HAND FORGED S&M™ COLLECTION

UHD HDR BENCHMARK

BEGINNER'S GUIDE

Getting Started with the

Spears & Munsil™ UHD HDR BENCHMARK

Setup & Evaluation Disc

SCOTT WILKINSON

V.1.0

SPEARS & MUNSIL UHD HDR BENCHMARK BEGINNER'S GUIDE

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Introduction

Have you recently purchased a big, beautiful Ultra HD TV? If so, congratulations! Or perhaps you're thinking about upgrading your current HDTV with a brand-new UHD TV. That would be a big improvement not only in terms of higher resolution, but even more importantly, in terms of increased brightness and higher dynamic range as well as a wider range of colors and improved video processing. In any event, buying a UHD TV represents a significant investment in your video entertainment, so you should get the best possible performance out of it.

Sadly, most people don't think about this very much. They take the TV out of the box, plug it in, turn it on, and leave it at that. Bad idea! Most TVs come out of the box with settings designed to make the picture stand out on a retail-showroom floor next to myriad other TVs under super-bright lights. But consumers don't live on a showroom floor. The environment in most homes is quite different, which means the TV's settings must be adjusted in order to get the best possible picture quality under those conditions.

Now, you might ask, what defines "best possible picture quality"? That's easy—it is adherence to a set of standards used by content creators to set up the video displays on which they view their work. In other words, the best picture quality on a consumer TV duplicates as closely as possible what the content creators saw as they were producing the content. This is known as "preserving the artist's intent," a laudable goal that all video displays should aspire to.

Matching the environment in which content creators work is also desirable, but that's impractical in many home situations. Production studios are usually painted dark gray with

little if any light in the room (other than a bias light, which we'll explain later). In most homes, people watch TV in rooms that do not conform to this ideal. They might have light-colored walls and perhaps lots of ambient light. It's important to take this into account when adjusting a TV's picture controls.

The good news is that it's relatively easy to optimize the picture quality of your new UHD TV for your particular home environment. All you need is a UHD Blu-ray player and a copy of the *UHD HDR Benchmark* setup disc from Spears & Munsil. Created by video scientists Stacey Spears and Don Munsil—whose previous Blu-ray and DVD setup discs are among the most highly regarded in the industry—*UHD HDR Benchmark* provides everything you need to adjust your UHD TV's settings for top performance.

The only way to improve your TV's performance beyond what you can do with *UHD HDR Benchmark* is to hire a professional calibrator. They have expensive instruments and extensive training to dig deeper into the TV's controls and wring every last bit of performance out of it. But hiring such a technician can cost hundreds of dollars, and you can usually get 70 to 80 percent of that ultimate performance simply by using *UHD HDR Benchmark* and the instructions provided here.

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UHD vs 4K

Before we begin, we want to clarify a couple of points. First, if you've read anything about UHD TVs, you know they are often labeled "4K," a term that is widely used interchangeably with "UHD." However, they are not synonymous. UHD refers to a resolution of 3840x2160, which is exactly twice the horizontal and vertical resolution of high-definition television (1920x1080). By contrast, 4K is correctly defined as a resolution of 4096x2160. That's a difference of only 256 horizontal pixels, so what's the big deal?

The big deal is that UHD rightly refers to the resolution of consumer displays, while 4K refers to the resolution used in commercial cinemas. Unfortunately, many manufacturers of consumer displays latched onto the term "4K" because they think it's sexier and easier for consumers to understand than "UHD."

One problem with using 4K in a consumer context is that it refers to horizontal resolution, whereas previous standards referred to vertical resolution; for example, 1080p, 720p, and 480i all referred to the number of pixels in the vertical direction. By that logic, UHD for consumers should be called 2160p. On the other hand, the resolution of digital commercial cinema has always been expressed in terms of horizontal resolution: 4K (4096x2160), 2K (2048x1080), and 1K (1024x540) all refer to the number of pixels in the horizontal direction.

The only exceptions to this distinction are some consumer-oriented video projectors from Sony, which have a native resolution of 4096x2160. Even so, when they play UHD content from a UHD Blu-ray or streaming source, they display a resolution of 3840x2160, leaving 128 inactive pixels on each side of the image.

Despite the Sony exception, we use the term UHD exclusively when referring to consumer displays. You will not see the term 4K used in that context anywhere in this guide or on the disc itself. We pride ourselves on being technically accurate, including the terminology used in our products.

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UHD HDR Projectors

In addition to modern flat-panel televisions, a growing number of consumer video projectors now sport a resolution of 3840x2160—or at least an approximation thereof—and the ability to reproduce high dynamic range (HDR) content. But consumer projectors cannot achieve anywhere near the brightness levels of flat-panel TVs, so they are more rightly called "extended dynamic range" or EDR rather than true HDR. Still, the *UHD HDR Benchmark* disc can be used to optimize HDR-capable projectors as well as televisions.

One more point about projectors: Many so-called UHD or 4K models actually use imaging chips with a native resolution of 1920x1080, and each pixel is quickly shifted back and forth diagonally between two positions. Each of these two "virtual pixels" can have different color and brightness by changing each one's values very quickly while the chip moves from one position to the other, so one physical pixel on the chip becomes two effective pixels on the screen. This happens so fast that you don't see the shifting; you only see an increased resolution. JVC calls this technique e-Shift, while Epson calls it 4K Enhancement.

The problem is that the effective resolution of these projectors is not true UHD. If you can tolerate a bit of arithmetic, UHD includes a total of 8,294,400 pixels (3840x2160), while HD has a total of 2,073,600 pixels (1920x1080). Pixel shifting with an HD imager doubles the number of pixels from 2,073,600 to 4,147,200, which is still only half the number of pixels in a true UHD image. Plus, the virtual pixels actually overlap each other and use sharpening algorithms. Even so, the detail generally looks sharper than a native HD image.

Interestingly, some consumer projectors based on DLP (Digital Light Processing) technology

use a single 1920x1080 imaging chip and quickly shift each pixel among *four* different positions, resulting in an effective resolution of 3840x2160. This is possible because the pixels on a DLP chip can be switched between positions much faster than LCD or LCoS pixels.

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Disc Navigation

To use *UHD HDR Benchmark*, you need to understand how to navigate the menu system. The main menus are found along the left side of the menu screen, and some of them include submenus, which are located along the top of the screen.

When you first start the disc, it opens to the Configuration menu (see Fig. 1), which is the top item in the main menu. Use the player remote's up/down/left/right cursor buttons to highlight the desired setting and press the remote's Enter button to enable that setting. (We will explain how to set the correct values in the Configuration menu a bit later.)

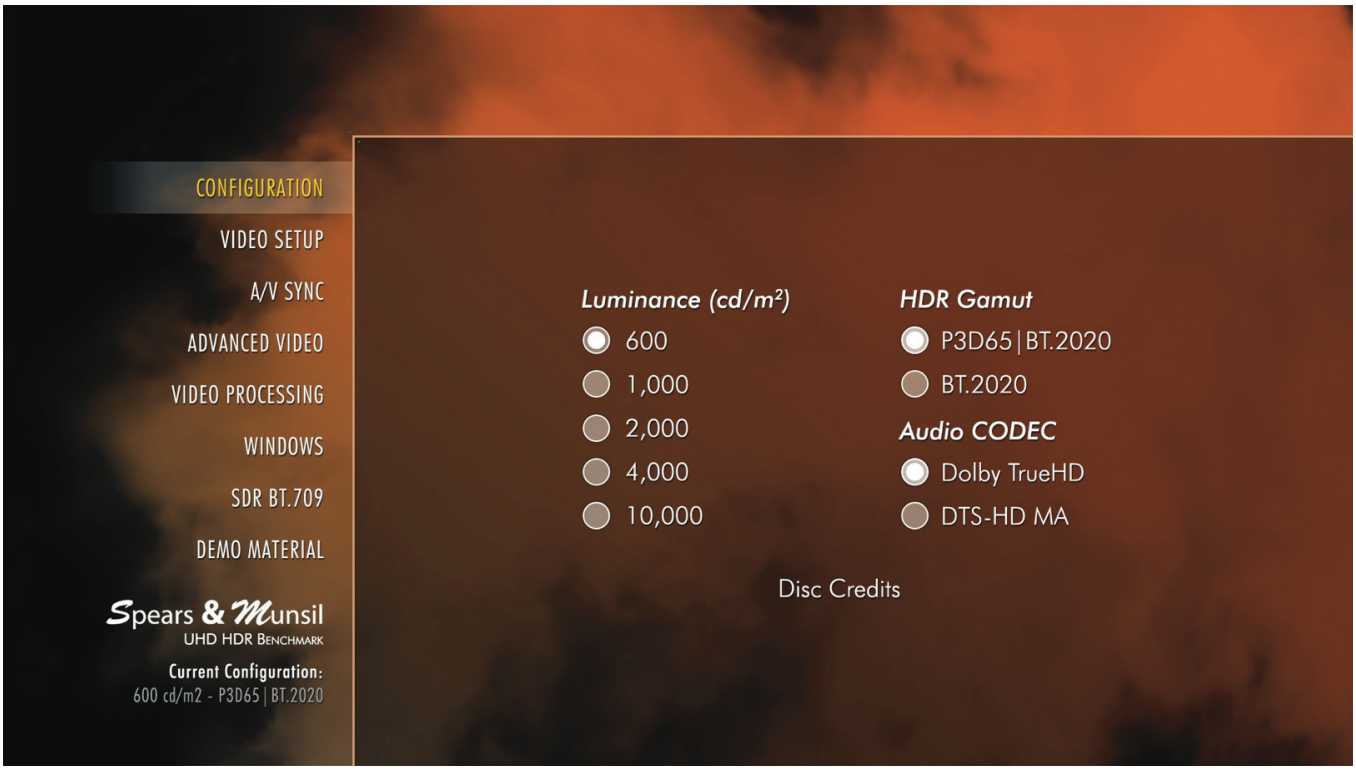

Fig. 1: The Configuration screen is the first menu you see when you start playing UHD HDR Benchmark.

