Fully integrated TPS6300x buck-boost converter extends Li-ion battery life

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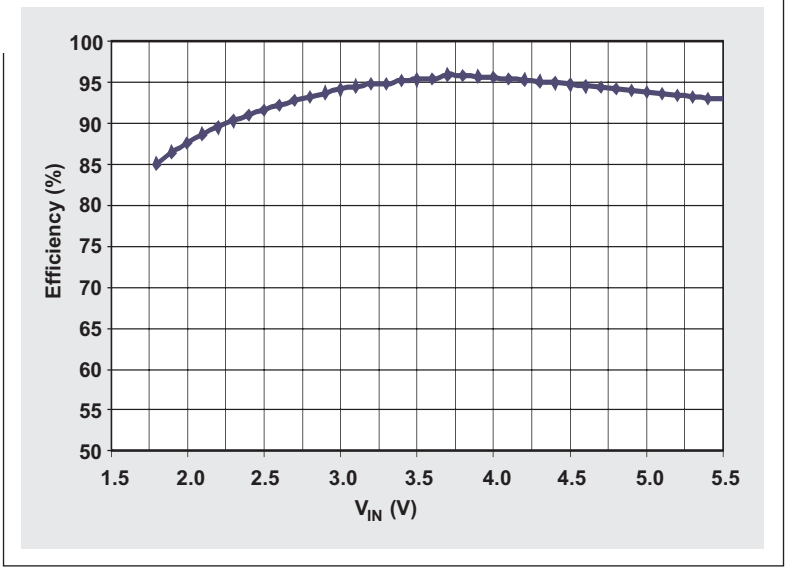
HPA Portable Power Applications

Introduction

For portable power applications to take advantage of the small size and high energy density of modern battery technology, they must operate efficiently over the full battery-discharge voltage range. This presents a design challenge for Li-ion-powered systems requiring a 3.3-V bus. While standard buck converters excel at efficiently converting a 4.2- to 3.0-V Li-ion battery to lower output voltages such as 1.8 V, and standard boost converters efficiently convert a Li-ion battery to higher output voltages such as 5 V, neither provides an optimal solution for generating the ever-present 3.3-V bus. Topologies such as the SEPIC and traditional buck-boost utilize the full battery capacity but suffer from drawbacks such as low efficiency, high cost, increased board area, and high part count. The TPS6300x, available in three configurations, can solve many of these problems. The TPS63000 has an adjustable output from 1.2 V to 5.5 V. The TPS63001 and TPS63002 outputs are fixed at 3.3 V and 5.0 V, respectively. All are available in the space-saving 10-pin QFN (DRC) package.

Figure 1. TPS63001 efficiency at 1.8 to 5.5 V with 320-mA load (V_{OUT} = 3.3 V)

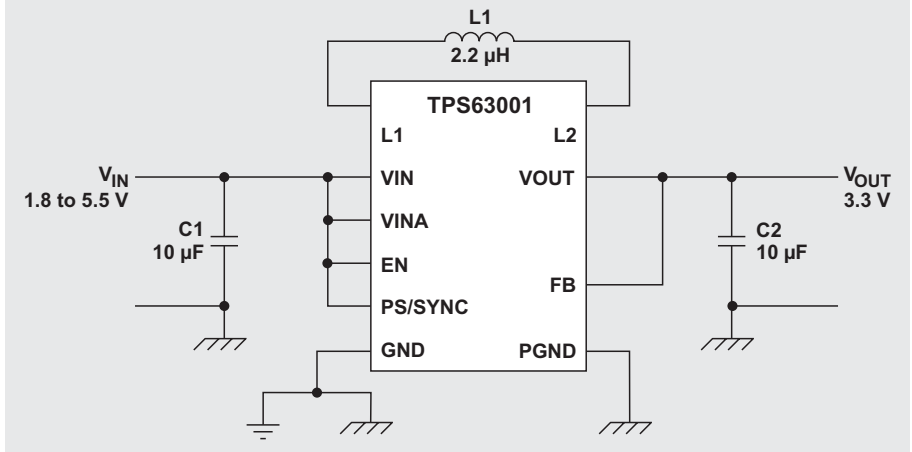


TPS63001

The Texas Instruments TPS63001 efficiently converts the Li-ion input to a 3.3-V bus with minimized part count, small board area, and reduced cost. It integrates both buck and boost functions into a single 3 × 3-mm QFN package, including switching FETs, compensation, and protection features. Only three external parts are required for operation: input and output capacitors and an inductor. The converter operates with a peak efficiency of 96% (see Figure 1). With a peak output current of 800 mA, it delivers enough current to power most portable loads. A wide input voltage range of 1.8 to 5.5 V allows operation with many popular power sources such as dual- and triple-cell alkaline and NiMH batteries as well as 3.3- and 5-V buses.

Figure 2 shows a typical 3.3-V supply that could be powered by a single Li-ion battery. A switching frequency of 1.5 MHz allows the use of a small 2.2-µH inductor and small 0603-sized ceramic input and output capacitors. High efficiency combined with a low

Figure 2. Typical application circuit



external part count reduces the total solution size to only 6 × 6 mm (see Figure 3).

