



EXPLAINED



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Since 2013, Ultra HD has been an important issue at consumer electronics shows, and there is every indication that this will not change anytime soon.

Preface

The German TV-Platform has chaperoned the evolution of Ultra HD from the outset, for example with numerous publications, such as the White Book “Beyond HD”, which was published for the 2013 Berlin Radio Show (IFA 2013) and focused on technologies and standards. For IFA 2015, we presented a brochure on available Ultra HD content, entitled “Das sieht gut aus” (“Looking Good”), while visitors were able to marvel at third-generation Ultra HD television sets in the exhibition halls. Written originally in May 2016, this book has been already updated several times. As of June 2018, it is available as a third, revised edition.

This brief chronicle of our publications exemplifies how the consumer electronics and home entertainment industry and its interaction with content producers and distributors has changed over the years. The pace of technological development keeps picking up continuously, and the expectations of markets and consumers keep rising – which, of course, includes Ultra HD. Driven by shortened incubation periods and ever-decreasing intervals between the presentation of new products, consumers are experiencing a genuine barrage of innovation, compared to the introduction of HDTV.

Ultra HD productions are placing high demands on television broadcasters and movie studios. Nevertheless, the quantity of available content and sources is considerably on the rise (see also page 22). But Ultra HD is still very demanding

with regard to the standardization of devices, interfaces, and transmission methods. This becomes clear when we look at the number of technical abbreviations and the variety of logos, which are actually meant to provide guidance to the consumer.

This is where the present brochure, Ultra HD Explained, comes in: There is plenty of need to explain Ultra HD. We are addressing primarily tech-minded consumers, but we would also like to inform professionals comprehensively about the state of the art in Ultra HD development and about the prospects for ultra-high definition television.

By the way: In order to ensure the interoperability of new hardware, the German TV-Platform has been hosting so-called “UHD Plugfests” for quite a while. These are workshops where manufacturers test the interaction of various hardware, usually before market launch. Some of the results and insights from these tests have also found their way into this brochure.

Stephan Heimbecher
(Sky Deutschland),
Head of the Ultra HD Working Group and
Board Member of the German TV-Platform

What is Ultra HD?

Ultra HD (Ultra-High Definition, frequently shortened to UHD) is a digital high-definition format. As the name suggests, Ultra HD can be regarded as an advanced version of the previous high-definition television (HDTV) standards. With a resolution of currently 3,840 pixels x 2,160 pixels, Ultra HD provides four times the resolution of Full HD. Compared to previous TV standards, the new format is capable of displaying significantly sharper images in far greater detail. This benefits medical applications as well as digital image and video processing too, where Ultra HD is also employed.

The development of Ultra HD is in full swing. During launch phase, development was focused almost exclusively on higher resolution. Today, attention is shifting to other aspects, such as an enhanced color display, high frame rate and higher contrast.



Ultra HD is No Longer a Niche Subject

Ultra HD is evolving much faster and finding wider consumer acceptance than HD initially did when it was introduced about ten years ago. About 68 percent of persons in Germany are already familiar with the terms Ultra HD or 4K*. According to a GfK survey from May 2017 more than 20 percent of the respondents claimed they already bought an UHD screen. Almost 30 percent of those who haven't so far are planning to buy one in the future. Of those, about 73 percent acknowledge an improved image quality of UHD screens.

By the end of 2017, 6 million UHD-capable TV sets have been sold in Germany**. This represents about 40 percent of all TV sets sold in Germany in the year 2017.

UHD-1 Phase 1 and 2 are now official

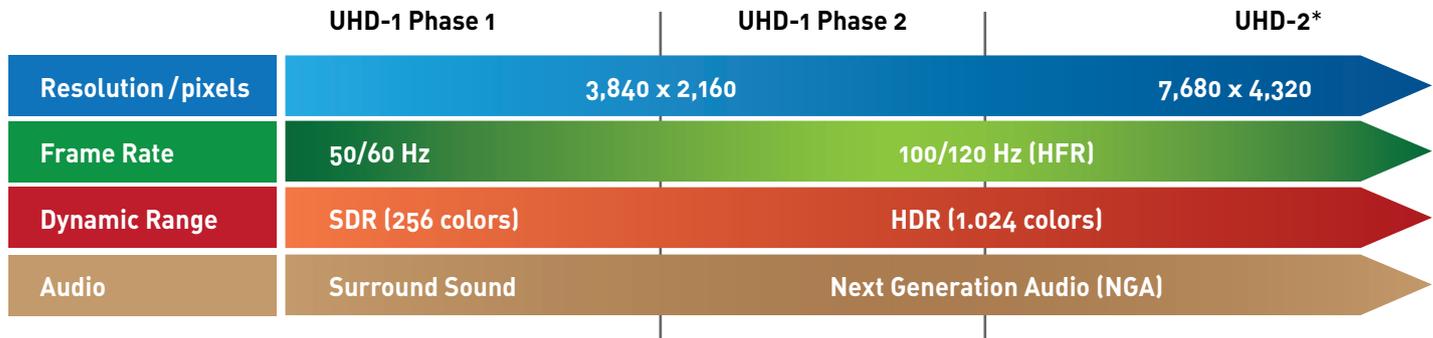
After the approval of the respective technical specification of UHD-1 Phase 2 by the DVB Consortium in October 2016, the formal publication by the European Telecommunications Standards Institute (ETSI) took place in early March 2017.

As far as High Dynamic Range (HDR) is concerned, DVB has decided to go with PQ and HLG, both of which have been specified by the International Telecommunication Union (ITU) in BT.2100. Further on High Frame Rate (HFR) frame rates up to 100/120 Hz will be possible.

For Next Generation Audio (NGA) two systems will be supported: AC-4 and MPEG-H Audio. HDR, HFR and NGA are treated at length in the present brochure.

Sources:

- * GfK survey on behalf of German TV-Platform, May 2017
- ** GfK Retail & Technology 2017, Germany, sales of PTV devices, GfK Panel Market



* European market launch currently not scheduled; in Japan from end of 2018

For the launch of UHD-1, the DVB (Digital Video Broadcasting) Consortium agreed on a two-phase model. In UHD-1 Phase 1, specifications for content, transmission method, and playback devices that support the above-mentioned resolution of 3,840 pixels × 2,160 pixels at frame rates of 50/60 Hz and a 10-bit color depth were adopted.

In theory, Phase 1 also includes the wider color space, BT.2020, and the H.265/HEVC compression standard, which is important for TV broadcasts, streaming, and Ultra HD Blu-ray. Suitable consumer devices and the first services became available in 2014.

Ultra HD or 4k – What Is the Correct Term?

Colloquially, Ultra HD is also called “4k.” This term however, is actually shorthand for the “Cinema 4k” standard, in which 4k content is produced and which has a resolution of 4,096 pixels × 2,160 pixels.

Due to the aspect ratio of 16:9, this (approximately 17:9) resolution is usually not found in consumer devices, with the exception of a few home cinema projectors.

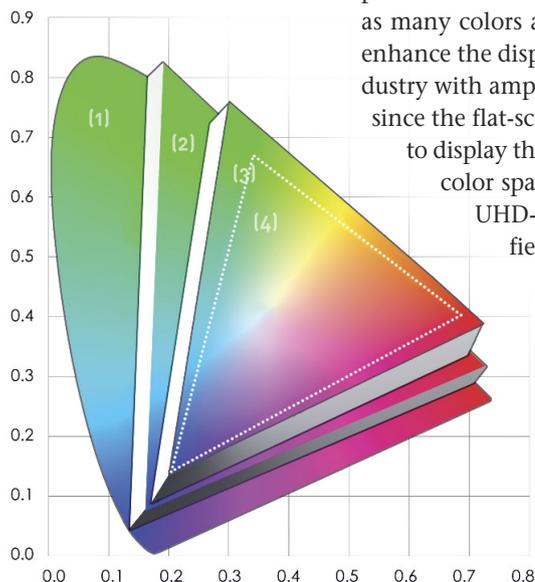
The industry, however, has partially adopted this somewhat confusing label, which means that “4k” may be seen on the packaging of Ultra HD television sets. But there is no need to worry: No matter whether the box says “Ultra HD,” “UHD,” or “4k,” your TV will be able to display the specified Ultra HD resolution of 3,840 pixels × 2,160 pixels.

Not Just More but Better Pixels

Wide Color Gamut

It is time for more color—It really is! The BT.709 color space introduced in 1990 at the launch of HDTV is still the standard for TV broadcasts, movies, and series today, but BT.709 only covers 36 percent of the visible color spectrum.

In the future, Ultra HD is supposed to use the wide color gamut (WCG) specified by BT.2020. The color range displayed would thus cover 76 percent of the visible spectrum—more than twice as many colors as BT.709. This will significantly enhance the display of colors and provide the industry with ample range for the future. However, since the flat-screen panels of today are not able to display the BT.2020 color space, the BT.709 color space was maintained in Phase 1 of UHD-1, and BT.2020 was only specified as an option.



