

WHAT IS ULTRA HD (4K)? THE FUTURE OF TV EXPLAINED

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The TV industry is already pushing for Ultra HD / 4K, which is the next step after Full HD. But what does it actually mean for our TVs, media boxes, movies and games? This article explains why Ultra HD is important and why there is much more to it than just higher resolution. Ultra HD is the future.

A SHORT INTRODUCTION – FULL HD VS. ULTRA HD

You probably remember when flat panel TVs started appearing in stores and TV makers started talking about HD and a new world of amazing details and immersive movies, TV shows and games. At that time we came from SD (Standard Definition, most often 720x480 or 720x576 pixels) so it was a quite big step forward.

Today, the TV industry supports two HD formats; often referred to as 720p (1280x720 pixels) and 1080p (1920x1080 pixels, Full HD). All our HDTVs come with Full HD resolution but content – movies, TV shows, games etc. – is 720p in many cases. There are, in other words, two sides of the equation: our screen and the content. Both are important but the truth is that content is often the bottleneck. Here is a short overview of the typical resolution classes for content:

- SD: DVDs, standard TV channels
- HD 720p: Most HD TV channels, some streaming services
- Full HD 1080p: Blu-ray, some streaming services

Ultra HD is the next step on the resolution ladder. It also goes by the name UHD or 4K (4K is actually a movie theatre format but the name is often used for Ultra HD). Just like the HD standard, which covers both 720p and 1080p, Ultra HD covers 4K (also called 2160p) and 8K (also called 4320p). As you might have noticed by now the naming methodology is not straightforward and the industry likes to refer to things in different fashions. Again we can offer a roughly outlined overview.

- Full HD = 1920x1080 pixels = 1080p = 2K
- Ultra HD = 3840x2160 pixels = 2160p = 4K
- Ultra HD = 7680x4320 pixels = 4320p = 8K

The difference in pixel resolution is quite significant and can best be illustrated like this:



Ultra HD exists in two variants and both offers far more pixels than Full HD, picture from Wikipedia

So, that was pixel resolution. Let's move on.

ULTRA HD IS ABOUT MORE THAN RESOLUTION

In the last section we told you what Ultra HD is, measured in pixels. But the Ultra HD standard covers more than resolution. Ultra HD was recently approved as the official name, and in the latest BT.2020 recommendation from ITU (who is responsible for the standards) other exciting elements are included.

FRAMES PER SECOND

With Ultra HD it has also been proposed that we increase "frames per second" (often referred to as frequency, Hz or fps). We need to once again look at the history of fps to understand the future.

Today, pretty much all Hollywood movies are shot at 24 fps (24 new pictures per second) and TV programs at 25 fps or 30 fps (25 pictures per second in PAL countries and 30 pictures per second in NTSC countries). Games are typically rendered at a frame rates between 30 and 60 fps on a game console and up to 120 fps on a PC. In other words; there is a huge difference between the frame rates; and therefore how smooth you will perceive motion. Ultra HD proposes that movies and TV programs can be recorded and reproduced at frame rates up to 120 fps; 120 pictures each second. Ultra HD will support 24, 25, 48, 50, 60 and 120 fps if the full recommendation is implemented in practice.

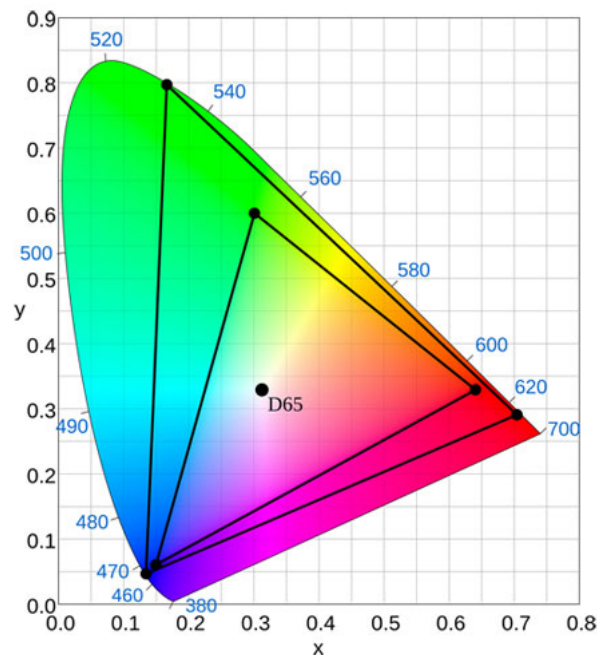
If you have watched The Hobbit in HFR format you have experienced a movie shot in true 48 fps, and then you probably know what 48 can do for picture quality and the movie experience. The two coming Avatar movies will most likely be shot at 60 fps so we are not even close to 120 fps yet. Some movie producers even believe that a

higher frame rate is a far greater improvement in picture quality than a step up in pixel resolution is right now. And yes, the move from 24 Hz to just 48 or 60 Hz is truly a small revolution in picture quality.

