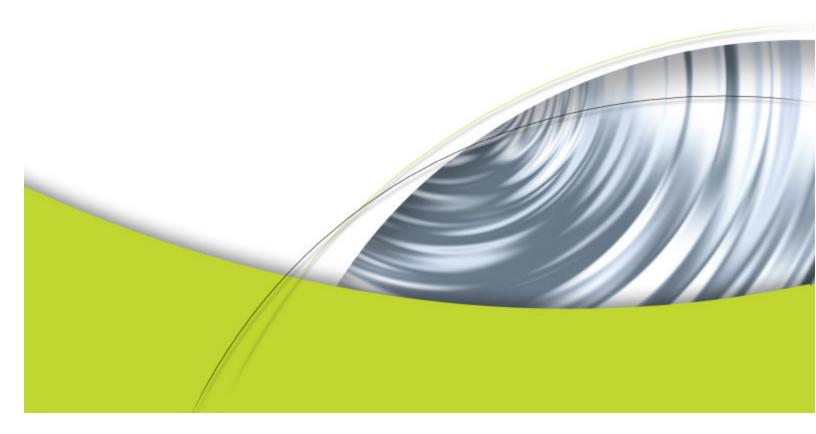# Technical Brief

NVIDIA nPower Technology
Power-Saving Technology for
Mobile Multimedia Devices

Power-Saving Technology for Mobile Multimedia Devices

Introduction

The NVIDIA® GoForce™ product line brings advanced multimedia features—video conferencing, streaming video, photographic-quality 3D, and image capture—to mobile devices such as mobile phones, mobile gaming platforms, and PDAs. As more sophisticated features are incorporated into these systems, long battery life becomes critical.

With NVIDIA nPower technology, GoForce products enable users to make full use of all the exciting features of the latest mobile devices without worrying about running out of battery power.
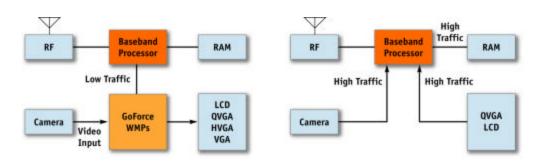
From an overall product perspective, NVIDIA nPower technology is a comprehensive approach to power reduction and energy management in wireless mobile devices. Intelligent architectural decisions, such as using dedicated hardware engines and embedding just the right amount of tightly coupled SRAM memory, form the foundation of an ultra low-power design. And, the unique and careful implementation of that design ensures that products will exceed users' expectations—not only in performance, but in battery life.

Architectural Approach to Power

The goal of NVIDIA nPower technology is to enable the creation of high-performance, multimedia-rich, wireless mobile devices with extended battery life. Because optimizing the energy use of just one device at the expense of another does not represent a complete solution, GoForce products approach power from an overall system perspective.

System Architecture Comparison

Figure 1 (left) is an example of a system architecture based on a GoForce wireless media processor (WMP). In this example, GoForce handles all functions for the multimegapixel camera preview without involving the baseband processor. The high-bandwidth datapath is straightforward: From the camera module, into the GoForce video input, and (after color space conversion and scaling) from the flat panel interface to the QVGA (and up to VGA resolution) display. With no need for processor intervention or external memory access to an external frame buffer, the

total power dissipation is less than 8 mW for 1.3 megapixel preview (GoForce 3000).

Figure 1.   GoForce (Left) vs. Baseband Only (Right)

Contrast that with Figure 1 (right), which is a baseband processor only and does not include a WMP. The camera is connected to the baseband processor, which must stop (or at least slow down) what it's doing in order to perform the color space conversion and scaling. Even if the baseband processor can support megapixel resolution, it's unlikely it can perform the calculations fast enough to achieve fluid motion on the preview display. Plus, the image data must be written to the system memory, which requires much more power than the internal frame buffer of the GoForce WMP. To display the image, information must be read back out of external memory (more power), and directed to the display. Directing it to the display may also require an external timing generator—another built-in function on all GoForce products.

