# Telairity Dives Deep Into 4K Technology – Part 4

The value of UHD over HD is that it allows us to get closer to screens of the same size, or view bigger screens at the same distance, with no change in visual quality. In either case, the screen will appear bigger to us, i.e., occupy more or our total viewing area. And that, we said, means UHD enables a more immersive or higher quality viewing experience.

This improvement, however, is not free. Its cost is quadrupling the number of pixels per display, from about 2 million to about 8 million. What are the implications of multiplying pixels?

Digitally speaking, every pixel is a number, specifically a binary number that represents a specific color shade. For each pixel, the display reads its number, and generates the colored block appropriate for that number in the location appropriate for that pixel in a size appropriate to the resolution format for a display of the given dimensions.

The pixel numbering standard in common use today for broadcast television is so-called “8-bit” color, which generates a binary number 24 bits long for each pixel, sufficient to enable a total palette of over 16 million colors.[1] Since 16 million is more color shades than even the most discerning human eye can distinguish, 8-bit color (24 bits/pixel) is sometimes called “true color”, as the first and simplest digital color scheme to enable everything the human eye can see (and more).[2]

The problem created by digital imagery in general, and HD and UHD television in particular, isn’t that digital technology is inferior to older analog technology, or that it is inadequate to express the full range of our senses. It is simply that digital technology able to provide a high quality experience takes a lot of bits, and improvements in quality take even more bits.

Specifically, an HD picture composed of 2 million pixels, each corresponding to a 24-bit number, requires 48 million bits to express. And that is just for a single frame. Full HD plays out at 30 frames a second, meaning a total bit rate of nearly 1.5 billion bits every second.

This is not just a large number; it is an overwhelming number. It is impractical to store 1.5 billion bits for every second of HD video captured, let alone transmit bits at that rate. Fortunately, there is a powerful remedy for the proliferation of bits required by digital rendering technology, namely digital compression technology. Compression technology is especially powerful for video, where standards like H.264 allow the elimination of 299 bits out of every 300, reducing 1.5 billion bits a second to a much more manageable 5 million bits a second.

But what happens to data rates when the television industry shifts from HD to UHD? In the next part of this series, we will look at the dark underside of the move to UHD display technology.

[1]Why are pixels 24 bits long described as "8-bit color"? It's because "8-bit color" refers not to pixel length, but rather to "channel" length, or the number of bits used to encode each of the 3 primary colors (Red-Green-Blue) that make up a pixel. Adding the 3 8-bit primary color "channels" together gives the overall total of 3 x 8 or 24 bits/pixel. There are 256 8-bit binary numbers (possible combinations of 1s and 0s between 00000000 and 11111111). Thus, an 8-bit channel provides 256 distinct shades each of Red, Green, and Blue, or 256 x 256 x 256 = 16,777,216 "mixed" colors.

[2]Although the long strings of 1s and 0s that comprise binary numbers can seem quite daunting on first encounter, understanding binary numbering is really very easy. The basic rule is just that every bit added to a binary number doubles the number of possible combinations supported. This can be seen most readily by starting at the beginning, with 1 bit, which has only 2 possible values (0, 1). Adding a second bit allows 4 possible values (00, 01, 10, 11). And so on: 3 bits have 8 possible values (000, 001, 010, 011, 100, 101, 110, 111), 4 bits have 16 possible values, 5 bits 32 possible values, etc. By the time you reach the 8-bit values used in "true color" RGB encoding, this doubling algorithm has passed by 64 (6 bits) and 128 (7 bits) to reach 256 possible combinations.

The doubling rule itself is most readily understood by the fact that adding a bit simply allows us to write all the numbers of the previous set twice over, the first time tacking a 0 on to the front of all the previous numbers, the second time tacking on a 1 (e.g., compare the 8 3-bit values with the 4 2-bit values shown above).

8 bits is regarded as "true color" since it is the first channel value safely past the outer limits of human color perception. That is to say, if you build up a color bar out of 256 strips, each with an adjacent shade of, for example, red—running from a strip of pure red on one end to a strip of pure black (no color) on the other—this color bar will not appear to the eye as 256 distinct stripes, but rather as a single continuous gradient, shading from red to black by insensible steps. Which is to say, when a color is divided into as many as 256 distinct steps, we have moved below the threshold of noticeable differences between adjacent steps—in other words, no one can tell shade 1 from shade 2, shade 2 from shade 3, and so on down the row of 256 shades.

In fact, for most people, the same would be true of a color bar built up from 128 strips (7-bit channels), but the very keenest eyes under ideal conditions might be able to distinguish very faint stripes in this bar. So 7-bit color channels (128 x 128 x 128 = 2,097,152 mixed colors) are not quite past the limits of human perception. But 8-bit color channels, which multiply the number of mixed colors by 8 (= 2 x 2 x 2), are easily sufficient to include not only all the colors anyone might ever be able to distinguish under any circumstances, but many millions more besides that no one can tell apart from their neighbors.

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