DESIGN SOLUTIONS

nanoPOWER

Make Your IoT Device Last Longer with a nanoPower Boost Converter

Introduction

Boost converters are widely utilized in consumer electronics to raise and stabilize the sagging voltage of Lithium-ion batteries under load. A new and growing consumer market is the Internet of Things (IoT), a 'cloud'-based network of wirelessly interconnected devices that frequently include audio, video, smart home and wearable applications. The IoT trend, combined with green energy (the drive to reduce wasted power and move to renewable forms of energy generation), demands that small devices operate autonomously for long periods of time while consuming little power. In this article, we present a typical IoT power management solution for small, portable gadgets, while also reviewing its shortcomings. We then introduce a nanoPower boost converter that overcomes these shortcomings, while able to 'operate on fumes' down to minimal amounts of residual battery energy.

Figure 1. Internet of Things Illustration

Typical Wearable Power Solution

A wearable heart monitoring patch (Figure 2) is typically very small and must last a long time, hence minimization of the size and power dissipation is crucial.

Such a device, powered by a 100mAh alkaline button cell and consuming 100µA in operation, will last 3 weeks. On the other hand, in shutdown mode, the device may need to last up to 3 years, which requires a leakage current of 4µA or less. A typical voltage regulator, with a leakage current of 0.2µA and a total quiescent current of 10µA will rob 1.8 months from the device's shelf life and two days of operation.

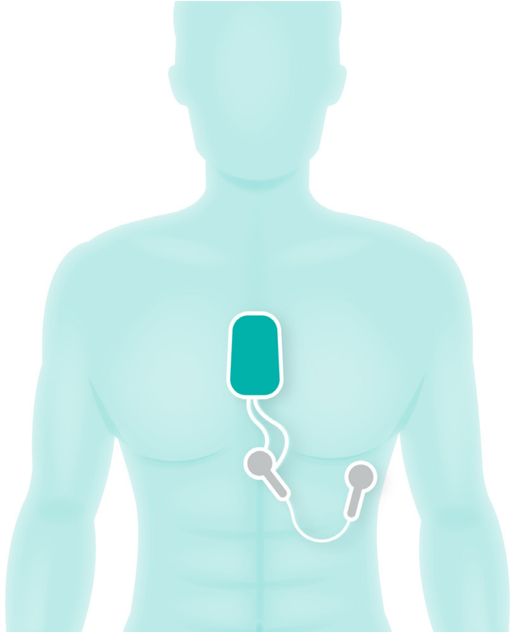

Figure 2. Patient Wearing a Heart-Rate Monitor

High efficiency and small size are challenging requirements. Increasing the frequency of operation will reduce the size of passives while increasing losses, thereby reducing efficiency. The proliferation of portable IoT devices creates a need for multiple customized versions of voltage regulators, especially with respect to output voltage and current specifications. Accordingly, an IoT device manufacturer may be forced to maintain a sizeable and costly inventory of different regulators and the passives required to support them.

A State-of-the-Art Solution

The ideal solution is a voltage regulator that addresses these shortcomings. The MAX17222 nanoPower synchronous boost converter is such a device. The MAX17222 offers a 400mV to 5.5V input range, a 0.5A peak inductor current limit, and an output voltage that is selectable using a single standard 1% resistor.

A novel True Shutdown™ mode yields leakage currents in the nanoampere range, making this a truly nanoPower device!

True Shutdown Current Advantage

Figure 3 illustrates the basic elements of the MAX17222 with respect to shutdown and quiescent currents.

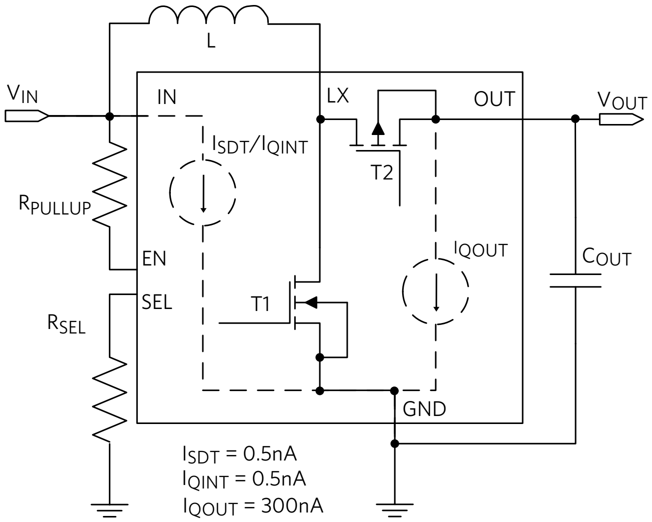

Figure 3. MAX17222 Shutdown and Quiescent Currents

The True Shutdown feature disconnects the output from the input with no forward or reverse current, resulting in very low leakage current. If you recall, the reduction in shelf life we calculated for the typical solution is 1.8 months out of 3 years for a 100mAh cell. With 0.5nA leakage current, the reduction in shelf life for the same cell over 3 years is reduced to only 3 hours!