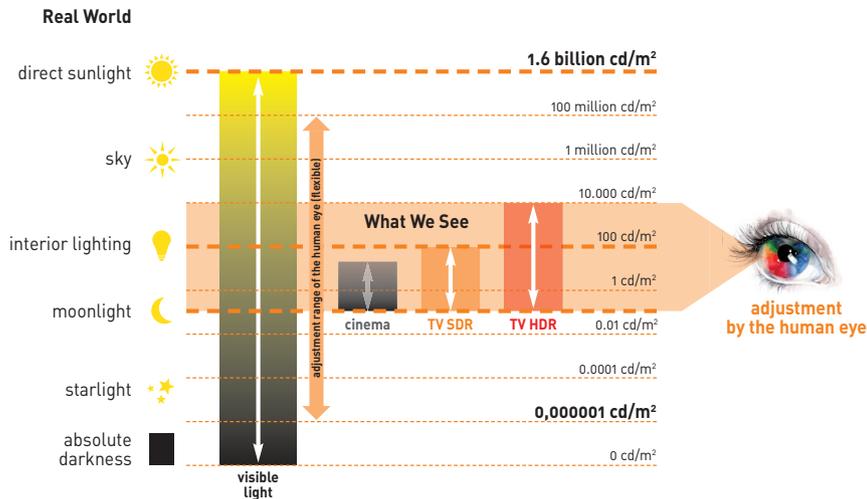
DCI-P3 (3) is an intermediate step that covers about 26% more of the visible color spectrum (1) than BT.709 (4), but still significantly less than BT.2020 (2).

It will take some more time until we reach BT.2020. So far, only certain laser projectors are capable of approximating this color gamut. In consumer electronics, an intermediate standard designated as DCI-P3 will therefore be adopted for the time being.

DCI-P3 – the Intermediate Standard

DCI-P3 was specified by Digital Cinema Initiatives and is used in digital cinema production. The standard covers 45.5 percent of the visible color spectrum and thus 26 percent more than the BT.709 color space. This intermediate step also makes sense because it allows theatrical productions to be displayed in their original color range in the Ultra HD format.

Thus, the first intermediate step and a clearly visible improvement of image quality have nearly been achieved and are paving the way for the industry to introduce BT.2020 eventually. However, in addition to color gamut and color depth (luminance levels), the dynamic range in which these are to be employed also plays a key role.



TV dynamic range: SDR and HDR compared to the real world

High Dynamic Range (HDR):

Wider contrast range, brighter white, darker black

High Dynamic Range (HDR)

In order to exploit the full video quality potential, it is not sufficient to simply increase the number of pixels, or to enhance color gamut and color depth. For a display that is true to nature and feels natural, a wider contrast range is essential. This improvement is called High Dynamic Range (HDR), while the dynamic range used for TV broadcasts and motion pictures so far is designated as Standard Dynamic Range (SDR).

High Dynamic Range is a vital element of Phase 2 of UHD-1. Up until now, the luminous density of video content ranged from 0.05 cd/m² to 100 cd/m² (candela per square meter, also called “nits”), which is approximately equivalent to the range between moonlight and a lamp. Colors

were only allowed to “unfold” within this very limited range. With HDR, the luminance range will now broaden — in theory — from 0.0005 cd/m² to 10,000 cd/m², which is equivalent to the range between starlight and a bright blue sky. However, in practice, these values are currently not actually achieved by available consumer hardware.

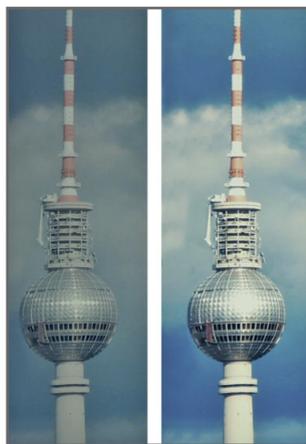
Our Eyes Love Shadows!

Since the market launch of Ultra HD Blu-ray, at the latest, HDR has shifted into the focus of attention, for both manufacturers and the media. After all, our eyes are much more sensitive to levels of brightness than to shades of color. If we want to provide our eyes with better images, we need a significantly wider contrast range. A typical color sampling of content (e.g. Ultra HD Blu-ray) transmits more information on brightness than on color, which means that luminance outweighs chrominance.

High Dynamic Range — a Key Element

Even though HDR and the (wider) color gamut, from a technical point of view, are two different aspects of image display, they are usually joined in standards.

The resulting palette of available colors with all their intensities is called “color volume.” High Dynamic Range is thus one of the three key components of color volume that the viewer is able to discern.



Test shots mastered in SDR (left) and HDR (right)

The three most important cornerstones for color volume are:

- HDR → enhanced contrast range between 0.0005 and 10,000 cd/m^2
- color depth → minimum 10 bit (1,024 colors, instead of 256 colors with 8 bit)
- color gamut → BT.2020

It is important to understand that HDR is not (only) about more brightness but a wider overall contrast range, i.e. the range between the darkest and the brightest area of an image. A peak luminous density of, for example, 1.000 cd/m^2 is of little use if, at the same time, areas of the image that should be dark appear too bright.

Communication between Content and Display Panel

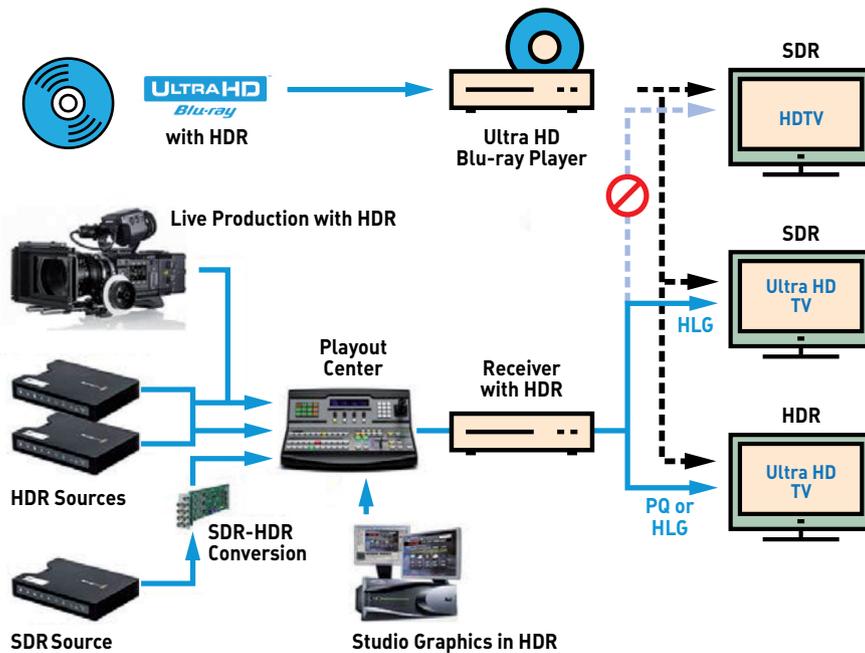
In order to make use of this larger color volume, HDR content and HDR-enabled flat-panel displays have to “communicate” with each other by way of a new logic. New rules have to be defined for TV sets to interpret (electronic) data and reconvert them into (optical) light signals which they are able to display. This is called Electro-Optical Transfer Function (EOTF). In a way, it is a reversal of the production process, where the camera “converts” light signals into data, and which is, by the same logic, called Opto-Electrical Transfer Function (OETF).

However, a camera “sees” light signals in a way that differs from the way our eyes see the world. Moreover, the human eye is extremely adaptable to a wide range of lighting situations. EOTF and OETF are thus not linear functions but curves. In the case of HDR, several proposals for the shape of these curves were made by the television and video industry. One of these proposals is already being implemented in the Ultra HD Blu-ray and in the transmission of Ultra HD streams via Internet: the “Perceptual Quantizer,” or PQ for short, developed by the Dolby Laboratories.

Two standards: PQ and HLG

Perceptual Quantizer (PQ) offers good HDR quality, but comes with the drawback that it is not backward compatible: Ultra HD TV sets that are not HDR-capable would not be able to “understand” the PQ signal and misinterpret its content — viewers would see only a “washed-out” image. Due to the large number of Ultra HD displays without HDR capability that have already been

Besides Video on Demand providers such as Netflix, Broadcasters like RTL, ZDF or Travelxp 4K are starting to offer UHD content with HDR



HDMI 2.x

If HDR is important to you, look out for the HDMI version of the interface/device.

HDR10 (PQ) requires HDMI 2.0a,
HLG requires HDMI 2.0b.

Dynamic HDR like Dolby Vision or HDR10+ is officially supported by HDMI 2.1.

sold on the German market, it is important for many content providers to offer their programming to these TV households in the best possible quality as well. A simulcast of SDR and HDR may not be economical in view of the high Ultra HD data rates. For this reason, some program providers are considering using another curve instead of PQ: Hybrid Log-Gamma (HLG).