COLORS

But what about colors? Well, major improvements are proposed in this area, too. With Ultra HD a new color gamut called Rec.2020 is introduced. Today, we use the so-called Rec.709 color gamut for Full HD. Do not mind the names, as it is relatively simple. It is best illustrated with a graph.

The human eye can only perceive a specific set of colors. We cannot perceive, for example, infrared (you cannot see the infrared light coming out of your TV remote) and there are other "colors" that are invisible to us, too. The typical human eye can perceive all the colors illustrated in the color spectrum graph below.



The entire graph represents all the colors that can be perceived by the human eye. The smallest triangle represents Rec.709 used in Full HD. The larger triangle represents Rec.2020, which is part of the Ultra HD standard

However, our TV screens, projectors and cameras cannot match all these colors so the industry has defined a smaller color gamut that movie folks and TV manufacturers can implement in products and productions; a color standard so to say. We need this standard to make sure that movie and TV productions appear correctly on our TV screens. In the graph above you can see both Rec.709 (used in the Full HD standard) and Rec.2020 (that can be used in Ultra HD).

Rec.2020 is the larger of the two and as you can see Rec.2020 gives us many more colors to work with. It gives us a larger color gamut to pick colors from, so to say. So, therefore Ultra HD also proposes an extension of what is often referred to as color depth; an increase from the current 8-bit to 12-bit per color (and a change from 24-bit to 36-bit for all colors combined). This may sound very technical but with the color gamut explanation in mind it is fairly easy to grasp. When a TV or camera

uses 8-bit per color it means that it can define 256 shades ($2^8 = 256$) of red, green, and blue, respectively. These three colors are used as basic colors to create all other colors. In other words; it allows us to create 256 shades of red, 256 shades of green and 256 shades of blue. In total this gives us 24-bit or 16.777 million ($256 \times 256 \times 256$) colors. The 16.777 million colors can be "picked" from inside the color gamut defined in Rec.709 that is used today for Full HD.



From left to right: 1-bit, 2-bit, 8-bit and 24-bit. Notice how the color gradation improves. We cannot show you 30-bit or 36-bit colors because your monitor cannot reproduce it. Pictures from Wikipedia

With Rec.2020 we get a larger "palette" of colors (a larger color gamut) and therefore it makes sense to have more color shades to work with. Ultra HD proposes 12-bit colors. With 12 bit the industry can choose from 4096 ($2^{12} = 4096$) shades of red, green, and blue, respectively. That leaves us with a total of 68.71 billion colors ($4096 \times 4096 \times 4096$),

There is also a 10-bit level in the Ultra HD standard. A summary would look like this.

- 8-bit for each RGB = 24-bit in total = $256 \times 256 \times 256 = 16,777$ million colors
- 10-bit for each RGB = 30-bit in total = $1024 \times 1024 \times 1024 = 1,07$ billion colors
- 12-bit for each RGB = 36-bit in total = $4096 \times 4096 \times 4096 = 68,71$ billion colors

We need to emphasize that Ultra HD displays, cameras and video productions do not necessarily have to take advantage of all the new, improved layers of colors and frames per second options but these elements *can* be utilized, if desired. As you might have guessed it places great demands on the equipment. An uncompressed video in 8K UHD with 120 fps and 36-bit colors requires 51.2 Gbit of uncompressed data running through a cable each second. It is obviously possible to compress video to much lower data levels but it is a massive amount of data we are talking about here.

BUT HOW DO I GET ULTRA HD?

Lots of numbers have been thrown in the air up until now so let us take a more holistic view of how to get Ultra HD into our living rooms. TV manufacturers have started talking about Ultra HD – and 4K – TVs and players but a product is no fun without the content. We need movies, TV series, games and more to be produced in Ultra HD before we can start enjoying. This is where Hollywood and the game industry come into the picture (bad joke, sorry).

The food chain can, roughly, be illustrated like this.



The food chain

So, Ultra HD has to be adopted in all links of the chain.

- The movie industry still often uses "film" to shoot but have started moving to digital video cameras (such as the Red Epic used for The Hobbit). The RED cameras can offer some of the new Ultra HD picture elements – but not all of them.
- Most modern studios have been optimized for producing 4K for movie theatres and Full HD for consumers but they need to start working with deeper colors and higher frame rates during edited and mastering. This probably means that a lot of the studios will have to replace equipment, including their studio monitors.
- There needs to be a form of distribution; either a physical or digital highway. Blu-ray does not support Ultra HD. The internet can carry it but most consumers are connected through too slow connections.
- The TV – or projector – needs to support not only the Ultra HD resolution but also the extended color and fps elements to take full advantage of all the factors of the Ultra HD standard.

