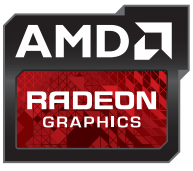
White Paper | AMD PROJECT FREESYNC



AMD

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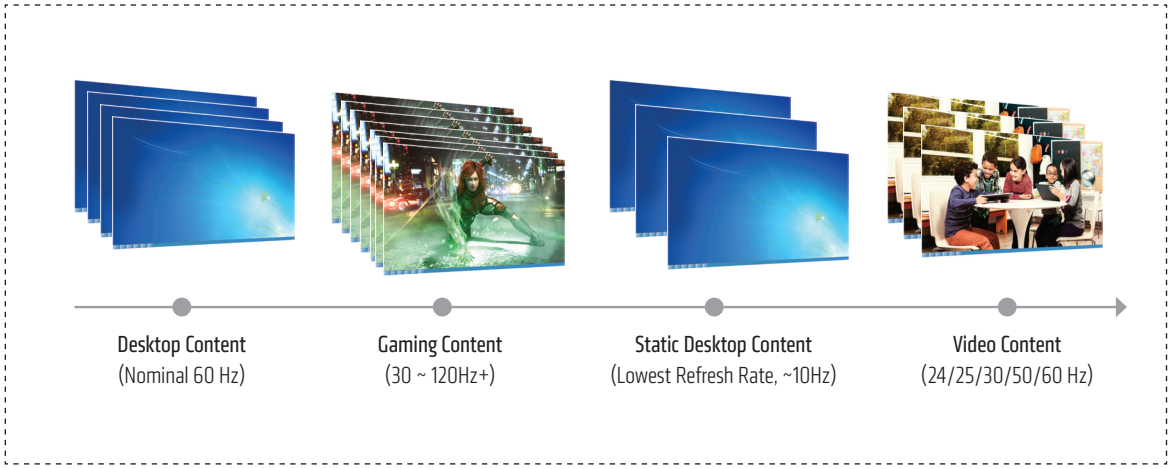
INTRODUCTION

This document describes AMD's dynamic refresh rate (DRR) feature, also known as "Project FreeSync".

For many years, the display industry has operated with the understanding that displays run at a fixed refresh rate (eg. 60 Hz). This is in contrast with the fact that there are many types of content that can be sent to a display, each with its own unique, and sometimes varying, frame rate. When the display refresh rate is not synchronized to the content frame rate, the user can experience undesirable effects such as tearing and stutter. For mobile applications, unnecessarily high display refresh rates for static and video content can increase power draw and reduce battery life. These factors have given rise to the need for a technology that allows the refresh rate of the display to adapt to the frame rate of the content, in a way that appears seamless to the end user. AMD has developed Project FreeSync, that uses a VESA industry standard (known as "Adaptive-Sync) to enable variable refresh rate capabilities over DisplayPort and Embedded DisplayPort interfaces.

Figure 1 shows how a variable refresh rate scheme can allow a graphics source to dynamically adjust display refresh rate based on typical content frame rates for power efficient, virtually stutter free and low-latency display update.

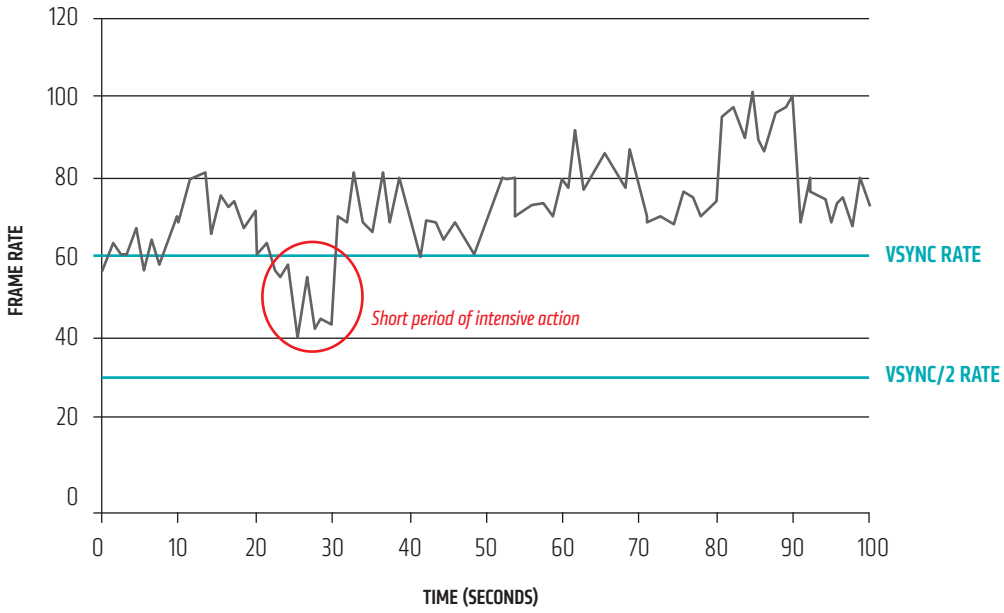
Figure 1: Content Adaptive Display Refresh



