



Technical Brief

PowerMizer[®] 8.0
Intelligent Power
Management Technology

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PowerMizer Technology

NVIDIA® is ushering in the era of visual computing. Visually immersive applications such as Google Earth, Adobe 3D, and DirectX 10 games are becoming commonplace. Operating systems such as Apple OS X and Windows Vista have integrated many graphics intensive features to enhance the user experience. With NVIDIA GPUs, mainstream notebooks can run applications that were once reserved for high-end workstation and compute-intensive servers.

To ensure all these applications are available on the go, NVIDIA GeForce® 9M Series and NVIDIA Quadro® notebook GPUs employ NVIDIA PowerMizer® 8.0—an intelligent, fully automatic power management technology aimed at providing the best balance of performance and battery life. PowerMizer 8.0 enables efficient system-level power management and delivers increased battery life for your notebook PC. PowerMizer gives the longest battery life, whether playing the latest DirectX 10 3D games (at high resolution with smooth frame rates and unprecedented image quality), watching HD video and Blu-ray discs, running industry-leading business applications (Microsoft Office Suite, Lotus Notes, Bloomberg, TradeStation, Reuters), or performing routine PC tasks (e-mail or Web browsing).

A key goal of this eighth generation of PowerMizer is to extend power management beyond the GPU. PowerMizer 8.0 not only uses special hardware to gate portions of the chip that are not being used, it also extends power savings to other parts of the notebook such as the power-hungry LCD. The intelligence designed into PowerMizer 8.0 is also helping to transform the PC as we know it.

Enter HybridPower

PowerMizer 8.0 works harmoniously with the latest Hybrid SLI® technology from NVIDIA. Hybrid SLI technology, and its GeForce Boost feature allows you to combine one or more discrete graphics cards with the motherboard GPU to achieve even more graphics horsepower, for use when playing graphics-intensive applications like video games.

The HybridPower™ feature of Hybrid SLI increases the versatility of notebooks like never before, enabling GPUs to run simultaneously when performance is required and powering one down for extended battery life during less intensive applications. HybridPower gives a performance notebook a battery life on par with that of lesser performing thin-and-light notebooks.

The latest version of PowerMizer was developed as a tightly integrated element of the GeForce 9M and Quadro notebook GPUs. PowerMizer 8.0 makes it possible for the GeForce 9M Series and Quadro notebook GPUs to deliver award-winning features and performance benefits while maintaining the longest battery life possible.

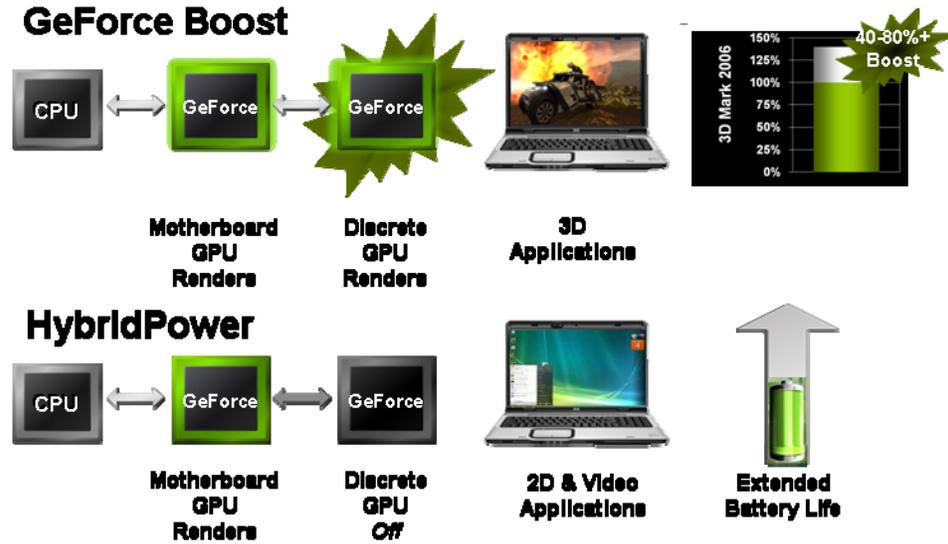


Figure 1. Simplified HybridPower/GeForce Boost Illustration

Table 1 summarizes the techniques PowerMizer uses to create the most comprehensive power-management solution.

