G-SYNC HIGH DYNAMIC RANGE

WP-08484-001_v01 | March 2017

Whitepaper

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NVIDIA G-SYNC™ High Dynamic Range (HDR) displays reproduce more realistic images with high brightness, excellent contrast, saturated color, and smoother motion than traditional standard dynamic range displays. The NVIDIA® G-SYNC HDR also provides stutter-free, tear-free, low latency gaming.

NOT ALL HDR DISPLAYS ARE CREATED EQUAL

Not all displays claiming to be HDR provide the same visual experience. True HDR displays need a thoughtfully engineered combination of the following:

- Higher brightness
- Greater contrast
- Wider color gamut
- Higher refresh rate

Higher Brightness

One of the most significant features of NVIDIA G-SYNC HDR displays is the dramatically increased brightness levels and the ability to express deep saturated colors at a high brightness level. Brighter, more spectacular content highlights makes an image pop compared to a standard dynamic range display.

A *Nit* is the most commonly used measure of brightness and is defined as one candela per square meter. Everyday examples of brightness include direct sunlight at over one billion nits, outdoor sunlight in the hundreds of thousands of nits, indoor ambient light around 15 nits, moonlight at around 0.1 nits, and starlight at about 0.000001 nits.

The real world has such a large range of luminance yet very few displays produce more than 200-300 nits. Consequently, virtually all consumer video and PC graphics content has been graded for only 100 nits—the brightness level at which the content is intended to be shown. Content creators have started to master video and game content at higher brightness levels anticipating that displays will eventually be able to reproduce images as the artist originally intended.

Brightness scale:

- Direct Sunlight – over 1 billion nits
- Outdoor light – Hundreds of thousands of nits
- Peak luminance of UHDA HDR10 LCD display – 1000 nits
- Typical standard dynamic range display – 200-300 nits
- Indoor lighting – 10s of nits
- Moonlight – 0.1 nits
- Starlight – 0.000001 nits

The HDR revolution is pushing display and panel manufacturers to produce much brighter displays with the intent of producing more realistic images. TV vendors and monitor OEMs are challenged to create displays with enough nits to create a consumer *wow factor*. Many challenges remain but certainly there are innovations in panel and backlighting technology on the march towards higher dynamic range. While HDR specifications and standards are evolving, organizations such as the UHD Alliance, are creating specifications for HDR displays. For LCD displays, the UHDA has set the benchmark of 1000 nits for peak brightness and the use of the HDR10 format for mastering HDR content. Today, NVIDIA G-SYNC HDR monitors are breaking new ground for PC gaming displays with the ability to produce 1000 nits of peak brightness and support for HDR10, setting a quality watermark for others to aspire to.

In August of 2015, the Consumer Technology Association (CTA) announced an industry definition for HDR Compatible Displays which included the definition of the HDR10 Media Profile. While other HDR formats exist, HDR10 has been the primary choice for game developers offering HDR extensions of their content for PC and console platforms. Of course, supporting HDR10 under the Windows environment requires application and graphics driver changes. NVIDIA Maxwell and Pascal GPUs support HDR10 output over DisplayPort and HDMI and NVIDIA is continually monitoring and evaluating new formats and standards as they emerge.

Greater Contrast

While brightness is one of the most obvious features of an HDR display, the contrast ratio is an equally if not more important feature that affects picture quality. Simply put, contrast ratio is the difference between the brightest and the darkest levels a display can produce—the dynamic range.

As explained in section Higher Brightness, the human eye can see about 12 orders of magnitude of brightness from the sun to starlight. However, our eyes adjust given the ambient light conditions. At any given moment, we can only see several orders of magnitude less than that range.

The new generation of HDR display tries to emulate that range by producing far higher contrast ratios with the use of new panel and backlight technology. The traditional LCD panel with a global dimming backlight is able to create a 1000:1 to 2000:1 contrast ratio—200 nits peak brightness and 0.1 nits black—only about three orders of magnitude.

