PowerWise® Solutions and the Future of Energy Utilization

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Introduction

Today's technological civilization is driven by energy – whether stored or captured, it is required to run our machines. Without energy and the proper method to convert it into useful power, much of our technological world would stop working. In 1908 William A. Smith stated, "Engineering is the science of economy, of conserving the energy, kinetic and potential, provided and stored up by nature for the use of man. ***It is the business of engineering to utilize this energy to the best advantage, so that there may be the least possible waste."***

It was noted even in the early part of the 20th century that it was good engineering practice to be conservative with the available resources. Today, it has become a requirement. In electronic design, power is a finite commodity. Additionally, much of the power that runs electronics ends up as wasted heat which provides no useful work. Think of the engines of the Internet and cellular infrastructure. A large blade server farm can house over 10,000 computers each using roughly 200 watts of power, not to mention the air conditioning required to pump the excess heat out of the buildings. Add the future requirements for streaming video and the power numbers sky rocket. This pattern of increasing power consumption will only continue as more countries add capability for their populations.

With this trend in mind, National Semiconductor has continuously developed products that provide a level of performance at reduced power consumption. This is the PowerWise brand – products that have exceptional performance-to-power ratios. PowerWise components can be found in every National product family from interface products to high-speed data converters, from communication devices to power regulators. What qualifies National's devices to be PowerWise components? Let's start by evaluating the metrics.

The Performance-to-Power Ratio

A simple metric for an automobile is the miles per gallon (MPG) or kilometer per liter (KPL) rating. As the cost of gasoline (our current infrastructure portable energy storage medium) rises, this metric becomes more important. This is the same concept as the performance-to-power ratio. This can mean two things to an engineer – ***lower power consumption and excess heat generated, or higher performance at the same power consumed.***

The obvious advantage of lower power is higher economy (less dollars spent on energy) or longer battery life (i.e., play time on a portable music player). A not so obvious advantage is longer service life from reduced heat wear on the electronics from semiconductor fatigue in the presence of elevated temperatures. The lower the ambient temperature, the longer service life a product or system will provide. This can also lead to reduced cost due to longer replacement periods.

In other cases, a new design may need to be implemented with the previous resources (space, power, waste heat limits, etc). A classic example could be a cable set-top box (STB). The physical space is either the same or smaller then the previous model, the power (which directly relates to the waste heat) is either the same or lower, however the design requirements probably specify a higher level of performance (i.e. a classic standard definition STB now moving to HDTV and adding DVR capability). This design change is a challenge in that the resources have not changed – the power and physical space remain the same. If the designer is going to succeed, then higher performance components that use the same or less energy will be required. This is the advantage of increasing the performance-to-power ratio.

Architecture Versus Process

National has understood for many years the importance of process technology – not only for consistent high quality, but also for higher performance at lower power. National was a pioneer with the industry's first CMOS operational amplifier as well as the architects of Low Voltage Differential Signaling (LVDS) communication devices and Low Dropout Regulator (LDO). High bandwidth, low leakage processes are essential to providing great overall performance in semiconductors. But that is only half of the story.

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The techniques and intellectual property that implement device designs are as important as the processes themselves. For example, National's newest PowerWise ultra-high-speed Gigasample ADC083000 A/D Converter uses a novel folding converter topology that greatly reduces the power required to sample at 3 Gigasamples per second at less than 2 Watts. This is an architecture that greatly reduces power consumption over other converter architectures such as flash converters. The folding architecture also scales well where flash converters double their power consumption with every bit of resolution that is added.

Systems Versus Components

Another important aspect of the performance-to-power ratio metric is not always apparent in looking at individual components. It is how these components enable lower power consumption. A good example of this is the use of Adaptive RF power in handsets (See ***Figure 1***. Using the LM3208 in combination with the LMV228 power detector, the Pdc component of the PA can be dramatically reduced – both of these devices would be considered PowerWise products for systematically reducing power in a cellular handset output stage.

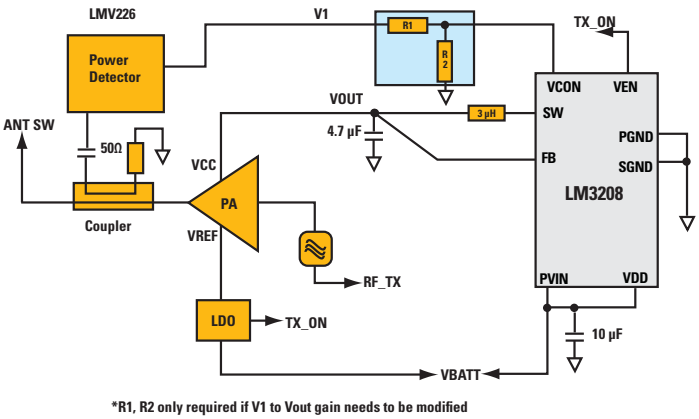

Figure 1

Tools for Increasing Efficiency

Another category that makes a National device part of the PowerWise product family, is the availability of tools to optimize their implementation. Some components need to have tools to help facilitate a high performance-to-power ratio. This applies mostly but not exclusively to switching power regulators. WEBENCH® design tool allows the engineer to "dial in" a performance level for power supply designs as a trade off to other parameters (i.e. size of components). A good example of this is the fourth-generation SIMPLE SWITCHER® family (i.e. LM25576). This family is supported in the WEBENCH tool with a control for optimizing the design of the system with trade-offs between conversion efficiency and footprint as shown in ***Figure 2***.

