1µA I_Q Synchronous Boost Converter Extends Battery Life in Portable Devices

Design Note 516

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Introduction

Boost converters are regularly used in portable devices to produce higher output voltages from lower battery input voltages. Common battery configurations include two to three alkaline or NiMH cells or, increasingly, Li-Ion batteries, yielding a typical input voltage between 1.8V and 4.8V.

The 12V output converter shown in Figure 1 is designed to run from any typical small battery power source. This design centers around the LTC®3122 boost converter, which can efficiently generate a regulated output up to 15V from a 1.8V to 5.5V input. The LTC3122 includes a 2.5A internal switch current limit and a full complement of features to handle demanding boost applications, including switching frequency programming, undervoltage lockout, Burst Mode® operation or continuous switching mode, and true output disconnect. The integrated synchronous rectifier is turned off when the inductor current approaches zero, preventing reverse inductor current and minimizing power loss at light loads.

This unique output disconnect feature is especially important in applications that have long periods of idle time. While idling, the part can be shut down, leaving the output capacitor fully charged and standing by for quick turn-on. In shutdown, the part draws less than 1µA from the input source.

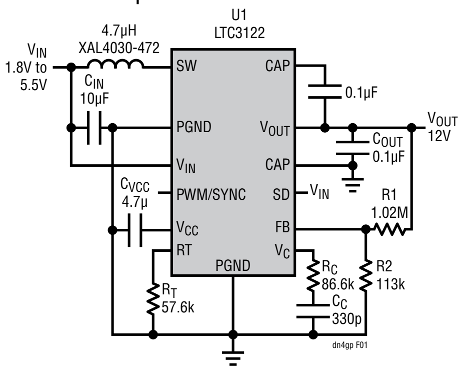

Figure 1. The 1MHz Operating Frequency and Small Inductor Make This Converter Suitable for Demanding Portable Battery-Powered Applications.

Because the batteries used in portable devices are usually as small as possible, they present high internal impedance under heavy loads, especially close to the end of their discharge cycle. Unlike other boost converters that struggle with high source impedance at startup, the LTC3122 prevents high surge currents at startup.

1.8V to 5.5V Input to 12V Output Boost Regulator

The circuit in Figure 1 is designed for high efficiency and small size. The LTC3122 operates at 1MHz to minimize the size of the filter capacitors and boost inductor, and uses Burst Mode operation to maintain high efficiency at light loads, as shown in Figure 2. At heavier loads, the converter can operate in constant frequency mode, resulting in lower input and output ripple. Constant frequency operation can result in lower EMI and is easier to filter.

Efficiency can be increased by running the LTC3122 at a relatively low switching frequency. Figure 3 shows the results of reducing the switching frequency from 1MHz to 500kHz.

Efficiency can be improved further by increasing the inductor size. Figure 4 shows the increase in efficiency

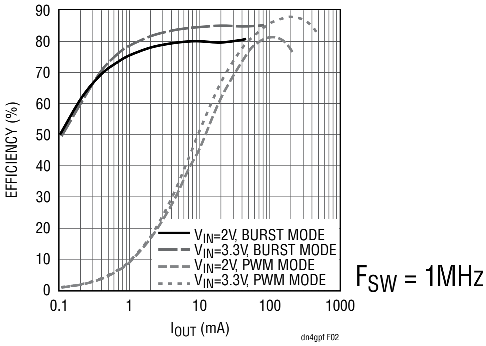

Figure 2. The High Efficiency of the LTC3122 Boost Converter Extends Battery Life in Portable Applications.

achieved by replacing the 4mm × 4mm boost inductor (XAL4030-472) with a 7mm × 7mm inductor (744-777-910 from Würth). The 90% efficiency at 10mA is 5% higher than the efficiency shown in Figure 3.

