AMD Radeon™ HD 6800 Series
Graphics
Display Technologies
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INTRODUCTION

Display devices have always been an integral part of the PC experience. Whether it is in the form of an external desktop monitor, a notebook’s embedded panel, or the touch screen of a PC tablet, display devices play a vital role in defining the user’s visual experience.

The new display technologies integrated into the AMD Radeon™ HD 6800 series GPUs are targeted to deliver pristine image quality and impressive performance in three different technologies:

**Multi-display Technologies**
- DisplayPort 1.2, a new display interface, boasts features such as higher bandwidth and daisy-chaining capabilities. Combined, these features complement the AMD Eyefinity\(^1\) multi-display technology very well.

**Stereoscopic 3D**
- The introduction of high refresh rate LCD panels (120Hz and higher) have inspired new stereoscopic 3D display devices for the PC and the CE markets. This whitepaper will explain how the new AMD Radeon™ HD 6800 series GPUs enables the PC to deliver a cinematic stereoscopic 3D experience.

**Wide Color Gamut**
- Monitors and notebook with wide color gamut panels, once reserved for the professional market, have become more prominent with several products shipping in the market. While these types of LCD panels display a wider range of colors, the drawbacks and challenges will be explained in this whitepaper, as well as the color gamut remapping technology integrated in the AMD Radeon™ HD 6800 series GPUs.

This whitepaper provides an overview of the capabilities and display technologies integrated into the AMD Radeon™ HD 6800 series GPUs display engine. These capabilities and technologies, when combined with cutting edge display devices, deliver the ultimate visual experience.

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\(^1\) AMD Eyefinity technology works with games that support non-standard aspect ratios, which is required for panning across multiple displays. To enable more than two displays, additional panels with native DisplayPort™ connectors, and/or DisplayPort™ compliant active adapters to convert your monitor’s native input to your cards DisplayPort™ or Mini-DisplayPort™ connector(s), are required. AMD Eyefinity technology can support up to 6 displays using a single enabled AMD Radeon™ graphics card with Windows Vista or Windows 7 operating systems – the number of displays may vary by board design and you should confirm exact specifications with the applicable manufacturer before purchase. SLS (“Single Large Surface”) functionality requires an identical display resolution on all configured displays.
DISPLAYPORT™ 1.2

In 2006, PC manufacturers (including AMD) collaborated in designing the next generation PC display interface, which would eventually be known as DisplayPort. DisplayPort was designed to replace DVI and VGA by offering features that are beneficial to both system integrators and end users. It was also designed to be flexible and easily extensible for new features that the market will require in the future.

The first generation of DisplayPort provided over 10.8 Gbps of raw bandwidth, which no other display interface could match. DisplayPort also supported very long non-active cables, optional latch designs for connectors, and audio support. In addition, with DisplayPort spread spectrum clocking can be enabled to reduce EMI, and source devices such as GPUs can operate in dual-mode. The latter is valuable for it allows the same connector to transport TMDS signals to support DVI and HDMI outputs using inexpensive level-shifting adapters.

The data link rates of DisplayPort 1.1a are fixed at either 1.62 Gbps per lane or 2.7 Gbps per lane, irrespective of the timing of the attached display device. This design only requires a single reference clock source to drive as many DisplayPort streams as there are display pipelines in the GPU. In contrast, DVI and HDMI both require a dedicated clock source per display timing. This unique DisplayPort feature allows for the most efficient multi-display design and complements the AMD Eyefinity technology. Please refer to the AMD Eyefinity Technology Brief for more information.

All the features of DisplayPort 1.1a proved that it was the superior PC display interface. To further enhance the DisplayPort interface, the same group of companies collaborated once more to define the next version of DisplayPort, which paved the way to DisplayPort 1.2.

In early 2010, the DisplayPort 1.2 specification was ratified in VESA. This new revision of the standard adds support for new and exciting features including High bit-rate audio, even higher bandwidth, and multi-streaming capabilities.