GAMING

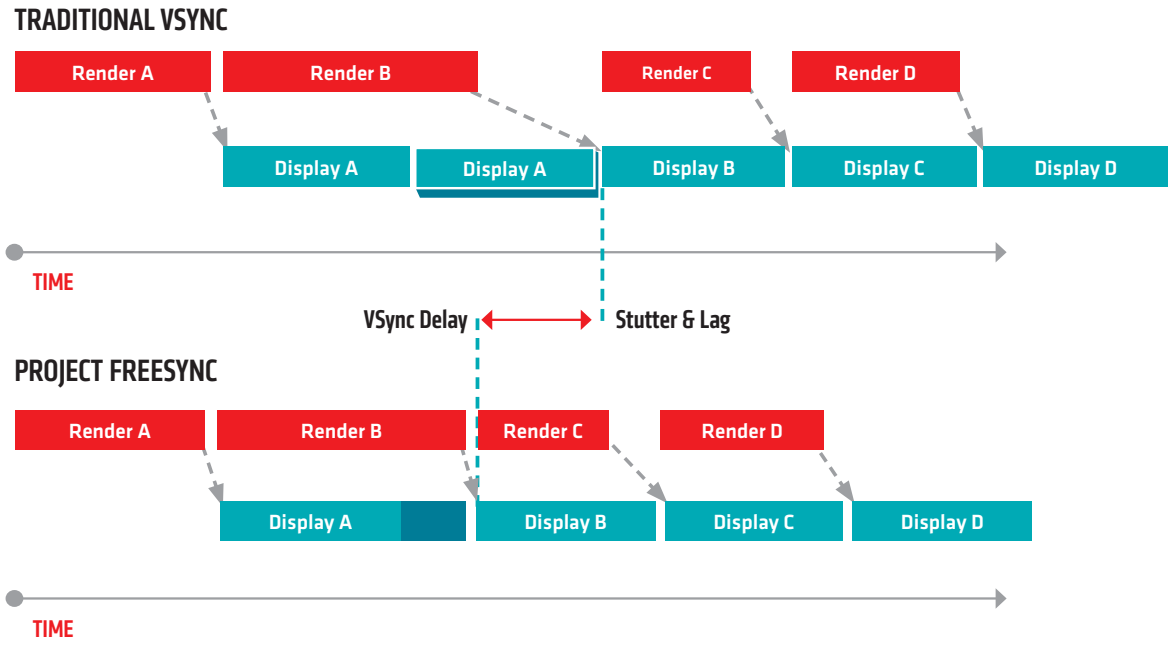
Variable refresh rate technologies have obvious benefits for the gaming experience. In a typical video game, the rendering frame rate varies widely over time due to the diversity of GPU computational work required throughout the game (illustrated in Figure 2). Some scenes with little detail or few effects will render quickly at a high frame rate while, while other scenes with more detailed environments which may include a greater number of effects (such as explosions, smoke, etc), can take a longer time to render. This variance in frame rate has traditionally presented gamers with a trade-off with respect to how they choose to refresh the display, such as choosing to enable the 'VSync' setting.

Figure 2: Illustration of Frame Rate over time in a typical video game



With 'VSync' enabled, the display buffer is only refreshed during the vertical blanking interval between frames, so that a full frame is always displayed and no tearing is ever visible. This is great if the game's rendering frame rate is always higher than the refresh rate of the display. If the game's frame drops below the refresh rate of the display (e.g. during a short period of intensive action), then the new frame will not be ready in time for the display's blanking interval, and the previous frame will be repeated on the display. This is illustrated in Figure 3 as Render Frame B took so long to render, that Frame A had to be repeated. This effect manifests itself as stutter and lag to the end user. The alternative for the gamer is to disable VSync, which helps eliminate stutter and lag, but can produce visible tearing, especially during scenes with fast movement.

Figure 3: Frame analysis of traditional VSync vs Project FreeSync



Variable refresh rate technologies such as Project FreeSync address these issues by dynamically changing the display refresh rate in response to the rendering frame rate of the game using DisplayPort Adaptive-Sync. In the case illustrated in Figure 2, the display will wait until Render Frame B is finished and ready before updating the display. This helps ensure that a frame is almost always displayed as soon as possible, avoiding lag. It also helps ensure that frames do not need to be repeated within the refresh rate range of the display, avoiding stutter. The display refresh rate is synchronized to the rendering frame rate, which helps avoid the issue of tearing associated with VSync-off. Project FreeSync provides the ideal solution for smooth gameplay with decreased lag and virtually no tearing.

