Boost Converters for Keep-Alive Circuits Draw Only 8.5µA of Quiescent Current

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Introduction

Industrial remote monitoring systems and keep-alive circuits spend most of their time idle. Many of these systems use batteries, so to maximize run time power losses,even during low power idle modes, must be minimized. Even at no load, power supplies draw some current to produce a regulated voltage for keep-alive circuits.

The LT8410/-1 DC/DC boost converter features ultralow quiescent current and integrated high value feedback resistors to minimize the draw on the battery when electronics are idle.

An entire boost converter takes very little space, as shown in Figure 1.

Ultralow Quiescent Current Low Noise Boost Converter with Output Disconnect

When a micropower boost converter is in regulation with no load, the input current depends mainly on two things—the quiescent current (required to keep regulation) and the output feedback resistor value. When the output voltage is high, the output feedback resistor can easily dissipate more power than the quiescent current of the IC. The quiescent current of the LT8410/-1 is a low 8.5µA, while the integrated output feedback resistors have very high values (12.4M/0.4M). This enables the LT8410/-1 to dissipate very little power in regulation at no load. In fact, the LT8410/-1 can regulate a 16V output at no load from 3.6V input with about 30µA of average input current. Figures 2, 3 and 4 show the typical quiescent and input current in regulation with no load.

The LT8410/-1 controls power delivery by varying both the peak inductor current and switch off time. This control scheme results in low output voltage ripple as well as high efficiency over a wide load range. As shown in Figure 5, even with a small 0.1µF output capacitor, the output ripple is typically less than 10mV. The part also features output disconnect, which disconnects the output voltage from the input during shutdown. This output disconnect circuit also sets a maximum output current limit, allowing the chip survive output shorts.

An Excellent Choice for High Impedance Batteries

A power source with high internal impedance, such as a coin cell battery, may show normal output voltage on a voltmeter, but its voltage can collapse under heavy current demands. This makes it incompatible with high switch-current DC/DC converters. The LT8410/-1 has an integrated power switch and Schottky diode, and the switch current limits are very low (25mA for the LT8410 and 8mA for the LT8410-1). This low switch current limit enables the LT8410/-1 to operate very efficiently from high impedance sources, such as coin cell batteries, without causing inrush current problems. Figure 6 shows the LT8410-1 charging an electrolytic capacitor. Without any additional external circuitry, the input current for

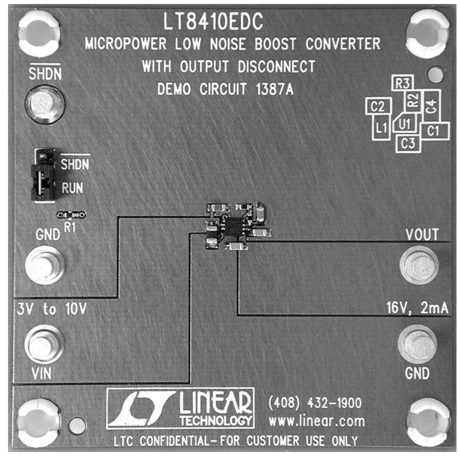

Figure 1. The LT8410/-1 is designed to facilitate compact board layout.