Table 1. PowerMizer 8.0 Power-Management Techniques

Power Efficient Design	Total System Optimization	Performance-on-Demand
Use of leading chip processes	CPU load balancing	Intelligent GPU utilization management
Efficient performance-per-watt design	PCI Express power management	Aggressive clock scaling
Integrated GPU power management monitors	Display brightness management	Adaptive performance algorithms

Go Green with PowerMizer

PowerMizer technology helps PC manufacturers meet stringent ENERGY STAR compliance requirements. You can ensure you are purchasing a green notebook by specifically seeking one that has earned the ENERGY STAR rating. In addition to GPU power management, PowerMizer manages notebook power consumption as a whole.



Comprehensive Notebook Power Management

PoweMizer 8.0 Features

PowerMizer 8.0 delivers numerous innovations aimed at increasing battery life. Not all PowerMizer features are supported in every GPU. Check the individual specifications of the GPU to determine which are supported on that particular model.

CPU Offload

The NVIDIA graphics engine has dedicated GPU hardware that efficiently runs complex geometry calculations and offloads them from the CPU. This helps extend battery life, yet delivers superior performance rendering cinematic-quality graphics. This ability directly translates to extended battery life when compared to equivalent work done on the CPU.

PureVideo[®] HD Technology

GeForce 9M Series and Quadro notebook GPUs also include PureVideo HD, the foundation for delivering the best-in-class HD video for users on the go. PureVideo HD comprises video processor engines and video decode software optimized for decoding the H.264, VC-1, and MPEG-2 formats for Blu-ray and broadcast HDTV. PureVideo HD achieves this more power-efficiently than ever, extending battery life for video playback both of older, DVD/TV content and newer HD-DVD/HDTV content.

HybridPower

The ultimate in notebook PC versatility. Combines the performance of the motherboard GPU and the attached discrete GPU (or GPUs) when operating performance-hungry applications. When operating less taxing utilities such as Web surfing, word processing, or spreadsheets, the discrete GPU (and all associated components, including dedicated graphics memory and the PCIe bus interface) can be powered off for extended battery life, giving you the best of both worlds right at your fingertips.

On-Chip Power Management

Circuitry within the NVIDIA GPU automatically reduces clock speed when running less demanding applications and turns off portions of the GPU that are not in use at a given moment to achieve the lowest possible operating power. This automatic demand-based monitoring is always at work, ensuring intelligent power management at all times:

- ❑ Intelligent dynamic clock scaling keeps clocks low for long battery life and automatically scales up to match an application's task activity.
- ❑ Aggressive dynamic clock gating turns off large not-in-use blocks of the GPU to achieve the lowest operating power.

On-Chip Thermal Management

PowerMizer enables a higher level of thermal manageability, at both GPU and system level, providing cooler and more reliable operation. This also extends battery life by minimizing power leakage, which is directly proportional to operating temperatures.

PCI Express Bus Power Management

PowerMizer 8.0 monitors and adjusts the number and power state of links across the PCI Express bus, greatly reducing the power consumption when the notebook is idle:

- ❑ NVIDIA's active state power management (ASPM) extends the reach of PowerMizer's PCI Express link power management. By detecting the level of activity on the PCI Express link, ASPM can determine the optimal time to place the link into a lower power state.
- ❑ NVIDIA's active state link management (ASLM) dynamically changes the number of PCI Express links to ensure no unnecessary power is being consumed by the high-speed bus.

SmartDimmer™ Backlight Brightness Control

The backlight is one of the largest power consumers in a notebook. Smart Dimmer technology reduces the LCD display's power consumption by dimming the backlight whenever possible based on user preferences and activities.

The GeForce 9M Series and Quadro notebook GPUs are the only components fully aware of, and responsible for, driving the notebook's LCD display. This capability forms the basis for SmartDimmer technology, which lets you preset certain brightness preferences through a control panel in Windows Vista (Figure 2). The GPU then manages the display within these limits.

