Maxim > Design Support > Technical Documents > Application Notes > Power-Supply Circuits > APP 3603

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APPLICATION NOTE 3603

Buck Converters Proliferate in Handhelds as Features and Processing Power Increase

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Abstract: Portable consumer electronics are integrating many new features. System designers are challenged to meet the consumer's expectations for small physical size and long battery life. Each new product feature requires extra space and extra processing horsepower. Meanwhile, there is less room left for the battery and an increasing demand for higher power-supply output current with greater efficiency in a smaller space. This article recognizes these current demands on power-supply design and compares different regulator types for use in small portable devices.

Introduction

Modern portable consumer electronics integrate so many new features that the latest incarnations often become hard to classify. While more features can increase sales, system designers are challenged to meet the consumer's expectations for small physical size and long battery life. Each new feature requires extra space and extra processing horsepower. This leaves less room for the battery and increases the power-supply demand for higher output current with greater efficiency in a smaller space.

The Demand for More Power Changed Designs Criteria

As recently as one or two years ago, most handheld electronics typically used no or one step-down (buck) converter and many low-dropout (LDO) linear regulators to power the various functional blocks. This worked well because popular processors were typically powered at 3.0V to 3.3V, a voltage range in which the LDO is suitably efficient with a single-cell Li+ battery input. However, as processing demands increased and IC process technology migrated to smaller submicron geometry, popular core voltages dropped to 1.8V, 1.5V, 1.3V, and even 0.9V. Typical I/O voltages, moreover, have dropped from 3.3V to 2.5V or 1.8V. At these low output voltages, the LDO becomes very inefficient and produces significant heat, negating some of the advantages of the low-voltage core and I/O. Consequently, to maintain high efficiency with low output voltages, designers must switch to a buck converter.

To compound the need for low supply voltages, many systems now rely on multiple processors. The cellphone + PDA combination is a good example as it generally has a baseband processor and an applications processor, each requiring individual power. Today's popular camera modules for cellular handsets and PDAs still tend to run on an LDO, but the associated graphics processor often needs a low voltage. Consequently, modern multifunction designs usually employ multiple buck converters. It is not uncommon to find three buck converters on the PCB.

While the newest custom power-management ICs (PMICs) already integrate one or more buck converters, that is often not enough for these handheld applications. With every new feature, there is the potential for yet another buck or the need for a buck with higher output-current capability. It is becoming apparent that those manufacturers who use discrete power-supply ICs to rapidly offer new features over a diverse product portfolio are the same manufacturers with the fastest growing market share.

The Challenge of Size

Until recently, the cost of adding a buck converter could be counted not only in real money, but also in substantial PC board real estate. Three years ago the typical small buck converter was packaged in a $15mm^2$ MSOP package and switched at 1MHz or less, requiring a big external inductor and usually large tantalum capacitors. As seen in **Figure 1b**, today's 1MHz buck converter is far improved with a $9mm^2$ TDFN package, ceramic capacitors, and newer, smaller inductors. However, the 1MHz buck converter is still far bigger than the typical LDO, as seen in **Figure 1a**.

The key to solving the size problem is that modern, submicron BiCMOS mixed-signal processes enable smaller power-supply ICs and faster switching frequencies for smaller external components. Today, many manufacturers offer 2MHz or higher in a small package. As **Figure 1c** shows, a 4MHz buck converter solution, such as Maxim's MAX8560, may be nearly as small as an LDO! With high-switching frequency, it is possible to utilize very small modern chip inductors, such as Taiyo Yuden's CB2012 series in 0805 case-size.

Although process advancements benefit both the 1MHz and 4MHz buck converters, the 4MHz buck still falls short of the 1MHz buck efficiency, as seen in **Figure 2**. High-speed switching causes more switching losses and capacitive losses in the converter, while the tiny inductor tends to have more magnetic-field core-loss. The efficiency difference is not so great, however, especially compared to the LDO's low 41% efficiency.

Summary

This leaves system designers with a choice for power management: a) smallest size, b) highest efficiency, or c) small size and high efficiency, the latter allowing a smooth trade-off between battery life and physical size. As the high-frequency buck converter (choice c) offers such a dramatic efficiency improvement with little increase in size, it is becoming the favored solution in multifunction, portable consumer handhelds. Looking to the near future, because the buck converter produces less heat than the LDO, it has the potential to displace the LDO as the smallest solution.

