



## Why Low Quiescent Current Matters for Longer Battery Life

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## Abstract

Battery life is getting increased scrutiny as our devices continue to shrink but are still expected to deliver more functionality and performance than ever before. Effectively extending battery life in future devices will require mastery of low quiescent current. This paper examines the role of low quiescent current in delivering the battery life essential for today's (and tomorrow's) wearable, mobile, and other smart, connected devices.

## Introduction

What makes all the talk and trends for wearables and the internet of things (IoT) possible? Medical patches that measure body temperature, deliver insulin, and monitor heart rate must run long and reliably. In addition, these devices typically sit in storerooms and medicine cabinets for a long period of time before any patient use. Doctors and users need certainty that their device's batteries will be alive and well at the time of use. Similarly, smartwatches, earbuds, and video game controllers must run for a long time between charges (**Figure 1**). Who wants to keep charging or changing the batteries, or have the device stop working when it's still needed? Imagine having to stop for a charge during a lengthy triathlon-style event. Furthermore, devices like electricity meters, gas detectors, and building automation systems, as well as flocks of field sensors, must have reliable uptime in the field, where they're expected to perform continuously in the background and cannot be charged or maintained

on a frequent basis. From healthcare and biosensing to wearables and environmental sensing, nearly all IoT devices rely on batteries that must perform reliably and over an extended period of time in a variety of conditions. Indeed, battery life has reached a critical juncture.

According to Global Industry Analysts, Inc., the global market for portable battery-powered products is anticipated to reach US\$865.4 billion by 2020, "driven by the growing need for ubiquitous mobility in the current emerging wireless age of networking."<sup>1</sup> Every IoT node needs a battery to run. A typical household of two people could have anywhere from 30 to 60 batteries in use.<sup>2</sup> Each device, of course, will have its own unique energy use patterns.

Let's examine how battery life is calculated, and discuss why quiescent current is important.

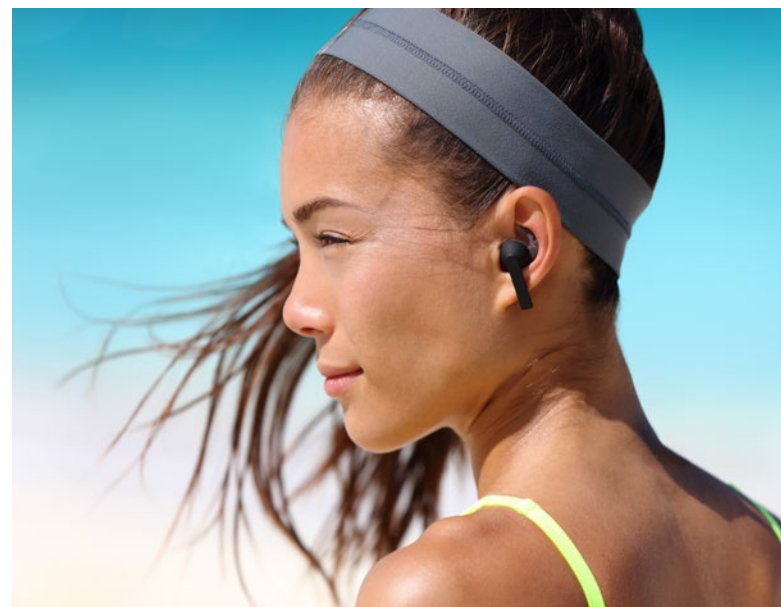


Figure 1. Smartwatches and earbuds are examples of systems where long battery life is essential.

## WHAT FACTORS INTO BATTERY LIFE?

Following manufacturing, many IoT node devices remain in standby mode, usually on shelves, until they are purchased and turned on for use. For most of their lifetimes, these devices are in standby mode, waking periodically to perform some action or transmit data to the cloud. This scenario is particularly true for products such as wearable fitness monitoring devices that users wear for relatively short time spans while they are exercising. Given this, there's a need to consider ways to optimize power usage when devices are in standby mode.

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As the number of IoT nodes grows, power becomes critical as sleep and idle-state functions take larger portions of time. In such situations, the power supply's quiescent current is the biggest contributor to a system's standby power consumption. For example, consider a system powered by a 3.0Vdc, 1.0Ah alkaline coin-cell battery with a shelf life of one year.

**Figure 1** shows coin-cell battery. Assuming that the current drain is about 4 $\mu$ A, reducing the current by a single microamp could increase the available shelf life by about three months.<sup>1</sup>



Figure 1 Coin-cell battery power source device that requires current.

Power supplies typically consist of regulators, such as switching regulators that boost up or buck down the voltage or low-dropout (LDO) regulators. Some also have power management ICs (PMICs) that manage multiple power architectures and perhaps even a battery charge

## DON'T UNDERESTIMATE THE IMPACT OF QUIESCENT CURRENT

When a power supply is in standby mode, power consumption is defined by quiescent current (IQ), which refers to a circuit's quiet state when it isn't doing any real work or inputs aren't cycling. Quiescent current, while minimal, can also substantially impact a system's power transfer efficiency during light load operation.

Sometimes, quiescent current gets mixed up with shutdown current. With quiescent current, the system is still hot and ready to wake at any time to take some action, which is generally how users like their devices. Shutdown

current, on the other hand, is a state where the system is completely powered down. While this is a desirable state for power efficiency, it's not always the best option for all applications. For example, a system that needs to be able to wake up at any time to take some action, such as a security system, would not want to be in a shutdown state.