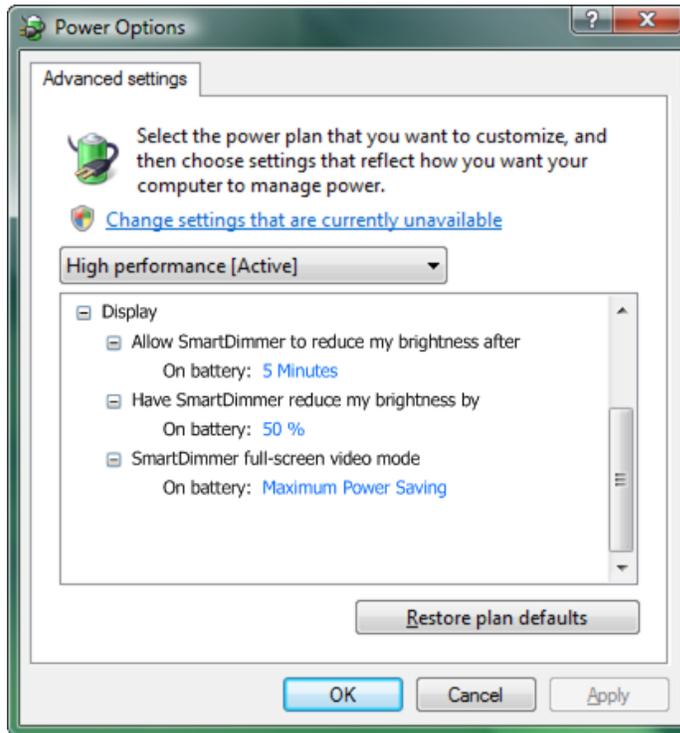


Figure 2. Windows Vista SmartDimmer Control Panel

Display Power Savings

We didn't just stop at the LCD panel's backlight. PowerMizer also manages the power consumed in refreshing the LCD screen and the components in the display path. All LCD panels have a refresh rate in which the GPU sends pixel image information from the local frame-buffer to the LCD panel through the LVDS bus link, as illustrated in Figure 3. By managing the LCD's refresh rate, PowerMizer can reduce the power consumed by the GPU, the local frame-buffer, and the LCD panel electronics during system idle.

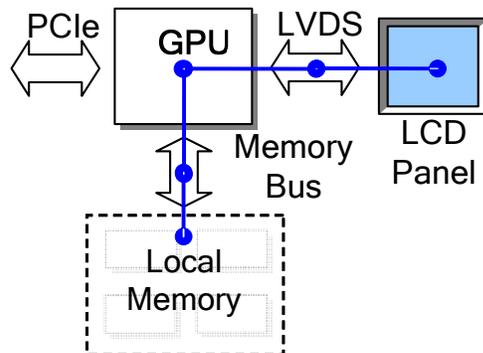


Figure 3. Display path

Dynamic Voltage Switching

This allows the GPU to switch to different voltage levels in addition to throttling clocks. By reducing voltages, NVIDIA GPUs significantly reduce power consumption, including power lost through leakage.

Intellisample™ Data Compression Technology

This minimizes the raw memory bandwidth and power required. Its low-power, self-refresh, power-down memory modes reduce the power consumption of video memory without compromising graphics quality.

Automatic AC Detection

This switches between performance mode and battery-saving mode.

Termination-Free Graphics Memory

When PowerMizer 8.0 is able to turn down the graphics memory clocks, the GPU is able to shut off the memory's power-hungry signal termination network without detriment.

MXM Power Management

The Mobile PCI Express Module (MXM) is an industry initiative to modularize notebook PC graphics. The momentum behind this initiative indicates that MXM is on its way to fundamentally alter the notebook PC market by accelerating time-to-market and enabling rapid configure-to-order manufacturing. PowerMizer 8.0 offers full support for this key initiative.

PowerMizer 8.0 uses a built-in protocol, plus associated power management software and hardware resources, to communicate power and thermal-related information between the notebook motherboard and the MXM graphics module, ensuring robust but power-efficient operation. So whether the NVIDIA notebook GPU in your notebook PC is a motherboard-down design or an MXM module design implementation, you're guaranteed full PowerMizer 8.0 benefits for the longest battery life.

Power Management Settings

PowerMizer User Interface

To accommodate the large user bases for both Windows XP and Vista, NVIDIA has maintained two interface schemes. In Windows XP, PowerMizer 8.0 provides a simple enable/disable interface for power management settings.

In Windows Vista, PowerMizer 8.0 control has been further streamlined to operate completely in the background, adaptively adjusting its power consumption based on GPU use with no additional graphical user interface.

Windows XP Settings

Under XP, in the **NVIDIA Control Panel** window, you can choose between two options—enable or disable PowerMizer. Shown in Figure 4, the control panel has been greatly simplified. Enabling PowerMizer all the time will allow the system to save battery power while on battery and AC power, reducing your electrical bills and helping the environment.