If a pullup resistor is used to enable/disable operation, the pullup current in True Shutdown mode must also be accounted for. If instead, the enable (EN) pin is driven by a push-pull external driver, which is powered by a different supply, then there is no pullup current and the shutdown current is only 0.5nA.

Quiescent Current Advantage

Referring to Figure 3, the input quiescent current (I_{QINT}) for MAX17222 is 0.5nA (Enable open after startup) and the output quiescent current (I_{QOUT}) is 300nA. To calculate the total input quiescent current, the additional input current needed to feed the output current (I_{QOUT_IN}) must be added to I_{QINT}. Since the output power is related to the input power by the efficiency ($P_{OUT} = P_{IN} \times \eta$), it follows that:

$I_{QOUT\_IN} = I_{QOUT} \times (V_{OUT}/V_{IN})/\eta$

If $V_{IN} = 1.5V$, $V_{OUT} = 3V$ and efficiency $\eta = 85\%$, we have:

$I_{QOUT\_IN} = 300nA \times (3/1.5)/0.85 = 705.88nA$

Adding the 705.88nA to the input current of 0.5nA yields a grand total input quiescent current of 706.38nA (I_{QINGT}). This calculation is 14 times better than the typical case previously discussed. With 0.7µA of quiescent current, the two days of reduced operation calculated for the typical solution becomes only 3.5 hours!

Enable Transient Protection Mode

The MAX17222 includes an option for enable transient protection (ETP) mode. When activated by the presence of a pullup resistor, extra on-chip circuitry powered by the output capacitor assures that EN stays high during short transient disturbances at the input. In this case, the quiescent current calculated above increases by a few tens of nanoamps.

R_{SEL} Advantage

The MAX17222 trades off the traditional resistor-divider that is used to set the output voltage value with a single output selection resistor (R_{SEL}), as shown in Figure 3. At startup, the chip uses up to 200µA to read the R_{SEL} value. This occurs only during the select resistor detection time (typically 600µs), virtually eliminating the contribution of R_{SEL} to the quiescent current. A single standard 1% resistor sets one of the 33 different output voltages, separated by 100mV increments between 1.8V and 5V! The result is a small reduction in BOM (one less resistor) and a lower quiescent current.

Efficiency Advantage

The MAX17222 features low R_{DSON}, on-board powertrain MOSFET transistors, to yield excellent efficiency even when operating at frequencies high enough to warrant a small overall PCB size.

Figure 4 shows the efficiency of MAX17222, with $V_{OUT} = 3.3V$ at various values for V_{IN}. The low quiescent current design extends the outstanding efficiency performance down to a few microamps of load current.

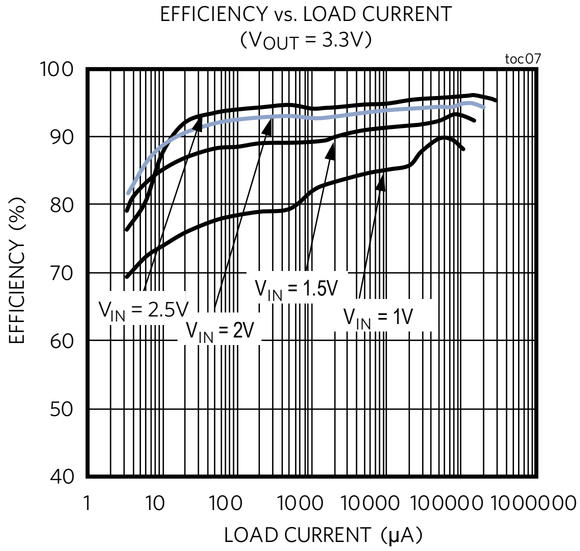

Figure 4. MAX17222 Efficiency Curves

Conclusion

The IoT market has generated an explosion of small, wirelessly connected and battery-operated devices. These devices continue to lower the power loss boundaries for operation (efficiency) and shutdown (leakage current). Maxim's MAX17222, ultra-low quiescent current, high-efficiency synchronous buck converter significantly increases the shelf and operation life of IoT devices and is an ideal choice for this class of applications.

Learn more:

MAX17222 400mV to 5.5V Input, nanoPower Synchronous Boost Converter with True Shutdown

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