

# Technical Brief

## **NVIDIA Quadro FX Family** High-Precision Graphics Pipeline

# Industry's Highest-Quality Workstations

High-precision computation is an absolute requirement for workstation professionals. Developers of computer-aided design (CAD), computer-aided manufacturing (CAM), and digital content creation (DCC) software constantly strive for high-precision images to maximize visual quality while depicting real-world items. This visual quality is necessary to render 3D models in real time for photorealistic or highly stylized images. Lack of precision in the images can cause many artifacts and problems that reduce the visual experience.

The new NVIDIA Quadro® FX family of professional workstation solutions introduces the high precision required for realistically depicting the most complex digital models and content. Workstation users gain access to the same high standards of precision and formats used by the film industry today.

The accuracy levels and choice afforded by the higher-precision formats result in applications that can achieve cinematic graphics in real time with industry-leading workstation graphics performance.

*“Rapid refinement of shading and lighting is critical to achieving each artist’s creative vision—especially in the deadline- and quality-driven world of 3D production. With the new NVIDIA Quadro FX workstation graphics solution and 3ds max, artists have an unparalleled ability to speedily preview sophisticated shading changes as they happen in the interactive viewport—whether for games, design visualization, broadcast television, or film.”*

**Chris Ford, product line manager of 3D Products, Discreet**

*“The joint introduction of the NVIDIA Quadro FX and GPU rendering within SolidWorks is revolutionary. There was a time when designers debated the value of 3D over 2D; then it was solids over wireframe; shaded images over black and white; then colored solids over grayscale. And we have consistently seen that with visualization breakthroughs, the designers’ productivity and satisfaction increase.”*

**Ilya Mirman, vice president of Marketing, SolidWorks**

---

## Subpixel Precision

Whether working with lines, triangles, wire mesh, shaders, or realistic 3D textures, today's workstation applications take advantage of numerous subpixel effects to generate realistic images. The NVIDIA Quadro FX solutions increase the precision for subpixel effects to 12 bits—four times higher than the closest competitor. The accuracy afforded by 12-bit precision raises the success rate for correctly mapping objects to pixel values, and reduces the number of artifacts and visual anomalies.

Figure 1 illustrates the type of problem that can occur with only 4 bits of subpixel precision—"spreckles" can distract the user's eye. Spreckles are significantly less evident on the NVIDIA Quadro FX, because they can be eliminated by the increased 12-bit levels of subpixel precision this solution offers.



Figure 1. 4 Bits of Subpixel Precision (Left) vs. 12 Bits on the NVIDIA Quadro FX (Right)

---

## 128-Bit True Color

Attaining high-level precision for workstation applications requires an adequate level of detail. If the situation involves specifying the color of an image used in an application, precision requires the ability to create and choose between enough colors to realistically depict each part of the image. Therefore, precision is related directly to the visual quality of the image that is a function of the color rendered.

On a computer display, colors are created as a mix of red, green, and blue (RGB) components. Each component is controlled by a number of bits. To understand the different levels of precision in this situation, consider a system with 16-bit color. One approach is to control each RGB component by using 5 bits, making it possible to program  $2^5$  or 32 levels of each color. (In this scheme, the 16<sup>th</sup> bit is typically used to turn transparency on or off.)

With 32-bit color, each RGB component can be controlled with 8 bits, for  $2^8$  or 256 levels of that color. As the number of bits increases, the level of color precision increases exponentially. Figure 2 illustrates the possible levels of color gradients.

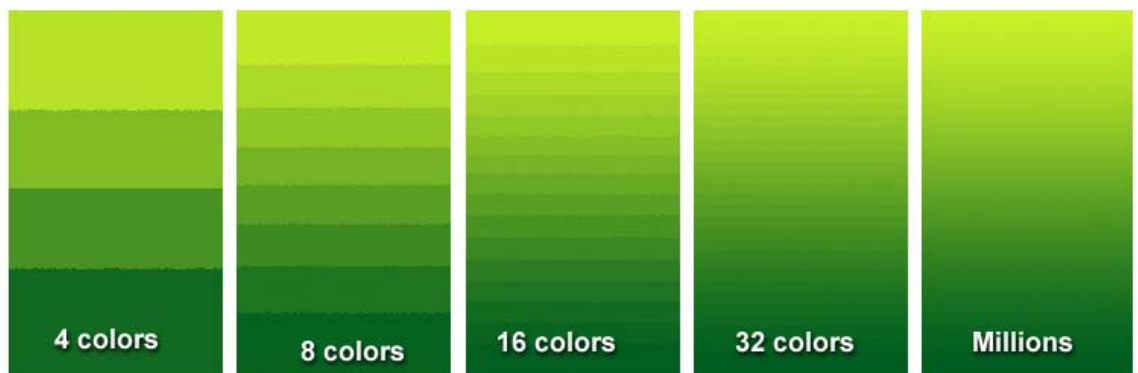


Figure 2. Images with More Colors Look Better

---

## Real-Time Issues

Currently, the high-water mark for rendered image visual quality is set by the film industry. Sophisticated rendering techniques for film rely on 16-bit or 32-bit floating point numbers for each RGB component (64-bit or 128-bit color). As real-time 3D graphics converge with cinematic quality, many complex operations previously limited to film rendering are becoming possible in real time. These real-time operations require a great deal of precision. Without higher numerical precision, many artifacts and problems occur, diminishing image realism and distracting the user.