To select a different main menu, press the remote's left-cursor button until the Configuration menu disappears. Then, press the remote's up- and down-cursor buttons to highlight the menu you want to see; if you press the up-cursor button at the top of the list, the highlight will jump to the bottom, and vice versa. When you've highlighted the menu you want, press the remote's Enter or right-cursor button to open the menu. Use the remote's cursor buttons to highlight the pattern you want to see and press Enter to display the selected pattern.

Once a pattern is displayed, you can jump directly to the next or previous pattern in the group by pressing the right- or left-cursor button, respectively. If you press the up-cursor button while viewing a pattern, the Luminance menu pops up. Press the Enter button to close the Luminance menu.

To return to the menu screen from any pattern, press the Top Menu button on the player's remote, which returns to the menu you were already in. If you want to go to a different menu, press the left-cursor button until the current menu disappears, then the up- or down-cursor button to highlight a different menu.

If you select a menu with submenus, such as Advanced Video (see Fig. 2), you will see the submenus across the top of the screen. To select them, press the up-cursor button until one of them is highlighted, then press the right- and left-cursor buttons to highlight the one you want. Press the Enter button to open the selected submenu and use the cursor controls as described previously to select and display the pattern you want.

Fig. 2: The Advanced Video menu is one of several that include submenus across the top of the screen.

As you look around the menu system, you will see many more patterns than we will cover in this beginner's guide. Don't be intimidated by the sheer volume of material on the disc; for now, focus on the patterns we will explain here.

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Preparation

Before using *UHD HDR Benchmark* to optimize your display, you need to make sure your system is set up properly. Here's what you need to know.

UHD Blu-ray Player

First, of course, you need a UHD Blu-ray player. If you don't have one already, they are available from LG, Panasonic, Philips, Sony, and Yamaha. Also, the Microsoft Xbox One S and One X gaming consoles have a UHD Blu-ray player built in.

You might also find models from Samsung at retail, but the company recently announced it will stop making them. Oppo also made UHD Blu-ray players—the UDP-203 and UDP-205 are among the most highly regarded in the industry—but the company stopped making them some time ago. If you already have one, use it!

If you don't have a UHD Blu-ray player already, we recommend getting one that supports Dolby Vision. Granted, *UHD HDR Benchmark* does not have Dolby Vision test patterns, so why get a player that supports it? Because players with Dolby Vision are generally better quality than those without it. Plus, *UHD HDR Benchmark* does have demo material encoded in Dolby Vision. But don't worry if you already have a player without Dolby Vision; it should work just fine with *UHD HDR Benchmark*.

HDMI Cable

It's best to connect the player to your display directly when using *UHD HDR Benchmark*. Connect an HDMI cable from the player's HDMI output to the display's highest-speed HDMI input (more about this shortly). Do not send the signal through an AV receiver or processor—even those that claim to pass UHD HDR signals—as you would in a normal system setup. Why? Because these devices can do unexpected things to the signal, such as upscaling, color-space conversion, and automatic black-level adjustments. You can figure out what they do to the signal and address any potential problems after setting up your display.

Be sure to use an HDMI cable that has been rated to pass data at HDMI 2.0's maximum bitrate of 18 gigabits per second. (HDMI 2.1 can reach bitrates up to 48 Gbps, but that is not needed for *UHD HDR Benchmark*.) Sometimes, this can be difficult to determine from descriptions and packaging, which often claim that the cable is "high speed" without specifying the actual maximum bitrate it supports. One way to be sure is to look for a special anti-counterfeit sticker on the package labeled "Premium Certified Cable" (see Fig. 3). This sticker indicates that the cable has been tested an authorized test center and certified by the HDMI Licensing Administrator, the official HDMI standards organization.

Fig. 3: Look for this sticker on the package of an HDMI cable to make sure it passes 18 Gbps.

Also, use the shortest possible HDMI cable from the player to the display. Lengths up to eight or nine feet should be fine; longer cables might cause problems with fine-detail test

patterns on the disc. The only exceptions are fiber-optic and other so-called “active” cables, which include electronics to assure that the entire signal arrives at its destination completely intact, even over long distances.

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Connecting to the Display

As mentioned earlier, connect a high-speed HDMI cable from the player's HDMI output to the display's highest-speed HDMI input. Most displays have more than one HDMI input, and in many cases, not all of them operate at 18 Gbps. Inputs identified as HDMI 2.0 are most likely to support the highest bitrate. Also, if one of the HDMI inputs is labeled ARC (Audio Return Channel), it will support the highest bitrate, so use that one if available. Otherwise, consult the display's manual to determine which HDMI inputs operate at the highest bitrate.

Even more confusing, the high-speed HDMI inputs on many TVs do not operate at 18 Gbps by default. Manufacturers often limit the bitrate on these inputs for maximum compatibility with older equipment. To enable the highest bitrate in many cases, you must dig into the TV's menu and find the setting that controls this function. Here are a few examples:

Hisense: For Android and Vidaa models, press the Home button on the remote, select Settings, select Picture, select HDMI 2.0 format, select Enhanced. For Roku TV models, press the Home button on the remote, select Settings, select TV Inputs, select the desired HDMI input, select 2.0 or Auto. Select Auto for all inputs to have them automatically self-configure with the best bitrate for the signal they receive.

LG: Should automatically switch to high bitrate when TV receives an HDR or BT.2020 color-space signal. To manually set high bitrate, find the parameter called HDMI Ultra HD Deep Color. Its location in the menu system has changed over the years; for the last two

years, it has been located in the Additional Settings submenu within the Picture Settings menu.

Samsung: Press the Home button on the remote, select Settings, select General, select External Device manager, select Input Signal Plus, select the HDMI input you are using, press the Select button to enable 18 Gbps for that input.

Sony: Press the Home button on the remote, select Settings, select External inputs, select HDMI signal formats, select Enhanced format.

TCL: Press the Home button on the remote, select Settings, select TV Inputs, select the HDMI input you are using, select HDMI Mode, select HDMI 2.0. The HDMI Mode defaults to Auto, which should automatically enable high bitrate when necessary.

Vizio: Press the Menu button on the remote, select Inputs, select Full UHD Color, select Enable.

The first time a Samsung or LG TV detects a new signal such as UHD HDR, it should prompt you to verify that the HDMI input needs to be at its highest bitrate. If you specify the incorrect answer here, you'll need to go into the menu system as described above and change it.

7

Display Settings

Now it's time to make sure your display's other settings are configured correctly to take full advantage of *UHD HDR Benchmark*. First, select the display's Cinema or Movie picture mode, which is generally the most accurate out-of-the-box mode. This picture-mode setting is normally found in the display's Picture menu.

Some TVs have more than one Cinema mode; for example, current LG TVs default to Cinema Home, but the mode labeled Cinema is best. You can verify this by displaying the HDR Color Space Evaluation pattern and looking at the ST2084 Tracking section (see Fig. 4). Each rectangle in that section looks solid gray—as it should—when you select the Cinema mode in a 2018 or 2019 LG TV. Likewise, the best mode in Sony TVs is called Cinema Pro.

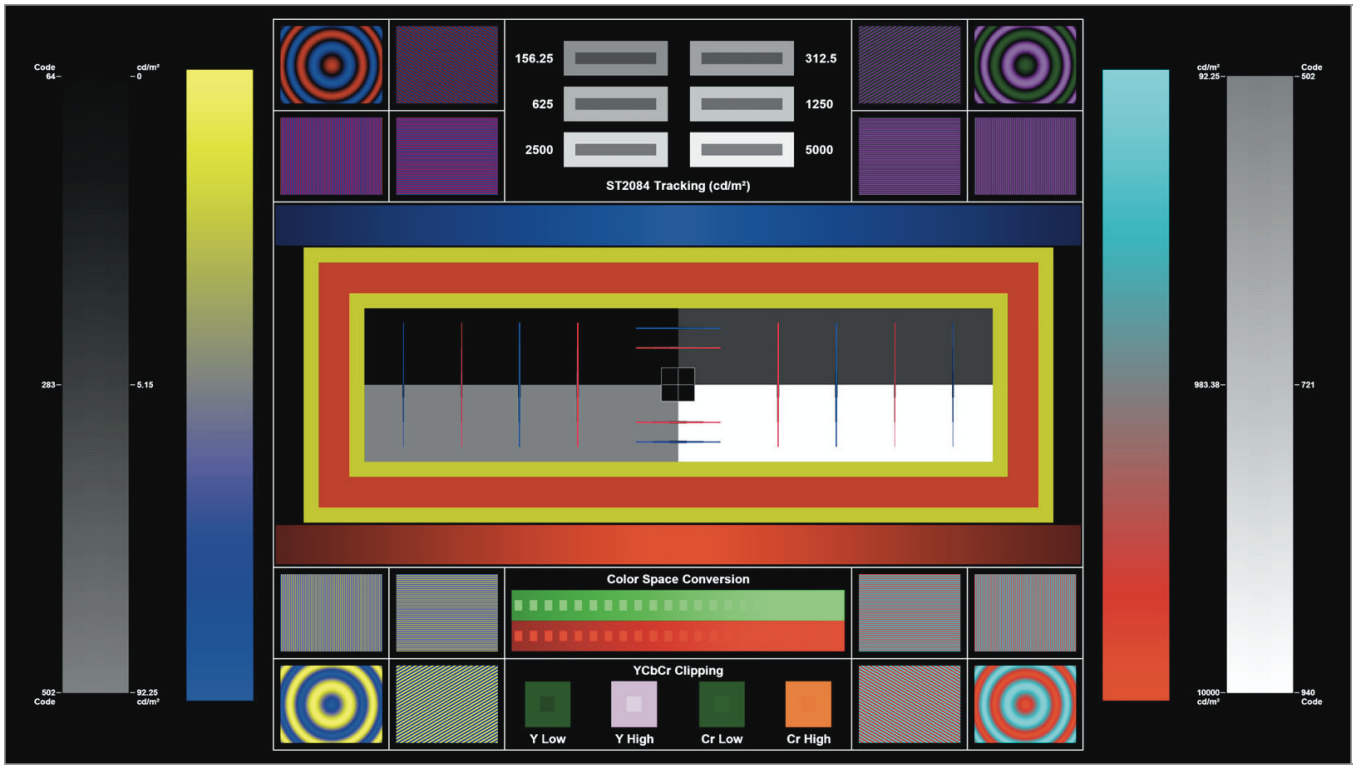


Fig. 4: In the Color Space Evaluation pattern, look at the ST2084 Tracking section at the top; each rectangle should be solid gray in the display's Cinema mode. (Menu: Video Setup)

Next, verify that the color temperature is set to Warm, which is generally the most accurate color-temperature setting. The Cinema picture mode normally defaults to this setting, but it's a good idea to double check. The color-temperature setting is often found deeper in the display's Picture menu in the "advanced settings" section.