On HDR flat-panel displays, HLG content is indistinguishable from PQ up to a certain brightness. When displayed on SDR panels, on the other hand, the image is comparable to a conventional TV signal without HDR. PQ and HLG have been specified by the International Telecommunication Union (ITU) for program production and exchange and have been adopted by the DVB Consortium for HDR Distribution in UHD-1 Phase 2.

Dynamic HDR

With static HDR methods such as PQ, the basic data for contrast, brightness and gamma is set at one level for the entire content asset. With dynamic HDR methods, these parameters are set per scene or frame for the desired impression. Dolby Vision is already on the market, Samsung has introduced HDR10+. Both “systems” are based on the PQ curve, supplemented by dynamic metadata. They require respective content to deliver the full experience, but offer downwards compatibility with today’s SDR TV sets.



Outlook

The standardization of HDR for broadcast is finalized. However, new HDR formats may be adopted in the future. This would entail corresponding adaptations for the HDMI interface. In November 2017, the HDMI-Forum disclosed the specifications for HDMI 2.1. It allows for transmissions with a bandwidth of up to 48 Gbit/s, higher resolutions up to 10,328 × 7,760 pixels, HFR up to 8K/120Hz and does officially support dynamic HDR formats. However, first devices with HDMI 2.1 interfaces are expected to hit the shelves not before 2019.

HFR – High Frame Rate

All visual improvements — such as expanded dynamic range, more colors, or a broader range of color shades — will provide viewers only with optimum added value as long as the images are not dulled by a loss of detail. Static images look great on an Ultra HD display: The depth of detail displayed by a TV frame with 3,840 pixels × 2,160 pixels is enormous. With fast movements or camera pans, however, the sharpness of the image is likely to suffer. This effect can happen at low frame rates, which for most Ultra HD content is still 24 Hz (for motion pictures) or 50 Hz (for sportscasts).

In theory, a doubling of the vertical and horizontal number of pixels also requires doubling the frame rate, in order to maintain a dynamic image definition. This component of UHD-1 Phase 2 is known as High Frame Rate (HFR). In UHD-1 Phase 1, frame rates of up to 50/60 Hz were introduced. In UHD-1 Phase 2 frame rates of up to 100/120 Hz are foreseen in accordance with the recommendation by the International Telecommunication Union (ITU).

High Frame Rate is supported by the newest generation of Ultra HD devices. For example, the entire 2018 range of LG's OLED TV sets are capable of playing High Frame Rate UHD-Videos with 120 frames per second.

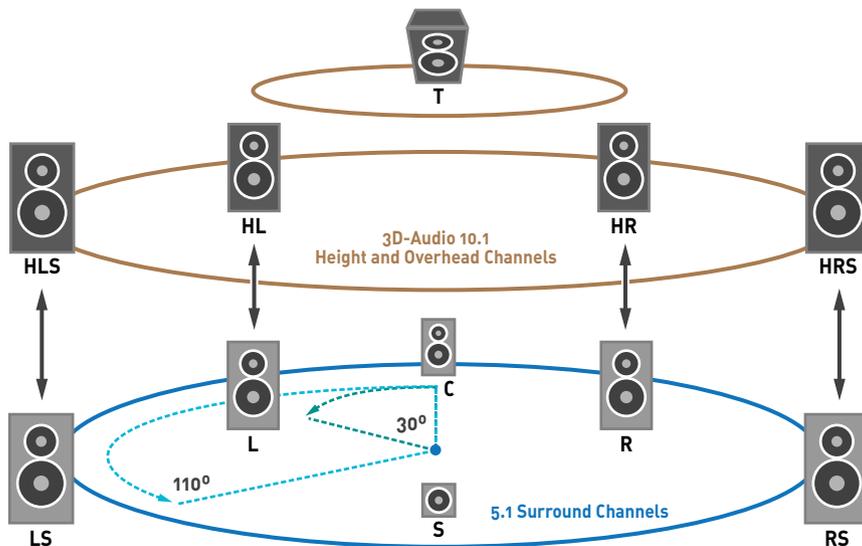
In live and sports productions with fast movements and pans, High Frame Rate (HFR) is of particular interest, in order to minimize jiggle and smearing effects. However, today's OB vans for live productions are not yet equipped to handle those high frame rates, even though they might be able to handle Ultra HD productions.

Despite being tested thoroughly within the industry, it may take several years until HFR will be employed in Ultra HD live production. A quite different story is how higher frame rates of up to 100/120 frames per second (fps = Hz) will impact the viewers' subjective perception. In theaters, 24 Hz is still standard, even with 4k presentations. For theatrical HFR productions, a frame rate of 48 Hz has been proposed and already employed in 2012 by director Peter Jackson for his adaptation of J. R. R. Tolkien's *The Hobbit*. Reactions from both critics and moviegoers were mixed: Many viewers found the look "too smooth" and lacking in "cinematic charm", especially for the subject at hand.

In April 2016, Ang Lee, the producer-director of motion pictures such as *Life of Pi* and *Brokeback Mountain*, presented a 4k/3D/120-Hz preview of his upcoming feature, Billy Lynn's *Long Halftime Walk*, at the National Association of Broadcasters' NAB Show in Las Vegas. Although the feedback was largely positive, he was also criticized for the material looking like a video rather than a theatrical release. Filmmakers like Ang Lee share this criticism and are working on solutions. One approach would be dynamic frame rates — just like color grades and aspect ratios-, depending on the mood or the requirements of the material.



Next-Generation Audio Experience



An immersive TV viewing experience does not depend on better video alone. For movies, episodics, and live events, good sound is just as crucial as visual content. For next-generation television broadcasts, consumers should have the same kind of acoustic experience that is already possible, in part, with Ultra HD Blu-ray.

New concepts for an enhanced audio experience are summarized within the Ultra HD standard under the term Next-Generation Audio, or NGA. Within the framework of its approval of the technical specification for UHD-1 Phase 2 in October 2016, the DVB Consortium has decided to support two systems: Dolby AC-4, developed by the Dolby Laboratories, and MPEG-H, developed by the Moving Picture Experts Group (MPEG).

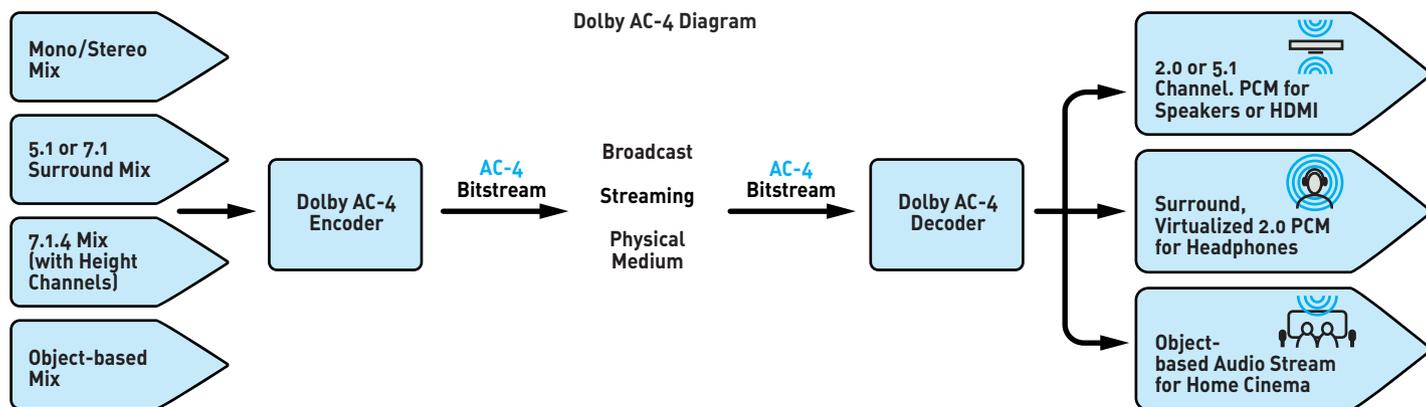
Dolby AC-4

Dolby AC-4 offers a complete end-to-end solution, which has already been field-tested (e.g. during the 2015 UEFA Champions League finals). In addition to TV broadcast, AC-4 could be used for streaming content at home and on mobile devices. Compared to other standards, AC-4 allows audio data to be compressed up to 50 percent more effectively.

Dolby AC-4 supports conventional channel-based surround sound as well as object-based sound formats. The decoder ensures that content is adapted to the output medium at hand. A very interesting and bandwidth-efficient aspect is the support of multilingual audio broadcasts. Several 1.0 substreams in different languages can be added to the main audio stream (e.g. 5.1 channel audio). Languages, carried on their own subchannel, will only be mixed into the main channel at the receiving end, which permits intelligent volume control and/or a manual adjustment of dialog volume. If the dialog portions are analyzed on the encoder side, this benefit is also available for dialog that has already been mixed by the broadcaster.

