Synchronous Boost Converter with Fault Handling Generates 5V at 500mA in 1cm^2 of Board Space

by Eddy Wells

Introduction

Today's power supply designs must meet a number of stringent and sometimes competing requirements. In many cases the requirement for a small solution is at odds with the need for high conversion efficiency and the need to safely deal with fault conditions. The LTC3529 step-up DC/DC converter is designed to provide a "no compromises" design, offering high efficiency to minimize dissipated heat and maximize battery life while still maintaining a small footprint for size-constrained power applications requiring a 5V supply.

The LTC3529 can detect a shorted output condition, disable the IC, and report the event to a host microprocessor. This feature is important for portable applications where devices communicate with each other directly, or system power applications where voltages on multiple boards must be monitored and maintained. As shown in Figure 1, the LTC3529 offers a compact and efficient solution consisting of only three tiny external components.

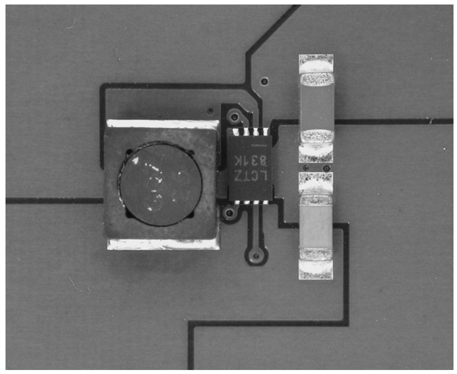

Figure 1. A tiny (1cm^2) yet complete solution drives USB On-The-Go bus power.

Lithium-Ion to 5V, 2.5W Converter

Figure 2 shows an LTC3529-based solution for converting from a single lithium-ion battery or 3.3V board supply to 5V with up to 500mA of load current. Requiring only an inductor and input/output filter capacitors, the entire converter occupies only about 1cm^2 of board space. The IC includes internal compensation, the output divider, and soft-start circuitry to minimize external components. In shutdown, the LTC3529 disconnects the output from the input and draws less than 1µA from the source.

In fixed frequency PWM mode, the efficiency for a typical Li-Ion source to 5V peaks at 92%, as shown in Figure 4, and remains above 80% for load currents greater than 30mA. The LTC3529 delivers up to 500mA of current at a 5V output and is therefore suitable for both low and high power USB applications. As with any DC/DC converter, a tradeoff exists between switching frequency, inductor value, output capacitance and output ripple.

To allow the use of tiny external components, the LTC3529 operates at 1.5MHz and is stable with a 4.7µH inductor and output capacitances of 4.7µF (compatible with USB On-The-Go specifications) or greater. The Li-Ion-to-5V converter in Figure 3 utilizes a 10µF output capacitor, and exhibits a peak-to-peak output ripple of only 10mV. Low ESR and ESL ceramic capacitors (such as X5R) are recommended for both V_{IN} and V_{OUT} bypassing.

Fault Detection

The LTC3529 is robust to output short circuits, a problem that arises as the terminals of the IC are exposed to the outside world to facilitate connection between portable devices or system board edge connectors. To defend against output shorts, the LTC3529 shuts down when an excessive current draw is detected through the internal MOSFET switches continuously for 15ms.

Figure 4 illustrates the fault handling protocol of the LTC3529. Based

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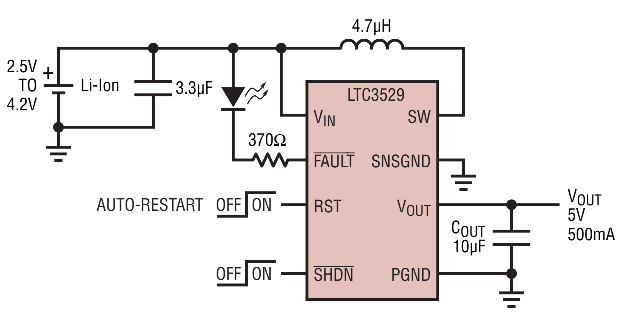

