

DESIGN NOTES

Buck-Boost Controller Simplifies Design of DC/DC Converters for Handheld Products – Design Note 424

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Introduction

A number of conventional solutions have been available for the design of a DC/DC converter where the output voltage is within the input voltage range—a common scenario in Li-Ion battery-powered applications—but none were very attractive until now. Conventional topologies, such as SEPIC or boost followed by buck, have numerous disadvantages, including low efficiency, complex magnetics, polarity inversion and/or circuit complexity/cost. The LTC[®]3785 buck-boost controller yields a simple, efficient, low parts-count, single-converter solution that is easy to implement, thus avoiding the drawbacks associated with traditional solutions.

High Efficiency Controller Capabilities

The LTC3785 serves applications requiring input and output voltages in the range of 2.7 to 10V—ideal for applications powered from one or two Li-Ion cells or multiple cell NiMH, NiCad or Alkaline batteries. It supports a single inductor, 4-switch, buck-boost topology, which is ideal for an output voltage that is within the input voltage

range. The high level of integration yields a simple, low parts-count solution. The LTC3785 provides for current-limit and shutdown in all modes of operation (which is not normally available with boost converters).

Very high efficiency is achieved by synchronous rectification, high side drive (allowing the use of N-channel MOSFETs), $R_{DS(ON)}$ current sensing, and Burst Mode[®] operation for efficient light load operation. Protection features include soft-start, overvoltage, undervoltage and foldback current-limit with burp-mode or latch-off for extended faults.

3.3V, 3A Converter Operates from 2.7V – 10V Source

The circuit shown in Figure 1 utilizes the LTC3785 controller to produce a synchronous, 4-switch, buck-boost design. It provides a fixed 3.3V, 3A output from a 2.7V – 10V input. It is short-circuit protected: the controller offers a choice of recycling or latch-off protection for severe overload faults.

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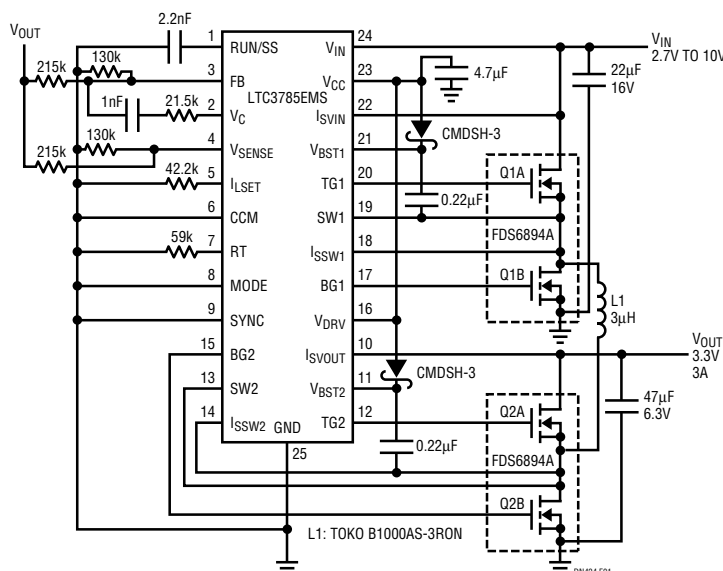


Figure 1. Schematic of Buck-Boost Converter Using the LTC3785 to Provide 3.3V at 3A from a 2.7V to 10V Source

The circuit produces seamless operation throughout the entire input voltage range, operating as a synchronous buck converter, synchronous boost converter, or a combination of the two through the transition region. At input voltages well above the output, the converter operates in buck mode. Switches Q1A and Q1B commute the input voltage, and Q2A stays on, connecting L1 to the output. As the input voltage is reduced and approaches the regulated output voltage, the converter approaches maximum duty cycle on the input (buck) side of the bridge, and the output (boost) side of the bridge starts to switch, thus entering the buck-boost or 4-switch region of operation. As the input is reduced further, the converter enters the boost region at the minimum boost duty cycle. Switch Q1A stays on, connecting the inductor to the input while switches Q2A and Q2B commute the output side of the inductor between the output capacitor and ground. In boost mode, this converter has the ability to limit input current, and also to shut down and disconnect the source from the output—two desirable features that a conventional boost converter cannot provide. Figures 2, 3 and 4 show input side and output side switch waveforms along with inductor current for buck (10V input), boost (2.7V input) and buck-boost (3.8V input) modes of operation.

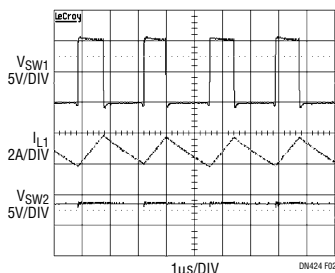


Figure 2. Input Side and Output Side Switch Waveforms Along with Inductor Current for Buck (10V Input) Mode Operation for the Circuit in Figure 1

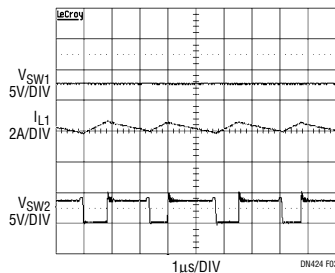


Figure 3. Input Side and Output Side Switch Waveforms Along with Inductor Current for Boost (2.7V Input) Mode Operation for the Circuit in Figure 1

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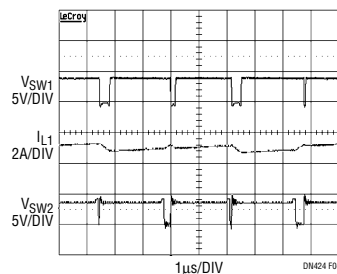


Figure 4. Input Side and Output Side Switch Waveforms Along with Inductor Current for Buck-Boost (3.8V Input) Mode Operation for the Circuit in Figure 1

95% Efficiency

Figure 5 shows efficiency curves for both normal (not forced continuous conduction) and Burst Mode operation. Exceptional efficiency of 95% is achieved at typical loads, resulting from sophisticated controller features including high side drivers and $R_{DS(ON)}$ current sensing. Even higher efficiencies are possible by using a larger ferrite inductor. This circuit easily fits in 0.6in² with components on both sides of the board. The curves show how Burst Mode operation improves efficiency at extremely light loads—an important determinant of battery run time.

Conclusion

The LTC3785 is the latest addition to our class of buck-boost converters developed by Linear Technology to satisfy the requirements of battery-powered applications, specifically those requiring an output voltage that is within the input voltage range. A topology based on the LTC3785 controller overcomes the deficiencies of conventional designs. It is elegant in its simplicity, high in efficiency, and requires only a small number of inexpensive external components.

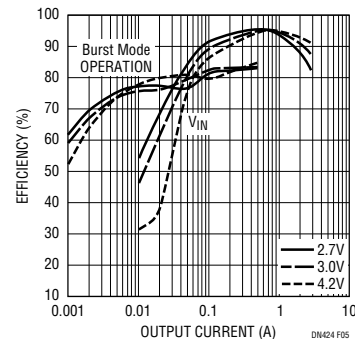


Figure 5. Efficiency in Normal and Burst Mode Operation for the Circuit in Figure 1

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