Figure 1 shows a 12V to 3.3V circuit. Figure 2 shows the efficiency of this circuit reaching 94%, which is 5% to 10% higher than a comparable nonsynchronous circuit.

Short-Circuit Robustness Using Small Inductors

The LT8610 and LT8611 are specifically designed to minimize solution size by allowing inductor size to be selected based on the output load requirements of the application, rather than the maximum current limits of the IC. During overload or short-circuit conditions, the LT8610 and LT8611 safely tolerate operation with saturated inductors through the use of a high speed peak-current mode architecture and a robust switch design. For example, an application that requires a maximum of 1.5A should use an inductor that has an RMS rating of >1.5A and a saturation current rating of >1.9A. This flexibility allows the user to avoid oversize inductors for applications requiring less than maximum output current.

Current Sense and Monitoring with the LT8611

The LT8611 includes a flexible current control and monitor loop using the ISN, ISP, IMON and ICTRL pins. The ISP and ISN pins connect to an external sense resistor that may be in series with the input or output of the LT8611 or in series with other system currents. The current limit loop functions by limiting the LT8611 output current such that the voltage between the ISP

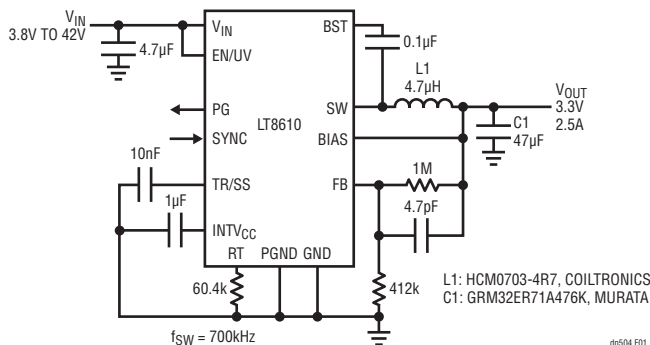


Figure 1. LT8610 12V to 3.3V Application Achieves High Efficiency

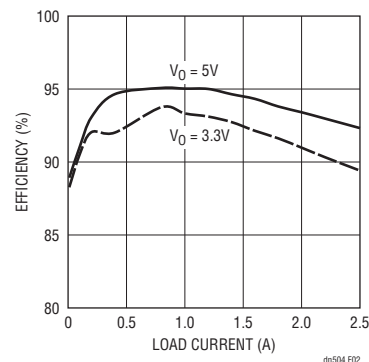


Figure 2. Efficiency of the 12V to 3.3V Application (Circuit Shown in Figure 1)

and ISN pins does not exceed 50mV. The ICTRL pin allows the user to control this limit between 0mV and 50mV by applying 0V to 1V to the ICTRL pin. The IMON pin outputs a ground-referenced voltage that is $20 \cdot (ISP - ISN)$, which allows easy monitoring and may be used as an input to an A/D.

The LT8611 current sense and monitoring functionality may be used to limit short-circuit current or to create constant-current, constant-voltage (CCCV) supplies. Figure 3 shows well controlled current during a short-circuit event. The LT8611 can also be combined with a microcontroller with A/D and D/A to create sophisticated power systems. Typical apps include maximum power point tracking (MPPT) for solar charging and programmable LED current source.

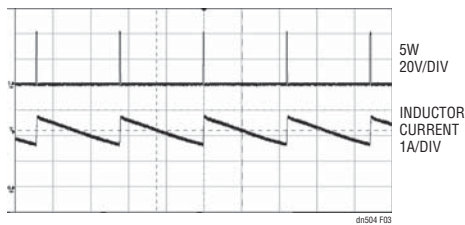


Figure 3. Short-Circuit Current is Well Regulated at 42V with the LT8611

Wide Input Range Operation at 2MHz

It is well known that higher switching frequencies allow for smaller solution sizes. In fact, a 2MHz switching frequency is often used in automotive applications to avoid the AM band and minimize solution footprint.

High switching frequencies, though, come with some trade-offs, including reduced ability to handle wide input voltage range commonly found in automotive and industrial environments. However, the LT8610 and LT8611 minimize these restrictions by allowing both high switching frequencies and high conversion ratios. This is due to their low minimum on-times (50ns typical) and low dropout, resulting in a wide input range, even at 2MHz. Figure 4 shows a 5V, 2A, 2MHz circuit that can accept 5.4V to 42V inputs. The circuit has a 2A output current limit.

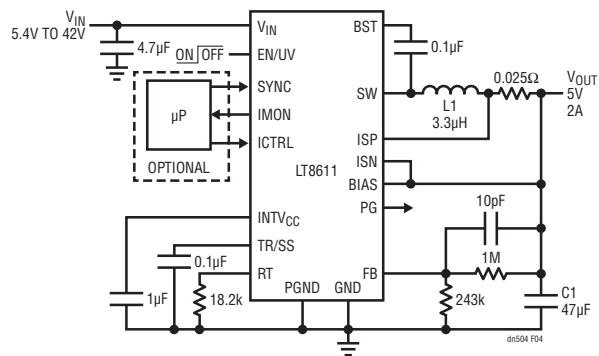


Figure 4. LT8611 Running at 2MHz Reduces Solution Size, Avoids AM Band, and Still Allows High Duty Cycle

Low Dropout Operation

As the input voltage decreases toward the programmed output voltage, the LT8610 and LT8611 maintain regulation by skipping switch-off times and decreasing the switching frequency up to a maximum duty cycle of 99.8%. If the input voltage decreases further, the output voltage remains 450mV below the input voltage (at 2A load). The boost capacitor is charged during dropout conditions, maintaining high efficiency. Figure 5 shows the dropout performance.

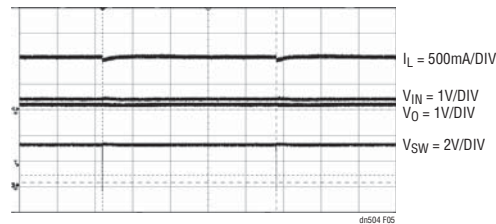


Figure 5. LT8610/LT8611 Dropout Performance

Conclusion

LT8610 and LT8611 are 42V, 2.5A synchronous step-down regulators that offer 2.5µA quiescent current, high efficiency, fault robustness and constant current (LT8611 only), constant voltage operation in small packages. This combination of features makes them ideal for the harsh environment commonly found in automotive and industrial applications.

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

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