These options can be applied to movies and series as well as to live sportscasts. Viewers may, for example, choose between two different commentators of a soccer match. And AC-4 not only provides the user with additional choices but also

uses less bandwidth than conventional transmissions: A multilingual audio stream with three languages, for example, could save about 50 percent in bandwidth.



MPEG-H Audio

MPEG-H Audio is meant to create immersive audio environments for TV broadcasts with object-based and multi-channel sound. In February, the MPEG announced that MPEG-H would be published as an international standard.

MPEG-H Audio, too, can be used with various transmission methods: It is not only suitable for television but also for Internet streaming and on mobile devices. Like Dolby AC-4, MPEG-H Audio is based on a multi-channel system that allows the transmission of additional audio channels in addition to the basic channel(s).

With movies and live telecasts, users will thus be able to choose between different dialogs or commentators. Objects may be transmitted as such or bundled into channels.

MPEG-H supports various audio formats, such as stereo, 5.1, 7.1, or object-based audio reproduction (up to 7.1.4). The goal has been an effective data compression that allows broadcasters and VoD providers to distribute their content as economically as possible.

Both Dolby AC-4 and MPEG-H Audio meet all the requirements to provide a next-generation audio experience within the Ultra HD standard.

5.1.4, 7.1.2 ...

For new home cinema sound systems, the number terminology was expanded for 3D audio by adding another digit. A 9.1 receiver, for example, allows for a 5.1.4 or 7.1.2 installation. The first digit represents the number of surround speakers, the second the LFE channel(s) (subwoofer), and the third the height or overhead (ceiling-mounted) speakers.

Higher Order Ambisonics (HOA)

New approaches to audio reproduction, such as Higher-Order Ambisonics (HOA), have also been taken into account for the two standards mentioned above. This is a process for recording and reproducing a sound field. The technique does not require a fixed number of speakers. Recorded values for sound pressure and sound-particle velocity are converted mathematically and transmitted as audio signals. Only four audio channels are

Other New Audio Systems

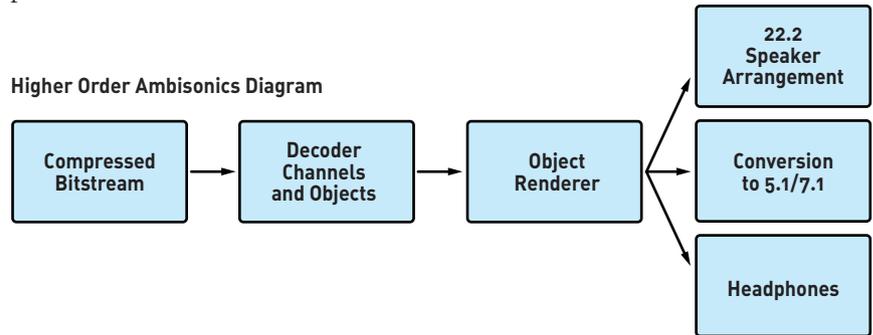
Innovations in the field of audio reproduction did not just come with the launch of the Ultra HD standard. An ordinary (HD) Blu-ray already benefits from so-called “object-based audio formats.” In the course of introducing Ultra HD, however, the aspect of “Next-Generation Audio” (NGA) will be driven forward as well. The successors of conventional surround sound are called Dolby Atmos, DTS:X, and Auro-3D.

These new audio formats no longer operate in terms of “channels,” and they expand the sound field to include additional vertical levels. Up until now, one or two subwoofers and a couple of satellite speakers had to do. From 2.1- to 7.2-channel audio, however, sound would always reach the listener from the front, from behind, or from the side—all in one horizontal plane.

Dolby Atmos and DTS:X are among the new object-based audio formats. Ceiling-mounted (overhead) speakers, height speakers, or reflecting

sufficient to create a three-dimensional sound pattern, whereas conventional 5.1 surround sound still creates only a two-dimensional sound pattern.

Higher Order Ambisonics Diagram



speakers directed upwards create a much more immersive and realistic sound experience. The systems do not prescribe the number of speakers to be set up. With the best possible set-up of the new sound system, the audio objects can be placed on a “virtual stage” as the filmmakers intended. This has the advantage that a wide variety of audio configurations are supported without any problems, and it also matters little if the speaker arrangement is not 100 percent symmetrical.

Another concept is called Auro-3D. Although the sound experience is extended vertically through a number of higher-mounted speakers, the audio signals are bundled conventionally into several preset channels.

It is easy for consumers to adapt to the new audio formats, since they may continue using their existing speakers for an NGA system. Moreover, since 2014, several AV receivers are available that support the new formats, Dolby Atmos, DTS:X, and Auro-3D.



UHD Logos

As wonderful as all the video and audio innovations are that we have presented here, it is tricky to stay on top of things with all the confusing new terms and abbreviations—and that applies to consumers as much as it does to the industry, i.e. manufacturers and retailers.

In order to facilitate access to the next generation of consumer electronics for buyers, several logos have been developed. Some of them are standardized and used throughout the industry (“market-wide”), while some have been devised by manufacturers, who use them only on their own products. Market-wide logos represent official standards and provide security to buyers when making a purchase decision, while the manufacturers’ logos only reflect their particular philosophy and certain technical features.



Ultra HD Blu-ray Logo

The Ultra HD Blu-ray logo was already presented to the public in May 2015 by the Blu-ray Disc Association (BDA). Since the fall of 2015, manufacturers and film producers can have their hardware and content licensed according to BDA specifications. The discs available and the corresponding players support a resolution of 3,840 pixels × 2,160 pixels, High Dynamic Range (PQ), the BT.2020 color space, and frame rates of up to 60 Hz. Ultra HD Blu-ray players are equipped with at least one HDMI 2.0a output with HDCP 2.2 copy protection.

With the logo, it is easy to distinguish standard HD Blu-ray players from Ultra HD Blu-ray players. Beware: Blu-ray discs or content designated as “4k-compatible” or “Ultra HD-compatible” do not contain genuine Ultra HD but “only” upscaled

HD material. Buyers should not allow themselves to get confused by this and look for the (genuine) Ultra HD Blu-ray logo.

Ultra HD Logo

The official Ultra HD logo was presented in September 2014 by Digital Europe and can since be found on hardware and packaging. Only display panels which meet the minimum requirements for the reproduction and display of Ultra HD carry this logo.



The requirements for display panels and projectors cover all physical basic parameters for Ultra HD reproduction via HDMI:

Display

- native resolution:
no less than 3,840 pixels × 2,160 pixels
- aspect ratio: 16:9
- color space: BT.709 minimum

Video In

- at least one HDMI input
with HDCP 2.2 copy protection
- supported frame rates:
24 Hz/25 Hz/30Hz/50Hz/60Hz
- minimum color depth: 8 bit
- color subsampling: 4:2:0 for
50Hz/60Hz and 4:2:2 for 24Hz/25Hz/30Hz

Audio

- minimum: PCM 2.0 stereo signal

The Ultra HD logo does not indicate the quality in which an Ultra HD panel displays content. This is also true for HDR capabilities, because the logo was introduced earlier than PQ and HLG. Of course, TV sets, projectors, and monitors that exceed the minimum requirements listed above are also permitted to carry the logo. There are, for example 5k TVs with an aspect ratio of 21:9.

The entire playback chain has to meet the parameters listed above from signal output through processing all the way to the display. For this reason, projectors, for example, which first convert an Ultra HD signal down to Full HD, only to upscale it again—by shifting or other technical means—to 3,840 pixels × 2,160 pixels, are not allowed to carry the Ultra HD logo.

Ultra HD Premium Logo

In January 2016, the UHD Alliance, an association of TV manufacturers, technology ventures, and representatives of the film industry, presented their own specification and logo at the CES in Las Vegas. While the Ultra HD logo and the Ultra HD Blu-ray logo designate technical aspects of the products that carry them, “Ultra HD Premium” is more of a “quality designation.” The Ultra HD Premium certification is not limited to devices but also covers parameters for content distribution channels and for professional flat-screen panels used for mastering. Since May 2016, Ultra HD Blu-ray players can also be certified, and other hardware is to follow. This way, the UHD Alliance closes the gap between content and its distribution.



Video display hardware—i.e. TV sets and projectors—have to cover a resolution of at least 3,840 pixels × 2,160 pixels, a color depth of 10 bit, and at least 90 percent of the DCI-P3 color gamut. In addition, they have to be able to process BT.2020 signals. In contrast to the Ultra HD logo requirements, High Dynamic Range (PQ) according to SMPTE standard ST 2084 is mandatory for a Premium certification by the UHD Alliance. Moreover, a combination of peak luminance and black level is prescribed that fits respective LCD and OLED flat-screen display panels.