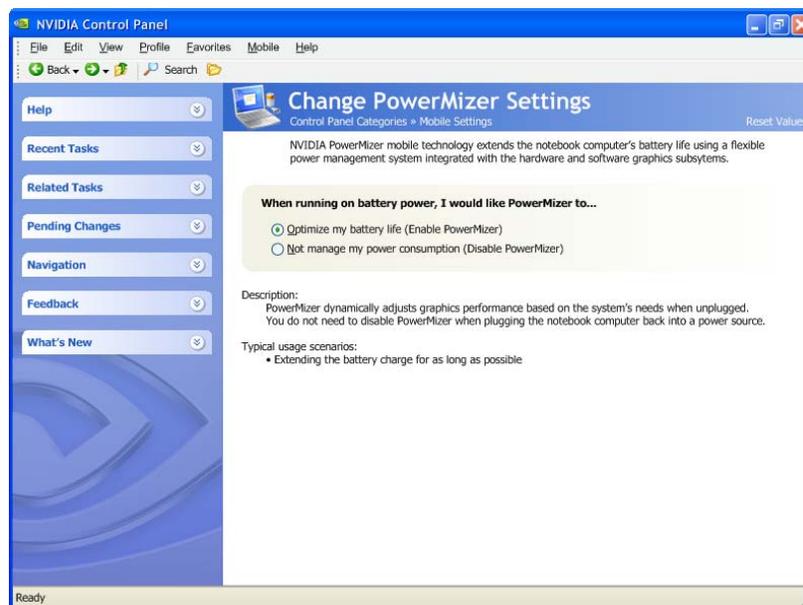


Figure 4. PowerMizer Control Panel: Windows XP

Windows Vista Settings

Under Vista, you have three options to choose from: balanced, power saver, and high performance (Figure 5). PowerMizer 8.0 continuously monitors GPU use regardless of which option you select. Using this approach, PowerMizer can intelligently determine the best performance to power balance. For example, if an photo-editing application suddenly requires more shader performance, PowerMizer will increase the the graphics clock and when that particular task is finished, it will begin to reduce clocks to save power.

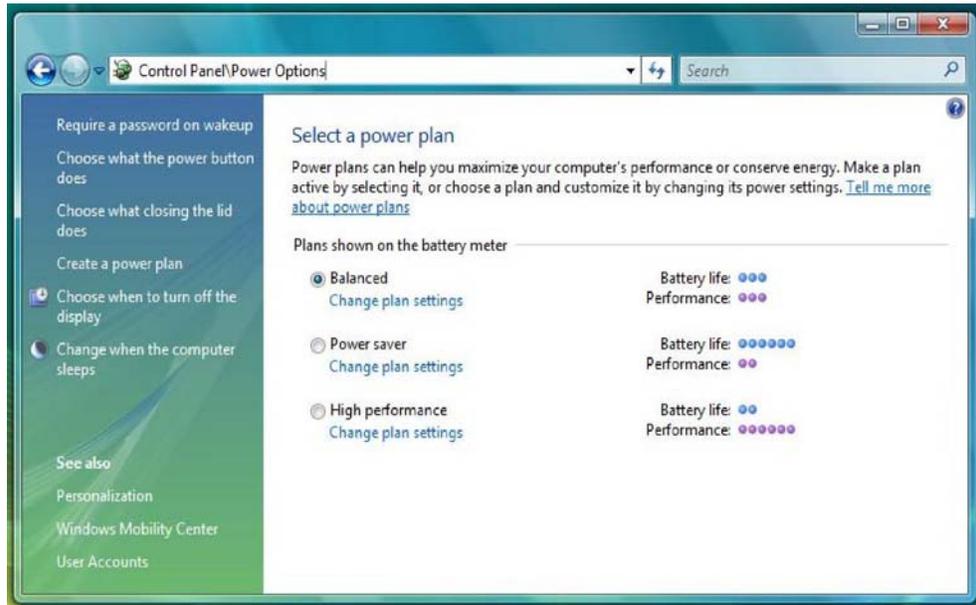


Figure 5. PowerMizer Control Panel: Windows Vista

GPU Performance Levels

NVIDIA notebook GPUs have pre-defined, power-optimized, performance states that enable the GPU to operate at the level of performance the application type requires. This ensures the GPU doesn't operate above what is necessary and wasting precious battery life. Three such modes are defined below.

The NVIDIA driver monitors the current system utilization to determine the optimal performance mode.