Many Sony and Samsung TVs offer two Warm settings: Warm1 and Warm2. Select Warm2 if it's not active already. Also, newer Vizio TVs do not have a Warm setting at all; in that case, select Normal.

Another important setting to check is often called Picture Size or Aspect Ratio. The available choices for this setting typically include 4:3, 16:9, one or more settings called Zoom, and hopefully, one called something like Dot-by-Dot, Just Scan, Full Pixel, 1:1 Pixel Mapping, or something like that. The setting with a name like those last ones displays each pixel in the content exactly where it's supposed to be on the screen, which is what you want.

Why are there settings that don't display each pixel in the content exactly where it's supposed to be on the screen? Many of the settings distort the image to fill the screen, moving pixels around and even synthesizing new pixels to do so. And some settings stretch the image ever so slightly in a process called "overscanning," which was used in analog TVs to hide information at the edges of each frame that was supposed to be invisible to viewers. This is irrelevant in the age of digital TVs and broadcasts, but many manufacturers still do it.

In all these cases, the process of stretching the image—which is called "scaling"—softens the image, reducing the detail you can see. To get the most from *UHD HDR Benchmark*, you need to make sure that any scaling, including overscanning, is disabled. Select Dot-by-Dot, Just Scan, Full Pixel, or whatever your TV calls 1:1 pixel mapping.

Hisense TVs have separate Picture Size and Overscan parameters. Turn Overscan off and set Picture Size to Dot-by-Dot.

To verify that you have disabled all scaling, display the Image Cropping Pattern (see Fig. 5), which is found in the Advanced Video|Evaluation menu. A single-pixel checkerboard appears in the center of that pattern. If scaling/overscanning are disabled, the checkerboard looks uniformly gray. Otherwise, the checkerboard will have strange distortions called "moiré." Once you select 1:1 pixel mapping, the moiré should disappear.

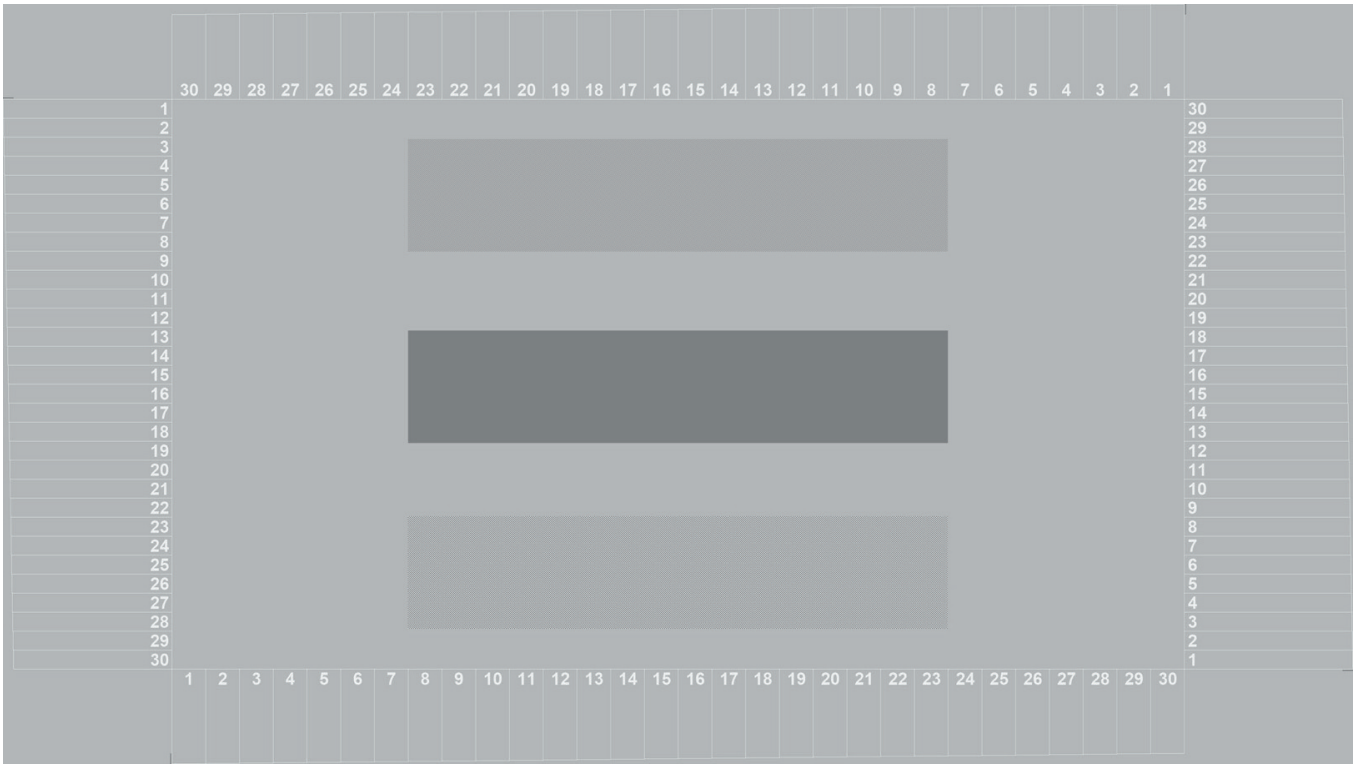


Fig. 5: When you select 1:1 pixel mapping in the display, the rectangle in the center of the Image Cropping Pattern will look uniformly gray. In addition, you will be able to see the ends of the rectangles labeled "1." (Menu: Advanced Video|Evaluation)

OLED TVs typically have a function called "orbit," which moves the entire image up, down, right, and left by a single pixel once in a while to reduce the chance of image retention or "burn in." If this feature is enabled—which it usually is by default—you will not be able to see the end of one of the rectangles labeled "1" in the Image Cropping pattern. Turn off the orbit function to verify that you can see the ends of all four rectangles labeled "1."

Next, make sure that all of the TV's so-called "enhancement" features are disabled. These typically include frame interpolation, black-level expansion, dynamic contrast, edge

enhancement, noise reduction, and others. Most of these "enhancements" actually degrade the image quality, so turn them off in general.

For standard dynamic range, the display's gamma setting should be as close to 2.4 as possible. Without getting too technical, gamma determines how the display responds to different brightness codes in the video signal. The SDR test patterns on are mastered with a gamma of 2.4, so that's what the display should be set to.

As you might expect by now, different manufacturers specify the gamma setting differently. Some specify the actual gamma value (for example, 2.0, 2.2, 2.4, and so on), while others specify arbitrary numbers (such as 1, 2, 3, etc.). To verify that your display's gamma is set to 2.4, display the Color Space Evaluation pattern (see Fig. 6) from the SDR BT.709 Setup menu and look at the Gamma Tracking section at the top. The gray squares should look uniformly gray. If they don't, adjust the display's gamma setting until they do.

