Low Ripple Micropower SOT-23 Buck Regulator with Integrated Boost and Catch Diodes Accepts Inputs to 40V

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Introduction

The LT3470 is a micropower buck regulator that integrates a 300mA power switch, catch diode and boost diode into a low profile 8-Pin ThinSOT package (see Figure 1). The combination of single cycle Burst Mode and continuous operation allows the use of tiny inductor and capacitors while providing a low ripple output to loads of up to 200mA. With its wide input range of 4V to 40V and low quiescent current of 26μA (12V in to 3.3V out) the LT3470 can regulate a wide variety of power sources, from 2-cell Li-Ion batteries to unregulated wall transformers and lead acid batteries.

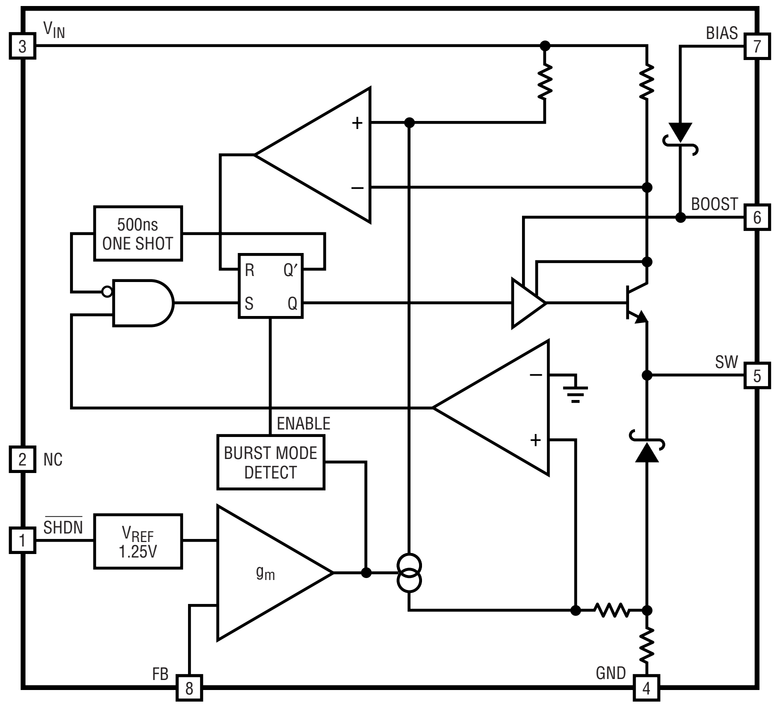

Figure 1. The block diagram of the LT3470 shows the integrated boost and catch Schottky diodes. Inductor current is kept under control at all times by monitoring the V_{IN} current as well as the catch diode current, thereby providing short circuit protection even if V_{IN} = 40V.

5V, 200mA from 40V Consumes Less than 1mW at No Load

Figure 2 shows a 5V, 200mA supply that accepts inputs from 5.5V to 40V. While the output is in regulation and with no load the power loss is lower than 1mW. The LT3470 can also be put in a shutdown mode that reduces the input current to <1μA by pulling the $\overline{SHDN}$ pin low. When always-on operation is desired, the $\overline{SHDN}$ pin can be tied to V_{IN}.

The LT3470 uses a control system that offers low (<10mV) ripple at the output while keeping quiescent current to a minimum. When output load is light, the LT3470 remains in sleep mode while periodically waking up for single switch cycles to keep the output in regulation. The current limit of these single switch cycles is about 100mA, which keeps output ripple to a minimum. At greater output loads the LT3470 no longer enters sleep mode, and instead servos the peak switch current limit (up to 300mA) to regulate the output. See Figure 3 for operating waveforms.

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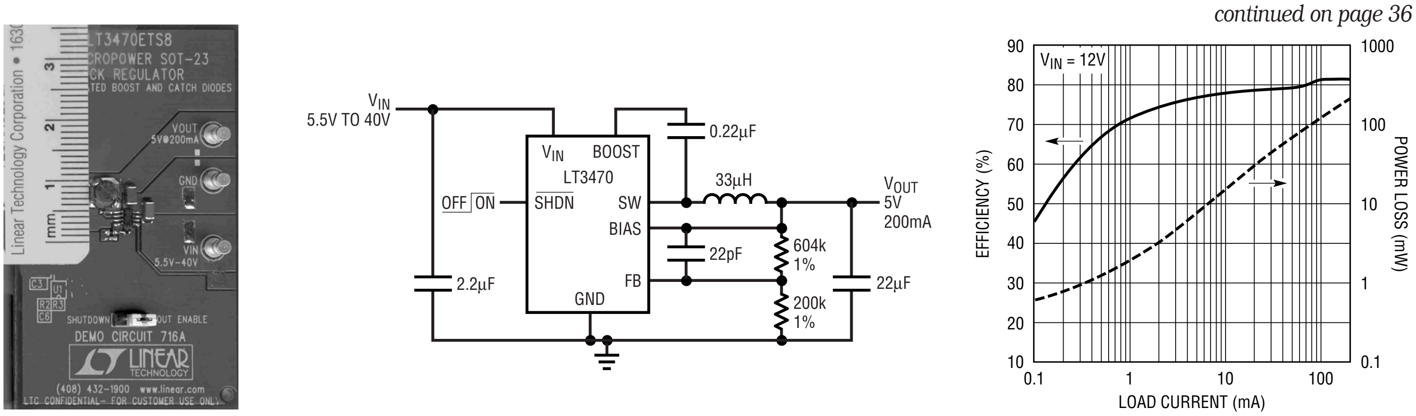

Figure 2. The LT3470 uses a minimum of board space and external components while delivering wide onput range and high efficiency. This buck regulator supplies up to 200mA at 5V from inputs up to 40V. Input power loss is below 1mW when there is no output load.