Idle

This is the minimal performance needed for the current display configuration, the lowest clock and voltage level the GPU can use and still remain active. It is used whenever the overall system activity is low.

HD Video

With the latest GeForce 9M Series of GPUs, an additional performance level has been added to address the full-video decode of Blu-ray and other HD video formats.

HD video formats have six times the resolution of standard definition DVDs and require a level of compute bandwidth that previously required the GPU to run in the maximum performance mode. Due to the advances in the GeForce 9M Series, PowerMizer 8.0 can decode HD video smoothly at lower power for the best balance of video quality and extended battery life.

Maximum Performance

When an application calls for maximum performance, the GPU will set its operating frequency at maximum. For high-intensity applications such as DirectX 10 games and enterprise-class simulations, the driver will continuously monitor the utilization of the GPU and determine whether to remain in maximum performance mode or to reduce clocks if the load on the GPU diminishes.

CPU Offload Example

Figures 6 and 7 show CPU utilization when running a Blu-ray H.264 HD movie using the CPU and GPU, respectively. You can see that under GPU video playback, 30% fewer CPU cycles are used. This dramatic reduction in CPU use means more of the HD movie is being decoded on the efficient, purpose-built video engine, resulting in longer battery life.

Note: Testing was conducted on an Intel Centrino based platform with 2 GHz Core2 Duo processor, and a GeForce 8600M GS, running Intervideo WinDVD8 playing a Casino Royale H.264 Blu-ray disc.

