Dolby Vision™ for the Home

WHAT IS DOLBY VISION?

Dolby Vision™ transforms the way you experience movies, TV shows, and games with incredible brightness, contrast, and color that bring entertainment to life before your eyes. By fully leveraging the maximum potential of new cinema projection technology and new TVs' display capabilities, Dolby Vision delivers high-dynamic-range (HDR) and wide-color-gamut content. The result is a refined, lifelike image that will make you forget you are looking at a screen.

Current consumer video delivery and cinema standards are based on the limitations of old technologies and require altering the original content before it can be reproduced for playback—dramatically reducing the range of colors, brightness, and contrast from that captured by modern cameras. Dolby Vision changes that, giving creative teams the confidence that images will be reproduced faithfully on TVs, PCs, and mobile devices that feature Dolby Vision.

Dolby Vision is a natural complement to Dolby Atmos®. It gives movie, television, and game creators the tools they need to create experiences that preserve the creative intent and let consumers experience truly immersive content without compromise.

For manufacturers of televisions, game consoles, personal computers, and mobile devices, Dolby Vision unlocks the full capabilities of their hardware and creates a premium experience that can increase use and enjoyment of these products.

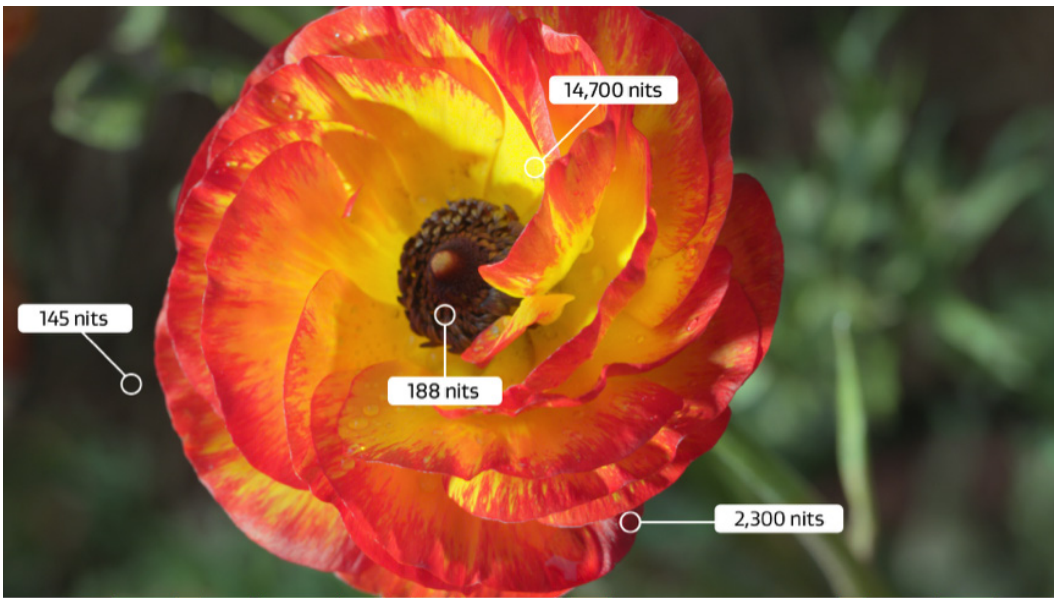
DOLBY VISION: ROOTED IN THE SCIENCE OF THE HUMAN VISUAL SYSTEM

There are three ways to improve picture quality for movies, TV shows, games, and user-generated content:

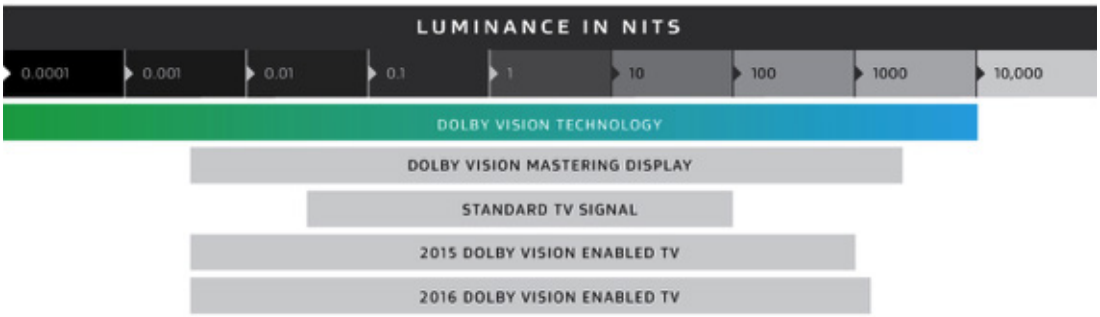
- More pixels: 4K, 8K, and beyond
- Higher frame rate (HFR)
- Better pixels (high dynamic range and wider color gamut): Dolby Vision

