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APPLICATION NOTE 6549

OP AMPS AND THE IMPORTANCE OF LOW QUIESCENT CURRENT

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Abstract: The increase in small, battery-powered products has placed a spotlight on the power consumption of operational amplifiers (op amps). This application note discusses why low quiescent current is an important characteristic for op amps, particularly for portable applications.

Introduction

Operational amplifiers (op amps) have come a long way since the 1940s, when they first appeared in their early forms. Their designs have continued to evolve since they were first introduced, such that well into the digital age they can still meet the needs of new and emerging applications. This application note discusses the importance of low quiescent current when it comes to op amps, particularly for portable applications.

Op Amps: Analog Insurance

You can think of op amps as analog insurance. With a long-standing role as a key building block in analog circuits, op amps manage useful functions like feedback control, differentiation, addition, multiplication, and integration. With digital systems, these components are useful in applications such as analog-to-digital converters (ADCs), digital-to-analog converters (DACs), buffers, and regulated power supplies. Their role in ensuring that the voltage levels in your design are where they should be is critical. Op amps also perform an important signal-conditioning role, ensuring that analog signals are clean before they are converted into digital signals.

We now have an increasing volume of battery-powered products in everyday use. Many of these, such as wearables and hearables, come in very small form factors. As a result, power consumption of op amps is under more scrutiny. For portable applications, op amps must operate from a lower, and typically single, positive supply voltage. They must also consume less current. Even with these specifications, some op amps still must operate at higher frequencies or with lower noise, while drawing less current. This certainly creates some design challenges.

The good news is that op amps are continuing to evolve and advance. These analog components are becoming more precise and are providing better thermal and long-term drift. Supply current is reducing, and the parts are getting smaller. Some IC vendors develop op amps for specific purposes. For example, some parts are designed for precision and low noise, and some deliver high voltage. There might also be variations that are low in power consumption and available in small packages, and with CMOS inputs with low input bias current. This array of part types is great for a variety of applications, including small, battery-powered designs.

How Lower I_Q Supports Longer Battery Life

Quiescent current, or IQ, is another specification worthy of close consideration. Quiescent current refers to a circuit's quiet state when it is not driving any load and its inputs are not cycling. It is typically nominal; however, it does have a big impact on battery life, especially when it comes to wearables, hearables, and internet of things

(IoT) sensor nodes. These types of products are typically designed to wake periodically to perform some action. Afterward, they fall back into standby mode. Some products, such as medical patches, could remain on stockroom shelves for extended periods of time before being put to use. For all of these products, users expect long battery life.

Battery life is calculated based on active, sleep, and hibernate currents of the central controlling unit, such as a microcontroller. The power supply provides energy to all of the system's functional blocks. While active current consumption plays an important role in extending battery life, runtime is ultimately influenced by how much time is spent in each power mode. Therefore, as sleep and hibernate modes occupy longer periods of time in a device, the standby current of each component becomes more critical. In such cases, the power supply’s quiescent current is the biggest contributor to standby power consumption in the system. That is why it is prudent to build power supplies with components that have low quiescent current.

For example, consider a small device powered by a lithium coin-cell battery with these specifications:

- 34mAh from 3V to 2V terminal voltage
- 1% per year self-discharge, which translates into a 39nA self-discharge current
- 10-year operating life, 390nA average load

For a device that spends a long time in idle mode, an op amp with low quiescent current (at nanoamp levels, for example) can produce significant energy savings. For example, let us take a look at an IoT sensing system that powers up for 15ms every minute to take a measurement. This system would use an average of 2.5μA an hour. Using the lithium coin-cell battery from our IoT sensing system example (34mAh rating) should supply the circuit for 18.6 months. Adding in the losses from an op amp even at a low 1.5μA , there is a substantial loss of 60%. By comparison, if we were to use an op amp with nanoamp current levels, losses contributed by this part would decrease to around 30%.