Just as AMD was the first to integrate DisplayPort technology into GPUs with the ATI Radeon™ HD 3000 series, the AMD Radeon™ HD 6800 series graphics will be the pioneer GPUs designed to support DisplayPort 1.2 features. Table 1 is a simplified comparison of display interface capabilities integrated into AMD Radeon™ HD 6800 series GPUs:

<table>
<thead>
<tr>
<th></th>
<th>DisplayPort 1.2</th>
<th>DisplayPort 1.1a</th>
<th>SL-DVI</th>
<th>DL-DVI</th>
<th>HDMI 1.4a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth</td>
<td>21.6 Gbps</td>
<td>10.8 Gbps</td>
<td>4.95Gbps</td>
<td>9.9 Gbps</td>
<td>6.75 Gbps</td>
</tr>
<tr>
<td>Video Data Rate</td>
<td>17.28 Gbps</td>
<td>8.64 Gbps</td>
<td>3.96 Gbps</td>
<td>7.92 Gbps</td>
<td>5.4 Gbps</td>
</tr>
<tr>
<td>Maximum Resolution Support @ 60Hz 24bpp</td>
<td>&gt;2560x2048</td>
<td>2560x2048</td>
<td>1920x1200</td>
<td>2560x1600</td>
<td>1920x1200</td>
</tr>
<tr>
<td>Audio Support</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Embedded Application Support</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>In-band Stereo 3D signaling</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Multi-stream support</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Table 1: Display interface capabilities of the AMD Radeon™ HD 6800 series GPUs
High Bit-rate 2

DisplayPort 1.2 supports up to twice the bandwidth of DisplayPort 1.1a. High Bit-rate 2 (HBR2) provides up to 5.4 Gbps/lane of bandwidth, or up to 21.6 Gbps in a full four lane configuration. This lends itself very well to many applications that require ultra-high bandwidth.

Chart 1 illustrates the wide range of display timings (resolution, refresh rate, and color depth) supported by various digital display interfaces.

![Chart 1: Comparison of video data rate versus resolution at different refresh rates and color depths](image)

As illustrated in Chart 1, DisplayPort 1.2 can easily support a multitude of display timings combining high resolutions, high refresh rates and high color depth. No other PC display interface can match this capability today.

4k x 2k Resolution

Ultra-high resolution projectors have existed for years but were targeted for professional applications. 4K TVs have also started appearing in many tradeshows and demonstration events. In the future, AMD envisions TVs and monitors supporting significantly higher resolutions, well above WQXGA (2560x1600). There are different proposals for 4k resolutions such as 3840x2160 and 4096x2160, both well over 8 MPixels. The only PC display interface that can meet the high bandwidth requirement to drive such displays and support a refresh rate of 60Hz is DisplayPort 1.2.

Although DisplayPort 1.2 HBR2 can easily accommodate resolutions up to 4096x2160 @ 60Hz, the AMD Radeon™ HD 6800 series GPUs are designed to support up to 4096x2160 @ 50Hz.
**Stereoscopic 3D**

Frame sequential 3D displays are those that display one view at a time (left or right) and require the use of liquid crystal shutter glasses. According to Stereo 3D experts, at least 60fps (or 60Hz) per eye is required for these types of displays to have a pleasant 3D experience. This means that the minimum total refresh rate required is 120Hz. Only DisplayPort 1.2 has enough bandwidth to drive display timings required for high resolution frame sequential 3D displays, and also removes the need for buffering.

**Multi-Stream Transport**

Leveraging the micro-packet architecture of DisplayPort, DisplayPort 1.2 adds the capability to address and drive several display devices through one DisplayPort connector. This feature has often been referred to as daisy-chaining or addressable displays.

Multi-stream transport, or MST for short, can be leveraged using two types of system design. Figure 2 illustrates how MST can be used with daisy-chainable monitors. Each of the monitors in the daisy-chain configuration, with the exception of the last monitor in the chain, must have DisplayPort receiver(s) and transmitter(s) in order to receive the video stream that is addressed to itself and the others down the chain. Once the monitor extracts the video and audio stream addressed to it, it will then transmit the rest of the video and audio streams down the chain. Each daisy-chainable monitor must have knowledge of the entire chain.

![Figure 2: Daisy-chaining monitors](image)

Figure 3 illustrates the alternate method of utilizing MST to drive multiple displays through the use of MST Hub or Splitter devices. The hub device receives a DisplayPort 1.2 MST signal from the source device and splits out the video streams independently to each display device. Using this type of configuration also allows the use of non DisplayPort 1.2 monitors. To support non DisplayPort outputs, such as VGA, DVI or HDMI, the hub or splitter must have the capability to convert the DisplayPort signal to the other types of display interface signals.
The number of display devices, and also the timings that each display device can be driven at will depend on the available bandwidth. Table 2 lists the multi-display configurations possible with HBR and HBR2 bandwidth:

<table>
<thead>
<tr>
<th>Resolution</th>
<th>HBR</th>
<th>HBR2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1366x768 @ 60Hz, 24bpp</td>
<td>Up to 5</td>
<td>Up to 6</td>
</tr>
<tr>
<td>1600x900 @ 60Hz, 24bpp</td>
<td>Up to 3</td>
<td>Up to 6</td>
</tr>
<tr>
<td>1920x1080 @ 60Hz, 24bpp</td>
<td>Up to 2</td>
<td>Up to 4</td>
</tr>
<tr>
<td>2560x1440 @ 60Hz, 24bpp</td>
<td>1</td>
<td>Up to 2</td>
</tr>
</tbody>
</table>

Table 2: Comparison of DisplayPort bandwidth vs number of displays

In 2009, AMD first announced the Eyefinity Multi-display feature. This differentiating feature has been well received by reviewers and end-users alike. While the appeal is mainly for ultra-wide screen and high resolution gaming, this feature also caters to those looking to increase their productivity through multi-monitor configurations. The AMD Radeon™ HD 6800 series will be the first GPUs to extend the capabilities of Eyefinity with DisplayPort 1.2 MST.

Using daisy-chainable displays or MST hubs significantly extends the number of display configurations possible with a reference board design that has at least one DisplayPort 1.2 connector. For example, with the ATI Radeon™ HD 5000 Series GPUs, six-display configurations are only possible using six DisplayPort 1.1a connectors. This was realized with the acclaimed ATI Radeon™ HD 5890 Eyefinity Edition graphics card.

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2 HBR2 bandwidth can support more than six displays with this specific timing, but the AMD Radeon™ HD 6800 Series GPUs support up to a maximum of six independent displays.
As an example of how to combine MST and AMD Eyefinity technology, consider figure 5. Using an MST hub, which is expected to be available in 2011, even the AMD Radeon™ HD 6870 reference board can drive up to six displays using only two DisplayPort connectors. This provides an upgrade path for end-users who have three monitors today, but may want to upgrade to five or six monitors in the future.

Aside from multi-output hubs, there will likely be less expensive DisplayPort 1.2 MST dongles in the market, which support two display outputs. Figure 6 illustrates how you can still support up to six displays using two of these dongles combined with the DVI or HDMI display outputs on the graphics card.
Maximum Eyefinity Resolution

The ATI Radeon™ HD 5000 series GPUs supported a maximum Eyefinity resolution of 8k pixels wide by 8k pixels high. The AMD Radeon™ HD 6800 series GPUs removes this limitation and supports a maximum Eyefinity resolution of 16k×16k, which enables new usage scenarios. Figure 7 shows one example of an Eyefinity configuration which would not have been supported with previous generation GPUs.

There are other possible configurations that can be supported by the AMD Radeon™ HD 6800 series GPUs combined with DisplayPort 1.2 MST monitors, hubs and dongles. Please note that to take advantage of this feature, Windows® 7 Aero glass must be disabled. In addition, only DirectX® 11 games allow resolutions above 8k×8k pixels.
High Bit-rate Audio
Radeon™ GPUs have supported pass-through audio through HDMI since the ATI Radeon™ HD 2000 series GPUs, without external audio cabling. In 2009, AMD released the ATI Radeon™ HD 4700, 4600 and 4500 and 4300 series GPUs which were the first GPUs to support audio through DisplayPort. Today, there are several DisplayPort monitors in the market that can take advantage of this feature, all of which have the option of attaching external speakers or a sound bar to the monitor.

Although DisplayPort 1.1a supports audio, the specification did not have provision to support high bit-rate compressed audio formats, such as those found in Blu-ray movies. DisplayPort 1.2 adds this capability and the AMD Radeon™ HD 6800 series will be the first GPUs in the market to support High bit-rate audio through DisplayPort. Table 3 lists the high bit-rate audio formats found in premium content, now supported through DisplayPort 1.2:

<table>
<thead>
<tr>
<th></th>
<th>DTS-HD Master Audio</th>
<th>Dolby TrueHD</th>
<th>PCM 7.1ch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitrate</td>
<td>Up to 24 Mbps</td>
<td>Up to 18Mbps</td>
<td>Up to 36 Mbps</td>
</tr>
<tr>
<td>Bits/Sample</td>
<td>24 bits/sample</td>
<td>24 bits/sample</td>
<td>24 bits/sample</td>
</tr>
<tr>
<td>Sampling Rate</td>
<td>Up to 192 kHz</td>
<td>Up to 192 kHz</td>
<td>Up to 192 kHz</td>
</tr>
<tr>
<td>Channels</td>
<td>Up to 8</td>
<td>Up to 8</td>
<td>Up to 8</td>
</tr>
</tbody>
</table>

