Miniscule Step-Up Controller Yields Wide Input and Output Ranges

by Theo Phillips and Hong Ren

Introduction

Small in stature, but big in power, the LTC3872 boost controller can produce an expansive range of output voltages with the bare minimum in components. Its design forgoes a few features and pins (TRACK, SYNC, and MODE, for instance) to squeeze into a slender 8-pin 3mm × 2mm DFN or leaded TSOT-23 package. Nevertheless, it gives up little in versatility, providing up to 60V in regulated output from a 2.75V–9.8V input. This input range accommodates one or two lithium-ion batteries, in addition to the common 3.3V and 5V input rails.

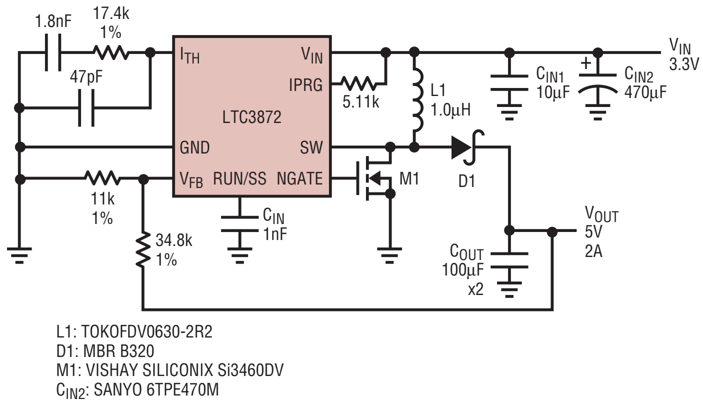

Figure 1. A 3.3V input, 5V output boost regulator delivering up to 2A. The large input capacitor C_{IN2} protects against inductive ringing in long traces to the main input supply, which could happen during load transients and startup.

Space-Saving Design

Matching the LTC3872's small size, its 550kHz constant frequency operation allows the use of a small-footprint surface mount inductor and ceramic capacitors. This saves space over boost controllers that use a constant on-time switching scheme, which can result in a lower operating frequency and physically larger filter components. No R_{SENSE}™ technology eliminates the need for a separate current-sensing resistor. Just a few additional resistors and capacitors are needed to program the output voltage and close the feedback loop; the user can adjust OPTI-LOOP® compensation to accommodate whatever output voltage and filter components are chosen.

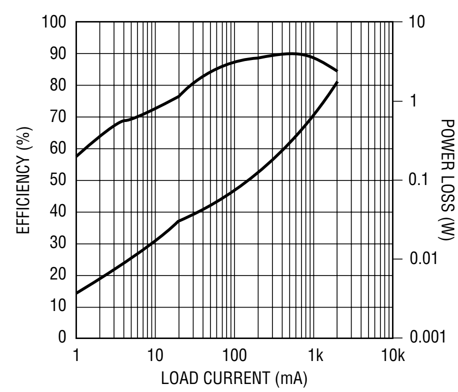

Figure 2. Efficiency and Power Loss for the application circuit of Figure 1.

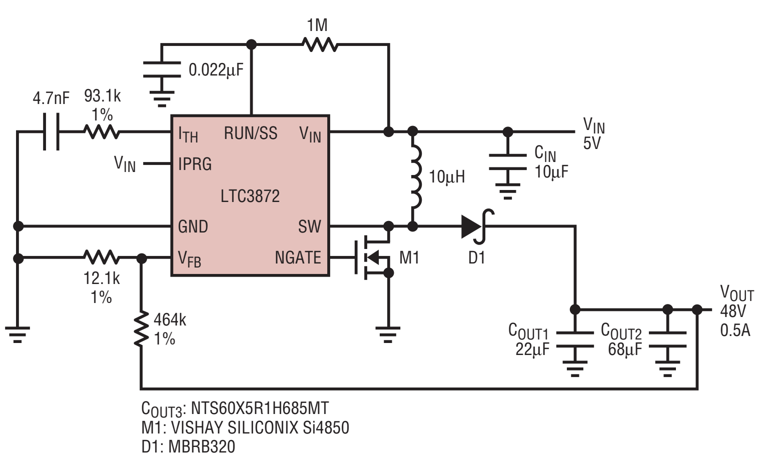

Figure 3. A 5V input, 48V output boost regulator delivering up to 0.5A

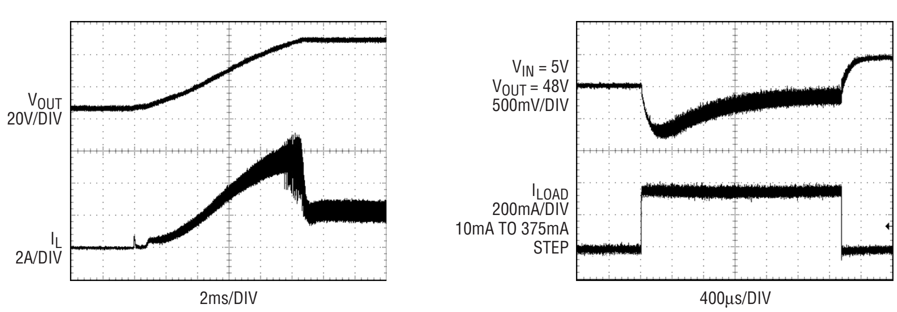

Figure 4. Startup and load transient for the circuit of Figure 3

Light Load Efficiency

At light loads, pulse skip mode maintains constant frequency operation. This has the dual benefit of minimizing ripple and keeping switching noise within a predictable, easily filtered band. Output voltage remains stable in the presence of transients, due to the LTC3872's current mode architecture.