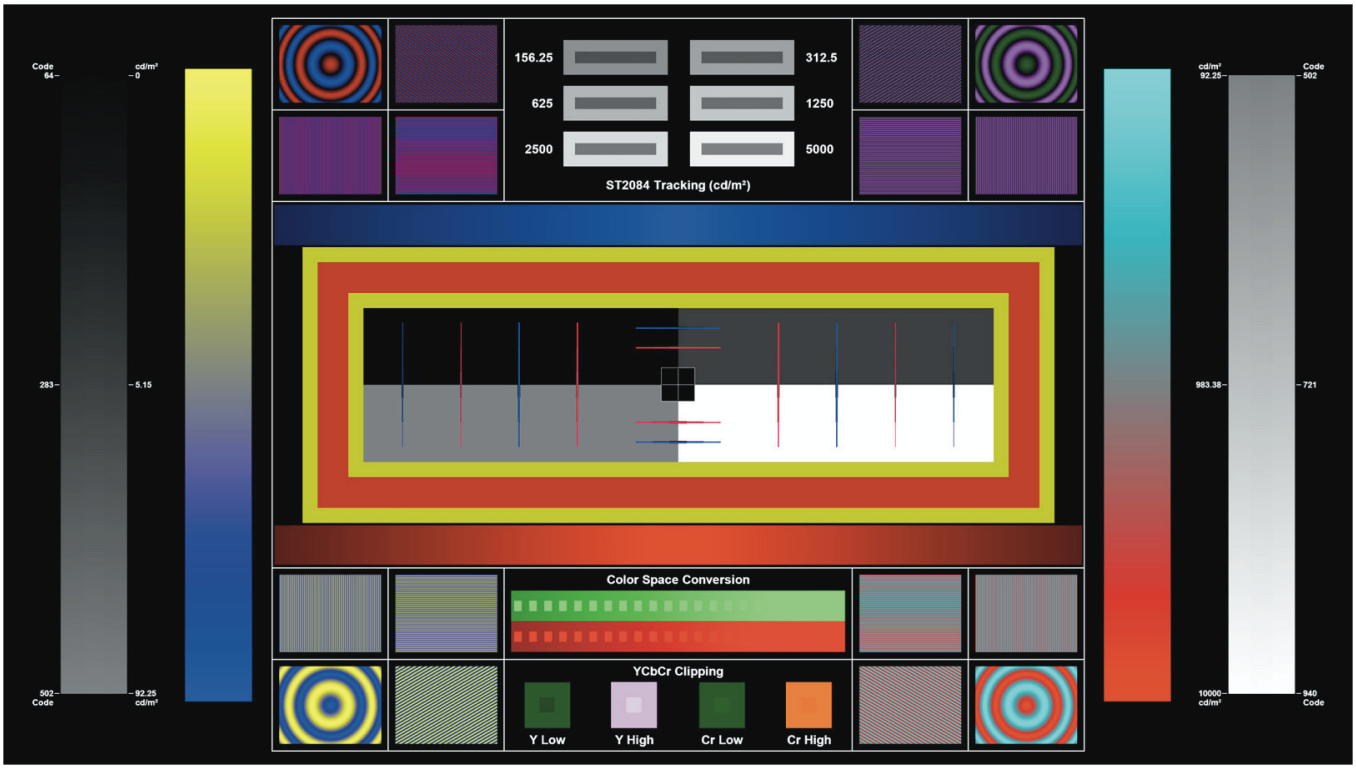


Fig. 6: The gray rectangles at the top of the SDR Color Space Evaluation pattern should look uniformly gray if the display's gamma is set to 2.4. (Menu: SDR BT.709 | Setup)

Unfortunately, this pattern doesn't work on LCoS projectors, nor does it work on Sony consumer LCD and OLED displays due to internal processing. If you can't get the rectangles to look uniformly gray, or at least close, your display might be doing some sort of sharpening or other processing that affects the gamma. If you can't set gamma so the rectangles look uniformly gray, your best option is to return the gamma control to its factory-default setting and let it go at that.

8

Player Settings

UHD Blu-ray players provide their own set of controls that you should check. Open the player's menu and see if it offers picture-adjustment controls (such as brightness, contrast, color, tint, sharpness, noise reduction, etc.). If so, make sure they are all set to 0/Off. The same controls are found in the display, which is where you should adjust them.

Virtually all players offer an output-resolution control, which should be set to UHD/4K/3840x2160. This will cause the player to upscale lower resolutions to UHD, which is the resolution of most material on *UHD HDR Benchmark*, so it will be sent to the display unaltered. (The disc has some HD material, but for now, let the player upscale it.)

In addition, some UHD Blu-ray players—such as those from Panasonic—have the ability to tone map HDR content before it is sent to the display. In the Panasonic players, however, turning this feature on introduces some banding in some of the test patterns on *UHD HDR Benchmark*. So, it's best to disable this feature when using the disc.

Most other picture controls in the player should default to "auto," which is fine. Depending on the player, these can include aspect ratio, HDR format, color space, color bit depth, 3D, and deinterlacing.

9

UHD HDR Benchmark Configuration

Now that the player and display preparation are complete, you need to configure the *UHD HDR Benchmark* disc itself to output its contents as needed for different situations. Play the disc and select Configuration at the top of the main menu (see Fig. 7).

Fig. 7: The UHD HDR Benchmark configuration screen lets you specify exactly how the material on the disc will be sent to the display.

As you can see, there are only three settings in the Configuration screen. The most straightforward setting is HDR Gamut—simply set it to P3D65|BT.2020. This is the color gamut of virtually all consumer displays and content. The BT.2020 option is included for use with Portrait Display's CalMAN calibration software, but it should not be used by most consumers.

The Audio CODEC setting is irrelevant for optimizing the video performance of your display. It determines which audio codec (short for "coder-decoder") is used when playing the demo material. Both settings—Dolby TrueHD and DTS-HD MA—are lossless and should sound identical. Virtually all modern audio devices, such as AV receivers and processors, support both formats, so it doesn't matter which one you select. If you are using a soundbar or other type of audio system, determine which codec it supports and select that one in the Configuration screen.

The Luminance setting determines the peak brightness of HDR content output by the disc. Most real-world HDR content is mastered with a peak luminance of 1000 candelas per meter squared (abbreviated cd/m^2 and more commonly called nits), while some content is mastered with a peak luminance of 4000 cd/m^2. In general, we recommend setting the Luminance to 1000 to match the peak brightness of most consumer content. You can also set it to 4000 in order to see how the display behaves with content mastered at 4000 nits.

Almost Ready!

We're almost ready to start setting up your display using *UHD HDR Benchmark*; there are only a couple more things to mention before we do. First, we want to make sure that the signal retains its 10-bit resolution from the player to the display.

For those who aren't familiar with the importance of a signal's bit resolution, content in standard dynamic range (SDR), such as broadcast TV, Blu-ray, and DVD, has 8-bit resolution, which means the brightness of each color (red, green, blue) at any given moment is represented by an 8-bit number. This works fairly well because the difference between the darkest and brightest parts of the image is limited.

Of course, the difference between the darkest and brightest parts of an image in high dynamic range (HDR) is much larger. So, more bits must be used to avoid the appearance of visible bands in subtle gradations. Current HDR video uses 10 bits, and we want to be sure that none of those bits are being ignored or discarded for any reason. Use the Quantization Rotate pattern (see Fig. 8) to verify that all 10 bits are getting from the player to the display.

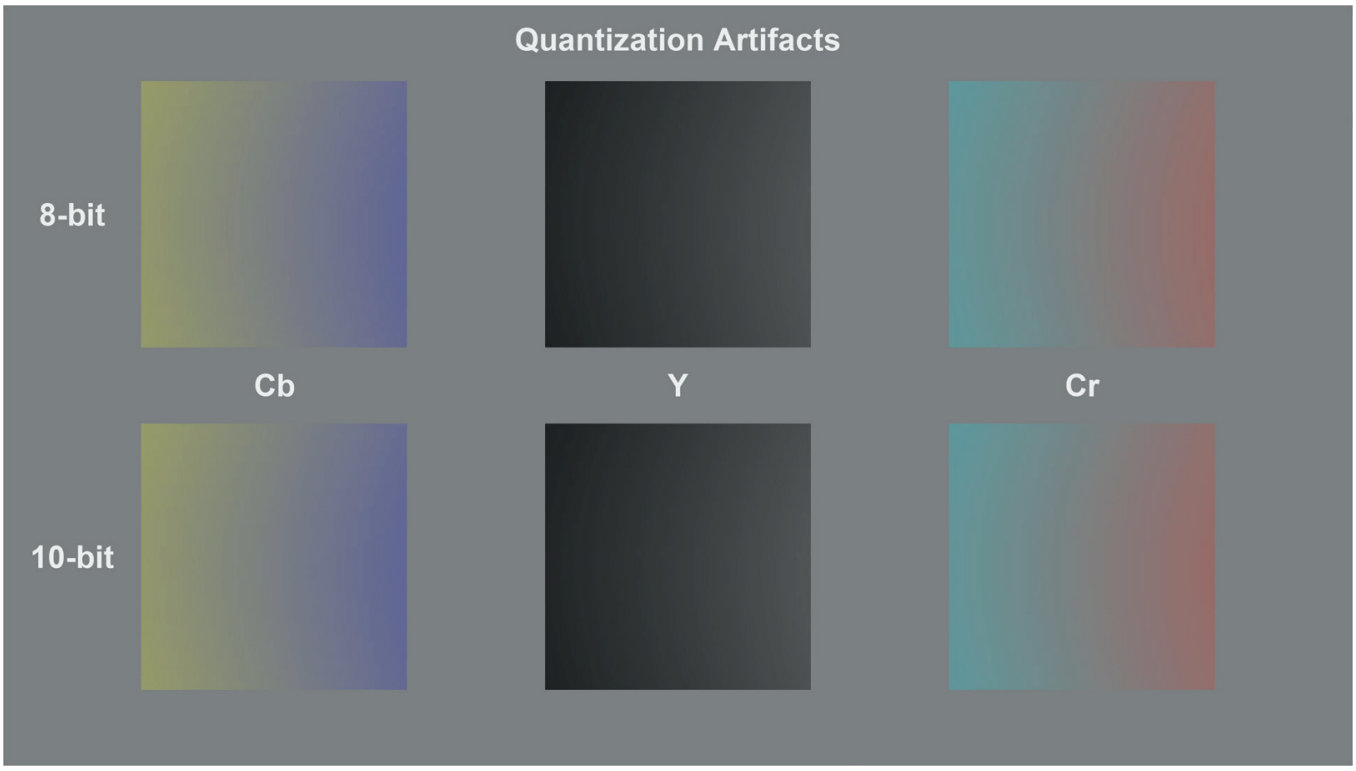


Fig. 8: The Quantization Rotate pattern includes three squares within which a pair of colors rotate (which, of course, you can't see in this still image). In the squares labeled "8-bit," you should see some banding in the area where the colors are blended, while you should see no banding in those areas of the squares labeled "10-bit." (Menu: Video Processing)

The final step is to consider how much light you normally have in the room when you watch something on the display. Ideally, the room should be quite dark, since this is how the content creators viewed their images. However, you might normally watch with some light in the room. In any case, it's important to perform the following procedures with the amount of ambient light that you would normally have in the room when watching the display.

If you normally watch in a dark room, good for you! That's the best way to experience video content, especially movies. In that case, however, you might want to consider putting a bias light behind the screen. This is most important with TVs, though some say a bias light should be used with projectors as well.