The inherent 16-bit and 32-bit floating point formats of the NVIDIA Quadro FX family result in the highest quality graphics. The 32-bit floating point format offers the ultimate image quality, delivering true 128-bit color and an infinite number of stunning color effects. Real-time high-precision color requires both processing and storing pixels in this 128-bit mode. Solutions that do not fully support a 128-bit pixel processing pipeline—such as platforms that only support 24-bit floating point formats—are unable to match the color of the NVIDIA Quadro FX solutions.

NVIDIA Quadro FX solutions also support a 16-bit floating point format for optimizing performance when full 128-bit color is not required. CAD/CAM applications move back and forth, using the format that is best suited to a particular computation so that the overall experience is optimized. For instance, some actions, such as indexing into a high-resolution texture, can only be optimally accomplished using a 32-bit floating point format. If the texture is larger than  $1024 \times 1024$  ( $2^{10} \times 2^{10}$ , requiring at least 10 mantissa bits per texture coordinate), a 32-bit floating point format is required to access all the data. Other computations can be accurately accomplished using a 16-bit floating point format, and can benefit from the maximized execution speed afforded by this level of precision.

Many of today's applications use techniques that attempt to work around the limitations of lower precision. Unfortunately, these workarounds lower performance and limit image variations for the user.

---

## Gamma-Correct Antialiased Lines

Gamma correction is crucial for accurately displaying an image on a computer screen. Intuitively, doubling the intensity value should result in a pixel that is twice as bright. However, this is not the case. The response curves of standard computer displays and the new flat panels do not mathematically equate to the light sensing of the human eye. The NVIDIA Quadro FX delivers "gamma-correct settings" that take into account the dramatic physical differences between how your eyes and the monitor perceive light and color, making for smoother and more natural edge transitions. Figure 3 shows the difference between gamma-corrected and non-gamma-corrected antialiased lines.

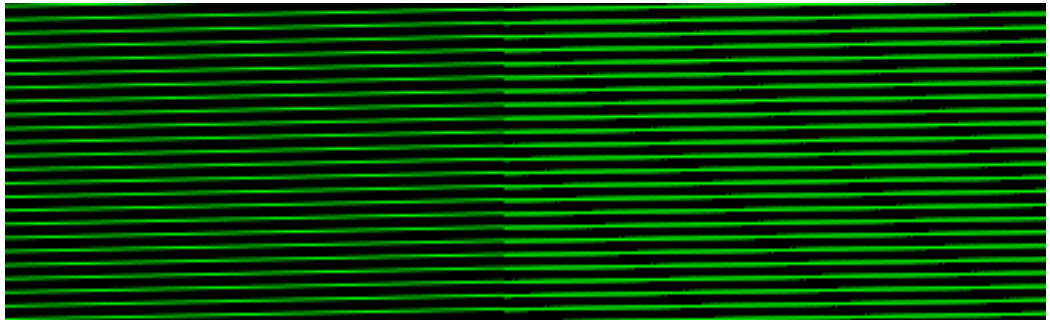


Figure 3. Gamma-Corrected Antialiased Lines Reduce Artifacts Seen on Non-Gamma-Corrected Antialiased Lines

The 16-bit and 32-bit floating point formats on the NVIDIA Quadro FX deliver more accurately matched visual images. And, the 32-bit floating point format meets the needs of cutting-edge applications. All images have a smoother, more appealing variation in color density. Surfaces that go from dark to light appear to increase more realistically in brightness across the surface of the object.

---

## Conclusion

The NVIDIA Quadro FX solutions push image quality to new levels for today's workstation professionals, with 12-bit precision at the subpixel level and the industry's only full 128-bit precision color throughout the entire graphics pipeline. The high precision delivers the realism and visual quality that is becoming a standard for workstation professionals. High-performance precision modes represent a milestone achievement for high-quality, real-time visualization, affording users the best application experience. Without compromising performance, the high-precision NVIDIA Quadro FX generation has delivered dramatic improvements in visual quality.



## **Notice**

ALL NVIDIA DESIGN SPECIFICATIONS, REFERENCE BOARDS, FILES, DRAWINGS, DIAGNOSTICS, LISTS, AND OTHER DOCUMENTS (TOGETHER AND SEPARATELY, "MATERIALS") ARE BEING PROVIDED "AS IS." NVIDIA MAKES NO WARRANTIES, EXPRESSED, IMPLIED, STATUTORY OR OTHERWISE WITH RESPECT TO THE MATERIALS, AND EXPRESSLY DISCLAIMS ALL IMPLIED WARRANTIES OF NONINFRINGEMENT, MERCHANTABILITY, AND FITNESS FOR A PARTICULAR PURPOSE.

Information furnished is believed to be accurate and reliable. However, NVIDIA Corporation assumes no responsibility for the consequences of use of such information or for any infringement of patents or other rights of third parties that may result from its use. No license is granted by implication or otherwise under any patent or patent rights of NVIDIA Corporation. Specifications mentioned in this publication are subject to change without notice. This publication supersedes and replaces all information previously supplied. NVIDIA Corporation products are not authorized for use as critical components in life support devices or systems without express written approval of NVIDIA Corporation.

## **Trademarks**

NVIDIA, the NVIDIA logo, and NVIDIA Quadro are trademarks of NVIDIA Corporation.

Other company and product names may be trademarks of the respective companies with which they are associated.

## **Copyright**

Copyright NVIDIA Corporation 2003.



**NVIDIA.**

NVIDIA Corporation  
2701 San Tomas Expressway  
Santa Clara, CA 95050  
[www.nvidia.com](http://www.nvidia.com)