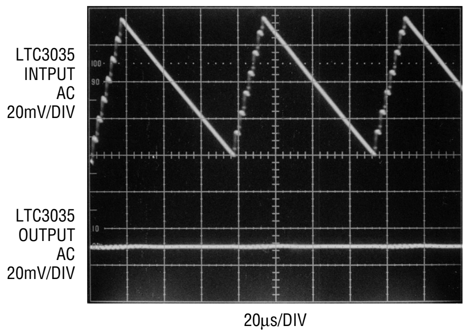

Figure 3. Input and output waveforms to the LTC3035 in the Li-Ion to 3.3V application, showing its excellent ripple rejection (I_{OUT} = 25mA, LTC3440 in Burst Mode®)

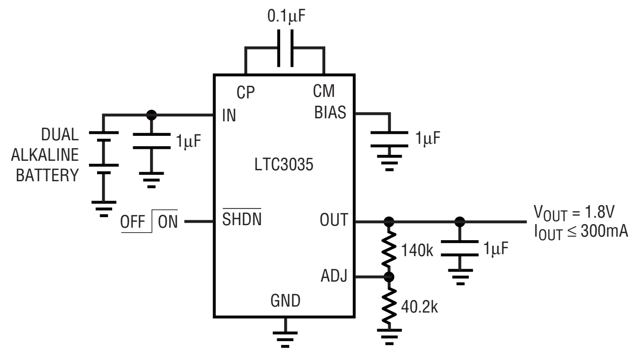

Figure 4. A very low dropout dual-alkaline to 1.8V application

High Efficiency, Low Noise Li-Ion to 3.3V

Figure 2 shows a high efficiency and low noise lithium-ion to 3.3V solution. The LTC3440, a buck-boost converter, converts the Li-Ion battery voltage to an efficient intermediate voltage (3.4V) at the input of the VLDO. The LTC3035 then regulates this intermediate voltage down to 3.3V, providing a lower noise output voltage. Figure 3 shows the input and output waveforms of the LTC3035 at 25mA of output current, illustrating its excellent power supply rejection characteristics for a lower noise solution.

For optimum total efficiency, the input to output voltage differential across the LDO should be as small as possible, since the magnitude of the dissipated power equals the product of the voltage differential and the output current. Because of the LTC3035's very low dropout voltage, its input voltage can be programmed to only 100mV above the 3.3V output and still maintain regulation at 300mA. Conventional LDOs with higher dropout voltages force greater input and output voltage differentials, effectively reducing efficiency by the same ratio.

Double Alkaline to 1.8V LDO

Handheld applications using two alkaline batteries in series demand low power solutions that use as much of the battery's operating voltage range as possible. In Figure 4, two series alkaline batteries are regulated down to provide a 1.8V supply taking advantage of the LTC3035's excellent dropout characteristics.

The dropout voltage and maximum output current capabilities of typical low power LDOs using P-type transistors suffer as the input voltage supply decreases, since the power transistor's overdrive reduces. With input and output voltages near 1.8V, conventional low power LDOs may have dropout voltages over 200mV, if they can deliver 300mA of output current at all. Using the LTC3035, the battery voltage can discharge much further to only about 50mV above the 1.8V output before the LDO begins to drop out at 300mA. Allowing the battery to discharge longer essentially extends the battery life for the application when compared to solutions that use higher dropout LDOs.

Conclusion

The very low dropout characteristics of the LTC3035 can be exploited in battery-powered applications to obtain higher efficiency and increased battery life. Its very low dropout voltage, excellent power supply rejection, low-quiescent current, and small solution size make the LTC3035 an ideal choice for many low power, handheld battery applications.

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The fast cycle-by-cycle current limit of the LT3470 keeps the switch and inductor currents under control at all times. In addition, the LT3470 uses hysteretic mode control where the switching frequency automatically adjusts to accommodate variations in V_{IN} and V_{OUT}. This means that the part switches at a slower frequency when the output is in short circuit or when V_{IN}/V_{OUT} ratio is high. This ensures that the LT3470 can handle a short circuit at the output even if V_{IN} = 40V and the inductor value is small. It is, however, important to choose an inductor that does not saturate excessively at currents below 400mA to guarantee short circuit protection.

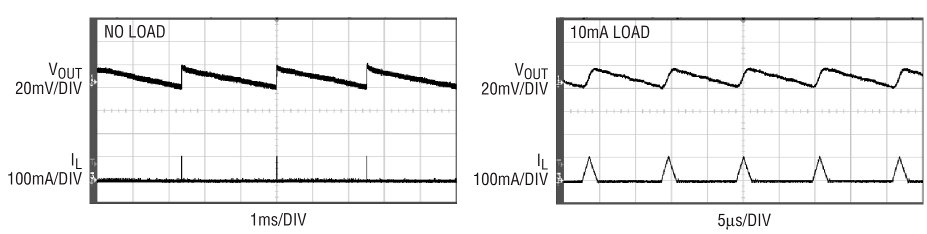

Figure 3. Operating waveforms show the output voltage ripple remains at 10mV in BurstMode operation, while requiring only a 22µF ceramic output capacitor.

Conclusion

The LT3470 is a small buck regulator with a unique combination of features that make it a great choice in applications requiring small size, high efficiency across a wide range of currents, and low output ripple. It can deliver up to 200mA from inputs as high as 40V using only an inductor, four small ceramic capacitors, and two resistors while consuming only 26µA during no load operation.