Mobile HDR Premium

The UHD Alliance is licensing the new Mobile HDR Premium Logo for mobile devices like smartphones, tablet computers and notebooks.

Devices have to cover a color depth of 10 bit, and at least 90 percent of the DCI-P3 color gamut.

In addition, dynamic range must at least cover a range between 0.0005 and 540 cd/m² (0.1 cd/m² and 600 cd/m² for Notebooks alternatively).



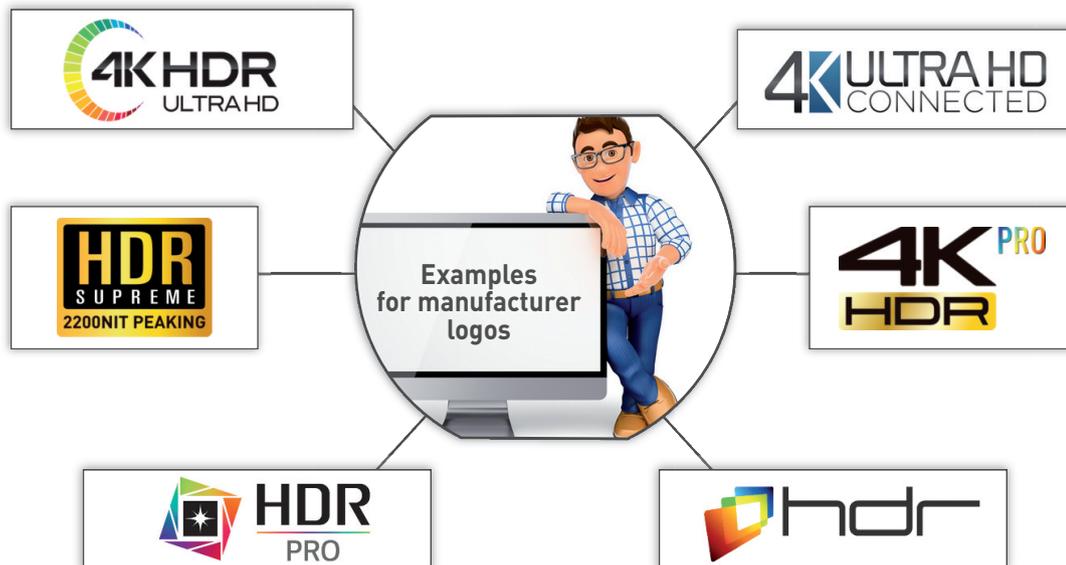
Manufacturer-Specific Logos

In addition to the official, market-wide logos and designations, there are numerous manufacturer logos surrounding Ultra HD, which are meant to direct consumer attention to specific characteristics of the brand at hand.

From the companies' point of view, this is an understandable marketing strategy, but it does not make life easier for potential buyers. For example, the fact that a manufacturer uses the term "HDR"

does not guarantee that the device complies with the standards of the UHD Alliance as described on page 15. To be on the safe side, consumers should watch for the "Ultra HD Premium" logo.

A rule of thumb when buying an Ultra HD TV: Anything that carries the designation "4k" or "UHD" will have Ultra HD. For other technical specifications, it is recommended to look for the market-wide logos. When in doubt, consumers are advised to consult expert retailers.



Players and Receivers for Consumers

Which devices are able to supply Ultra HD flat-panel displays with suitable content? The choice of content is as diverse as the options for displaying it. Below, we are presenting consumer electronics hardware that already supports the Ultra HD standard.

Ultra HD Blu-ray Players

The Ultra HD Blu-ray is, so to speak, the “king of UHD content.” At present, no other medium offers a better quality in Ultra HD. In order to play back this new medium, new Ultra HD Blu-ray players are required, since existing Blu-ray players, unfortunately, do not support the new format.

Products are available from companies like LG, Panasonic, Samsung, Sony and Oppo. The players support Ultra HD Blu-rays with and without High Dynamic Range (all HDR10, some Dolby Vision), Wide Color Gamut, and High Frame Rate. Object-based audio formats — such as Dolby Atmos, DTS:X, and Auro-3D — are also supported. Moreover, the players are fully downward compatible, i.e. they will play regular (HD) Blu-ray Discs, 3D Blu-ray Discs, DVDs, and (V)CDs.

The support of apps and major VoD services (partly even in Ultra HD) makes these players perfect allrounders for the living room.



Ultra HD Blu-ray players



DVB-S2 satellite receiver

In spite of initially steep prices for hardware and discs, the new medium has already caught on with consumers.

TV- and Media-Receivers

A large part of Ultra HD TV sets sold are equipped with integrated tuners and an HEVC decoder for receiving Ultra HD content. Nonetheless, stand-alone receivers are in high demand with consumers, many of whom gladly pay a few euro extra for additional features and ease of operation. Since late 2015, the first Ultra-HD-capable satellite receivers are available.

Since October 2016 pay-TV provider Sky Germany is shipping satellite and cable receivers for reception of Ultra HD. Media receivers for Ultra HD reception are available from Deutsche Telekom and Vodafone.

Streaming Set-Top Boxes

In a category of their own, we find Amazon's Fire TV 4K, Apple TV 4K and the Nvidia Shield console. All devices are extremely compact and, on top of games and apps, offer the option of receiving Ultra HD content in both SDR and HDR transmitted by streaming. The Ultra HD portfolio of Amazon Video, iTunes and Netflix can thus be displayed directly on virtually any TV, without smart-TV support. This is very convenient for owners of an Ultra HD TV purchased in 2013 or 2014, which may not support streaming services by themselves. The only requirement—apart from a stable Internet connection with approximately 25 Mbit/s—is an HDMI 2.0 input with HDCP 2.2.



AV Receivers

In many cases, AV (audio/video) receivers are interposed between external devices and Ultra TV displays. Not only do they facilitate the switch between various signal sources but are often also the centerpiece of the home audio system. Newer receivers already support audio formats such as Dolby Atmos, DTS:X, and Auro-3D.



While the support of sound content is usually quite simple, consumers should find out the receiver's technical specifications before buying. As an interface between the signal source and the playback device, the AV receiver has to meet the same requirements as the components that it is connected to. HDMI 2.0a and 2.0b—as well as HDCP 2.2—are required for a hassle free UHD experience including the display of HDR content.

Displays for Consumers

Size Matters

Ultra HD devices are about to become standard equipment in TV households. In 2017, about 40 percent of all TVs sold in Germany were Ultra HD sets.

The desire for larger screen diagonals is probably one of the main reasons why consumers opt for Ultra HD when buying a new TV set. Screen diagonals range from 40 to 79 inches, with display panels of between 55 and 65 inches being the most popular. There are hardly any panels with Ultra

HD resolution that have diagonals of less than 40 inches. At the other end of the spectrum, there are only a few sets with diagonals larger than 79 inches, and they all fall into the high-end category.

In terms of technology, buyers of flat-screen display panels have a choice between LCD and OLED, and in addition to various features and extras, they can choose between plane and curved displays. Another decisive factor may be the choice of the Smart-TV operating system that the user prefers.



Micro-LED

As a third display technology, Micro-LEDs are on the horizon, combining the advantages of LCD and OLED. At CES 2018, Samsung revealed a modular TV set based on extremely tiny, self-illuminating LEDs. Working without colour filtering or backlight, the technology shines with an extrem level of pixel density and a very high contrast ratio.

LCD TVs

New LCD TV sets incorporating advanced technologies like QLED are capable of peak brightness of up to 2,000 cd/m². At CES 2018, Sony showed a prototype even capable of delivering 10,000 cd/m². The backlighting is being improved continuously, in order to optimize the display of black. The display of colors, on the other hand, is excellent. The first LCD TVs are now available that cover the DCI-P3 color space almost 100 percent.

Video quality in the LCD segment varies widely, depending on the lighting and video enhancement technology used. Low-priced entry-level models often meet only the minimum requirements of the Ultra HD standard. One indicator for good video quality is the “Ultra HD Premium” already mentioned, which applies to both LCD and OLED TVs.

Bottom line: LCD is a common technology with a high peak brightness. Top-of-the-line products also provide very good black levels.

OLED TVs

The main competitor of LCD is no longer plasma but OLED, which stands for “Organic Light-Emitting Diode.” The makeup of an OLED display panel is quite different from an LCD panel. Each pixel of an OLED display is its own light and color source. This way, black levels down to 0.0005 cd/m² can be achieved, which is close to pure black.

The contrast ratio of an OLED flat-screen panel is also excellent, and the color display for the latest OLED generation already covers more than 95 percent of the DCI-P3 color space. Since the screen does not require a light-emitting layer and/or local dimming, OLED display panels are extremely thin.

While a new generation of LCD TV sets provides very good black levels, new OLED TV sets are capable of peak brightness of up to 1,000 cd/m².