In addition to higher power requirements and higher demands on the system processor, the bus bandwidth requirements are greater in systems without a GoForce.

Hardware Engines

The GoForce family includes custom hardware-based acceleration engines for the following, computationally complex functions:

- ❑ 3D graphics (128-bit)
- ❑ MPEG-4 codec
- ❑ JPEG codec
- ❑ Video input
- ❑ 2D graphics (64-bit)
- ❑ LCD controller

These hardware engines are highly optimized to perform their specific functions, and they perform them far more efficiently than a general purpose CPU that executes software instructions. This results in higher performance and longer battery life.

Amazing On-the-Go 3D Graphics

GoForce 3D 4800 and GoForce 3D 4500 elevate the quality and performance of on-the-go gaming to a new level. Never before has it been possible to achieve rich, immersive 3D graphics on a mobile device at power consumption levels that enable hours (and not just minutes) of exciting gaming.

Running a typical 3D game, GoForce 3D WMPs consume approximately 20 mW of power. A particularly complex and visually rich game uses 35 mW to 50 mW. NVIDIA achieves these remarkable numbers by utilizing an entirely new 3D architecture optimized specifically for mobile devices. Multitexturing, early-Z, and an intelligent pipeline that only uses as much power as required, combined with 128-bit wide onboard memory, mean that GoForce 3D WMPs can provide incredible performance at very low power consumption.

Customized, dedicated hardware engines inside the GoForce 3D 4800 and GoForce 3D 4500 are what make high-level gaming performance and immersive visual quality possible. No general purpose processor (CPU or DSP) comes close to providing the required MIPS. And even if such a processor existed, a software-based solution would dissipate 100 to 1,000 times as much power. A high-capacity 800 mAh battery would last less than two minutes.

Capturing a Megapixel Image

Let's take the example of capturing a megapixel image. JPEG encoding of a 1.3 MP image requires approximately 175 MIPS. If you performed this task in software on a typical processor, the device would dissipate approximately 280 mW, assuming it operated at 300 MHz (this allows for overhead to drive the LCD, camera, operating system, and so on). The GoForce 3000, by comparison, dissipates approximately 13 mW while performing a megapixel JPEG encode, including continuous QVGA display refresh.

Similarly, a baseband may claim that it supports JPEG encode without a separate accelerator chip. However, the power dissipation of the processor could be more than ten times higher than a system solution that includes a dedicated wireless media processor such as GoForce, and still not provide the same level of performance.

Reducing Power Consumption

Table 1 contains typical power dissipation numbers for a processor driving a QVGA display, but with most peripherals (such as MMC, AC97, UART, and I2C) switched off. The GoForce wireless media processor can provide additional system-level power savings by allowing the processor to operate in idle mode when it would otherwise operate in active mode.

Table 1.   Typical Processor Power Consumption

Core Frequency	Active (Clock On)	Idle (Clock Off)
33 MHz	–	45 mW
200 MHz	178 mW	63 mW
300 MHz	283 mW	77 mW
400 MHz	411 mW	121 mW

Working alone, a processor needs to be in active mode when previewing a megapixel camera image onto the LCD. If a GoForce product were added to the system, it would handle the entire preview operation, dissipating less than 6 mW (GoForce 2150), without CPU involvement. The processor could be placed in a low-frequency or idle mode. Table 1 shows the dramatic power savings from switching from active mode to idle mode.

Working in Other Applications

Hardware engines affect other applications as well. A good example is when a user accesses a graphically rich Web site. A GoForce WMP provides substantial system power savings by allowing the processor to run at a far lower clock speed, and offloading accelerating functions such as line draw, rectangle fill, and screen-to-screen copy. This could reduce power consumption (Table 1) by more than 50 percent (178 mW versus 411 mW).