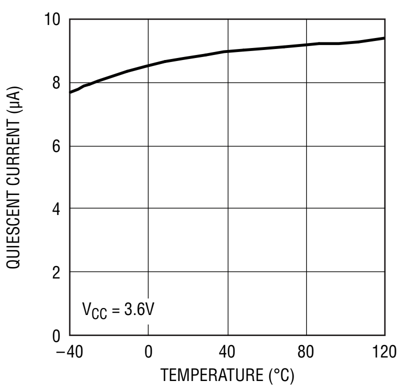

Figure 2. Quiescent current vs temperature—not switching

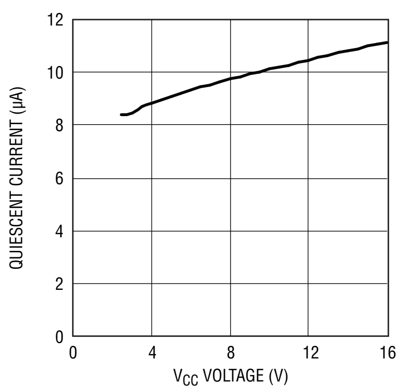

Figure 3. Quiescent current vs V_{CC} voltage—not switching

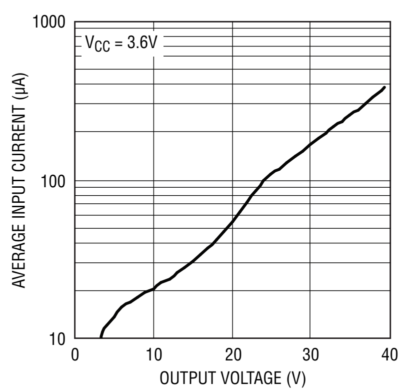

Figure 4. Average input current in regulation with no load

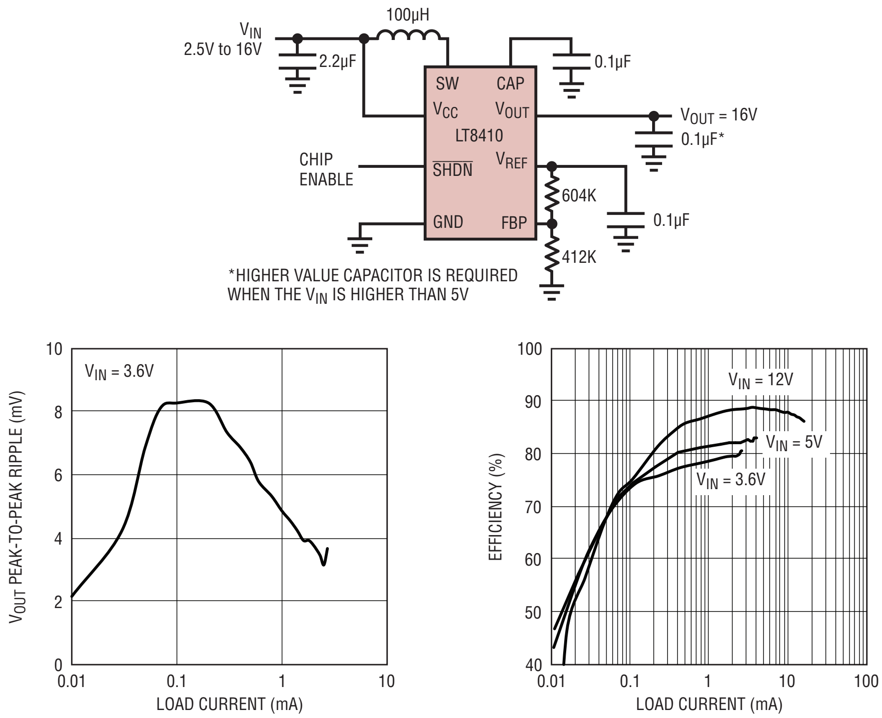

Figure 5. General purpose bias with wide input voltage and low output voltage ripple

the entire charging cycle is less than 8mA.

Tiny Footprint with Small Ceramic Capacitors

Available in a tiny 8-pin 2mm × 2mm DFN package, the LT8410/-1 is internally compensated and stable for a wide range of output capacitors. For most applications, using 0.1µF output capacitor and 1µF input capacitor is sufficient. An optional 0.1µF capacitor at the V_{REF} pin implements a soft-start feature. The combination of small package size and the ability to use small ceramic capacitors enable the LT8410/-1 to fit almost anywhere. Figure 1 shows the size of a circuit similar to that shown in Figure 4, illustrating how little board space is required to build a full featured LT8410/-1 application.

$\overline{\text{SHDN}}$ Pin Comparator and Soft-Start Reset Feature

An internal comparator compares the $\overline{\text{SHDN}}$ pin voltage to an internal voltage reference of 1.3V, giving the part a precise turn-on voltage level. The $\overline{\text{SHDN}}$ pin has built-in programmable hysteresis to reject noise and tolerate slowly varying input voltages. Driving the $\overline{\text{SHDN}}$ pin below 0.3V shuts down the part and reduces input current to less than 1µA. When the part is on, and the $\overline{\text{SHDN}}$ pin voltage is close to 1.3V, 0.1µA current flows out of the $\overline{\text{SHDN}}$ pin. A programmable enable voltage can be set up by connecting external resistors as shown in Figure 7.