Figure 2. Li-Ion to 5V synchronous boost converter

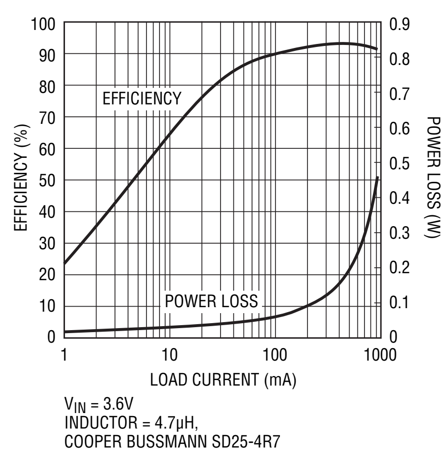

Figure 3. Efficiency for the circuit in Figure 2

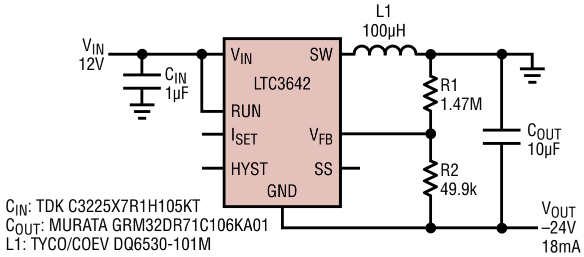

Figure 5. Generating a negative 24V output voltage from a positive 12V input voltage

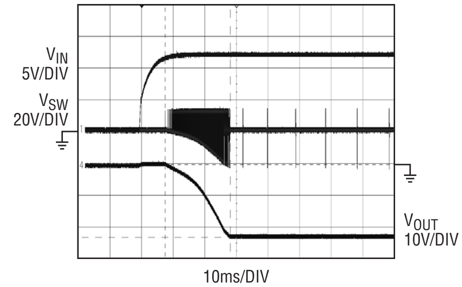

Figure 6. The LTC3642's wide input voltage swing makes it suitable for generating a negative output from positive input voltage.

portable medical instruments and certain automotive applications.

Positive-to-Negative Converter

The LTC3642 can produce a negative output voltage from a positive input voltage without the use of transformers (see Figure 5). In this configuration, the LTC3642 actually operates in an inverting buck-boost mode. Its wide input voltage range, up to 45V, provides sufficient headroom to generate any negative voltage between –0.8V and –40.5V. Figure 6 shows LTC3642 producing a –24V output from a 12V input supply from start-up. The LTC3642 is inherently stable in this configuration with no external compensation components required.

Conclusion

The LTC3642, LTC3631 and LTC3632 are a rugged DC/DC converters for use in applications where a stable voltage output must be produced from poorly regulated high voltage rails. Their compact size and high efficiency make them easy to use in a wide variety of low power applications, including mobile and battery powered devices.

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concern, and extreme accuracy is not paramount. Such applications include clocking microprocessors and microcontrollers, acting as a time base for low speed serial communication protocols such as USB and RS232, digital audio applications, clocking switching power supplies and anywhere a general purpose clock is needed.

Conclusion

When comparing clock power dissipation it is important to consider not just the dissipation of the oscillator itself, but also how the oscillator's features and start-up times effect the dissipation of the entire system. Crystal oscillators not only dissipate more current than other solutions, but can have other start-up and control characteristics that lead to power waste. When the LTC6930's on-the-fly frequency programmability and one-clock-cycle settling time are considered, it is clear that it conserves much more system power than its dissipation specification would indicate

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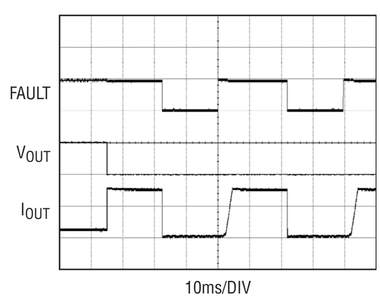
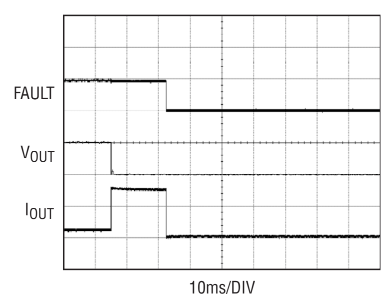
on a pin-selectable setting, the IC can be configured to either periodically attempt to power up (RST pin high, Figure 4a), or remain shut down until power is cycled to the device (RST pin low, Figure 4b). The waveform indicating the fault condition is seen at the Fault pin and is produced by an internal open-drain device whose input is pulled high in the event of a fault. The Fault pin can either be connected to a microprocessor or drive an LED.



4a. RST high: converter attempts power-up every 15ms.



4b. RST low: converter remains shut down until power is cycled.

Figure 4. A fault detection mechanism powers down the converter, providing robustness to output shorts

Conclusion

High conversion efficiency and the ability to detect and handle output shorts make the LTC3529 an ideal solution for either peer-to-peer portable applications or point-of-load board power with robust fault handling. The 1.5MHz switching frequency and highly integrated design of the LTC3529 yield compact solutions with minimal design effort.