A 3.3V Input, 5V/2A Output Boost Converter

Figure 1 shows a typical LTC3872 application—a 3.3V input to 5V output boost regulator which can deliver up to 2A load current. Figure 2 shows the efficiency/power loss curve. In spite of the converter's small size, efficiency peaks at 90% and stays above 80% down to 20mA. In shutdown mode it draws only 8µA.

The LTC3872 uses the drain to source voltage of the external N-channel MOSFET to sense the inductor current. Eliminating a separate sense resistor can increase efficiency by 1%–2% at heavy loads. Absent a short circuit at the output, the maximum current that the converter can draw from V_{IN} is determined by the $R_{DS(ON)}$ of the MOSFET (a function of the gate drive voltage V_{IN}). This maximum current can be adjusted by using the three-state current limit programming pin IPRG.

A 5V Input, 48V/0.5A Output Boost Converter

Figure 3 shows the LTC3872's ability to deliver high output voltage. In this topology, the limitation on V_{OUT} is the 60V maximum rating of the SW pin. Where even higher output voltages are required, a sense resistor can be inserted between the source of the MOSFET and ground, with the SW pin tied to the high side of the sense resistor. The output is well-controlled against overshoot and undershoot during startup and load transients (Figure 4). At high duty cycle under heavy loads, the commutation cycle (here, 1/550kHz) is too brief to allow the average inductor current to equal the converter's required input current. In this case, the on-time of MOSFET M1 is extended, and inductor current ramps up to the level required to maintain output regulation (Figure 5).

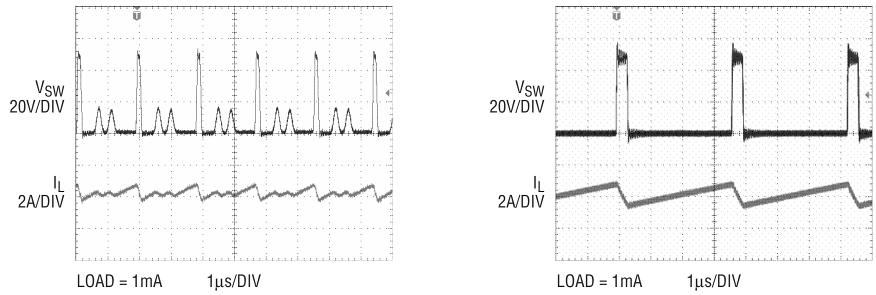

Figure 5. At light loads, the circuit of Figure 3 uses pulse skip mode. In this mode operation does not exceed the (80%) maximum duty cycle of the converter at 550kHz. At heavy loads, the maximum duty cycle is extended by allowing the switching frequency to fall.

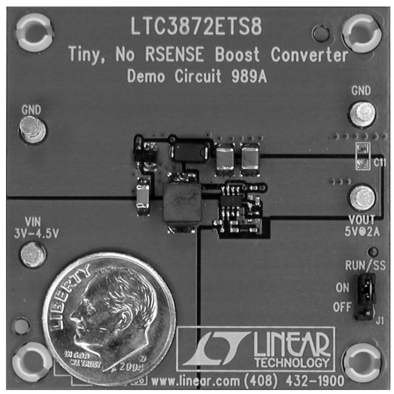

Figure 6. A typical LTC3872 application occupies just 2.25cm².

Conclusion

The LTC3872 is a tiny current-mode, non-synchronous boost controller that requires no sense resistor—a typical design occupies 2.25cm^2 (Figure 6). The small solution size and wide input voltage range make it an easy fit for a variety of applications.

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ON/OFF signal is caused by a valid pushbutton OFF.

From the start of the shutdown sequence, the system power turns off in 500ms, unless an edge (a high-to-low or low-to-high transition) at the WDE pin is detected within the 500ms period to extend the wait period for another 500ms. This KILL Wait time (500ms/cycle) is designed to allow the system to finish performing its house keeping tasks before shut down.

Once the µP finishes performing its power down operations, it can either let the KILL Wait time expire on its own or set the $\overline{KILL}$ pin low to immediately terminate the KILL Wait time. When the KILL Wait time expires, the LTC2952 sets EN low. This turns off the DC/DC converter connected to the EN pin. In the sequence shown in Figure 10, the KILL Wait time is reset twice with edges on the WDE pin (t5 and t6) before finally expiring (t7).

When the DC/DC converter is turned off (EN goes low), it can take a significant amount of time for its output level to decay to ground. In order to guarantee that the µP has always powered down properly before it is re-started, another 500ms (Enable Lock Out period) timer is started to allow for the DC/DC converter output power level to power down completely to ground. During this Enable Lock Out period, the EN pin remains in its low state regardless of any transition at the internal ON/OFF signal. At the end of the 500ms Enable Lock Out time (t8) the LTC2952 goes into its reset state, ready for the next turn on sequence. Note that at this reset state the EN pin remains strongly pulling down.

Conclusion

The LTC2952 is a versatile, full featured Power Path Management IC that provides robust pushbutton ON/OFF control with a simple and graceful communication interface to the system microprocessor. Its wide voltage range, gate drive capability and low power fit an extensive number of applications requiring efficient management of two or more power paths. To further complement the requirements of highly reliable systems, the LTC2952 also offers voltage and watchdog monitoring capabilities.

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