Table 3: Compressed and uncompressed audio formats supported through DisplayPort 1.2

This capability is attractive to HTPC enthusiasts who want the latest in audio technologies in the market.
**AMD HD3D TECHNOLOGY**

Stereoscopic 3D is a technique of creating the illusion of depth using a stereo image pair. Each image represents the scene as viewed by the left or the right eye. The illusion of depth is achieved when the display device (along with the passive polarized and active glasses in most 3D systems) is able to present the left image only to the left eye and the right image to the right eye. To fully understand how AMD HD3D technology can deliver stunning 3D images, it is helpful to first examine the Stereoscopic 3D gaming pipeline.

The majority of DirectX® games available in the market do not support stereo 3D natively. This means that the stereo image pair must be generated external to the game engine. This can be achieved with third party stereo 3D conversion software, such as iZ3D or Dynamic Digital Depth’s gaming driver.

The stereo 3D conversion software intercepts DirectX® calls from the game. Using these calls, the stereo 3D conversion software generates the stereo image pair, or the Left and Right eye view. For certain types of 3D displays, the stereo 3D conversion software blends the two views together to form a single frame using a format that the display supports (e.g., Row interleave, checkerboard, side-by-side, etc…). Once the frame is in the correct format, the stereo 3D conversion software sends the frame to the GPU, which will then be sent to the 3D display device.

*Figure 8: Stereo 3D conversion software architecture*
Frame Sequential Displays

Frame sequential 3D displays (also known as page flipped displays) require special treatment. To support frame sequential 3D displays, the output of the stereo 3D conversion software is also frame sequential and does not need to be converted into any of the formats illustrated in Figure 8. However, the stereo 3D conversion software requires a new API known as AMD’s quad buffer.

![Diagram](image)

Figure 9: Stereo 3D conversion software architecture using AMD’s quad buffer

AMD’s quad buffer API provides the infrastructure for stereo 3D conversion software to support frame sequential 3D displays by creating a double-height buffer using the existing front & back buffer in DirectX®. After the stereo 3D conversion software stores the left and right images in the quad buffer, they are fetched by the display engine which ensures that the frames remain in ordered sequence throughout the pipeline. Before the frames are transmitted, the display engine formats the output to provide frame polarity information to the display device. Two standardized methods of conveying frame polarity information are supported by the Radeon™ HD 6800 series GPUs. These will be described in the next section.

For more information regarding AMD’s quad buffer API, please visit [http://developer.amd.com](http://developer.amd.com).
HDMI 1.4a Packed Frame

The HDMI 1.4a specification has provision on how to support Stereo 3D display devices. This specification provides a mechanism for the source device, in this case the GPU, to convey frame polarity information, while maintaining full resolution. There are several Stereo 3D TVs in the market today that support the HDMI 1.4a specification.

Similar to AMD’s quad buffer described in the preceding section, for every stereo image pair, the output frame is organized in a standard format known as packed frame. The GPU creates a buffer that is twice the height of the resolution of the frame, with active space in between frames. As per the spec, the left frame is always on top, and the right frame is at the bottom of the packed frame.

After this packed frame is assembled, the GPU will send it over the HDMI link as a packed frame. Once the TV receives this packed frame, it unpacks the frame and presents it to the viewer in a frame sequential or page flipped manner. Since the polarity of each frame is known, the display can then control the emitter to send the correct signal to the shutter glasses.

The AMD Radeon™ HD 6800 series GPUs, as well as the new LCD 3D TVs productized in 2010, support the following packed frame 3D modes specified in the HDMI 1.4a specification:

- 1920x1080 @ 24Hz (48Hz total)
- 1280x720 @ 60Hz (120Hz total)
- 1280x720 @ 50Hz (100Hz total)

DisplayPort MSA Misc1 Bits

The DisplayPort standard specifies a method in which the source device can send frame polarity information through the DisplayPort link. This method is often referred to as the MSA method. MSA (Main stream attribute) is a secondary packet sent by the GPU to the display device, which is transmitted during the vertical blanking interval. This table shows how the GPU sets the MISC1 bits for left and right images.
Due to the high bandwidth requirement of Stereo 3D as well as the MSA method for signaling, monitor vendors are designing their next generation Stereo 3D monitors to support DisplayPort. These monitors should be available next year, and the AMD Radeon™ HD 6800 series are the first GPUs that are ready to support these monitors. This method is also applicable to embedded DisplayPort to support embedded stereo 3D panels for notebook and All-in-one platforms.