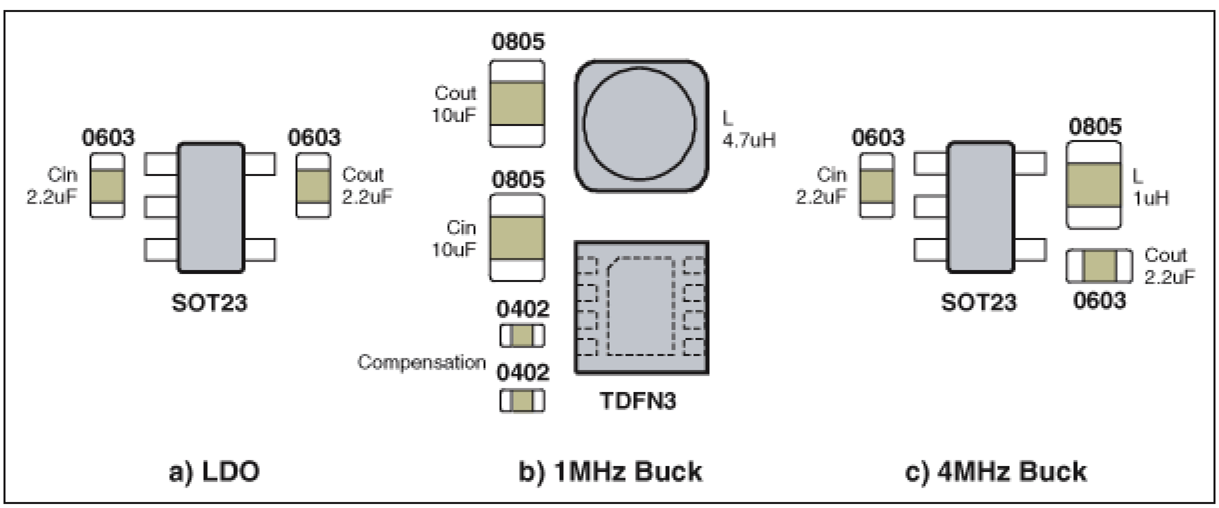

Figure 1. While not so efficient, an LDO linear regulator (a) is a physically small solution. The traditional

1MHz buck converter (b) provides very high efficiency, but at a large size penalty. The newest high-speed 4MHz buck converters (c) are sized close to the LDO and close to the 1MHz buck in efficiency.

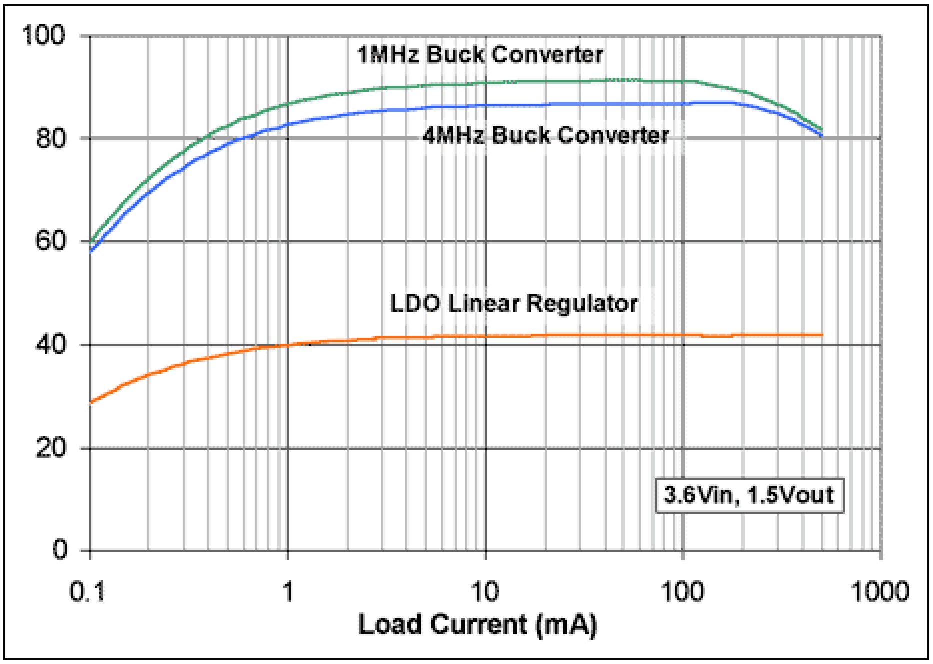

Figure 2. Both buck converters are far more efficient than the LDO linear regulator. The 4MHz buck converter, however, sacrifices a few efficiency points to achieve a dramatically smaller solution.

Related Parts		
MAX8560	4MHz, 500mA Synchronous Step-Down DC-DC Converters in Thin SOT and TDFN	Free Samples

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