DESIGN NOTES

One IC Generates Three Sub-2V Power Rails from a Li-Ion Cell

Design Note 419

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Introduction

Shrinking geometries in IC technology have pushed the operating voltages of today's electronics well below 2V, presenting a number of design challenges. One common problem is the need for multiple supply voltages: for example, one voltage for a CPU core, another for I/O and still others for peripherals. Sensitive RF, audio and analog circuitry may require additional dedicated quiet supplies, separate from less noise-sensitive digital circuits. As the number of supplies increases, it becomes impractical to use a separate power supply IC for each voltage and special-requirements subsystem. Board area would be quickly consumed by power supplies. One solution to the space crunch is power supply integration, provided by a triple regulator like the LTC®3446—three voltages from a single IC.

Triple Supply in a Tiny Package

The LTC3446 combines a 1A synchronous buck regulator with two 300mA very low dropout (VLDO™) linear regulators to provide up to three stepped-down output voltages from a single input voltage, all in a tiny 3mm × 4mm DFN. The 2.7V to 5.5V input voltage range is ideally suited for Li-Ion/Polymer battery-powered applications, and for powering low voltage logic from 5V or 3.3V rails. The output voltage range extends down to 0.4V for the VLDO regulators and 0.8V for the buck converter.

Each output is independently enabled or shut down via its own enable pin. When all outputs are shut down, V_{IN} quiescent current drops to 1µA or less, conserving battery power. The regulation voltage for each output is programmed by external resistor dividers. The buck regulator loop response can be tailored to the load by adjusting the RC network at the I_{TH} pin.

High Efficiency and Low Noise

The 1A synchronous buck provides the main output with high efficiency, up to 90%. This buck converter features constant-frequency current-mode operation at 2.25MHz, allowing small capacitors and inductor to be used. The two 300mA VLDO regulators can be connected to run off the buck output to provide two additional lower voltage outputs. This way, the buck performs the bulk of the step-down at the high efficiencies typical of switching

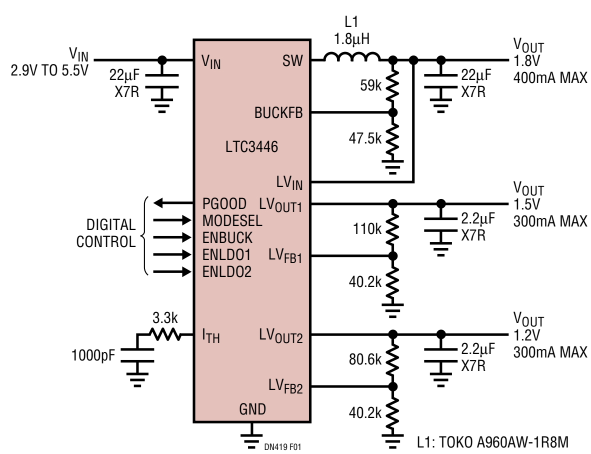

Figure 1. Schematic Showing the LTC3446 Power Supply Configured to Deliver 1.8V from the 1A Buck, and 1.5V and 1.2V from the 300mA VLDO Regulators. The VLDO Regulators Are Powered from the Buck Output via the LV_{IN} Pin.

regulators, while the VLDO regulators provide additional lower voltages with good efficiency at the extremely low noise levels typical of linear regulators.

The schematic in Figure 1 shows the LTC3446 configured to deliver 1.8V from the buck, 1.5V from the first VLDO regulator, and 1.2V from the second VLDO regulator. Figure 2 shows the Figure 1 circuit assembled onto a printed-circuit board.

Selectable Burst Mode® Operation or Pulse-Skipping at Light Load

The LTC3446's buck regulator features Burst Mode operation for optimum efficiency when operating at light loads, at the cost of increased output ripple and the introduction of switching noise below the 2.25MHz clock frequency. Burst Mode operation can be defeated by bringing the MODESEL pin high, which commands the LTC3446 to continue to switch at the 2.25MHz clock frequency down to very light loads, whereupon pulses are skipped as needed to maintain regulation. Figure 3, which shows the efficiency of the buck regulator vs load current, also illustrates the typical efficiency gains from using Burst Mode operation at load currents below 100mA.

Very Low Dropout (VLDO) Linear Regulators

The VLDOs in the LTC3446 employ an NMOS source-follower architecture to overcome the traditional tradeoff between dropout voltage, quiescent current and load transient response inherent in most PMOS- and PNP-based LDO regulator architectures. The V_{IN} pin (refer to Figure 1), supplies only the micropower bias needed by the VLDO control and reference circuits, typically at single-cell Li-Ion voltages. The actual load current is sourced from the LV_{IN} pin, which can be connected to the buck regulator output.

Each VLDO regulator provides a high accuracy output that is capable of supplying 300mA of output current with a typical dropout voltage of only 70mV from LV_{IN} to LV_{OUT}. V_{IN} should exceed the LV_{OUT} regulation point by 1.4V to provide sufficient gate drive to the internal NMOS pass device. Typical single-cell Li-Ion operating voltages extend down to 3.2V, supporting VLDO output voltages of up to 1.8V.

A single ceramic capacitor between 1μF and 2.2μF is all that is required for output bypassing. A low reference voltage of 400mV allows the VLDO regulators to be programmed to much lower voltages than are commonly available in LDO regulators.

Power Good Detection

The LTC3446 includes a built-in supply monitor. The PGOOD open-drain output pin is pulled low while any enabled output is more than ±8% from its regulation value. Once all enabled outputs are within this tolerance window, the PGOOD pin becomes high impedance. A microprocessor can monitor this open drain output pin to assess when a recently enabled output has completed startup.

Conclusion

The LTC3446 packs an efficient 1A buck regulator and two 300mA VLDO regulators in a tiny 3mm × 4mm DFN package. With an output voltage range extending down to 0.4V for the VLDO regulators and 0.8V for the buck, and an input voltage range covering the single-cell Li-Ion range up to 5.5V, the LTC3446 is ideal for powering today's multi-voltage, sub-2V systems.

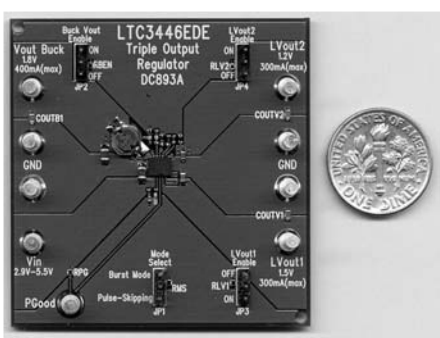

Figure 2. The LTC3446 Triple Power Supply Assembled on a Printed Circuit Board

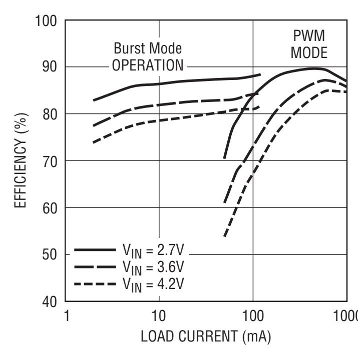

Figure 3. Efficiency of the LTC3446's Buck Regulator vs Load

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dn419f LT/TP 0707 409K • PRINTED IN THE USA