CCD Bias Supply Integrates "Output Disconnect," Schottkys and Feedback Resistors

by Jesus Rosales

Introduction

CCD imagers continue to advance in increased resolution, faster readout rates and continuous video capability. All of these advances require increased power, but power supply designs must add power without reducing efficiency or increasing size. The LT3487 monolithic switching regulator offers a tiny, highly integrated, efficient bias supply solution for CCD applications. It integrates both boost and inverting regulators, Schottky diodes, a boost side output disconnect and ground-side feedback resistors—all in a 3mm × 3mm DFN package. The LT3487's boost side DC current limit of 750mA and inverting switch limit of 900mA is more than sufficient to power the latest and next generation CCD imagers. The output disconnect ensures that power is not wasted due to DC leakage to the load in shutdown.

CCD Draws High Power from Discharged Li-Ion

Figure 1 shows the LT3487 in a high power CCD application that provides 45mA at 15V and 90mA at –8V from a nearly discharged Li-Ion battery at 3.0V. This power handling allows the LT3487 to be used in digital cameras with video capability.

This particular converter operates over a wide input voltage range between 2.3V and 16V. Both channels run at a 2MHz switching frequency, enabling the use of tiny inductors and capacitors. The fixed frequency PWM control provides outputs with low, predictable ripple.

External components are minimized as both channels incorporate on-chip Schottky diodes. Each channel also requires only one external resistor to set the output voltage. The second resistor in each divider is provided on-chip and trimmed to provide an accurate 25µA input current.

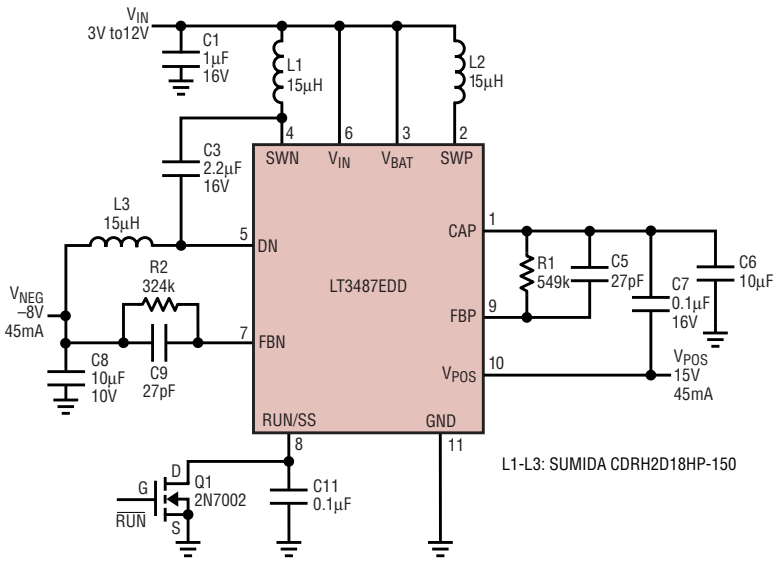

Figure 1. A compact 15V, –8V CCD bias application

Soft-Start and Sequencing

When a DC/DC converter begins delivering power into an uncharged output capacitor, it normally runs in current limit until the output comes up into regulation. This large spike of current pulled from the input may not be acceptable in many applications where V_{IN} has limited current sourcing capability. The LT3487 has soft-start functionality that clamps the internal V_C node to a slowly rising soft-start voltage, limiting the peak switch current. This allows the current in the inductor to rise much more slowly. The output comes into regulation more slowly, and the spike of current from V_{IN} is eliminated.

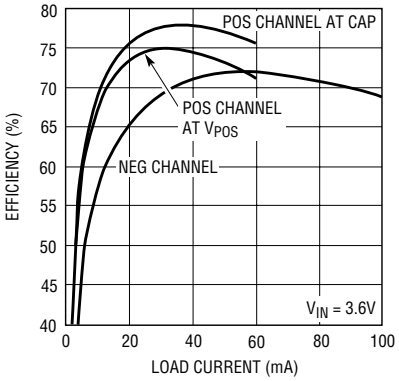

Figure 2. Efficiency of CCD bias application with 3.6V V_{IN}

In multiple channel regulators, the sequencing of the outputs can also be important. A typical CCD requires the positive output to come into regulation before the negative, and to collapse after it when the regulator shuts down. The intelligent soft-start of the LT3487 provides sequenced soft-start of both channels with a single external capacitor. The LT3487 sources 1.4µA from the RUN/SS pin that charges the soft-start capacitor; to shut down the device, use an open drain transistor to sink this current. With an adequately sized soft-start capacitor, the positive channel slowly comes up into regulation, and then the negative channel begins its own slow rise into regulation. Figures 3 and 4 show the output voltages and input currents with and without a soft-start capacitor. Note that even without a soft-start capacitor, the negative channel does not start up