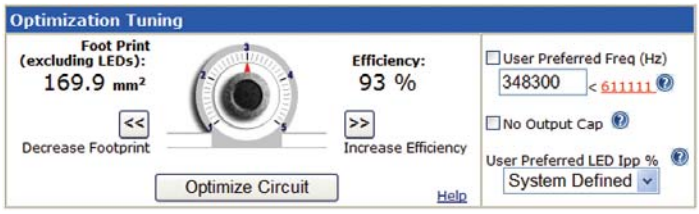

Figure 2. WEBENCH Optimization Control

Intellectual Property and Systems Knowledge

National has not only been providing solutions for increasing the performance-to-power ratio for the analog sections of systems, but for the digital cores as well. National's PowerWise Adaptive Voltage Scaling (AVS) solutions have been used in digital cores found in many cellular handsets. This is truly a system solution that works in combination with the processor and an external Power Management Unit (PMU) such as the LP5552. The intellectual property in the processor core monitors the performance of the system and adaptively adjusts the supply and bias voltages to significantly reduce power consumption in the digital processor up to 70%. AVS PowerWise products constantly adjust in real time to provide the highest level of performance at the lowest power consumption resulting in greatly increased operating time from a single charge.

As digital processes shrink to ever smaller geometries, static power will begin to overtake the dynamic power as more transistors are packed into a smaller space. Process engineers are constantly struggling to find ways to reduce internal leakage which at larger geometries (above 90 nm) were manageable. PowerWise AVS solutions can be applied to these problems to greatly reduce the static power and increase either run time (batteries) or to reduce overall power dissipation.

Reference Designs

Reference designs are important in providing engineers a template for good design practices, especially when looking to increase performance without increasing power consumption. Much of the difficult design issues such as proper component selection and placement, layout and routing are provided in these reference designs.

Building on the knowledge gained from helping customers create high performance analog systems, National is providing a library of reference designs that illustrate the best system performance. An example is the latest addition to this library – the ADC083000 reference design which not only implements a complete instrumentation (i.e., Oscilloscope, Automatic Test Equipment etc.) analog front end (AFE), but also uses the new PowerWise LMH6555 1.2 GHz differential driver as part of the signal chain. This component in combination with our PowerWise ultra-high-speed ADC083000 data converter and timing solutions provides a great starting place for engineers involved in designing instrumentation.

The Future

From Email to Streaming Video

For a good example of why energy efficiency is important, let's examine a phenomenon to which most can relate. In the early days, the Internet (circa 1990) was used to move small files and mostly emails. Emails of the day only contained text and HTTP was just beginning to be used to support HTML encoded rich content. As the World Wide Web emerged and e-commerce began, the Internet was moving a much larger amount of data traffic including photos and extremely rich content. Once a simple method was found to compress audio (MPEG 1 Layer 3 or MP3), audio was being shipped around as well, absorbing the available bandwidth and driving consumers to find faster connections to the Internet.

Today we see the emergence of a new breed of bandwidth draining content called streaming video. Recent data released by Ellacoya Networks in June, 2007 showed that YouTube accounted for 20% of HTTP traffic or nearly 10% of all Internet traffic. This is the first time that HTTP based traffic has exceeded Peer-to-Peer (P2P) applications such as email. As consumers demand more video over IP networks, it won't only affect the infrastructure, but also the end devices. Mobile video streaming is very demanding and requires not only decompression, but high quality audio. Add in local compression for sending video in real time (now appearing on many handsets), then power is once again being consumed for additional features.

In the not-to-distant future, streams of video with audio will be the normal traffic found on the Internet. Most handheld portable devices will support video recording and playback as well as real-time streaming which will also require low-latency and high-bandwidth availability. All of these features require large increases in infrastructure as well as local processing power. This is why the performance-to-power ratio is so important to design.

Conclusion

As the market forces drive the adoption of streaming video, instant bandwidth, and unlimited storage capacity, the resources required to fuel it all remain finite. According to the US Department of Transportation, in the 1970's automobiles on US highways only averaged 12 MPG, today's vehicles can easily reach 30 MPG on the same fuel used 35 years ago. Additionally, high-performance "muscle cars" of today can easily boast 500 HP and still achieve reasonable mileage. This is what increasing the performance-to-power ratio can achieve. The same gains can be made in electronic devices, and National's PowerWise product family of products enable this performance increase in systems from the processor core through the the signal path.

For more information on PowerWise technology, visit:
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