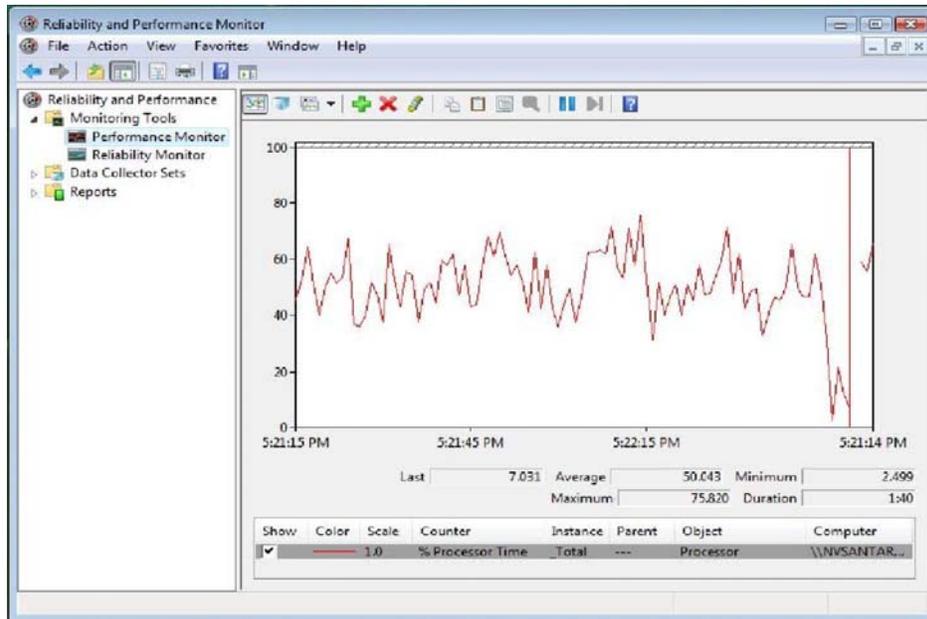


Figure 6. Blu-ray HD Movie Playback on the CPU

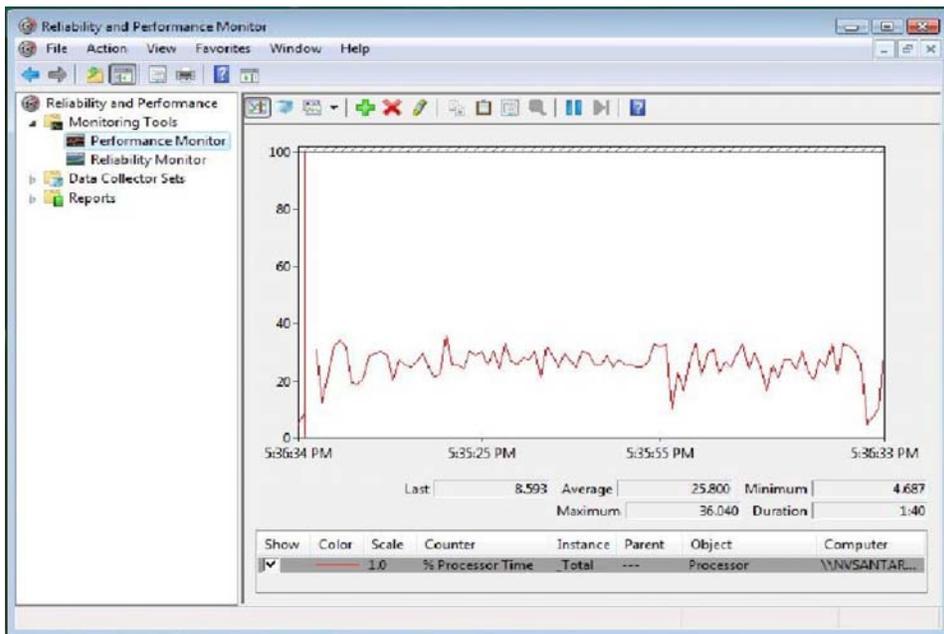


Figure 7. Blu-ray HD Movie Playback on GPU

By off-loading the video decoding from the CPU to the GPU, PowerMizer dramatically lowers CPU utilization, resulting in longer battery life.

Conclusion

The NVIDIA GeForce 9M Series and Quadro notebook GPUs deliver the ultimate in visual computing for the new, unified, at-work, or at-play notebook user. PowerMizer 8.0, NVIDIA's latest comprehensive and intelligent power management technology, enables breathtaking cinematic graphics and HD video quality with industry-leading performance in your notebook.

PowerMizer leverages many technologies: a dedicated graphics engine, PureVideo architectural advancements, MXM graphics support, efficient automatic AC detection, on-chip configuration/performance/thermal monitors, SmartDimmer technology, leading-edge manufacturing technologies, and active power management of the notebook's PCI Express link. NVIDIA has a long tradition of advancing the frontier of the notebook user's graphics experience and expectation and PowerMizer 8.0 is a key element in delivering this for our latest notebook GPUs.

Together with PowerMizer 8.0, the GeForce 9M Series and Quadro notebook solutions deliver the highest performance with the longest battery life, offering true mobility for notebook users.

Appendix: Fundamental Power Management Techniques

Power Equation

At the core of power management technologies is the power equation itself:

$$P = CV^2f$$

The power equation describes the relationship between power (P), capacitance (C), voltage (V), and frequency (f). When you reduce any of the terms on the right side of the equation, the required power is reduced. For example, if the clock frequency is reduced, then power consumption is reduced. If voltage is reduced, overall power is exponentially reduced.

Dynamic Clock Scaling

Power consumption is directly proportional to clock frequency, so the lower the frequency of the GPU, the less power is consumed. NVIDIA designed the GPU to run at frequencies as low as 100 MHz during the Win-Idle state, which lowers the typical power consumption.

PowerMizer raises the frequency when performance is needed and then drops it back down when not needed. Many clocks in the graphics subsystem—an engine clock, memory clock, and pixel clock—are carefully managed to deliver a great user experience while consuming the least amount of power.

Dynamic Clock Gating

Clock gating is equivalent to reducing frequency to zero. According to the power equation, if frequency is zero, then power equals zero. GeForce 9M Series and Quadro notebook GPUs use clock gating extensively to ensure that all the unnecessary portions of the GPU use zero power.

Voltage Scaling

An increase in voltage results in an exponential increase in consumed power. Therefore, managing voltage is vital for managing power consumption. GeForce 9M Series and Quadro notebook GPUs use an advanced semiconductor process technology to operate at the lowest voltage of any notebook GPU. Other GPUs use a higher voltage at all times, or scale voltage up to deliver performance, thus shortening battery life. The finer process-geometries in the NVIDIA solutions enable a design that can run at lower nominal voltages.

When the notebook is plugged in, the NVIDIA GPU supports increasing the voltage to operate at peak frequencies for maximum performance. This provides desktop-equivalent performance in a notebook.

AC Power Auto Detect

When the notebook is plugged into a wall outlet running on AC power, users want full performance because battery life is not a concern. PowerMizer 8.0 recognizes when a machine is running on AC power and allows the GPU to run the clocks up to the maximum if an application requires it. PowerMizer continues to monitor GPU use and still conserves power when the GPU is not being taxed, resulting in lower electricity costs and sparing the environment.

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