Low Output Voltage Synchronous Boost Regulators Extend Battery Life in Single Cell Applications

by Mark Jordan

Introduction
The LTC3423 and LTC3424 Synchronous Boost Regulators are designed for single cell (Alkaline, NiMH, or NiCd) portable electronics that require a low voltage supply, typically between 1.5V to 2.5V, at load currents up to 0.8 amps. These products are designed to prolong battery life for applications where an available higher voltage supply (2.7V to 5.5V) can provide internal bias for the IC. Before the LTC3423 and LTC3424 became available, power supplies for low voltage, high current solutions included a buck converter from the higher voltage output, a simple, but relatively inefficient solution. These new devices offer a solution that is just as simple, but with much improved efficiency. The simple block diagrams in Figures 1A and 1B show how this difference arises: double conversion is shown Figure 1A, and the approach of regulating the low voltage supply directly from the cell is shown in Figure 1B.

Features
Both devices are additions to the family of 3MHz, Micropower Synchronous Boost Regulators, intended for low output voltage applications. High frequency operation allows the use of a small surface mount inductor and tiny ceramic capacitors. Efficiencies of up to 95% are achieved through internal features such as loss less current sensing, low gate charge-low $R_{DS(ON)}$ synchronous power switches and fast switching transitions to minimize power loss. An external Schottky diode is not required, but can be added to maximize efficiency. An applied bias voltage of at least 2.7V is required for the internal gate drive and supply of the IC.

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permits positive or negative TEC bias, allowing either heating or cooling in response to feedback loop demands. The temperature control set point is fixed by the bridge resistor value adjacent to the thermistor, in this case 12.5kΩ. Alternately, a DAC controlled potential, supplied to the LTC2053 – input, can establish the set point. The considerable feedback lag due to thermal time constants requires loop compensation. Loop gain-bandwidth is set at the LTC2053 by the feedback capacitor. Various laser modules have different thermal characteristics, mandating care in setting loop gain-bandwidth values. Optimal performance is determined by observing loop response to 0.10°C temperature setpoint step changes while adjusting gain-bandwidth values. Figure 2, the amplified thermistor bridge difference, shows a nearly critically damped response to such step inputs, indicating proper loop compensation. Once optimized, this controller can easily maintain 0.01°C stability under widely varying ambient temperature conditions. Figure 3’s strip-chart recording measures cooling mode stability against an environment that steps 20°C above ambient every hour over 10 hours. The data shows .0035°C peak-to-peak variation, indicating a thermal gain of 5700.

**Notes:**
1. “A Thermoelectric Cooler Temperature Controller for Fiber Optic Lasers” Linear Technology Magazine, pg. 10–13, September 2001. See also LTC Application Note 89, with the same title but considerably more detail.
2. This forum must suffer brevity. Those finding this discussion intolerably brief are commended to LTC Application Note 89, where thermal loop optimization techniques are treated in an appropriately studious manner.
3. That’s right, a strip-chart recording. Stubborn, locally based aberrants persist in their use of such archaic devices, forsaking more modern alternatives. Technical advantage could account for this choice, although deeply seated cultural bias may be a factor.

**Single Cell to 1.8V at 700mA Application**

Figure 2 shows a circuit for generating 1.8V directly from the single cell at 700mA load current. Figure 3 shows the efficiency curves over the operating voltage range of the battery. The efficiency peaks at 95% with a fresh battery, and drops to 90% when the battery terminal voltage is 0.9V. If Burst Mode is enabled at light loads, the efficiency stays above 70% down to 500μA load.

**Conclusion**

Linear Technology’s Low Output Voltage Synchronous Boost converters allow designers of handheld electronics to efficiently regulate a voltage as low as 1.5V directly from a single cell. They provide solutions for prolonged battery life, small circuit board size and easy programmability all in a small MSOP-10 Package.