Faster Time to Market

In addition to being used as a discrete component, op amp functionality can also be integrated into a system on a chip (SoC). Designing with an SoC, however, minimizes the flexibility that discrete components offer. This approach can also extend the design cycle, as the application developer must work with (and wait for) an SoC vendor to create a chip that fits the design’s particular specifications. Given that fast time to market is essential for consumer products like wearables, hearables, and IoT devices, it is prudent to use a small, discrete op amp with low quiescent current.

Maxim's MAX40007 nanoPower op amp is ideal for small, battery-powered portable products, like wearables, smartphones, tablets, and medical devices. Shown in **Figure 1**, the MAX40007 consumes just 750nA and is available in a 1.1mm x 0.76mm WLP. It can also be designed in quickly. With its small size and low quiescent current, the IC is suited for early generation designs—when using discrete parts that won’t take up much board space or add significant current drain, this can be a time-to-market advantage. Operating from a single 1.7V to 5.5V supply, the op amp can be powered by the same 1.8V, 2.5V, or 3.3V nominal supply that powers the system’s microcontroller.

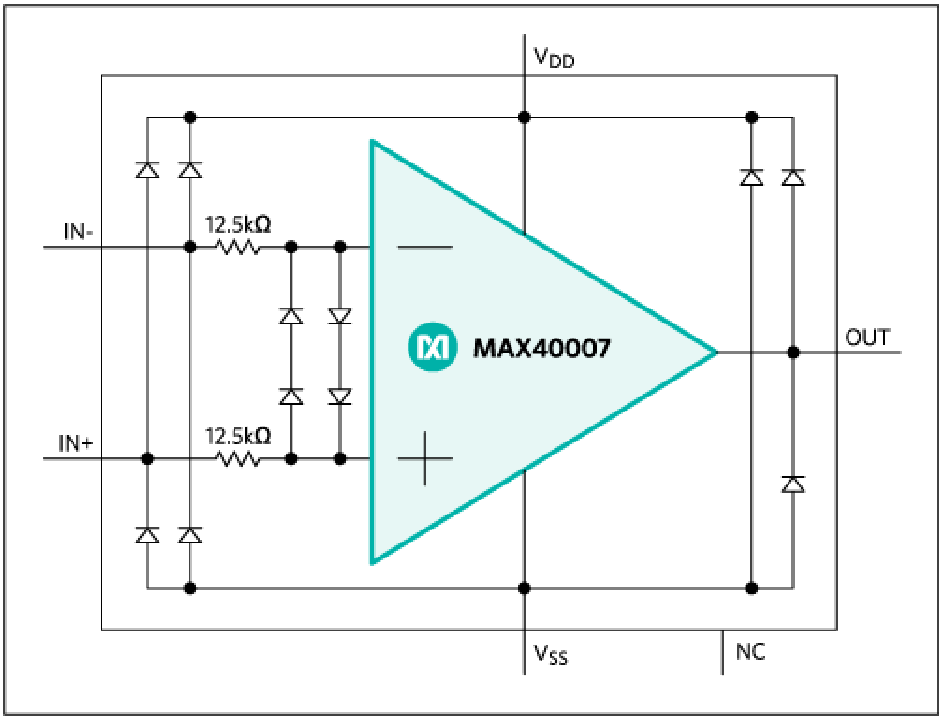

Figure 1. The MAX40007 nanoPower op amp is available in ultra-tiny WLP and SOT23 packages.

As an example end application, consider the portable patient monitoring design shown in **Figure 2**. To the left of the processor, in the signal chain block, two op amps are used to filter the signals from the pulse-oximetry, secure authentication, and blood pressure sensors before they are processed by the ADC. As a portable device, this patient monitoring design can benefit from low quiescent current and small form factor for its underlying components.