OLED technology was advanced in the last few years mainly by Korean manufacturers. There are only very few suppliers of large-site OLED panels, and they also supply third-party manufacturers. The availability of OLED panels is continuously improved by adding new production facilities, but prices are generally significantly higher than those of LCD panels.

Bottom line: OLED is the newer und still somewhat more costly technology. Black levels and colour display is outstanding, current top-shelf models provide comparably very high levels of peak brightness.

Inches/ cm

40 inches = 102 cm

55 inches = 140 cm

65 inches = 165 cm

79 inches = 201 cm



Projectors



For home cinemas, there is also a wide selection of projectors which are able to display Ultra HD content.

State-of-the-art projectors do provide a native resolution of 4,096 pixels × 2,160 pixels, which is the original 4k resolution of professional 4k cinema projectors. Of course, these projectors can also display the Ultra HD resolution of 3,840 pixels × 2,160 pixels.

In general, buyers should watch for native Ultra HD support, but those projectors are often still very expensive. The newest range of projectors using e-shift technologies to display UHD content or to upscale an existing Full-HD resolution to an Ultra HD display also delivers very good image quality. Many current available new projector models — for example from Sony, Epson or JVC — do support HDR (HDR10 and HLG) and BT.2020.

Ultra HD Monitors

In the field of gaming as well as in professional graphics and video editing, monitors with Ultra-HD resolution are not uncommon anymore. With games, the higher resolution provides an enhanced image and even gives players an edge in competitions and tournaments over those using screens with lower resolutions.

In graphics and video editing, Ultra HD monitors expand the desktop and may even replace multi-monitor setups. The panels' color representation is fully up to par with professional display panels with lower resolutions. Moreover, they can serve as preview monitors for high-resolution images and videos. Another area of application for Ultra HD monitors is in the surveillance of objects or production plants. The high resolution permits the space-saving placement of several live streams or controls on a single flat-screen display panel.

Technically, the monitors were not designed for the playback of Ultra HD motion picture material. They often lack the interfaces required for high-definition playback (e.g. HDMI 2.0, HDCP 2.2), and many of the devices do not even significantly support any of the Ultra HD standard's video enhancements, other than the higher resolution.



Smartphones

Owners of recent smartphones may already have an Ultra-HD-capable device in their pockets, since many smartphones are able to record video with 3,840 pixels × 2,160 pixels at 30 frames per second. These recordings may then be played back without any problems on an Ultra HD device or monitor. However, additional benefits—like wider color gamut or HDR—are rarely available on those small devices, and most of the smartphone screens also do not achieve a resolution of 3,840 pixels × 2,160 pixels. There are some “pixel kings,” though, which are capable of displaying the full Ultra HD resolution on their screens with a 5.5-inch (14-cm) diagonal.

Smartphones are unlikely to become the preferred reception or playback devices for Ultra HD content, since the human eye is barely able to notice the difference between Ultra HD and Full HD on the small smartphone displays.



Ultra HD Content There Is Plenty to See!

Linear TV and VoD (in Germany)

By now, the supply of Ultra HD content is growing continuously. Live-TV, movies and series are available across many distribution channels in Germany today. Sky Deutschland has launched its Ultra HD service already in 2016, showing selected football and handball matches, distributed via satellite, cable networks and IPTV providers. Ultra HD movies are available on demand.

Deutsche Telekom has launched its Ultra HD offering in fall 2017. It contains the Ultra HD TV channels of Sky and Insight TV as well as movies on demand (Videoload). It also allows access to Ultra HD content of Netflix and Youtube. Furthermore, one match per week of German Hockey League and Basketball Bundesliga are shown in Ultra HD quality. The Ultra HD media receiver is compatible with HDR formats PG and HLG.

The Ultra HD offering of Vodafone/Kabel Deutschland also contains the Ultra HD TV channels of Sky, broadcasted via cable. In addition, Vodafone also offers Ultra HD content via IPTV like Red Bull TV, "auto, motor und sport" and AXN.

By end of April 2018, "RTL UHD" was launched on the satellite platform HD+, showing Formula 1 racing throughout 2018. The travel channel Travelxp 4K (Ultra HD HDR), is also available for

HD+ customers. The company is also running its own Ultra HD channel "UHD1", showing attractive content in co-operation with partners, e.g live sport on Eurosport4K or series produced by RTL.

Some other Ultra HD channels are available via satellite: "pearl.tv", QVC (home shopping) at Astra 19.2 east; "Travelxp 4k", "FTV UHD" (Lifestyle), "Funbox 4K" and "HOTBIRD 4K1" at Eutelsat HOTBIRD 13 east.

Besides linear TV and "classic" Video-on-demand, HbbTV (Hybrid broadcast broadband Television) has to be mentioned as well. For example, the public broadcaster ZDF has already added Ultra HD content to its media library, which was produced in HDR. It can be accessed via HbbTV, using the color keys on the remote control. This requires, of course, a smart TV with an Internet connection, which should be also capable of displaying Ultra HD HDR (HLG) content for an optimal viewing experience.

Streaming

Amazon Video and Netflix have been offering Ultra HD content since 2014. (Amazon's high-definition streaming programs were offered free of charge to Amazon Prime customers and thus constituted their first contact with Ultra HD con-





unitymedia



tent for many of them.) In the meantime, Netflix and Amazon Video have expanded their Ultra HD portfolios considerably. Series, movies and TV shows can be accessed via preinstalled smart-TV apps, external set-top boxes and streaming devices like Apple TV 4k. Amazon, Apple and Netflix are supporting HDR (HDR10 and Dolby Vision). Amazon Video is also supporting the dynamic HDR method HDR10+ (see also page 9).

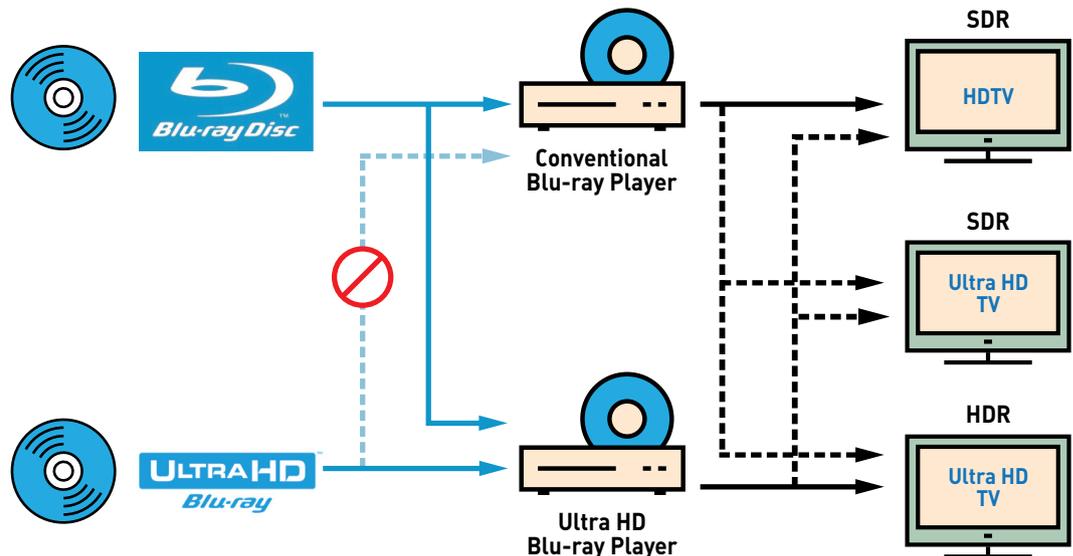
For streaming Ultra HD content in good quality, an Internet connection with maintained speeds between 18 and 25 Mbit/s is required, which is not available to all users.

Ultra HD Blu-ray

The primary medium for Ultra HD content at this time is the Ultra HD Blu-ray (the word “Disc” is no longer part of the official designation). Since

early April 2016, content as well as compatible Ultra HD Blu-ray players have hit stores. By now, consumers can choose from a decent selection of devices and many Ultra HD Blu-rays are available — seen as a positive signal for the Ultra HD Blu-ray, which has indisputable benefits over other distribution channels. For example, playback does not require an ongoing Internet connection (which might entail quality fluctuations and even interruptions). The image quality is superior to VoD/streaming, since content is played back with a color depth of 10 bits, HDR, and bit rates of up to 128 Mbit/s.

Moreover, the new audio formats—Dolby Atmos, DTS:X, and Auro-3D—are supported. In contrast to conventional (HD) Blu-ray Discs and (SD) DVDs, there are no longer any regional codes, which pleases collectors and viewers who like to watch movies in their original language or in their own mother tongue.