The camera and studio stuff we leave to Hollywood but we are obviously very interested in the last two links of the chain. The only side note we have regarding movie production is that many movies are already produced at resolutions higher than 4K so 2013 is different from the early 3D days. However, almost zero movies are produced with deeper color support and higher frame rates. So, we will see a lot of 4K conversions of older movies but they are not utilizing all of the wonders of the Ultra HD standard. We need new movies, shot with digital cameras for that. The distribution form will be covered in the next section but let us first round off with a quick note on some of the latest 2013 Ultra HD TVs.

Ultra HD TVs are hitting markets with true 3840x2160 (4K) resolution. Most major TV brands are on the bandwagon, including **LG, Sharp, Samsung** and more. However, TV makers have not been able to answer a vital question at trade shows. Will these TVs also show 4K in 48 fps or 60 fps? And what about 4K with deeper colors? If the TVs do not support for example 4K in 48 fps you cannot enjoy The Hobbit as Peter Jackson and his team intended you to enjoy it. But there are more things to worry about. Join us in the next section.

A FORMAT WAR: THE INTERNET VS. PHYSICAL MEDIA (BLU-RAY)

Soon we can buy impressive Ultra HD TVs for our living rooms. Prices are already starting to plummet, but price is not our biggest concern. Even if Hollywood starts working on 4K versions of catalogue titles the important question is how to get the beautiful pictures into our TVs? We are not talking about where or how to buy the 4K

movies but simply how to input the signal into the TV. Right now we have the following issues.

- **The distribution issue:** Blu-ray supports none of the elements of the Ultra HD standard; neither 4K, nor higher fps, nor deeper colors.
- **The connection issue:** HDMI cannot move enough data. The current version of HDMI used in almost every TV can move 4K at 24 fps but not at 48 fps and not with deeper colors. And when you add 3D into the mix it gets even worse.
- **The data issue:** The current compression formats such as MPEG4 H.264 are not effective enough to support Ultra HD.

All three issues have to be solved – simultaneously. There is a new HDMI cable standard in the works that will support at least 4K in up to 60 fps but that looks like a rather shortsighted solution. We must demand more. What about 120 fps, better colors, and 3D? The Blu-ray association has also started work on a 4K version of Blu-ray but it will most likely only support the low-level requirements of Ultra HD – again, a very shortsighted solution. We just replaced our 2D Blu-ray players with 3D Blu-ray players so who wants to buy a 4K Blu-ray player this year and a “higher 4K” Blu-ray player again in 2-3 years?

Instead, the industry has started talking about a world without physical media. A world where Blu-ray could fade out and disappear – it is not impossible to imagine. Blu-ray is already holding back the technological state of the market, so internet distribution and streaming has arisen as a better long-term alternative. The internet is more flexible as it can scale up much faster. But before we can even start talking about distribution of Ultra HD via the internet we need more effective compression. That applies even if the industry decides to bet on a physical format.

This is where H.265 compression (also called HEVC) comes into play. H.265 is a new compression technology for mpeg4 video, and the successor to the widely-used H.264 that enabled us to enjoy HD and video back when it was adopted. Just like H.264 brought us into a new era, H.265 is expected to do the same for Ultra HD and offer better video streaming via the internet to TVs and mobile devices. One of the clear advantages of video streaming via the internet is that it can – theoretically – allow us to ditch a physical format AND the HDMI cable.

You could, theoretically, just have a TV with an Ethernet plug – or even a TV connected via WiFi – where you could stream everything directly into the TV without cables, boxes etc. Or you could have a box connected wirelessly to your TV that would circumvent the requirement for a HDMI cable. At least that is the vision. The alternative is to use a box with a HDMI cable running to the TV like we do today but that would require a new HDMI standard and then we must return to a discussion of the issues stemming from the limited bandwidth of HDMI.



It is very plausible that we will see 4K streaming before we see 4K Blu-rays. At CES Netflix demonstrated 4K streaming.

It is a new format war but this time it is not a war of two physical formats. It is not a new VHS vs. Betamax or Blu-ray vs. HD-DVD war. This time we have two completely different distribution forms, with Blu-ray; a physical format of discs in one ring corner and internet streaming; a virtual highway that is invisible in the other ring corner. This format war has already raged for many years without most of us noticing it as it has had at least one intangible contender. The winner is not necessarily the one that offers the best picture quality right here and now but the one with the most promising perspectives. And it is hard to argue Blu-ray's case – unless something drastic happens.

ULTRA HD IS THE FUTURE

We hope that our in-depth article has given you insight into the technical aspects of Ultra HD, as well as the prospects and immediate challenges. As you have seen the Ultra HD standard is about much more than just pixel resolution. Debaters who argue that Ultra HD is irrelevant forget that the format not only brings more pixels to the table but also offers significant improvements in motion due to higher frame rates and significant improvements in colors due to a wider color gamut and deeper color support.

It is an undisputed fact that a large display or canvas is required to take full advantage of the resolution that Ultra HD offers – for both 4K and 8K – but some of the other advantages can easily be enjoyed on much smaller every-day TVs.