What is a bias light, and why is it important? A bias light is a white light that sits behind the screen. It helps "bias" or shift the dynamic range of your eyes so that you experience less eye strain when watching video in a dark room. The light should be a specific "color" of white, technically called D65.

You can purchase a bias light with the correct color of white from Scenic Labs, the same company that distributes *UHD HDR Benchmark*. The company's bias light is called The MediaLight, and it has a dimmer that lets you set its brightness according to your display's brightness.

To set the bias light's brightness, use the Bias Light pattern (see Fig. 9). Interestingly, the bias light should be brighter for SDR that for HDR, so take a look at the Bias Light pattern in the Video Setup menu (HDR) and the SDR BT.709|Setup menu. Adjust the brightness of the bias light to roughly match the brightness of the central rectangle in the pattern.

Fig. 9: Set the brightness of the bias light to roughly match the brightness of the central rectangle in the Bias Light pattern. This setting will be different for HDR and SDR. (Menu: Video Setup and SDR BT.709|Setup)

Okay, it's finally time to optimize your display!

10

Optimize Standard Dynamic Range

We'll start with adjusting the controls for standard dynamic range. Why not start with HDR? For one thing, a lot of consumer content is still SDR, so optimizing the controls for SDR is important. Also, in some cases—Sony, in particular—the SDR settings affect HDR, so optimizing SDR first is important for getting HDR performance correct.

The five controls you'll be adjusting in the display are generally called Brightness, Contrast, Color, Tint, and Sharpness. The patterns to set these controls are found in the SDR BT.709 Setup menu (see Fig. 10).

Fig. 10: To optimize your display's SDR performance, select SDR BT.709 in the main menu along the left side and Setup in the submenu along the top.

These patterns have a peak brightness of 100 cd/m^2, which is the standard for SDR. They will not look as nearly bright as the display can be, but they are correct for SDR.

Brightness

The first control to adjust is Brightness, which raises and lowers both the black level and peak brightness of the display. In other words, it shifts the entire dynamic range up and down. We are only concerned with its effect on the black level; we will adjust the peak brightness using the Contrast control after we set the Brightness.

Display the Brightness pattern (see Fig. 11) and look for four vertical stripes in the center of the image. If you can't see four stripes, increase the Brightness control until you can. Then, decrease the control until you can't see the two stripes on the left but you can see the two stripes on the right. The inner stripe on the right will be barely visible, but you should be able to see it.

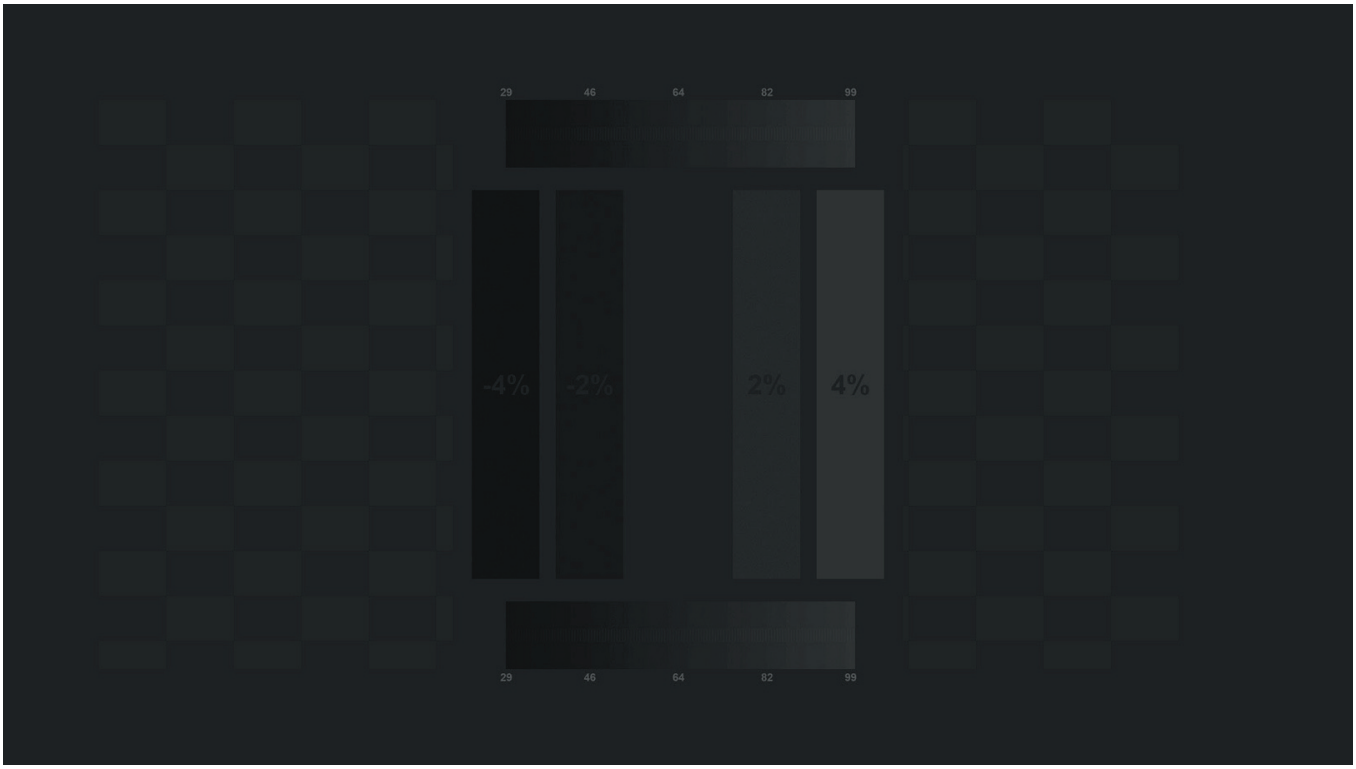


Fig. 11a: If the display's brightness is set too high, you can see all four stripes in the center of this pattern. (Menu: SDR BT.709 | Setup)

Fig. 11b: If the display's brightness is set too low, you can't see any of the four stripes in the center of this pattern. (Menu: SDR BT.709 | Setup)

Fig. 11c: If the display's brightness is set correctly, you can see the two stripes on the right but not the two stripes on the left. (Menu: SDR BT.709 | Setup)

If you can't see either stripe on the right (or perhaps you can't see only the inner stripe on the right), the display is said to be "crushing blacks," and you won't be able to see all the detail in dark parts of normal content. If you can see the two stripes on the left, the black level is too high, and content will look washed out.

Contrast

Next is the Contrast control, which raises and lowers the peak brightness while leaving the black level alone—theoretically, at least. In practice, these two controls often affect each other, so we'll go back and check Brightness after adjusting Contrast.

Display the Contrast pattern (see Fig. 12), which includes a series of blinking, numbered rectangles. (The meaning of those numbers is not important for the purposes of this guide.) Increase the display's Contrast control until the row of highest-numbered boxes disappears. Then, decrease the Contrast control and watch the blinking rectangles reappear, lower numbers first. Stop decreasing the Contrast control as soon as you can barely see the highest-numbered blinking rectangle.

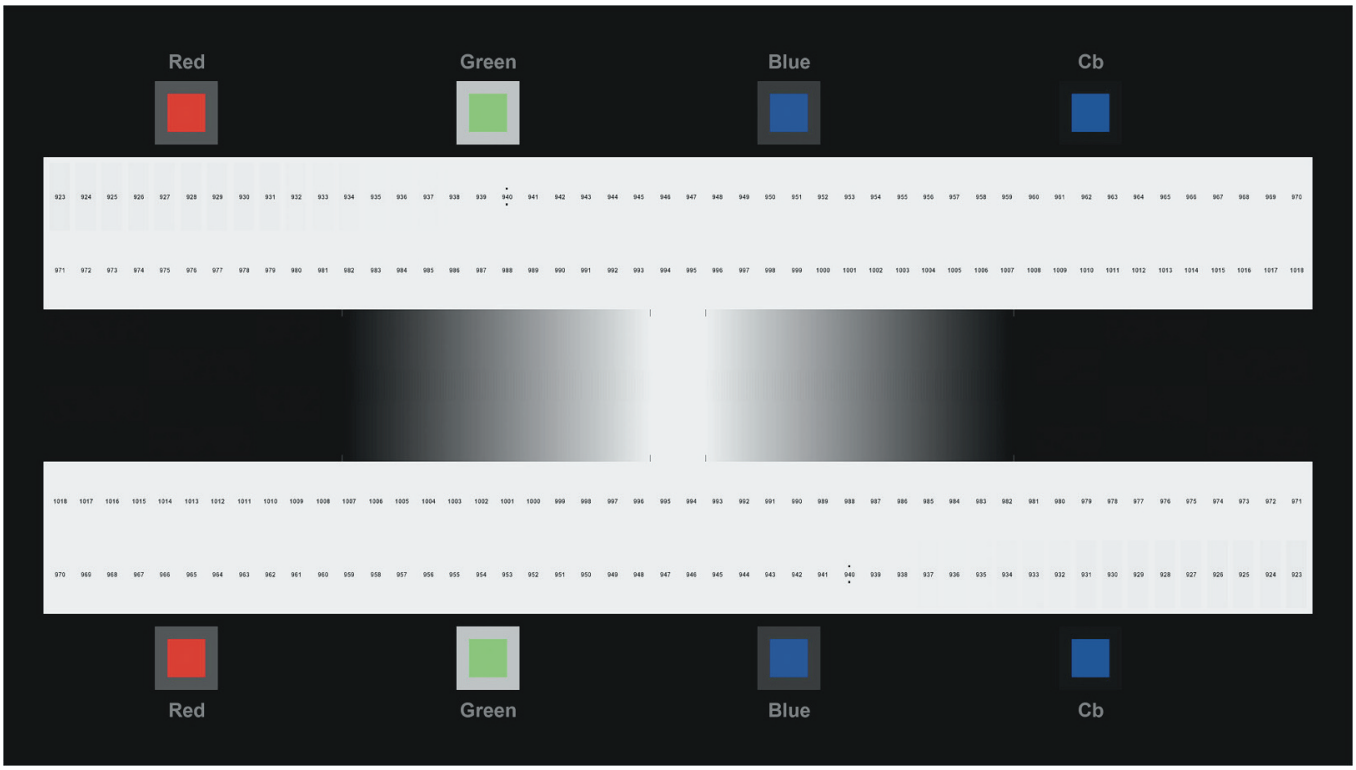


Fig. 12a: If the contrast is set too high, you can't see some of the highest numbered blinking rectangles. (Menu: SDR BT.709 | Setup)