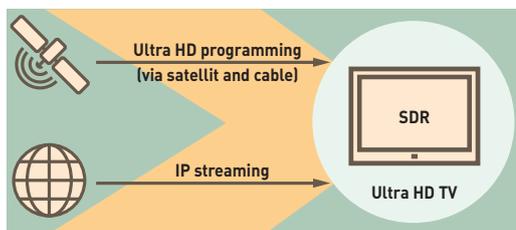


Ultra HD in Your Own Living Room

As the preceding chapters have shown, Ultra HD is a multi-faceted subject. Core technologies, such as High Dynamic Range (HDR), Wide Color Gamut (WCG), High Frame Rate (HFR), and Next-Generation Audio (NGA) are important contributing components that will bring about significant changes in the audio and video experience. Many of these innovative technologies are already available today in receivers and playback devices for Ultra HD, and at the same time, interested consumers are faced with a steadily increasing choice of Ultra HD content and services.

Below, we would therefore like to take a closer look at three typical scenarios for making Ultra HD happen in your own living room today—occasional users, more advanced consumers, and for genuine Ultra HD enthusiasts.

Case #1: Ultra HD for Beginners



Your goal: Occasional use of Ultra HD content with a minimal investment or with existing hardware.

In the simplest case, access to the world of Ultra HD is possible with just an Ultra HD TV set (i.e. an Ultra HD flat-screen display panel with an integrated tuner and an HEVC decoder). If you have purchased your last TV set not too long ago, you may already meet this requirement, i.e. you may already have an Ultra-HD-capable TV set in your living room.

State-of-the-art Ultra HD TV sets are often equipped with triple tuners, i.e. they allow TV reception over the air with an indoor antenna (DVB-T/T2), via cable (DVB-C), and via satellite (DVB-S/S2). DVB-T2 will not be used for Ultra HD broadcasts in Germany. Ultra HD content — e.g. Sky — is available via satellite, cable providers and Deutsche Telekom. Since most Ultra HD TV sets are also “smart TVs,” viewers have a choice of Ultra HD programs distributed via VoD/streaming as well. This scenario does not necessarily require an HDR-capable Ultra HD TV set. However, broadcasters have begun airing Ultra HD-HDR content via satellite. Producing new series and feature films in HDR has quickly become almost standard for streaming providers. In order to enjoy this content in best possible quality, a HDR TV set is necessary.

What you need:

- Ultra HD TV set with DVB-S2 or DVB-C tuner
- Satellite dish or cable hookup
- Broadband Internet access for using IPTV/streaming services

What you should pay attention to:

- CI+ slot on your Ultra HD TV set for watching encrypted (conditional access) Ultra HD content (currently not supported by Sky Germany)
- HDR capability to make your Ultra HD TV future-proof

HDCP 2.2

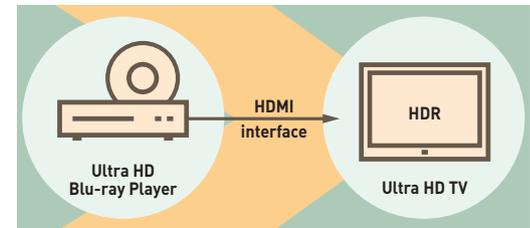
HDCP 2.2 is a new copy protection system which is intended to protect Ultra HD content in particular from video piracy. This new protocol is already applied in the field of VoD/streaming and with the Ultra HD Blu-ray. In the playback chain (e.g. Ultra HD Blu-ray-Player — AV receiver — Ultra HD TV set), all devices need to be equipped with an HDMI 2.0 connection which supports HDCP 2.2.

If this is not the case, the display will remain dark when playing back protected content, and the sound system will remain silent. For this reason, when buying Ultra HD equipment, it is imperative that it has a sufficient number of HDMI 2.0 inputs and outputs with HDCP 2.2.

Case #2: Advanced Ultra HD

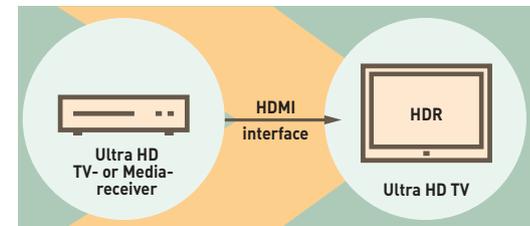
Your goal: Upgrading your technical infrastructure for the regular use of Ultra HD content and services.

Movie buffs might already have cast an eye on the Ultra HD Blu-ray, which, in addition to Ultra HD's higher resolution, also brings the wider color gamut (WCG) and HDR into the home theater. In order to benefit from all of these options, it is important to have not only an Ultra HD Blu-ray player (which can, of course, also play back all the predecessor formats) but also an HDR-capable Ultra HD TV set that also supports the new HDCP 2.2 (cf. box, "HDCP 2.2").



It is also essential in this scenario to use the proper HDMI cable when connecting the Ultra HD Blu-ray player and the Ultra HD TV set (cf. box on p. 26, "The Right HDMI Cable"). It is possible that not all HDMI interfaces support Ultra HD content, HDCP or different HDR formats in the same way. It is therefore recommended that you take a look at the Ultra HD TV's instruction manual.

Alternatively, or in addition to an Ultra HD Blu-ray player, an Ultra HD cable-, satellite- or IPTV-receiver permits the reception of Ultra HD content via satellite.



The Ultra HD services of pay-TV providers like Sky Germany, in particular, are available this way, in order to enable the provider to encrypt the signal (and the receiver to decrypt it via a smartcard). When connecting an Ultra HD receiver to an Ultra HD television set, users have to watch out for the same “HDMI pitfalls” described above in connection with the Ultra HD Blu-ray player.

When buying the necessary hardware, the Ultra HD Premium logo can serve as a helpful guideline. Ultra HD TV sets as well as Ultra HD Blu-ray players carrying this logo meet all the technical requirements necessary for a hassle-free interaction between the various devices.

What you need:

- HDR-capable Ultra HD TV set with HDCP 2.2 support
- Ultra HD Blu-ray player and/or Ultra HD satellite-, cable- or IPTV-receiver with HDCP 2.2 support

What you should pay attention to:

- Hardware carrying the Ultra HD Premium logo
- TV set with at least two Ultra-HD-capable HDMI inputs (for simultaneous connection of multiple Ultra HD sources)
- Certified HDMI cable carrying the Ultra HD Premium logo

The Right HDMI Cable

In order to avoid signal transmission problems with Ultra HD content, watch for the HDMI Premium Logo and use a version-2 HDMI high-speed cable.

HDMI-Premium-certified cables support the full bandwidth of 18 Gbit/s, as mandated by the HDMI 2.0 specifications. They are capable of transmitting Ultra HD signals with High Dynamic Range (HDR) and Wide Color Gamut (WCG) and with frame rates of up to 50/60 frames per second.

If you want to play it safe and have to deal with cable lengths of more than 10 meters, we advise to talk to your local dealer, who is preferably a home cinema specialist.



Case #3: Ultra HD Aficionados

Your goal: Full-scale switchover to Ultra-HD-capable technology in your entire home entertainment network for the enjoyment of Ultra HD content and services on a permanent basis.

The Ultra HD aficionado not only wants better video but also good audio and will therefore upgrade his home network with an AV receiver, adding another link to the chain. This link is placed between the player/receiver (Ultra HD Blu-ray player/Ultra HD DVB-S2 receiver) and the display (Ultra HD TV set).

In this scenario, too, the HDMI cable connection plays a key role—even more so than in the direct connection between player/receiver and display. Among other things, the user has to ensure that

the AV receiver also supports HDCP 2.2, which is intended to protect an Ultra HD Blu-ray's content in the same way as it protects Ultra HD content delivered by Pay-TV providers or VoD/streaming services. In addition, the AV receiver must be able to handle HDR, in order to ensure that HDR-relevant information (so-called metadata) is passed through to the Ultra HD TV set.

What you need:

- HDR-capable Ultra HD TV set with HDCP 2.2 support
- Ultra HD Blu-ray player and/or Ultra HD satellite-, cable- or IPTV-receiver with HDCP 2.2 support
- AV receiver with HDCP 2.2 support as well as HDR pass-through capability

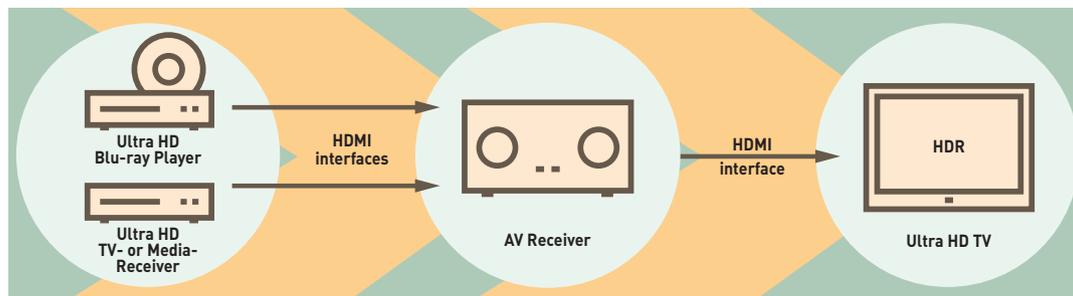
What you should pay attention to:

- hardware carrying the Ultra HD Premium logo
- TV set with at least two Ultra-HD-capable HDMI inputs (for simultaneous connection of multiple Ultra HD sources)
- certified HDMI cable carrying the Ultra HD Premium logo

The Audio System

At this place, we do not want to go into any details about the requirements for setting up an audio system for an immersive audio experience. Individual local conditions play a major role here.