4K televisions have "more pixels," and newer standards for UHD TV also include high frame rates, but these standards don't make each pixel able to better represent the full range of brightness we see in reality. Dolby Vision is the Dolby Laboratories solution to meet this challenge.

The natural world has a much broader range of color and brightness than current broadcast, Blu-ray™, and cinema systems support. For example, just in the simple flower shown here, brightness ranges from 145 nits for the background all the way to 14,700 nits for the yellow part of the petal. (Note: A nit is a unit used to measure brightness and is equivalent to a candela per square meter.)



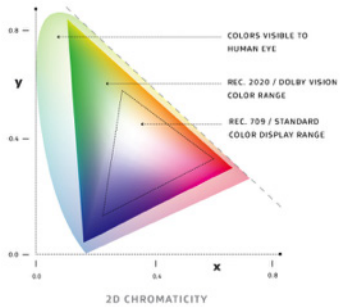
The current TV and Blu-ray standards limit maximum brightness to 100 nits and minimum brightness to 0.117 nits, while also limiting the range of colors (or color gamut) that can be displayed. These and other limits to modern HDTV standards are a legacy of the cathode ray tube (CRT).

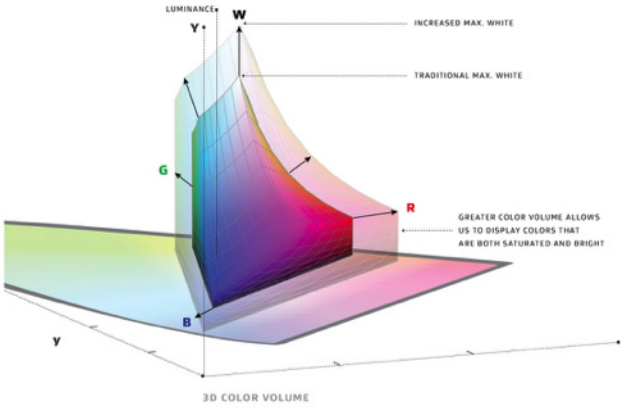


HOW MUCH DYNAMIC RANGE DO WE NEED?

The Dolby imaging research team ran a set of experiments with ordinary viewers to answer this question. The researchers tested what viewers preferred for black level, diffuse white level, and highlight level. They determined that a system that could reproduce a range of 0 to 10,000 nits satisfied 90 percent of viewers asked to pick an ideal range.

One of the other critical problems with the current brightness and color-range restrictions comes from how an actual TV represents color. The diagram at left below shows the colors the typical eye can see, the colors that current HD standards can represent and the additional colors made visible by Dolby Vision. But this doesn't represent everything—to really see, you must also look at the range of brightness, the color volume. The graph on the right showcases the color volume and the increase in color volume provided by Dolby Vision.





A TV display is an additive color system—red, green, and blue—meaning that the brightest pixel is white, made up of full brightness of each of the primary colors. The problem with restricting maximum brightness to 100 nits (as in TV and Blu-ray) is that the brighter the color, the closer it becomes to white, so bright colors become less saturated. For example, the brightest saturated blue on an ordinary display is a mere 7 nits, so a blue sky will never be as bright and saturated as it should be. With the maximum Dolby Vision brightness of 4,000 nits using today's monitor capabilities and up to 10,000 nits in the future, a content creator has the range to represent a sky that is truly bright and saturated, making it seem more natural.

WHY DOLBY VISION?

Movie and television directors tell stories; game designers create immersive, engaging game experiences. One of the real challenges for all these creators lies in the limitations of the medium. Dolby has worked closely with Hollywood studios, cinemas, and consumer equipment makers over the last 50 years to make the stories and experiences as engaging as possible—first with noise reduction, then 5.1 surround and 7.1 surround, and now with Dolby Vision and Dolby Atmos.