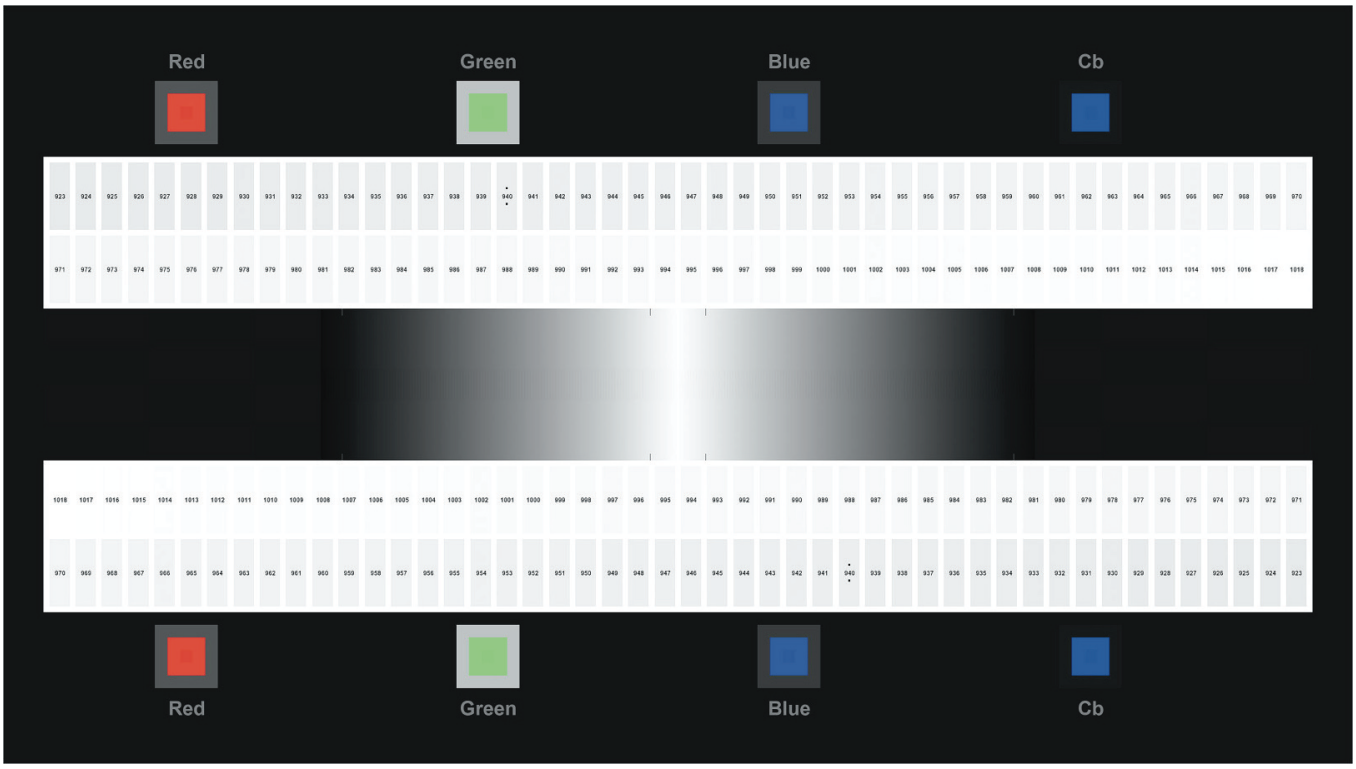


Fig. 12b: If the contrast is set correctly, it is the highest setting at which you can see all of the highest numbered blinking rectangles. (Menu: SDR BT.709 | Setup)

If some of the blinking rectangles are not visible, the display is said to be "clipping," and

you won't be able to see details in bright portions of normal content. Once you can see all the rectangles, you could decrease the Contrast setting further, and you would still see them. But if you did that, the display would not be as bright as it could be, and you want it to be as bright as possible without clipping. So, set the Contrast control as high as it can be while keeping all blinking rectangles visible.

Before we move on, go back and check the Brightness pattern. Does it still look correct? If not, tweak the Brightness control as needed, then go back to the Contrast pattern and see if it still looks correct, adjusting as needed. Go back and forth between these two patterns until they both look correct with no more tweaking.

Color and Tint

The Color control increases and decreases the saturation of red, green, and blue—the three primary colors used by virtually all video displays. Overly saturated colors look cartoonish, while undersaturated colors look washed out. The goal here is to set the Color control so the saturation conforms with the specifications used by content creators as closely as possible.

The Tint control shifts the overall color toward green or magenta. If it's too green, people look sickly; if it's too magenta, people look sunburned. The goal is to set Tint so people and other familiar objects (such as grass, the sky, and so on) look natural.

In most cases, there is actually no need to adjust the Color and Tint controls, which are usually set correctly at the factory. Plus, it's nearly impossible to set these controls accurately unless your display provides a feature called "blue-only mode," which shuts off red and green to display only the blue component of the image.

If your display does not have blue-only mode, you can look at the pattern through a blue filter. Unfortunately, blue filters are very inconsistent, especially with different types of displays, such as LCD and OLED, and using them can easily lead to poor results. As a result, *UHD HDR Benchmark* does not come with a blue filter.

If your display offers blue-only mode, you can check to see if the Color and Tint controls are set correctly and tweak them if necessary. Call up the Color and Tint pattern (see Fig. 13) and engage the display's blue-only mode, which is usually found in the display's "advanced video" menu. The left half of the screen should look black and the right half should look solid blue.

Fig. 13a: Here's the Color and Tint pattern in full color with no blue filter or blue-only mode.

Fig. 13b: If the display's Color and Tint controls are set correctly, the Color and Tint pattern will look uniform black on the left and uniform blue on the right when viewed in the display's blue-only mode. (Menu: SDR BT.709 | Setup)

Fig. 13c: If the display's Color setting is set too high, you will see a lighter blue rectangle in the upper part of the blue area. (Menu: SDR BT.709 | Setup)

Fig. 13d: If the display's Color setting is set too low, you will see a darker blue rectangle in the upper part of the blue area. (Menu: SDR BT.709 | Setup)

Fig. 13e: If the display's Tint setting is set too high, you will see a lighter blue rectangle in the lower part of the blue area. (Menu: SDR BT.709 | Setup)

Fig. 13f: If the display's Tint setting is set too low, you will see a darker blue rectangle in the lower part of the blue area. (Menu: SDR BT.709 | Setup)

Sharpness

A display's Sharpness control is designed to—what else?—sharpen the image by artificially enhancing the edges or boundaries separating different areas of the picture. Unfortunately, this can introduce an artifact called "ringing," which looks like a halo around the edges.

To see this effect, display the Sharpness test pattern (see Fig. 14), which consists of black lines on a gray background. Increase the display's Sharpness control until you can see white on both sides of the black lines. Then, decrease the Sharpness control until the white halos are no longer visible.

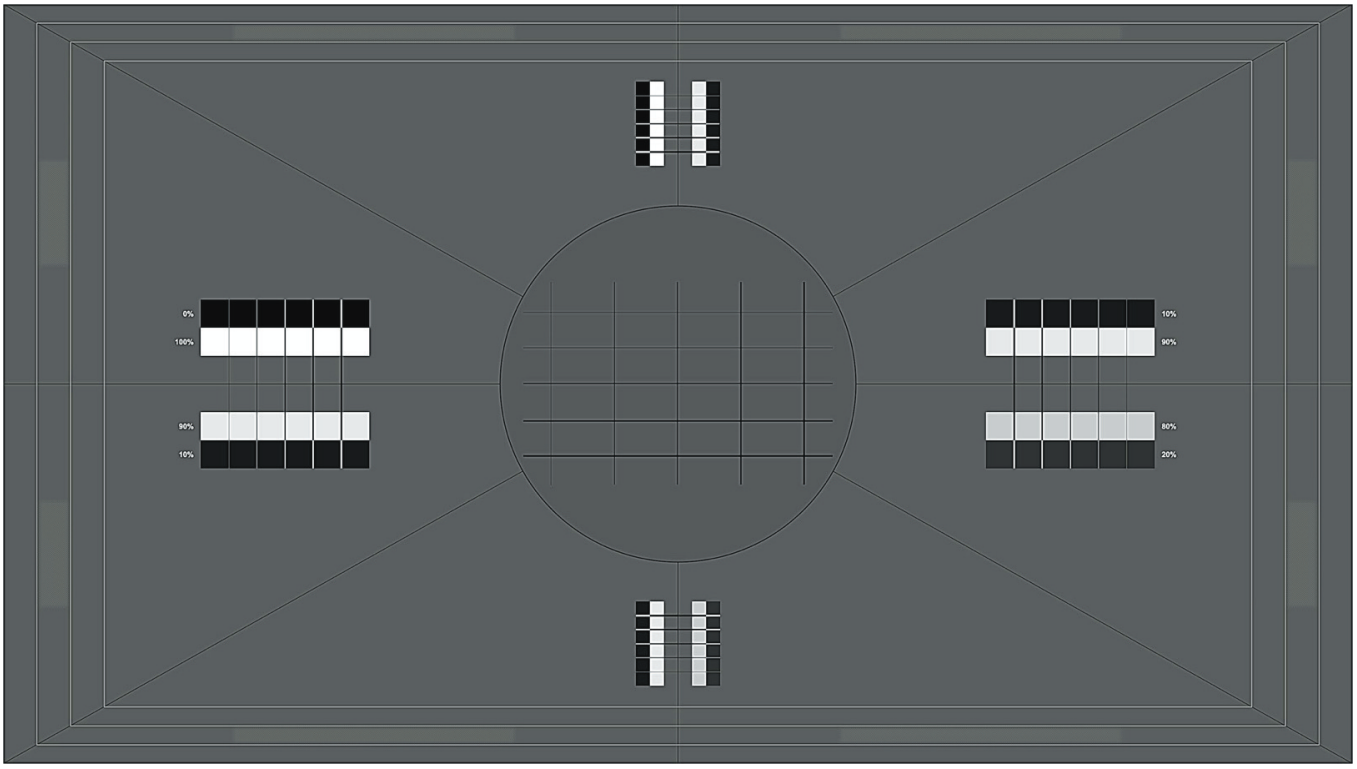


Fig. 14a: If the display's Sharpness control is set too high, you will see white halos around the black lines. (Menu: SDR BT.709 | Setup)