Tip: If you do not want to install a full-fledged 3D-sound setup with a lot of speakers, you might be better off considering a soundbar. These devices are capable of simulating immersive surround sound while consuming little space in your room. To consumers without any experience, we recommend seeking the advice of qualified specialized retailers.





Bottom Line and Outlook

Ultra HD is developing at a continuously pace. Initial standardization hurdles were cleared in no time. And the new standard is a true milestone: It does away with numerous legacy issues and limitations of the past and—literally—sets new standards in terms of video and audio quality. Never in the history of television have so many improvements been tackled simultaneously: higher resolution, high dynamic range (HDR), wide color gamut (WCG), higher frame rates (HFR), and next-generation audio (NGA).

Fully implementing them over the next few years will be an immense task for the entire industry, which should not only focus on the technological development of Ultra HD. This mission requires

continual consumer education and information so that Ultra HD, as a TV technology will be fully embraced by viewers and not “fizzle out” as merely a technical gimmick.

In the future, the German TV-Platform will boost its efforts on both ends of the issue and offer its members a platform to exchange views and swap ideas about the latest trends and to advance Ultra HD technology.

For viewers and consumers, the present brochure of German TV-Platform provides comprehensive information about the development and the benefits of Ultra HD—because Ultra HD offers all that is needed for a perfect entertainment experience.

German TV-Platform



About Us

The German TV-Platform is an association of commercial and public-service broadcasters, device manufacturers, network operators, service and technology providers, research institutes and universities, state and federal authorities, and other companies, associations, and institutions concerned with digital media.

For more than 25 years, it has been the goal of this non-profit organization to establish digital technologies in television broadcasting, based on open standards. In the German TV-Platform's working groups, representatives from nearly every field in the consumer-electronics and media industry are committed to set the course on key issues of digital broadcasting.



Right from the start of Ultra HD: On 16 May 2014, the Ultra HD WG attended Sky Germany's UHD production of the German Soccer Association's cup game at Berlin's Olympic Stadium.

The Ultra HD Working Group in Brief

The Ultra HD Working Group (WG) was established in mid-2014 to continue the successful work of the organization's previous project and working groups.

It is headed by Stephan Heimbecher (Sky Deutschland) and deals primarily with the launch and evolution of Ultra HD. This includes numerous practical projects, such as organizing regular "Plugfests," or attending Ultra HD productions. Other issues which the WG is concerned with include general advancements in video and audio quality in other forms of digital television, such as HDTV. The WG's spectrum also covers new developments in moving pictures, such as Virtual Reality (VR) and Augmented Reality (AR).



Since late 2014, the Ultra HD WG regularly conducts so-called "UHD Plugfests", which have since been joined by the U.K.'s Digital Television Group (DTG).

Glossary

BT.709

Color space for cathode ray tubes (CRTs) specified by the International Telecommunication Union (ITU). BT.709 covers about 36 percent of the visible color spectrum.

BT.2020

Color space for display devices (e.g. flat-screen panels) specified by the International Telecommunication Union (ITU) for displaying UHD content.

Thanks to more powerful technologies (such as → LCD and → OLED), compared to CRTs, BT.2020 covers about 76 percent of the visible color spectrum.

BT.2100

→ High Dynamic Range (HDR) for program production and exchange specified by the International Telecommunication Union (ITU).

color depth

Indication of the color shades available through sampling of the chrominance signal. Traditional 8-bit sampling yields 256 shades, while 10-bit sampling yields 1,024 shades.

color gamut

Color gamut indicates which colors a screen is able to display, in relation to the full range of visible colors. The gamut is represented by a triangle against the area representing the entire color spectrum.

color volume

Color volume designates the interaction of the colors which a display (e.g. television screen) is able to represent (→ color gamut), the existing color shades (→ color depth), and the dynamic range (→ HDR or → SDR).

H.265 cf. HEVC

HDCP 2.2 [high-bandwidth digital content protection—version 2.2]

Copy protection method preventing (through encryption) the illegal duplication of → UHD-1 content. For plug-in connections, an unencrypted UHD-1 signals is therefore not available at any contact point.

HDMI 2.0 [high definition multimedia interface—version 2.x]

Minimum version of the standard HDMI (high definition multimedia interface) required to transmit → respective UHD content.

HDR [high dynamic range]

In the video image, HDR designates a dynamic range higher than → SDR (standard dynamic range). Dynamic range is the range between the darkest and brightest area of an image, in the most extreme case between black and white. Dynamic range is expressed in the unit for luminous density, candela per square meter (cd/m^2), also

called “nit.” For → UHD-1, the target is to achieve a range between $0.0005 \text{ cd}/\text{m}^2$ and $10,000 \text{ cd}/\text{m}^2$.

HEVC [high efficiency video coding]

Currently the most powerful video encoding method, allowing → UHD-1 video signals to be compressed very effectively. Receiving devices for UHD-1 signals therefore have to be equipped with an HEVC decoder. The International Telecommunication Union (ITU) has designated the standard for HEVC as → H.265.

HFR [high frame rate]

HFR describes an increase in the number of frames per second, which reduces video blur during fast movements by either camera or object(s). Considerably higher than the traditional frame rates of 24, 50, or 60 fps (frames per second) or Hz (hertz), HFR boasts frame rates of 100 or 120 Hz.

HLG [hybrid log-gamma]

An open → HDR standard jointly developed by the BBC (U.K.) and NHK (Japan), adopted by the International Telecommunication Union (ITU) in → BT.2100. While HLG content is hardly distinguishable from → PQ content on an → HDR flat-screen display panel, the display of HLG content on an → SDR flat-screen display panel is comparable to that of Ultra HD signals without HDR. HLG is thus downward compatible to SDR.

immersive

This term—from a Latin word that can be loosely translated as “enveloping” — is used in relation to Ultra HD for describing the user’s immersion into a video and audio experience unlike anything he or she has ever seen or heard before and which comes very close to the natural way we see and hear.

LCD [liquid crystal display]

A technology for flat-panel displays which uses liquid crystals with an externally controllable transparency to represent the individual pixels. In order to display images as intended, LCDs require backlighting that is as white (color-neutral) as possible. Light-emitting diodes (LEDs) are the only technology used for this purpose today. These LEDs may be arranged across the surface, at the edges, or in a defined pattern behind the liquid crystals.

NGA [next-generation audio]

This term summarizes all new audio transmission systems supported by → UHD-1 and → UHD-2. Their common goal is to get as close as possible to natural hearing. NGA includes various systems, from surround sound all the way to 3D audio. Traditional channel-based systems are increasingly replaced by object-based formats.

OLED [organic light emitting diode]

A technology for flat-panel displays which uses organic light-emitting diodes to represent the individual pixels. Each pixel is composed of three of these organic LEDs in the primary colors, red (R), green (G), and blue (B), also known as “color triplet.”

Unlike → LCDs, OLEDs do not require separate backlighting, since the light-emitting diodes, as the term implies, generate their own externally controllable light flux. OLEDs are characterized by more brilliant colors and more intense black levels.

PQ [perceptual quantizer]

An open → HDR standard developed by Dolby and adopted by the International Telecommunication Union (ITU) in → BT.2100.

SDR [standard dynamic range]

SDR designates the dynamic range commonly found with traditional video resolutions (SD, HD, Full HD), i.e. the range between the darkest and the brightest spot, in the most extreme case between black and white. The span of SDR video content ranges from 0.05 cd/m² to 100 cd/m².

UHD-1 [ultra high definition—version 1]

The main characteristic of UHD-1 is a resolution of 3,840 pixels × 2,160 pixels, with a 16:9 aspect ratio, i.e. a resolution four times as high as Full HD. Since a horizontal

line contains nearly 4,000 pixels, this resolution is also known colloquially (but inaccurately) as “4k.”

Step by step, UHD-1 is intended to be further enhanced by adding → HDR, → WCG, and → HFR.

UHD-2 [ultra high definition—version 2]

The main characteristic of UHD-2 is a resolution of 7,680 pixels × 4,320 pixels, with a 16:9 aspect ratio, i.e. a resolution four times as high as → UHD-1. Relative to Full HD, this means an increase in resolution by a factor of 16. Since a horizontal line contains nearly 8,000 pixels, this resolution is also known colloquially (but inaccurately) as “8k.”

WCG [wide color gamut]

This term designates the transition from the → BT.709 to the → BT.2020 color space, which is achieved by gradual improvements of flat-panel displays.

LEGAL NOTE**Publisher**

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