Embedded Memory

The size, width, and type of memory used are critical components of the NVIDIA nPower technology (Table 2). In a GoForce 2150, for example, the 160 KB of embedded SRAM adds tremendous value by letting the critical functions for preview and capture of 1.3 MP images be performed entirely within the chip, while dissipating less than 10 mW of power.

With 640 KB of memory, the GoForce 4000 extends the list of functions that can be performed entirely on-chip to include CIF resolution MPEG-4 encode, decode, and simultaneous codec.

GoForce 3D 4500, with over 1 MB of 128-bit wide embedded memory, lets a large number of complex textures be stored on-chip, thereby minimizing the amount of data that needs to be transferred to/from the CPU. This reduces the power required by the GoForce 3D 4500, as well as the overall system.

Table 2.   GoForce Embedded Memory

	GoForce 3D 4800	GoForce 3D 4500	GoForce 4000	GoForce 3000	GoForce 2150
Embedded Memory	1280 KB	1280 KB	640 KB	320 KB	160 KB

In addition to offering system power savings, the tightly coupled memory with a wide data bus (128-bit for GoForce 3D WMPs, 64-bit wide for all others) provides a second benefit—tremendous applications and graphics performance at one-eighth to one-quarter the clock rate required with 16-bit external memory.

For example, a competitive wireless media processor that does not contain sufficient embedded memory to store the entire screen image may claim low power numbers. But when you factor in the power dissipated by the external memory (as well as the dollar and board space cost of that memory), the solution is not competitive with the NVIDIA GoForce.

Flexible Clocking

A unique feature of GoForce products is that the clock structure is designed so that any module within the chip can be clocked at just about any frequency, independent of the frequency of the other blocks in the chip. Furthermore, the clock frequency of a module can be modified at any time, on the fly. This means that each module runs at the minimal required clock speed to accomplish its assigned task.

Further power reduction is accomplished by a proprietary technique that automatically gates off the clock to any stages of data pipelines that do not currently contain data.

Low-Leakage Process

The battery life of a wireless mobile device that's not in active use (standby) is as critical as how long you can talk, how long you can play a game, and how many pictures the device can capture. Here again, the GoForce family, using NVIDIA nPower technology, excels. This low-leakage 0.15 micron process is nearly a thousand times more power efficient than a typical process (0.0015 nA/um in LL vs. 1.00 nA/um for standard high speed).

The challenge of using a low-leakage process is that with slower switching times, the design will not operate at extremely high frequencies. This means you cannot simply increase the clock frequency to improve performance. Even if you could, increasing clock frequency directly increases power consumption, which is not a viable alternative.

A fundamentally different approach is required—one that utilizes hardware accelerator engines engineered at the microarchitecture level to provide high performance while minimizing power consumption. By using these design techniques and highly optimizing the design, the GoForce 4000, for example, can perform an operation such as a CIF resolution MPEG-4 encode at 30 frames per second, which requires in excess of 400 MIPS while operating at a clock rate of only 72 MHz.

Conclusion

NVIDIA GoForce wireless media processors don't just feature low-power chips. They actually reduce the overall power consumption of the system, because just using a chip that moves the power dissipation from one place to another within a product does not result in longer battery life.

Users who rely on a baseband processor for multimedia applications may be disappointed in their system's gaming, graphics, and video performance. A high-megahertz processor may run applications in software, but won't achieve the highest possible performance and will burn significantly more power than the GoForce 2150, GoForce 3000, GoForce 4000, GoForce 3D 4500, or GoForce 3D 4800.

Extending the NVIDIA nPower technology to GoForce 3D 4800 and GoForce 3D 4500 is a significant differentiator to the OEM and the consumer community because it enables stunning, high-quality 3D gaming performance without compromising the battery life or features of the mobile system.

NVIDIA nPower technology is a combination of chip architecture, innovative design, and targeted process technology that enables GoForce products to extend battery life of high-performance multimedia mobile devices.