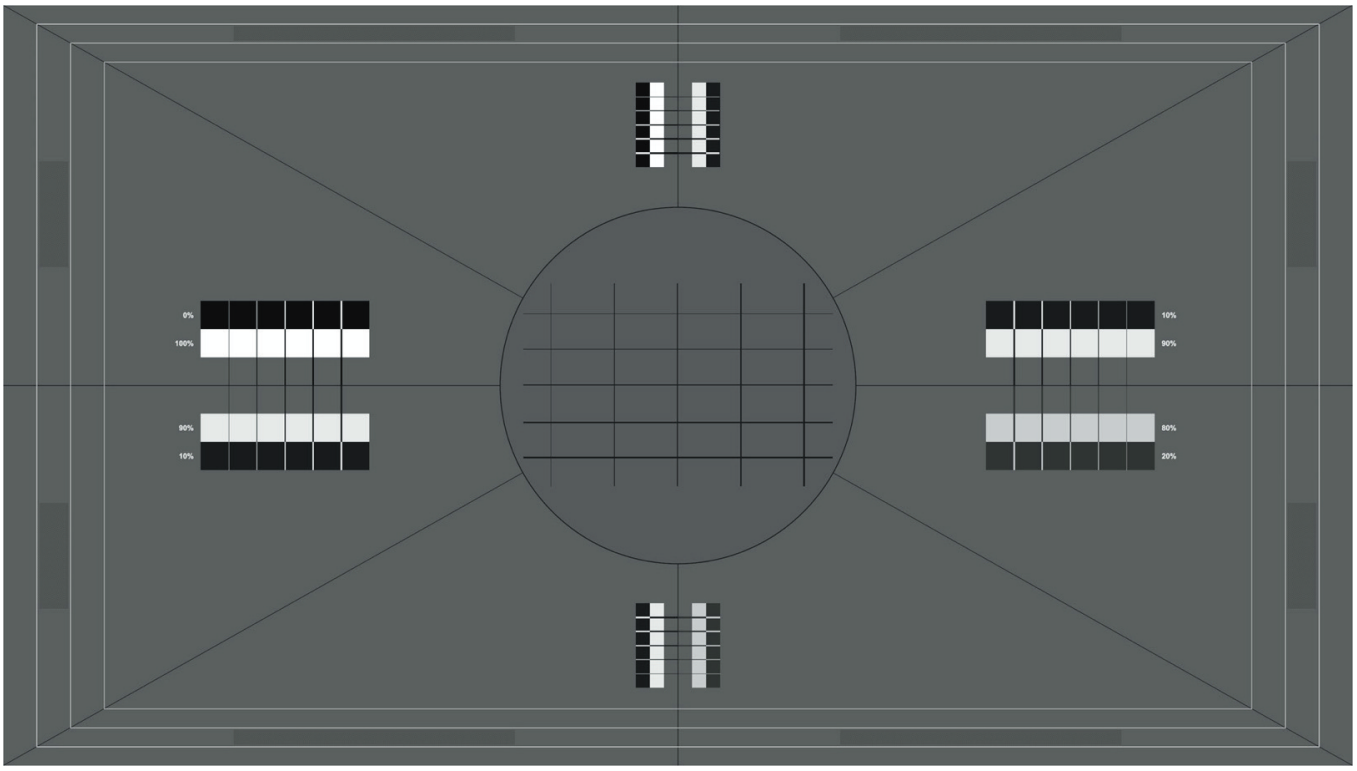


Fig. 14b: If the display's Sharpness control is set correctly (often its minimum setting), you won't see white halos around the black lines. (Menu: SDR BT.709|Setup)

The Sharpness control of most displays is set too high out of the box. In many cases, setting it to its minimum value yields the best results. Sometimes, the minimum value visibly softens the image, in which case, increase it until you see halos around the black lines, then back it off until the halos are no longer visible from your normal seating position.

11

Optimize High Dynamic Range

Now that your display's standard dynamic range is optimized, it's time to take a look at high dynamic range. We'll go through the HDR versions of all the same patterns patterns, which are found in the Video Setup menu (see Fig. 15).

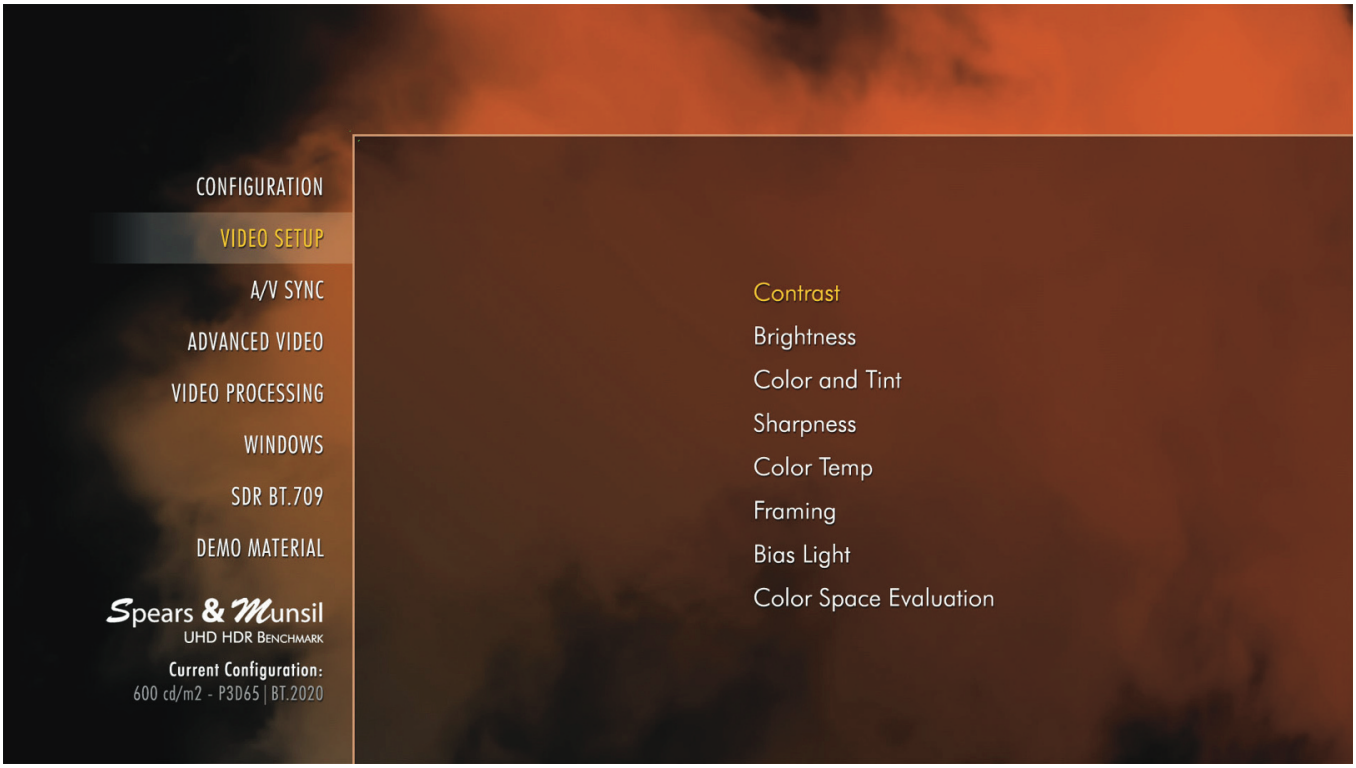


Fig. 15: The Video Setup menu provides HDR versions of the same patterns that you used to optimize the display's SDR performance. (Menu: Video Setup)

In this case, the peak brightness of the patterns is determined by the Luminance setting in the disc's Configuration menu. For now, make sure that Luminance is set to 1000.

In SDR, all modern displays can render any video signal completely. But in HDR, the parameters in the signal might exceed the display's capabilities, especially when it comes to brightness and color gamut. In some cases, the setup patterns might not look exactly as they did in SDR. Still, it's helpful to make sure the display is behaving as it should with HDR content.

As before, start with the Brightness pattern to see if the Brightness control is set correctly for HDR. You should be able to see the two vertical stripes in the right half of the pattern, while the two stripes to the left should be invisible. If you can see the stripes on the left, reduce the Brightness control until they are invisible. If you can't see the stripes on the right, increase the Brightness control until you can barely see the stripe just to the right of the center.