VIDEO PLAYBACK

Project FreeSync may also be applied to use cases other than gaming. For example, it could be used to enable essentially seamless playback of video at almost any frame rate (Eg. 23.98, 24, 25, 29.97, 30, 48, 50, 59.94, 60 fps). In the case of video content with a fixed frame rate, the refresh rate is set up to match the frame rate of the video content. Project FreeSync can help provide judder-free playback at almost any video frame rate without the need for costly Frame Rate Conversion (FRC) post-processing. This can also help reduce power consumption during video playback.

SYSTEM POWER SAVINGS

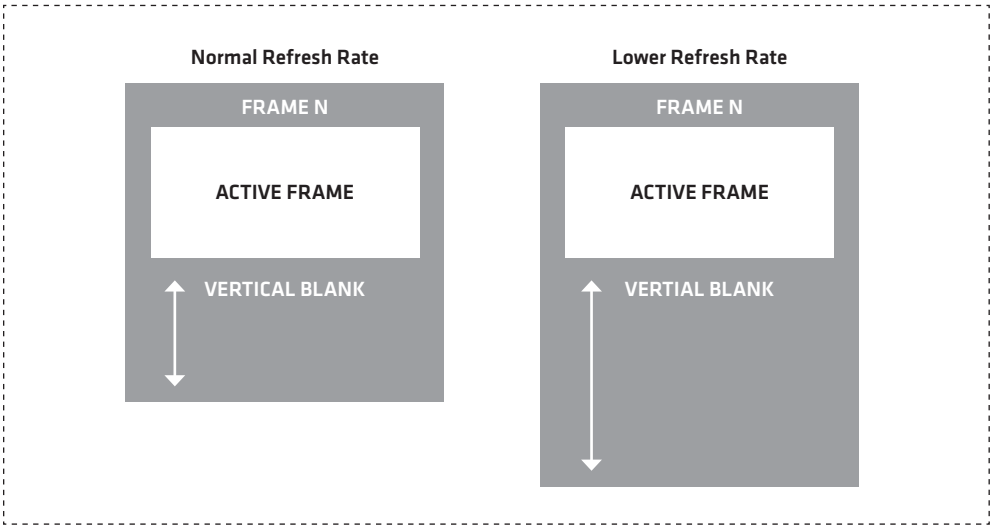
AMD's variable refresh rate technology has been available to notebook PC makers for quite some time as a system power saving feature for embedded notebook panels (known as DRR). The DisplayPort Adaptive-Sync feature is already a capability of the Embedded DisplayPort interface. When the system enters a static screen state (no new content), the refresh rate of the display is lowered to the minimum rate that it can support, to save power. The transition between refresh rates is invisible to the end user, and it comes at a low cost to PC makers, since no additional hardware is required to enable this feature.

IMPLEMENTATION OVERVIEW

AMD's Project FreeSync implementation involves adjusting the vertical blank duration on a frame-by-frame basis to alter the resulting frame period and hence the refresh rate.

Please refer to Figure 4 for an example where vertical blank time is increased for lower refresh rate.

Figure 4: Vertical Blank Adjustment



In this mode of operation, timing changes related to the vertical blank must be ignored by the DisplayPort™ receiver, which must now track the timing from the source. The DisplayPort™ source will tell the sink to enter this mode of operation using a register write. For a plug and play user experience, the graphics driver reads the capability of the display to establish support for this feature. The display's EDID must properly indicate that it is a "continuous frequency display" and report the range of refresh rates that the display supports. This allows the graphics driver to set up the range (from minimum to maximum) of refresh rates supported by the display.

IMPLEMENATION DETAILS

REQUIRED COMPONENTS

The requirements to enable dynamic refresh rate via Project FreeSync are:

- AMD driver build: Upcoming AMD Catalyst™ beta driver (to be announced)
- Operating System: Windows® 7 and Windows® 8.1
- AMD Parts:
  - *AMD Radeon™ R9 290 Series graphics card*
  - *AMD Radeon™ R7 260 Series graphics card*
  - *2014 A-Series Desktop and Mobility APUs, formerly codenamed "Kaveri", "Temash" and "Kabini"*
- Display Interface: DisplayPort™ or eDP required for first version
- Compatible Display or Embedded Panel (notebooks) supporting DisplayPort Adaptive-Sync

CONCLUSION

In summary, AMD's Project FreeSync utilizes DisplayPort Adaptive-Sync to provide variable refresh rate capability that offers a number of benefits:

- Helps improve battery life by reducing the refresh rate of the panel when the screen is static.
- Ensures that the transition between refresh rate is seamless and undetectable to the user.
- Can be enabled by plug and play, making it transparent to the operating system and end user.
- Reduces implementation complexity on the Timing Controller (TCON) and panel by keeping the GPU's pixel clock rate constant and varying blank parameters.
- Dynamically adapts the display refresh rate to fixed video content frame rate for a power efficient and virtually stutter-free video playback experience.
- Dynamically adapts the display refresh rate to variable gaming content render rate for low latency and a smooth, virtually stutter-free gaming experience.