Dolby Vision gives the director and colorist (or the game programmer and the lighting and effects designer) the tools they need to accurately represent the vibrant colors, bright highlights, and detailed shadows that help draw the viewer into the scene.

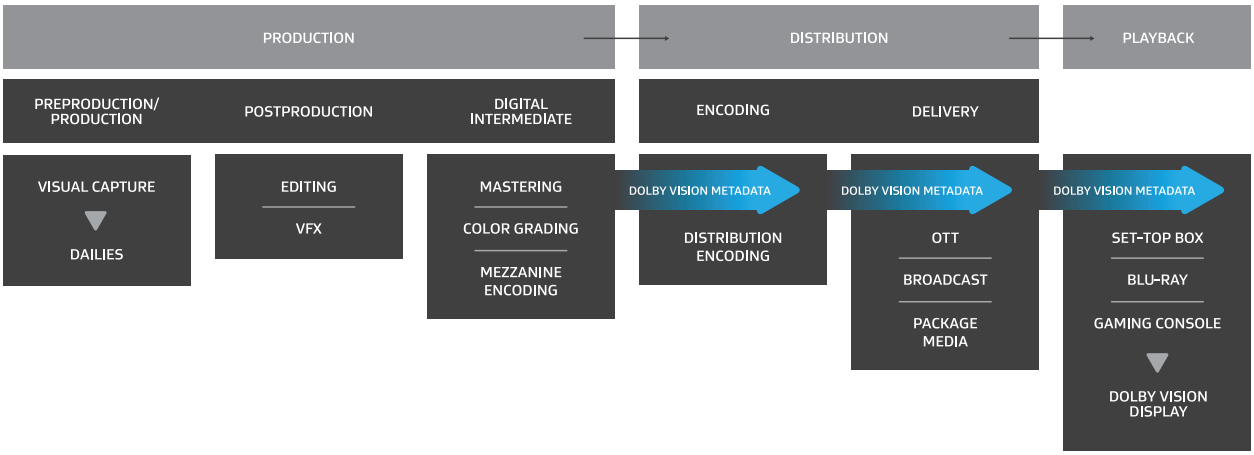
WHAT THE CONTENT CREATOR SEES IS WHAT THE VIEWER GETS

The limitations in today's system comes as a natural result of the limitations of current TV and Blu-ray standards. The maximum brightness for broadcast TV or Blu-ray discs is 100 nits. But modern TVs often have 300 to 500 nits maximum brightness, so TV manufacturers stretch the brightness of the content to try to use the capabilities of the display. This distorts the images. And because each manufacturer stretches the output differently, every viewer will experience a movie, TV show, or game in a different and unpredictable way.

Dolby Vision solves this problem. Content creators color-grade their content using Dolby Vision compatible reference monitors, which have dramatically higher dynamic range and wider color gamut, to ensure the highest-fidelity mastering. The Dolby Vision picture contains metadata about the system used to create the final version of the content. Because any Dolby Vision television has been carefully calibrated by the manufacturer and Dolby technicians, our technology can use this metadata and the higher-quality content to produce the best and most accurate representation on every display. This honesty to the creator is why Dolby Vision is being adopted by major studios for the cinema and for delivering the best Hollywood content to the home.

HOW DO YOU ENABLE DOLBY VISION?

Dolby has designed Dolby Vision to make integration into existing content creation and distribution as easy as possible.



CONTENT CREATION

The Dolby Vision workflow is very similar to existing color-grading workflows. The goal is to preserve more of what the camera captured and limit creative trade-offs in the color-grading and mastering process.

The Dolby Vision HDR reference monitor (capable of up to 4,000 nits luminance) is used to make the color and brightness decisions. The goal of the Dolby Vision grading process is to capture the artistic intent in the reference grade. Directors, editors, and colorists should use the grading system and the monitors to make the best, most engaging imagery they can, taking full advantage of the dynamic range of the display.

After the reference grade is finished, the Dolby Vision color-grading system will analyze and save the dynamic metadata that describes the creative decisions made on the display. The content mapping unit (CMU) maps the content with the metadata to a reference display at a standard brightness (100 nits).