Power supply and system designers using microcontrollers such as advanced multi-DMIC fabrication processes, who help lower a product's overall power consumption, which could, in turn, positively impact battery life. Some designers will opt for a boost converter to extend battery life when the battery voltage drops to low levels. However, unless the right converter is selected, this approach can actually result in higher quiescent current, which drains the battery faster.

Form factor of the end product is another important consideration. Consumers—and therefore, designers—like their IoT node devices to be smaller and lighter. The challenge is a smaller battery is typically the largest and heaviest component on a device's board. A smaller battery would, of course, mean less capacity—which is contradictory to the demand for longer battery life. So designers must balance capacity and size with efficient power management techniques. Increasing a system's power efficiency presents one common way to increase battery life.

It makes sense to pay close attention to the quiescent current specifications in power regulators such as boost converters—the lower the current, the more you can extend battery life. What is needed, particularly for today's ultra-small designs, is technology that can deliver both lower quiescent current along with a form factor that is smaller than what is currently available on the market. In this case, even currents measured in the milliamperes are not low enough to make an impact on battery life. Today's wearable mobile, and IoT designs call for more comprehensive current flow.

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## CHOOSING THE RIGHT BOOST CONVERTER

Boost converters are DC-to-DC converters whose output voltage is greater than that of the source voltage. Looking at the boost converter market, Vn (3V) boost power management circuits are the fastest growing segment, according to industry analysis **Figure 3** shows revenue projections for the global boost converter market. Based on the requirements for the IoT applications that are driving the growth, designers are seeking boost converters offering lower voltage rds, longer battery life and smaller solution size.

Choosing the right boost converter that will successfully extend battery life calls for close examination of some key criteria, including:

1. Quiescent current: The lower the current, the better the performance in low-current applications.
2. Load regulation: The better the load regulation, the better the performance in applications with varying loads.
3. Efficiency: Measured in Vn, VOUT, and DUTY, the higher the percentages, the better for increased battery life (Vn/VOUT efficiency at 100% load is ideal).



Figure 3. Global revenue projection for boost converters.

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Evaluating the vendor's track record in power management technologies is also important. Trusted vendors have long histories of delivering advanced technologies to customers of all sizes and in a variety of industries, continually enhancing their expertise and their products over time. Some also provide customers with online simulation tools for evaluating efficiency curves and bill of materials (BOM) costs based on their design specifications. Access to evaluation kits and boards provides a quick way to prototype designs of various sizes. In addition, the availability of ultra-small packages is essential for cost- and size-sensitive designs.

## ULTRA-LOW QUIESCIENT CURRENT BOOST CONVERTERS WITH TRUE SHUTDOWN

Maxim now offers boost step-up DC-to-DC converters with ultra-low quiescent current (200nA) and True Shutdown™ technology, ideal for battery-powered applications that require long battery life. The MAX7222 nanoPower boost regulator features a 220mA/100µA/100 peak inductor current and Figure 4, with True Shutdown technology, the output is disconnected from the input without forward or reverse current. Output voltage can be selected using a single standard 1% resistor. The MAX7222 features post-charge mode transient protection (PTM), which allows the output to remain regulated for input voltage dips to 800mV, depending on the load current. The boost converter is available in 2.8mm x 1.6mm 5-lead WDF and 8-pin uDFN packages and features 92% peak efficiency to minimize heat dissipation.

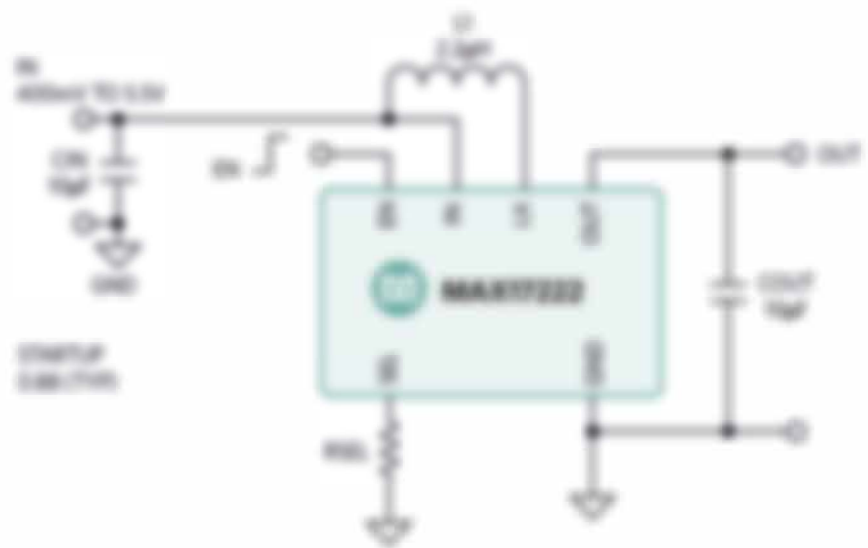


Figure 4. nanoPower boost regulator block diagram.

## SUMMARY

When looking at ways to extend battery life in your next design, don't underestimate the impact of quiescent current (I<sub>q</sub>). It's important to understand the power profile of your end product - this will give you targets to aim for. When it's time to consider the components that go inside, look for devices that offer quiescent current at the lowest end of the temperature spectrum as possible. The combination of low quiescent current, along with specifications like true shutdown, low input voltage range, and high efficiency at the  $\mu$ A level, will help you deliver smart, connected products that meet customer demands for high uptime and charge.

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