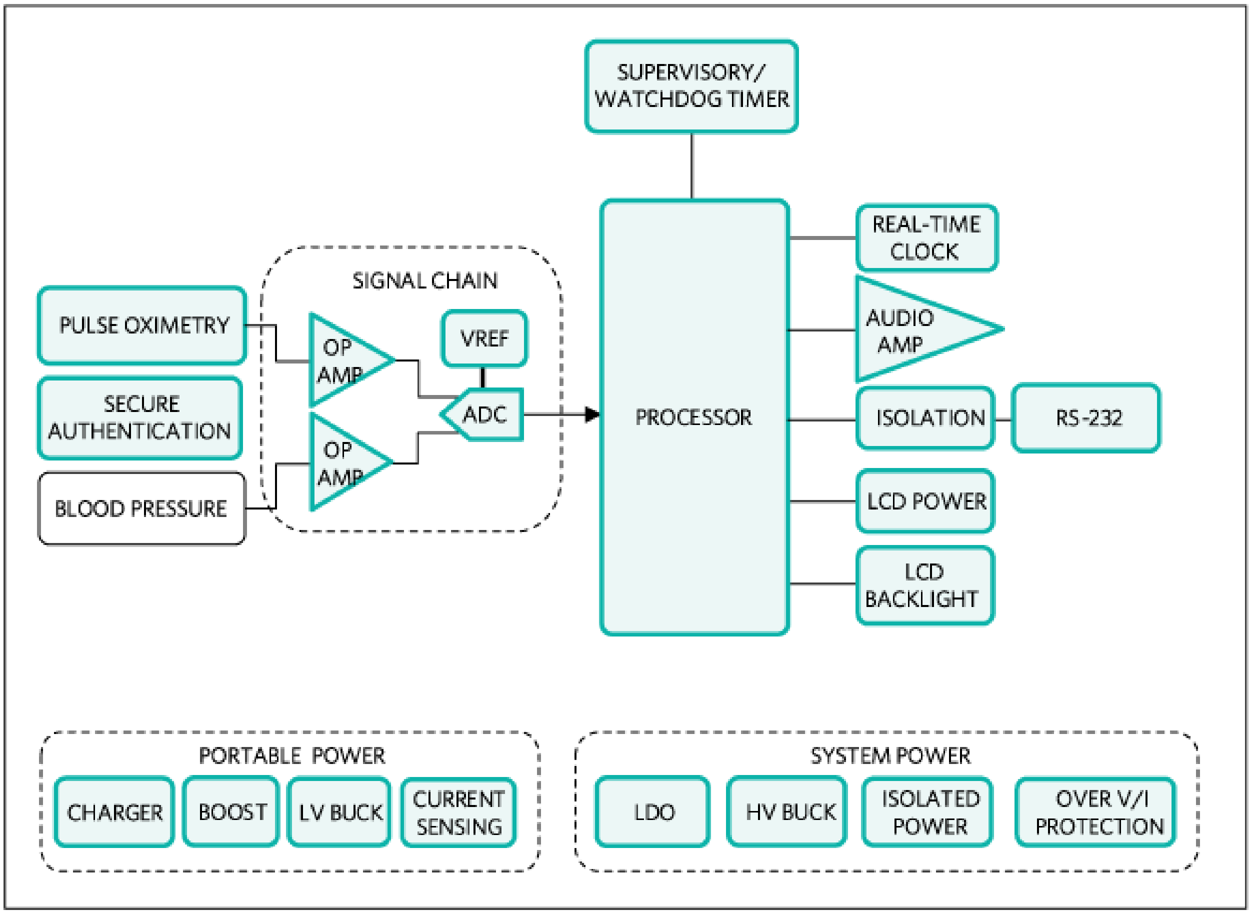

Figure 2. Block diagram of an example patient monitoring design, showing key components inside.

Conclusion

The proliferation of small, battery-powered products has placed a spotlight on the power consumption of op amps. These analog components are increasingly more precise, use less power, and they are getting smaller. Very small op amps with low quiescent current (IQ) have proven to be ideal in meeting the design requirements of increasingly ubiquitous battery-powered devices such as wearables, hearables, and IoT sensors.

A similar version of this application note appeared on Electronic Products on October 17, 2017.

Related Parts		
MAX40007	nanoPower Op Amp in Ultra-Tiny WLP and SOT23 Packages	Free Samples

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