The turn-on voltage for the configuration is:

$$1.30 \bullet \left(1 + \frac{R1}{R2}\right)$$

and the turn-off voltage is:

$$(1.24 - R3 \bullet 10^{-7}) \bullet \left(1 + \frac{R1}{R2}\right) - (R1 \bullet 10^{-7})$$

where R1, R2 and R3 are resistance in Ω. Programming the turn-on/turn-off voltage is particularly useful for applications where high source impedance power sources are used, such as energy harvesting applications.

By connecting an external capacitor (typically 47nF to 220nF) to the V_{REF} pin, a soft-start feature can be implemented. When the part is brought

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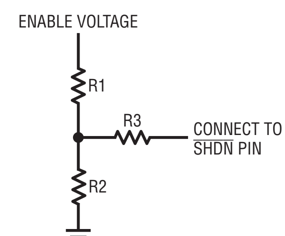

Figure 7. Programming the enable voltage by using external resistors

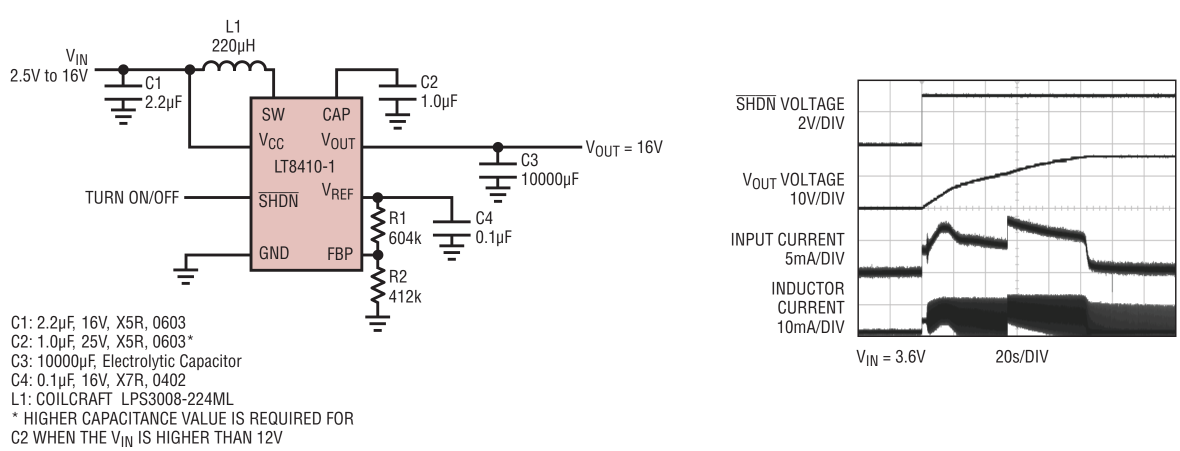

Figure 6. Capacitor charger with the LT8410-1 and charging waveforms

and expensive solution than typical microprocessor-controlled methods.

The simplest scheme uses a resistor divider from the V_{REF} pin to the CTRL pin, where the top resistor in the divider is an NTC (negative temperature coefficient) resistor. While simple, this method suffers from nonlinear temperature coefficient of the NTC resistor. A more precise method uses a transistor network as shown in Figure 7. The PTC (Positive Temperature Coefficient) of the CTRL pin voltage is realized by an emitter follower of Q1 and a V_{BE} multiplier of Q2.