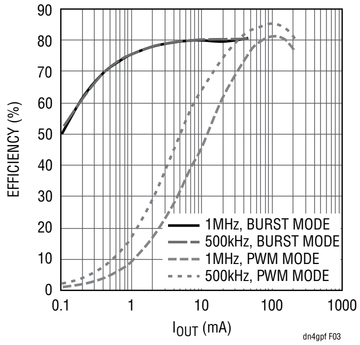

Figure 3. The Efficiency is Greatly Affected by the Operating Frequency. At 100mA Load an Additional 4% Can Be Gained by Reducing the Switching Frequency from 1MHz to 500kHz.

Battery size should be taken into account when considering inductor size. Using a relatively small inductor running at a high frequency may necessitate a correspondingly higher capacity battery to achieve the same run time at relatively lower efficiency. In other words, space gains achieved with a smaller inductor may be replaced by the need for a bigger battery.

Output Disconnect

Typical boost converters cannot disconnect the output from the input because of the boost diode. Current always flows from the input through the inductor and boost diode to the output. Therefore the output can not be shorted or disconnected from the input, a significant problem in many applications, especially in shutdown. In contrast, the LTC3122 includes an internal switch that disconnects the boost MOSFET body diode from the output. This also allows for inrush current limiting at turn-on, minimizing the surge currents seen by the input power source.

Figure 5 shows the output of the LTC3122 disconnected in shutdown. The output voltage is pulled to zero by the load following shutdown, and the LTC3122 consumes less than 1μA of current.

Start-Up Inrush Current Limiting

To simulate a real battery-operated application, the circuit in Figure 1 was tested with 1Ω of equivalent series resistance (ESR) placed between the power source and the LTC3122 circuit. Once the LTC3122 is enabled, it controls the startup so that the input power source can lift the output rail to regulation. The input current slowly ramps up. The input current overshoot required to charge the output capacitor is limited to only 200mA and the input power source voltage droop is limited to 0.5V, as shown in Figure 5.

Conclusion

The LTC3122 boost converter serves the needs of battery-operated applications that require low standby quiescent current and high efficiency. Unlike many other boost converters, it includes features, enabling operation from batteries near full discharge when battery ESR becomes high. Its very low quiescent and shutdown currents, combined with output disconnect, extend battery run time in applications with long idle periods. The LTC3122 includes a complete set of features for high performance battery operated applications and comes in a small, thermally enhanced 3mm × 4mm package.

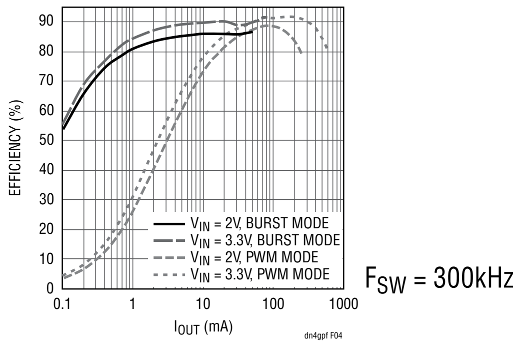

Figure 4. With a Lower Switching Frequency and a Larger Inductor, a Smaller Battery Can Be Used. Efficiency Gain Up to 30% in the 1mA to 10mA Load Range (in PWM Mode) Can Significantly Improve Applications That Operate with Light Loads.

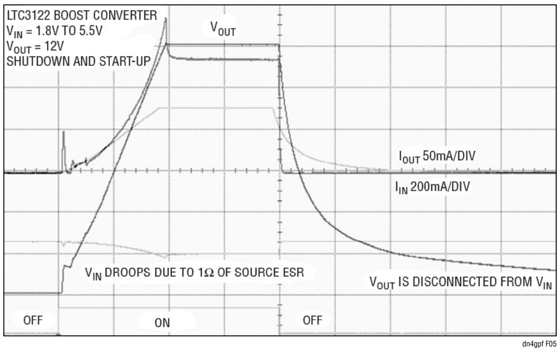

Figure 5. Inrush Current Limiting at Turn-On Minimizes Surge Currents Seen by the Input Source. The Output Is Disconnected from Input During Shutdown.

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