

# DESIGN NOTES

## Wide Input Voltage Range Buck-Boost Converter Simplifies Design of Variable Input Supplies – Design Note DN413

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### Introduction

Many of today's portable electronic devices require the ability to operate from a variety of power sources including USB, wall adapters, and alkaline and lithium batteries. Designing a power conversion solution that is compatible with this wide array of power sources can be daunting. The LTC<sup>®</sup>3530 monolithic synchronous converter simplifies the task by operating in both buck and boost modes over an extended input voltage range of 1.8V to 5.5V. No complicated topology is required to account for varying inputs that can be above, below or equal to the output.

The LTC3530 utilizes a proprietary switching algorithm that provides seamless transitions between buck and boost modes while simultaneously optimizing efficiency over all operating conditions. Using this advanced control algorithm, the LTC3530 is capable of high efficiency, fixed frequency operation with input voltages that are above, below, or equal to the output voltage, while requiring only a single inductor. This capability makes the LTC3530 well suited for lithium-ion/polymer and 2-cell alkaline or NiMH applications which require a supply voltage that is within the battery voltage range. In such cases, the high efficiency and extended input operating range of the LTC3530 offer greatly improved battery run-time, as much as 25% in some cases, over alternative solutions.

At 3.3V output, a load current of up to 600mA can be supported over the entire lithium-ion input voltage range;

250mA of load current is supported when the input is 1.8V. The output voltage is user-programmable from 1.8V to 5.25V via an external resistor divider. The LTC3530 includes a soft-start circuit to minimize the inrush current transient during power-up. The duration of the soft-start period can be programmed via the time constant of an external resistor and capacitor.

The switching frequency of the LTC3530 is user programmable via a single external resistor, allowing the converter to be optimized to meet the space and efficiency requirements of each particular application. An external resistor and capacitor provide compensation of the feedback loop, enabling the frequency response to be adjusted to suit a wide array of external components. This flexibility allows for rapid output voltage transient response regardless of inductor value and output capacitor size.

The LTC3530 features an automatic transition to Burst Mode<sup>®</sup> operation at a user programmable current level to improve light load efficiency. For noise sensitive applications, the LTC3530 can be forced into fixed frequency operation at all load currents by connecting the BURST pin to  $V_{IN}$ . The LTC3530 also features short-circuit protection and overtemperature shutdown. Internal reverse current limiting circuitry prevents damage to the part should

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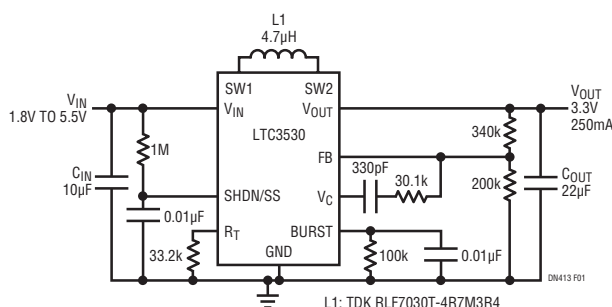


Figure 1. 3.3V at 250mA from a 1.8V to 5.5V Input

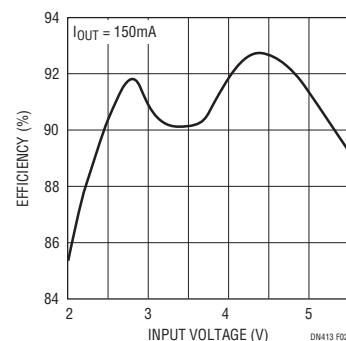


Figure 2. Efficiency vs Input Voltage of the Circuit in Figure 1

the output voltage be pulled above regulation through an external path.

### Efficiency

Figure 1 illustrates a typical LTC3530 application circuit configured with a 1MHz switching frequency, which represents a good compromise between the PCB area and efficiency for most applications. The efficiency curve versus input voltage for this application circuit is shown in Figure 2. The LTC3530 achieves greater than 85% efficiency with an input voltage greater than or equal to 2V. These high levels of efficiency in combination with its wide input voltage range make the LTC3530 an attractive solution for battery-operated products and other efficiency-sensitive applications.

### Programmable Burst Mode Operation

The LTC3530 provides automatic Burst Mode operation, which greatly improves efficiency at light load currents. Burst Mode operation reduces the operating current of the LTC3530 to only 40µA in order to improve light load efficiency and extend battery runtime. The LTC3530 automatically transitions to Burst Mode operation when the average output current falls below a user programmable level set via an external resistor. When the load current rises above the Burst Mode threshold, the part automatically returns to fixed frequency PWM operation.

The precise control circuitry of the LTC3530 allows the Burst Mode threshold to be set at load currents as low as 20mA. In addition, the LTC3530 directly monitors the average load current thereby providing a Burst Mode transition threshold that is independent of input voltage,

output voltage, and inductor value, unlike other devices that rely on the level of peak inductor current.

In noise sensitive applications, the LTC3530 can be forced into fixed frequency PWM operation at all load currents by simply connecting the BURST pin to V<sub>IN</sub>. In addition, the BURST pin can be driven dynamically in the application to provide low noise performance during critical phases of operation, or to reduce voltage transients during periods of expected large load transitions.

### 1.27mm Profile Li-Ion to 3.3V Regulator

The high switching frequency and advanced buck-boost switching algorithm of the LTC3530 allow the use of small external components. Figure 3 shows a circuit that is optimized to reduce the total application size. The entire converter has a maximum height of 1.27mm and occupies a PCB area of only 0.135 square inches making it ideal for height constrained applications such as PC cards. Figure 4 shows the efficiency versus input voltage for this area-optimized application circuit. This converter is able to support a 600mA load for output voltages above 2.4V and obtains greater than 86% efficiency over the entire Li-Ion input voltage range.

### Conclusion

The LTC3530 with its high efficiency, wide input voltage range, and tiny circuit size is well suited to a variety of battery operated products and other efficiency-sensitive applications. With the IC's array of programmable features, the circuit can be customized to meet the needs of any application, while still maintaining a compact total solution footprint.

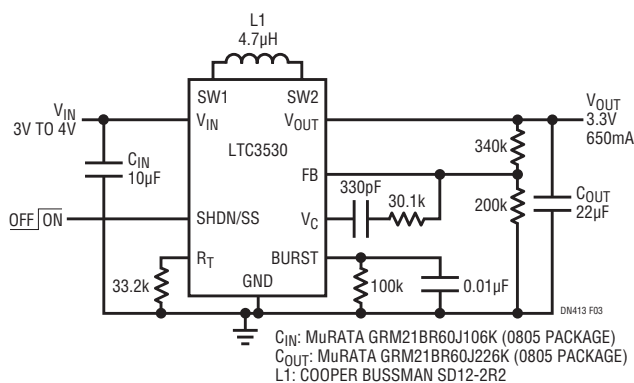


Figure 3. 1.27mm Profile and Area Optimized Application Circuit

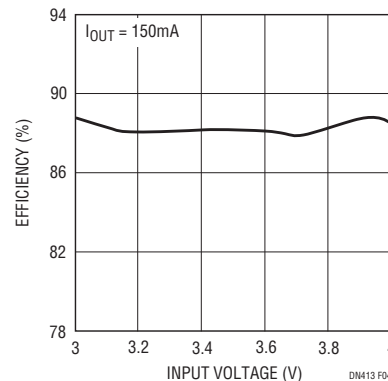


Figure 4. Efficiency vs Input Voltage of Figure 3 Circuit

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