Using different techniques to spatially isolate the bright and dark regions of the screen, the contrast ratio can be drastically improved. Edge-lit displays, where LEDs are placed at the sides of the panel and light guides direct light across the panel, are able to increase contrast ratio significantly by creating more isolation. Edge-lit is often the only choice when power limitations and thinner form factors are required, as in thin bezel displays like some TVs and most laptops. HDR displays are higher up the scale with a full array direct backlight with local dimming zones of LEDs placed directly behind the panel that can produce contrast ratios over 10,000:1, depending on the number of zones implemented. The recently announced G-SYNC HDR 4 K, 144 Hz monitors with 384 zone full array direct backlight are setting new standards for high contrast.

Further technology improvements in this area are on the horizon. TV manufacturers have used display technologies such as OLED and have been able to reach higher contrast levels, but at the cost of trading-off peak brightness and long term reliability, problems that would be much worse for PC monitors. Innovations in LCD panels such as micro-LED and recent announcements from Panasonic show promise but are not yet in shipping products.

Wide Color Gamut

Reproducing more of the colors the human eye can see is crucially important to making high-quality HDR displays. For the last couple of decades the most commonly used color space for the PC industry has been sRGB. It uses the same three color primaries as the Rec. 709 color space defined for HDTVs. This format was defined in the era of CRT displays and was extremely useful for representing the most achievable range of colors.

After 20 years, the limitations of this color space have become apparent. The sRGB color space covers only about 35% of the colors the human eye can perceive. Display technology has improved enough that the other, wider color gamut's can now be used to display the highly-saturated reds and deep greens that are visible in the real world but previously not seen on TVs or PC displays.

The DCI-P3 color space comes from SMPTE as a standard for digital cinema projection. It is the first significant and achievable step for display panel manufacturers as they attempt to go beyond the sRGB space to improve visual experience. The 4K G-SYNC HDR monitors combine 1000 nits with the DCI-P3 gamut allowing much brighter and saturated colors to display, which will amaze the user accustomed to a 200 nits sRGB experience (see Table 1).

Table 1. Color Gamut

Color Gamut	Coverage of Visual Spectrum Relative to sRGB
sRGB	1.0
Adobe RGB	1.17
DCI-P3	1.26
BT. 2020	1.72

BT. 2020 (see Table 1) is considered an even more aggressive target for the display industry, perhaps to be implemented in future displays. To date, no consumer displays can reproduce anywhere near 90% of the BT.2020 color space. However, many HDR content formats use it as a container for HDR content as it is assumed to be future proof. The HDR10 format uses this color space as well—support for 10-bit encoded BT. 2020. The next challenge for content creators both from the video and game industries is how to take advantage of this wider palette and produce a visually pleasing experience to amaze the consumer with more realistic colors.

High Refresh Rate

Traditional TV and PC monitors were tailored to the demands of the broadcast industry and 60 Hz refresh rates were considered good enough. However, content with very fast motion sequences can suffer the effects of motion blur. As refresh rates increase above 60 Hz, the brain perceives motion to be smoother, appearing much more realistic. PC monitors targeting high frame rate gaming content at 120 Hz or higher are the natural extension of this effect. While NVIDIA GPUs support HDR over both the HDMI and DP display interfaces for PC platforms, DisplayPort 1.4 is considered the more popular choice going forward. Using the High Bit Rate 3 (HBR3) link rate allows DisplayPort monitor inputs to support 4 K @144 Hz versus 4 K @ 60 Hz maximum for the latest HDMI 2.0b standard. In fact, G-SYNC HDR monitors driven by the NVIDIA family of Pascal GPUs supporting DP 1.4 with HBR3 are the first display device (TV or monitor) to demonstrate HDR and 4 K @ 144 high refresh rate. Additionally, the gaming market requires low latency between the cable input to displaying images on the glass. For HDR, this is even more technically challenging. The first HDR TVs have at least 21 – 45 ms of latency, unacceptable for competitive gamers.

G-SYNC HDR displays combine high refresh rates with the high brightness, high contrast, and more realistic color creating images that will dazzle consumers who will only now realize what they had been missing in standard dynamic range displays. In addition, G-SYNC HDR monitors take that one step further, guaranteeing minimal input lag and a stutter-free, tear-free gaming for the ultimate visual experience.