Assuming:

$$V_{BE(Q1)} = V_{BE(Q2)} = V_{BE}$$

and

$$\frac{dV_{BE(Q1)}}{dT} = \frac{dV_{BE(Q2)}}{dT} = \frac{2mV}{°C}$$

then the CTRL pin voltage is

$$V_{CTRL} = V_{REF} - \frac{R8}{R7} V_{BE}$$

with

$$PTC = \frac{dV_{CTRL}}{dT} = \frac{R8}{R7} \bullet \frac{2mV}{°C}$$

Given V_{OUT} at room and dV_{OUT}/DT, the R1/R2 and R8/R7 can be calculated as follows

$$\frac{R8}{R7} = \frac{V_{REF}}{V_{BE} + \frac{2mV}{°C} \bullet \frac{V_{OUT}}{dV_{OUT}/dT}}$$

$$\frac{R1}{R2} = \frac{V_{BE} \bullet \frac{dV_{OUT}}{dT} + \frac{2mV}{°C} \bullet V_{OUT}}{\frac{2mV}{°C} \bullet V_{REF}} - 1$$

Resistors R5–R9 are selected to make I(Q1) = I(Q2) ≈ 10µA, and

$$\frac{dV_{BE(Q1)}}{dT} = \frac{dV_{BE(Q2)}}{dT} = \frac{2mV}{°C}$$

Simulation using LTspice always gives a good starting point. The circuit shown in Figure 7 is designed to have V_{APD} = 50V (V_{OUT} = 55V) at room and dV_{APD}/dT = 100mV/°C (dV_{OUT}/dT = 100mV/°C). The measured temperature response is shown in Figure 8, which is very close to the design target.

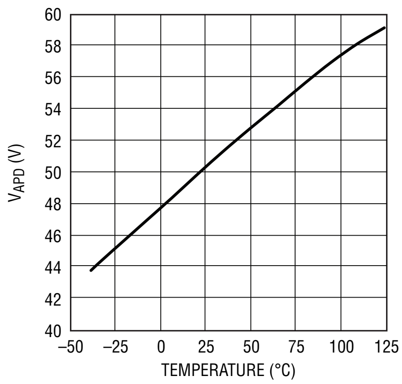

Figure 8. Temperature response of the circuit shown in Figure 7

Conclusion

The LT3571 is a highly integrated, compact solution to APD bias supply design. It provides a useful feature set and the flexibility to meet a variety of challenging requirements, such as low noise, fast transient response speed, and temperature compensation. With a high level of integration and superior performance, the LT3571 is the natural choice for APD bias supply design.

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out of shutdown, the V_{REF} pin is first discharged for 70µs with a strong pull down current, and then charged with 10µA to 1.235V. This achieves soft start since the output is proportional to V_{REF}. Full soft-start cycles occur even with short $\overline{SHDN}$ low pulses since V_{REF} is discharged when the part is enabled.

In addition, the LT8410/-1 features a 2.5V to 16V input voltage range, up to 40V output voltage and overvoltage protection for CAP and V_{OUT}.

Conclusion

The LT8410/-1 is a smart choice for applications which require low quiescent current and low input current. The ultralow quiescent current, combined with high value integrated feedback resistors, keeps the average input current very low, significantly extending battery operating time. Low current limit internal switches (8mA for the LT8410-1, 25mA for the LT8410) make the part ideal for high impedance sources such as coin cell batteries. The LT8410/-1 is packed with features without compromising performance or ease of use and is available in a tiny 8-pin 2mm × 2mm package.

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of handling 60V transients. Figure 4 shows the circuit efficiency at multiple input voltages.

The current limit of the application is set to 1.2A, therefore, the power path components are sized to handle 1.2A maximum. To reduce the application footprint, the LT3663 includes internal compensation and a boost diode. The RUN pin, when low, puts the LT3663 into a low current shutdown mode.

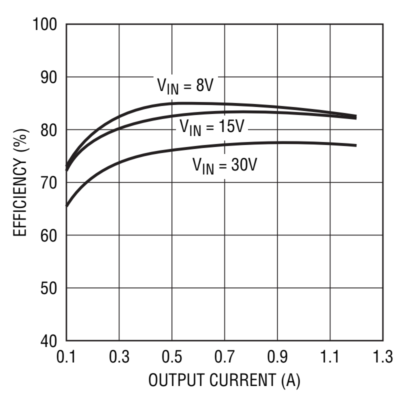

Figure 4. Efficiency of the circuit in Figure 3

Conclusion

The accurate programmable output current limit of the LT3653 and LT3663 eliminates localized heating from an output overload, reduces the maximum current requirements on the power components, and makes for a robust power supply solutions.

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