The AMD Radeon™ HD 6800 series GPUs also support stereo 3D video playback. The stereo 3D video pipeline is similar to the gaming pipeline, where a third party application is required to convert 2D content to 3D, or to decode native Stereo 3D content. These applications also convert the format of the frame, depending on the type of 3D display device attached to the PC.

The AMD Radeon™ HD 6800 series GPUs support the following new features:
- UVD accelerated MVC Decode for Blu-ray 3D movies
- Windowed mode playback of Blu-ray 3D movies through HDMI and DisplayPort
- Clone mode 3D movie playback

For more information, please refer to the AMD Video Technologies technical whitepaper.

**Open Ecosystem**

AMD promotes open ecosystems. Working with display and shutter glass vendors, software vendors and others, will ensure the highest level of interoperability with the software and hardware devices in the market. The technologies described in this section, including industry display standards, not only enable a multitude of solutions in the market - they also allow partners to innovate and improve upon current technology.
COLOR ACCURACY

Color gamut is the range of colors that can be represented by a display device. The most common method of illustrating a display device’s color gamut is by using a gamut diagram, similar to figure 11. The supported color gamut of the display is represented as the area bounded usually by a triangle - in this case labeled sRGB.

![Color Gamut Diagram](image)

**Figure 11:** Color gamut diagram for sRGB

The majority of display devices in the past had the capability to fully display the sRGB color gamut. (Note: This is usually advertised as 72% NTSC). In addition, the majority of content are also captured in sRGB color gamut, including pictures and videos. Even the Microsoft Windows® desktop is rendered in sRGB color gamut.

Today, there are LCD monitors in the market that can display a color gamut greater than sRGB. Some monitors can cover 80% NTSC, while professional monitors can cover Adobe RGB (92% NTSC) or more. The problem arises when the end user views sRGB content on wide color gamut monitors without color correction - the colors become distorted and over saturated in most cases. This problem can be addressed by a process called color correction or color gamut remapping.

**Figure 12:** Difference between corrected and uncorrected image

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3 Simulated saturation to show the difference between color corrected and uncorrected image on wide gamut panels
While the uncorrected image may seem more vivid, some of the colors look unnatural - especially flesh tone colors. One can imagine the problem this would cause in professional graphics applications where color accuracy is paramount. Even for mainstream consumers, uncorrected color images could lead to frustration for those who print photos at home, or those who view and purchase items through the internet.

Previous generation GPUs, for example the ATI Radeon™ HD 5000 series, had the capability to perform gamut remapping. However, the capability had a limitation, in that the color gamut remapping or color correction is performed in non-linear space (i.e. gamma space). This limits the precision and accuracy of the color gamut remapping process.

The AMD Radeon™ HD 6800 series GPUs remove this limitation by performing the color gamut remapping in linear space, as illustrated in figure 13:

![Figure 13: Comparison of color gamut remapping hardware](image)

Adding the de-gamma step in the display engine and an advanced gamut remapping algorithm ensure high precision color gamut remapping throughout the pipeline, resulting in excellent color reproduction even on wide gamut panels. In addition, since the color gamut remapping process is performed by the display engine hardware and not through software, it will not incur any performance penalty and can be applied to full screen and windowed applications.

AMD plans to publish an API that can take advantage of this new hardware capability, along with SDK documentation. These will soon be available for application developers at [http://developer.amd.com](http://developer.amd.com).
SUMMARY

AMD is a recognized industry leader in display technologies, providing innovation through introduction of new technologies and display interfaces in our products. The AMD Radeon™ HD 6800 series GPUs marks the introduction of several key display technologies:

- First GPU to support DisplayPort 1.2 Multi-Streaming
- First GPU to support both DisplayPort and HDMI 1.4a for stereoscopic 3D
- First GPU to support enhanced color gamut remapping for wide color gamut displays

The AMD Radeon™ HD 6800 series GPUs combine DisplayPort 1.2 and AMD Eyefinity technology to deliver the most flexible and immersive multi-display experience. Support for Stereoscopic 3D using next generation display interfaces will enable end users to bring home the cinematic 3D experience once reserved for theatres. Finally, end users can now take advantage of accurate color reproduction with the improved color gamut remapping capabilities of these new GPUs. All these features combined, positions the AMD Radeon™ HD 6800 series as the GPUs of choice for HTPC enthusiasts and gamers alike.
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