After the Standard Dynamic Range version has been approved, the colorist exports the images with metadata. The dynamic metadata generated to create the SDR grade can be used to render the Dolby Vision master on displays, which may offer a wide performance range. A 600-nit TV will look great; a 1,200-nit TV will look even better—both referencing the same metadata and Dolby Vision reference images.

The same algorithms used in the Content Mapping Unit for off-line grading can be used to create a traditional compatible grade for live broadcasts in Dolby Vision.

GAME CREATION

Most modern game engines currently support full HDR rendering. Adding support for Dolby Vision requires:

- art created with Dolby Vision in mind
- reference monitors for viewing Dolby Vision content
- game engines compatible with Dolby Vision

Dolby is working with leading creators of game engines to ensure that their engines are compatible with Dolby Vision.

TRANSMISSION/TRANSPORT

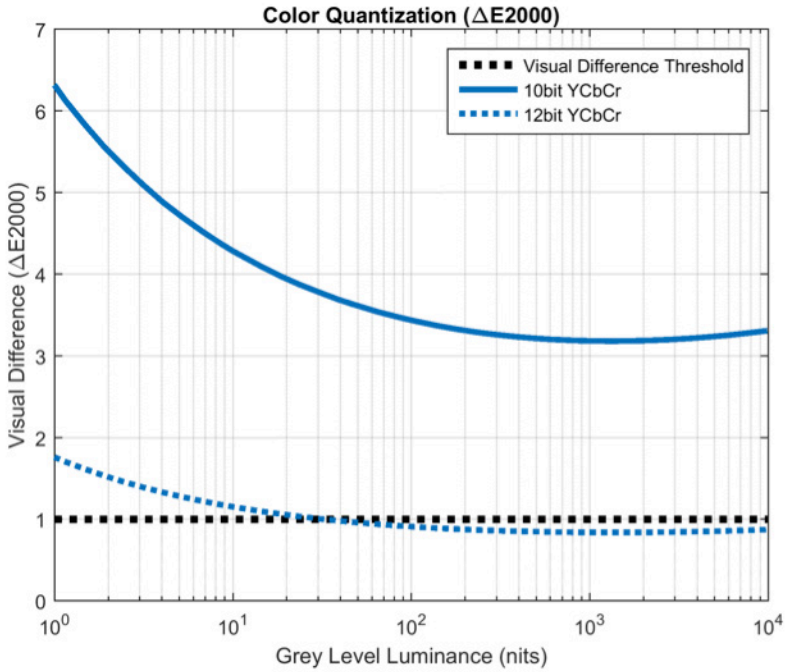
Dolby Vision doesn't require new codecs—it can be delivered with industry-standard HEVC and AVC codecs. The full Dolby Vision signal can be encoded, with pre-processing, into either a single HEVC Main-10 stream or into two AVC or HEVC layers with lower bit depth, plus metadata, making it well-suited to a wide range of televisions, personal computers, and mobile devices. The client uses the data to reconstruct and play back the full signal, using existing video decoders.

Dolby is working with leading standards organizations, including the Blu-ray Disc™ Association, DVB, MPEG, UltraViolet™/DECE, and the SCSA to ensure that Dolby Vision content can be delivered in a standardized way in those ecosystems.

WHAT BIT DEPTH DO WE NEED?

After establishing that the Dolby Vision should be able to represent brightness from 0 to 10,000 nits, scientists at Dolby looked for an efficient way to deliver this high-dynamic-range video. In current 100-nit Standard Dynamic Range (SDR) systems, video is coded with 8-bits-per-component precision, using a gamma curve. Using the same gamma approach would require 14 bits when the range is increased by a factor of 100. Fortunately, the human visual system is much less sensitive to changes in highlights than in dark areas. Therefore, Dolby developed a new electro-optical transfer function (EOTF) that can code the entire 10,000-nit range with 12 bits instead of 14, without introducing any artifacts. This new perceptual quantizer (PQ) has been standardized as SMPTE ST-2084 and is used in various HDR-related standards and applications.

Some generic HDR approaches use the PQ EOTF with 10 bits instead of 12. Why is it important to use 12 bits instead of 10? The human visual system has different sensitivities at different levels of brightness, and it is particularly sensitive to small changes over large areas of nearly uniform brightness. The following graph shows how noticeable 10- and 12-bit quantization is, depending on luminance. 10-bit quantization is always above the visual threshold, meaning that the average user can see noticeable differences with each change of luminance value. In natural scenes, noise in the scene can often mask this difference, but areas such as blue sky will often show banding or contouring if the quantization steps are too coarse.