Advanced control topology maximizes efficiency

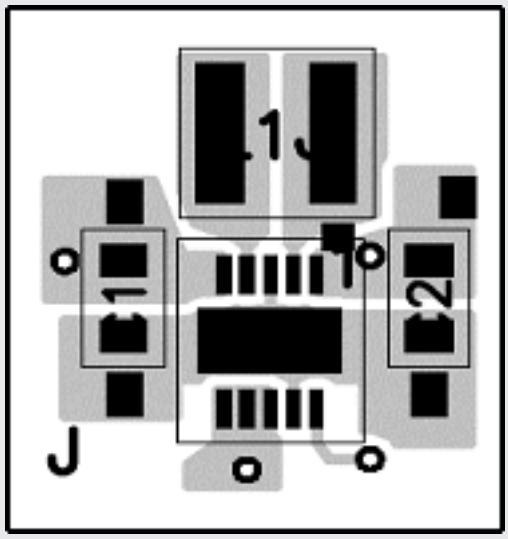
The TPS6300x is based on the standard H-bridge buck-boost power stage shown in Figure 4. It contains both buck and boost switching-FETs configurations that are connected to a single inductor. Unlike a standard buck-boost mode that continuously switches all four FETs simultaneously, the TPS6300x utilizes a proprietary modulator design that switches only two FETs at a time. This control scheme significantly reduces unnecessary switching losses. The TPS6300x also reduces power loss by operating in the more efficient buck or boost mode rather than the traditional buck-boost mode.

As the Li-ion battery discharges down to and below 3.3 V, a buck-boost converter must transition from buck mode to boost mode. Many buck-boost control schemes exhibit efficiency drops, power-supply jitter, or unstable output voltage at this transition point. The TPS6300x transitions seamlessly between buck and boost modes on a pulse-by-pulse basis as necessary. This provides constant PWM switching over the buck and boost range with no overlap or dead time between the two modes.

Additional features

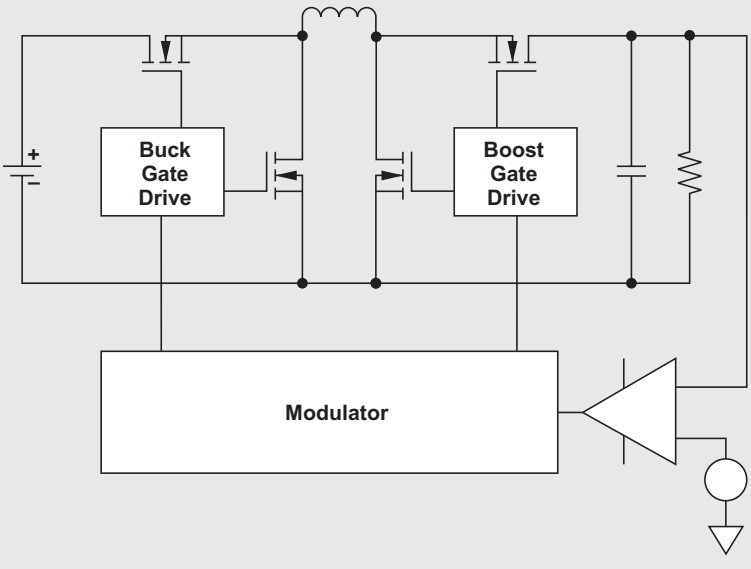
The TPS6300x contains additional integrated features that enhance its usability in portable applications that have, for example, an extremely low quiescent current (less than 50 µA), a user-selectable power-save (PS) mode that maintains efficiency at light loads, or external synchronization to help minimize system noise.

Figure 3. Typical layout in a 6 x 6-mm area



Average-current-mode control topology provides fast transient response and low output ripple in both buck and boost modes. Output regulation tolerance is ±1% over the input and load ranges. Internal compensation is optimized for an external inductor of 2.2 to 4.7 µH with an output capacitor between 10 and 22 µF.

Figure 4. Block diagram of power section



Short-circuit protection provides a foldback current limit that reduces the output current limit from its maximum value of 1.7 A to 800 mA when the output voltage falls by 3%.

This reduces power dissipation on the device during an output overload condition. When the overload has cleared, normal operation resumes. One advantage of this approach is the ability to charge large-output capacitors such as super capacitors.

PS-mode features maintain very high efficiency, even at light loads below 300 mA. In the PS mode, switching occurs only long enough to raise the output voltage slightly above the output-voltage set point. Switching then stops until the output voltage falls below the set point again. This "on then off" switching provides excellent efficiency at light loads.

Other applications

The TPS6300x also operates in a current-regulation mode to drive a white-light-emitting diode (WLED). This is accomplished by replacing the output voltage divider network with a resistor in the return path of the WLED. Since the typical forward voltage drop of a WLED is 4.2 to 3.5 V, powering it from a Li-ion cell presents a problem to most power-supply topologies because the supply is required to both buck and boost its output voltage. The TPS6300x's buck-boost functionality solves this problem and easily delivers 500 mA of current for a torch or flash application.

Conclusion

The TPS6300x is an ideal solution for converting a Li-ion battery to a 3.3-V bus. Its features such as high efficiency, small board area, low cost, and seamless transition from buck mode to boost mode make it an easy choice for the design engineer needing a high-performance design with quick turnaround.

Related Web sites

power.ti.com
www.ti.com/sc/device/TPS63000

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