The biggest difference between the SDR and HDR is normally seen in the Contrast pattern. In HDR mode, many displays appear to clip a video signal's highest levels of brightness, which exceed the display's peak-brightness capabilities. Technically, this is not clipping per se; it is more accurately called "crushing the highlights."

Crushed highlights are a result of a process called "tone mapping," whereby the display tries to gracefully manage brightness levels that exceed its capabilities. In this process, the display automatically reduces a signal's brightness values as they increase beyond a certain point in order to keep the entire brightness range within the display's capabilities.

Some displays start tone mapping at a relatively low level and gradually reduce the brightness, while others only reduce the brightness values close to the display's peak capabilities. In the latter case, the tone mapped brightness levels end up being very close together, which resembles clipping in the Contrast pattern. If the display starts tone mapping at a lower level, the Contrast pattern might not appear to show any "clipping" at all.

Adjusting the Contrast control will not eliminate crushed highlights; in fact, it could degrade the display's tone mapping. This is especially true with content mastered at 4000 cd/m^2; in that case, virtually all consumer displays will crush highlights to some degree.

So, we recommend leaving the Contrast control at its default setting for HDR. The HDR Contrast pattern lets you see how the display tone maps high brightness levels, but don't try to reduce or eliminate the crushed highlights by adjusting the Contrast control. If the disc's Luminance parameter is set to 1000 and you're looking at a higher-end LCD TV (which probably has a peak brightness of 1000 cd/m^2 or higher), you might not see any crushed highlights, but if you set the Luminance to 4000, you almost certainly will.

To reiterate, many displays will crush the brightest portions of an HDR image; this is normal. Looking at the HDR Contrast pattern lets you see how much the display crushes the highlights, but you should not try to adjust the Contrast control in an attempt to eliminate this effect.

As with SDR, the Color and Tint controls are probably at their best settings by default in HDR mode. You can look at the Color and Tint pattern using the display's blue-only mode to check, but you shouldn't have to adjust the Color and Tint controls.

Finally, check the Sharpness pattern to see if there is any ringing. If you see white halos flanking the black lines, reduce the display's Sharpness control until the halos disappear.

12

Demo Material

Now that you have optimized the SDR and HDR performance of your display, it's time to see just how good it can look on real-world content. In addition to test patterns, *UHD HDR Benchmark* includes some beautiful video footage shot by Stacey Spears in 7680x4320 resolution and HDR. The footage has been downscaled to 3840x2160 for the disc, and it is some of the best video imagery available to consumers.

To view it, select the Demo Material item in the main menu (see Fig. 16). You will see many options; for now, select 1000 BT.2020, which was finalized with a peak luminance of 1000 cd/m^2—the same peak luminance we used to optimize your display.

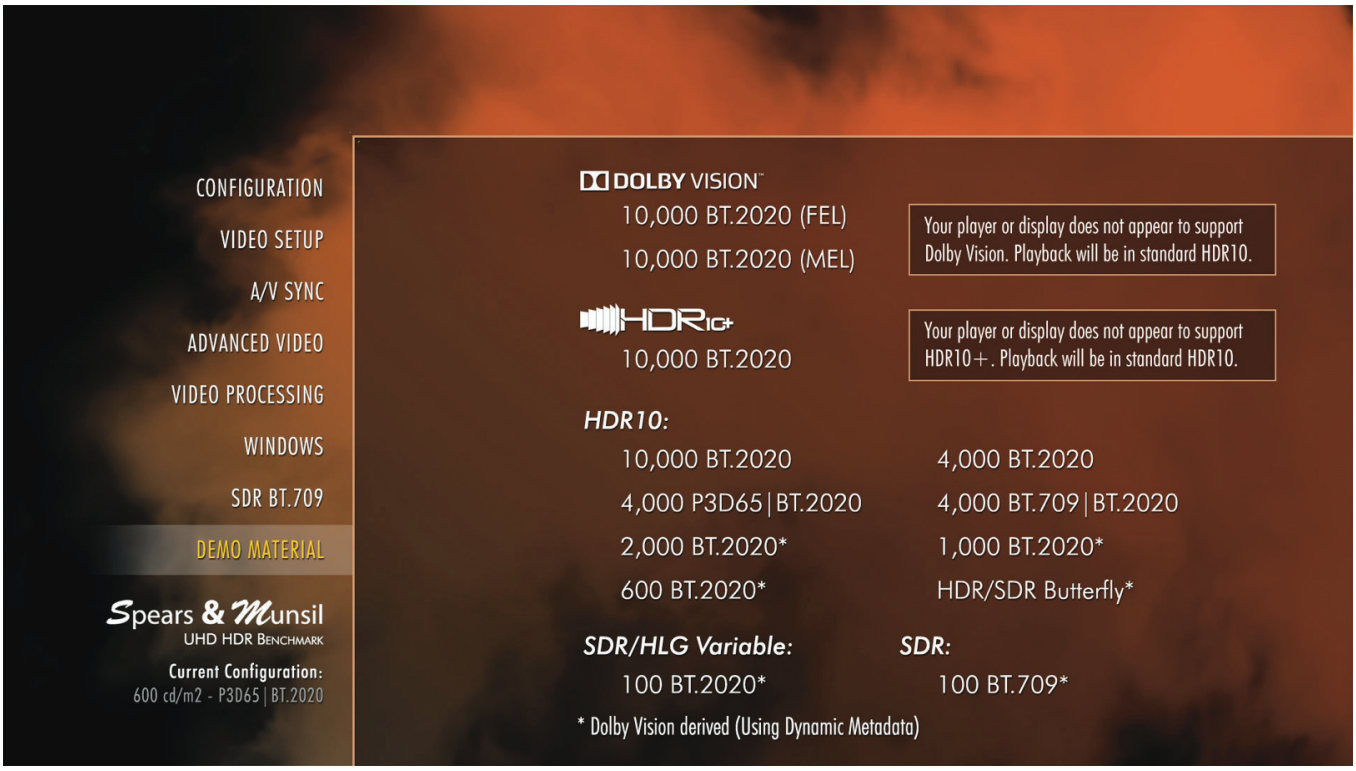


Fig. 16: There are many versions of the demo material that let you see how the display performs with content mastered in different ways. If your player and/or display does not support Dolby Vision or HDR10+, you will see the corresponding messages shown here. If your player and display support these formats, you won't see these messages. (Menu: Demo Material)

As you watch this material, be sure to notice how natural the colors look—the blue of the sky and water, the green of the foliage, the white of the snow, the yellow and orange of the sunset. Also, notice the detail in things like the hair of mammals and feathers of birds as well as blades of grass and points of light in nighttime city skylines. It should appear as if you are looking out a window.

To see how much HDR improves the overall image, play the HDR/SDR Butterfly footage. In this case, the screen is split; the left half is in HDR, and the right half is a mirror image in SDR. The HDR side is much brighter than the SDR side, and the HDR side should look much more realistic and compelling.

The other versions of the demo material are provided to demonstrate various aspects of the display's performance. For example, the versions at 4000 and 10,000 cd/m^2 let you see how the display's tone mapping performs, since there are no current consumer displays with a peak luminance that high. (As mentioned earlier, some commercial content is mastered at 4000 cd/m^2, but none is mastered at 10,000 cd/m^2, which is the highest luminance allowed in HDR.)

13

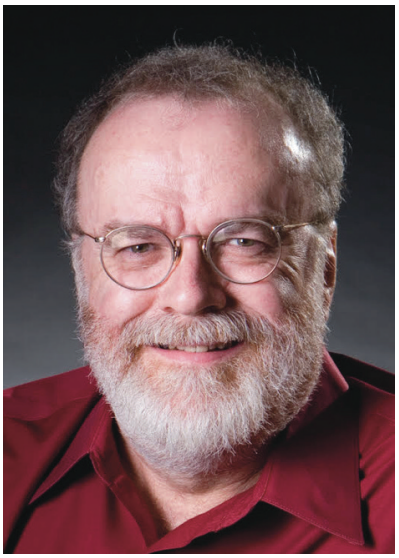
That's All, Folks!

As should be obvious by now, video-display technology is far more complicated than it used to be. Sure, you can simply take a display out of the box, turn it on, and watch your favorite content—easy peasy! But in that case, the display rarely looks as good as it can, and it does not reflect the artist's intent. Content creators spend thousands of hours to make their content look a certain way, so it's definitely worthwhile for consumers to spend a couple of hours optimizing the display to see it as the creator intended.

The good news is that you only need to optimize the display once, after which virtually all content will look its best. Once you see how good your favorite movies and TV shows can look, you'll be glad you spent the time adjusting your display to deliver its peak performance.

Now, it's time to sit back, relax, and revel in the best video images from your new UHD display. Enjoy!

About the Author



Scott Wilkinson has enjoyed nearly 30 years as an author and editor in the home-theater industry. He can be heard each weekend discussing audio and video technology on Leo Laporte's nationally syndicated radio talk show, *The Tech Guy*.

Scott's most recent position spanned five years as the editor of AVSForum.com. Previous experience includes senior editorial positions at HomeTheater.com and UltimateAV-mag.com as well as *Home Theater* and *Stereophile Guide to Home Theater* magazines (both of which Scott helped launch), *The Perfect Vision*, *Audio/Video Interiors*, *Connected*, and etown.com. For eight years, he also hosted a weekly podcast called Home Theater Geeks, in which he interviewed notable technologists in the audio and video industries.

As a professional musician, Scott plays many different wind instruments, such as tuba, trombone, didgeridoo, conch-shell trumpet, recorder, ocarina, and various ethnic flutes. He can be heard on the soundtracks of the movies *Gladiator*, *White Squall*, and *Mystic India* as well as the video games *Myst 4*, *Uncharted, and World of Warcraft*. Scott has also recorded two albums with his avant-garde trio Many Axes and one with his wife, singer-songwriter Joanna Cazden.