PLAYBACK

Dolby Vision works with a variety of hardware to enable great visual experiences on a wide range of display devices, including higher-end OLED TVs with stunning black levels to LCD TVs with advanced technologies like quantum dot, mass-market edge-lit TVs, and in the future, PCs and mobile devices.

The following table shows the technology components that each type of device must support in order to play back and render a Dolby Vision signal.

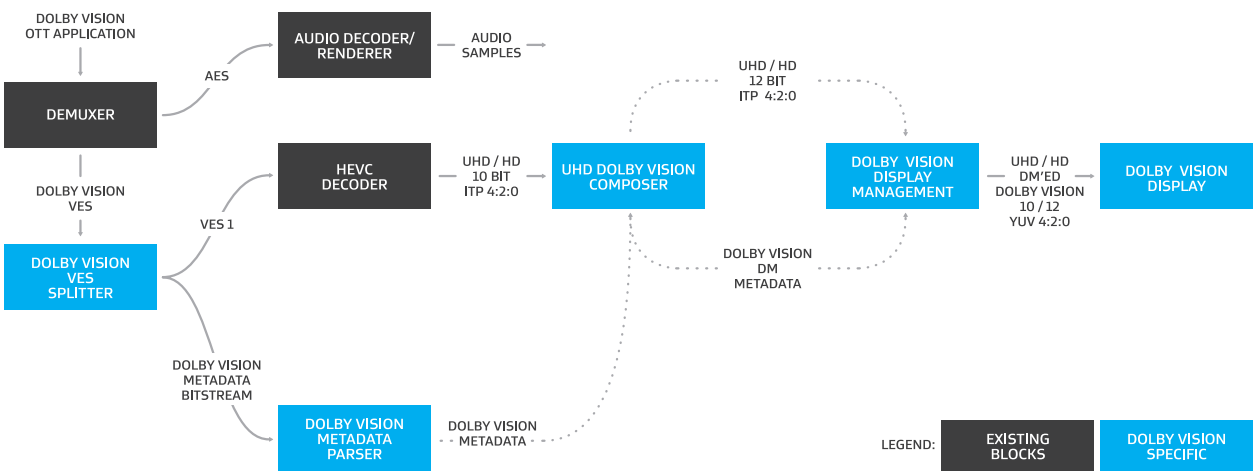
TECHNOLOGY COMPONENT	TELEVISION	SET TOP BOX, GAME CONSOLES, DMA, PC	MOBILE OR LAPTOP
DOLBY VISION DECODER	✓ (FOR OTT APPS)	✓	✓
DOLBY VISION DISPLAY MANAGEMENT	✓	✗	✓

Dolby is working with its partners in the industry to provide easy-to-integrate solutions for both silicon and software-only applications