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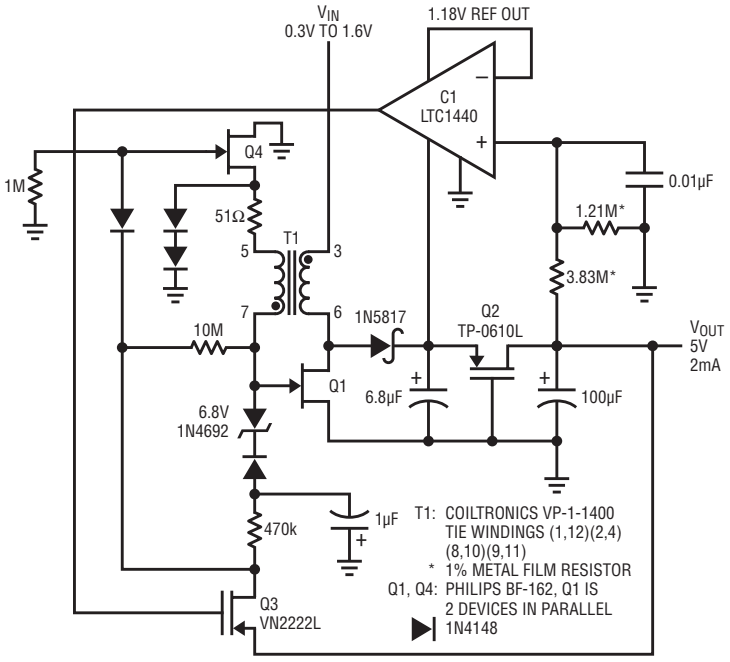

Figure 5. Adding Q3, Q4 and bootstrapped negative bias generator reduces quiescent current. Comparator directed Q3 switches Q4, more efficiently controlling Q1's gate drive. Q2 and zener diode isolate all loading during Q1 start-up.

Q3's shunt control of Q1 is simple and effective, but results in a 25mA quiescent current drain. Figure 5's modifications reduce this figure to 1mA by series switching T1's secondary. Here, Q3 switches series-connected Q4, more efficiently controlling Q1's gate drive. Negative turn-off bias for Q4 is bootstrapped from T1's secondary; the 6.8V zener holds off bias supply loading during initial power application, aiding start-up. Figure 4 shows minimal penalty imposed by the added quiescent current control circuitry.

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until the positive side reaches 87% of its final voltage. The output disconnect is also designed so that both channels can collapse together gently when the chip is shut down.

Output Disconnect

In a standard boost regulator, the inductor and Schottky diode provide a DC current path from the input to the output, even when the regulator is shut down. Any load at the output when the chip is shut down can continue to drain the V_{IN} source. The LT3487 addresses this issue with an on-chip output disconnect. The output disconnect is a PNP pass transistor that eliminates the DC loss path. The pass transistor is controlled by a circuit that varies its base current to keep it at the edge of saturation, yielding the best compromise between voltage drop across the PNP and quiescent current. The disconnect in the LT3487 can support loads of 50mA with a V_{CE} of less than 210mV.

V_{BAT} Pin

The V_{BAT} pin is an innovation that allows output disconnect operation in a wide range of applications. V_{BAT} monitors the voltage at the input of the boost inductor and allows the positive output to stay active until the CAP node falls to 1.2V above V_{BAT}. This ensures that output disconnect continues operating even after the part goes into shutdown. Since output disconnect continues to work, the positive output doesn't fall sharply to ground before the negative bias discharges. The V_{BAT} pin allows the inductors to be powered from a different source than V_{IN} while still maintaining the disconnect operation. This can be useful in a system using a 2-cell supply where a low voltage boost provides 3.3V for the V_{IN} supply. By connecting V_{BAT} as well as the inductors to the 2-cell supply, the positive output is able to stay on as long as possible when the part goes into shutdown.

Applications

The LT3487 can be used in a CCD bias as well as other applications that require a positive and negative bias such as ±12V data acquisition systems. The boost channel can produce voltages up to 30V as long as the part can meet the required duty cycle. Similarly, the inverting channel can produce voltages down to –30V. This high voltage capability allows the LT3487 to be used in many LCD applications.

Conclusion

The LT3487 simplifies and shrinks CCD bias supplies without compromising on performance or features. The soft-start and output disconnect features ensure that the input battery doesn't encounter current spikes or shutdown leakage. The high current capability satiates even the most power-hungry video applications.

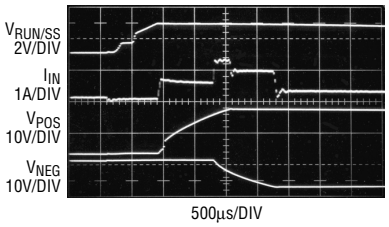

Figure 3. Startup without soft-start capacitor

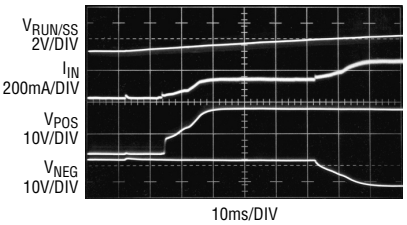

Figure 4. Startup with 100nF soft-start capacitor