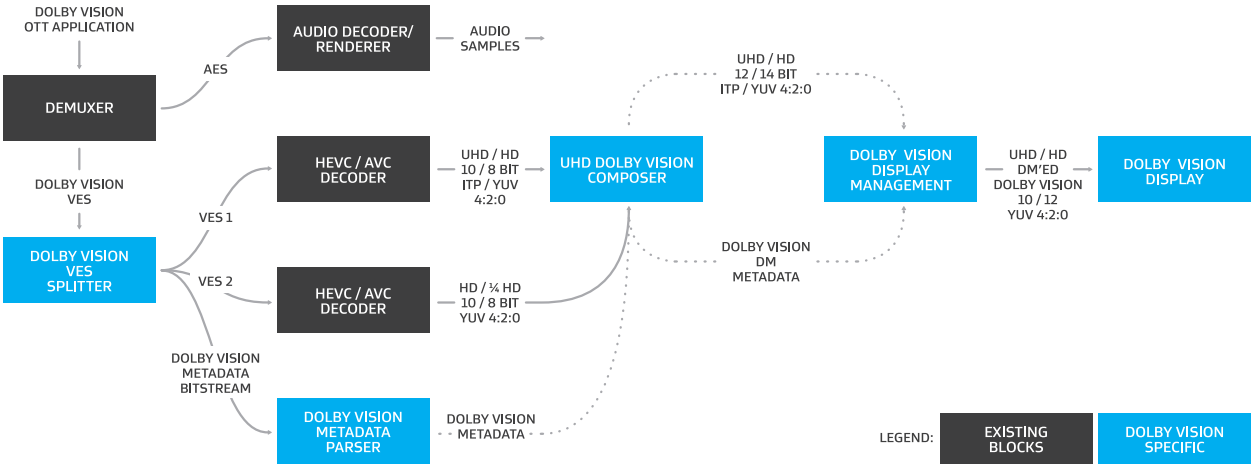
DECODER AND COMPOSER

Dolby Vision is compatible with a wide range of video codecs. It's currently qualified with HEVC and AVC decoders. There are multiple ways to encode and decode Dolby Vision signals – depending on the needs of the content creator and on the capabilities of the target display hardware, Dolby Vision signals can be delivered using a single HEVC Main-10 stream or as two AVC-8 or HEVC-8 or HEVC-10 streams. The single layer HEVC Main-10 profile of Dolby Vision can be decoded by a standard HEVC decoder, then post-processed using a Dolby Vision module to produce the full range 12 bit Dolby Vision signal.

Decoder and Composer: Single Layer



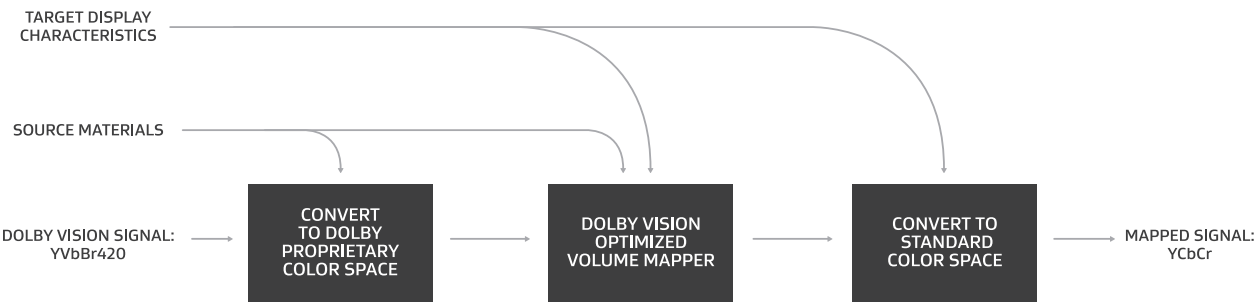
Decoder and Composer: Dual Layer



For dual layer AVC or HEVC Dolby Vision profiles, the source stream is split, and the base and enhancement streams are fed through separate decoders. The Dolby Vision composer is responsible for reassembling the full-range signal from the base layer, the enhancement layer, and the metadata.

DISPLAY MANAGER

The display manager is tuned for the target display device: it knows the maximum and minimum brightness, color gamut, and other characteristics of that device. Metadata that accompanies the full-range Dolby Vision video signal carries information about the original system used to grade the content and any special information about the signal. Using this metadata, the display manager intelligently transforms the full-range signal to produce the best possible output on the target device.



A major difference between the Dolby Vision approach and other HDR solutions is the metadata that accompanies each frame of the video all the way to the display manager in the consumer-playback device. Systems with generic HDR carry only static metadata that describes the properties of the color-grading monitor that was used to create the content and some very basic information about the brightness properties (maximum and average light levels) for the entire piece of content. Dolby Vision adds dynamic metadata that is produced during content creation; the dynamic properties of each scene are captured. With this information, the Dolby Vision display manager is able to adapt the content to the properties of the display much more accurately. It allows hues to be preserved properly, which is critical for display of skin tones. Even with mass-market edge-lit TVs, the overall impression of colors is preserved much more accurately.

Guided by the Dolby Vision metadata, the Dolby Vision display manager enables great visual experiences on a wide range of display devices ranging from higher-end OLED TVs with stunning black levels to LCD TVs with advanced technologies like quantum dot, all the way down to mass-market edge-lit TVs.

Technology has moved far beyond current imaging standards for TV and movies. This end-to-end solution delivers dramatic imaging that fully expresses the original creative intent. Dolby Vision enhances today's viewing experiences and is ready for the next wave of innovation from TV, movies, games, and streaming services.