Benefits of HD Panel-level Color Performance Testing

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Benefits of HD Panel-level Color Performance Testing – A White Paper

CIE, the International Commission on Illumination, has published various recommendations for color measurement in HDTVs and display panels, as well as calculation procedures which can be used for this task. These procedures have been extended in various ISO and ASTM standards. However, manufacturers are often confronted with a number of different measurement recommendations, each of which may seem valid, and each of which could give rise to a different colorimetric test result. It is important that color measurement procedures be uniquely and unambiguously identified, to ensure consistency between different manufacturers' products. This white paper provides background on HD panel-level color performance testing, and explains how a strong and well-defined program of performance testing can promote consumer confidence and provide a higher level of customer satisfaction.

I. The Color of HDMI

The HDMI standard requires manufacturers to disclose specific HDMI features that are enabled in any given product. The idea is to provide consumers with the descriptive information they need to understand any enabled features that are based on certain capabilities of HDMI, such as Deep Color functionality and the x.v.Color™ extended color gamut.

For each feature, the guidelines specify a minimum level of functionality that must be met by the device in order to use the terminology. For example, an HDTV device described as supporting Deep Color must be capable of accepting a Deep Color signal (i.e., >8 bit color depth), processing the signal so that the resulting stream is greater than 8 bit color depth upon delivery to the panel, and having a panel that renders color bit depth of greater than 8 bits per color.

The last clause of the above requirement is very important. While HDMI LLC Authorized Testing Centers (HDMI-ATCs) test for electrical parametric and protocol compliance against the HDMI specification, there is a need to build upon this basic interface testing with additional performance testing programs designed to simplify consumer purchase decisions and enhance the high definition entertainment experience. There are no HDMI-ATC panel-level color performance compliance specifications, or test tools designed to ensure accurate panel-level color delivery.

II. Deep Color and x.v.Color Overview

The difference between Deep Color and x.v.Color can be easily understood. Deep Color maximizes the number of available colors within the borders defined by a given color space or gamut, such as sRGB. x.v.Color, by contrast, expands the borders of the available color space, allowing for the display of colors that will meet and even exceed what the human eye can discern.

Color space can also be defined by YCbCr, which is a family of color spaces used in video systems. The luma component is the Y, and Cb and Cr are the blue and red chroma components. Luma is a signal that does not carry color, only brightness information. Chroma components are signals that carry only color information.

Deep Color

The majority of today's HDTVs and HD Panels support the ITU-R BT.601-1/709/709-4 color standards. These standards only specify 60 to 80 percent of all the variety of available colors, even if the display panel itself is capable of supporting more. Most panels usually have a color bit depth of 24 bits Red-Green-Blue (RGB) total, with 8 bits for each color. This relatively limited color bit depth is the leading cause of onscreen effects noticeable to the consumer.

A key addition to the HDMI 1.3 specification is the support for 30-, 36-, and 48-bit RGB color depth or "Deep Color." Deep Color increases the number of colors on an HDTV or display panel from millions to billions. This gives the panel a color accuracy and vividness like nothing seen before in consumer display technology. Deep Color eliminates on-screen color banding, enabling tonal transitions that are very smooth, and color graduations that are very subtle. It also allows increased contrast ratio, and can represent many more shades of gray between black and white. Deep Color also minimizes banding, the visual effect that occurs when a small number of colors or gray shades are used to display an image, and details are lost as a result.

x.v.Color

The term gamut can be used to refer to the range of available colors reproducible by an HDTV or panel when a scene is illuminated by a reference white (6500-degree illuminant D for NTSC/PAL and HD Systems). Gamut is defined by the chromaticity value or CIE chromaticity coordinates for a given system. This range of colors, or variable saturation, is reproduced in the picture monitor according to some set of signal values, such as defined in sRGB.

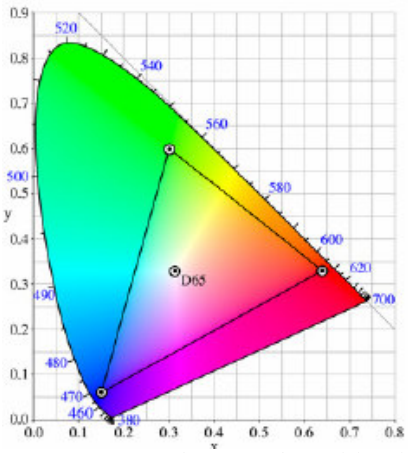

Figure 1. C.I.E. sRGB Color Space Chromaticity Diagram

On the C.I.E. chromaticity diagram (Figure 1), if any three color points are chosen, the area included by the connecting triangle represents the range of colors (gamut) that can be produced by mixing the three chosen colors. The three points are known as the primary colors. The connecting triangle encloses the full range of colors which can be produced by the display.

x.v.Color was specified in October 2005 and published in January 2006 as IEC 61966-2-4. x.v.Color is a color gamut that supports 1.8 times as many colors as the sRGB color gamut. An x.v.Color capable panel, along with Deep Color to reduce banding, can display the complete range of colors that can be discerned by the human eye. When a color is said to be "out of gamut," this means that the color cannot be correctly converted on the target device.

III. Panel-level Color Performance Testing

As with all types of products, not all HDTVs and HD panels are designed equally. Meeting consumer expectations is more than just asking “Does it display a picture?” Consumers want to know “Is this the high-performing, fully-compliant product I was expecting?” Accordingly, there needs to be a means by which consumers, manufacturers, and retailers can easily identify products certified to a marketable performance level.

Now that HDMI-ATCs guarantee baseline protocol stability for HDMI, the next challenge is to evaluate how well products perform in creating the HD entertainment lifestyle experience that consumers demand. Retailers and consumers want consistent and guaranteed performance levels for new features. Therefore, a strong Quality of Experience (QoE) program and “eco-system” is necessary to evaluate new HD performance features so that ultimately, retailers and consumers can be confident that their HD components will deliver the added performance value that justifies the price premium.

Each of today’s newer HD display technologies - plasma, LCD, DLP, LCOS, D-ILA, etc. - produce light energy with a Spectral Power Density (SPD) that is typically different

from the SPD produced by CRT displays. Some of these display technologies produce strong peaks of light at color frequencies where CRTs produce very little light. Each of the new display technologies can still produce a standard color of white by adjusting the relative balance of colors in the red, green, and blue portions of the spectrum (Figure 2).

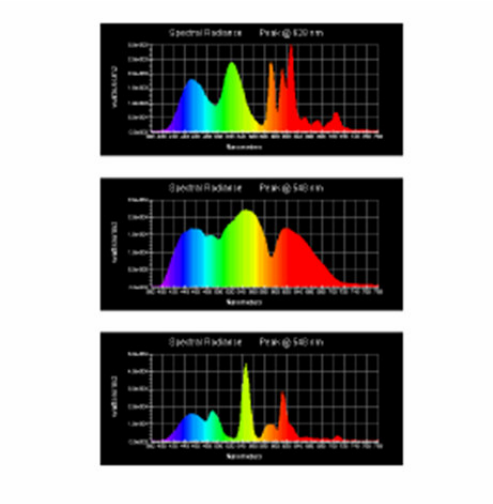

Figure 2. Different Display Technologies SPDs

Because new display technologies may produce strong peaks of light at just about any color frequency, it is now critical that test specifications and processes accurately duplicate the CIE standard observer response at all color frequencies. The testing environment must support sensors that see light over the entire visible spectrum with amplitude response that accurately matches the three color sensors of the human eye.

The average response of human eye receptors to light across the visible spectrum is shown by the Standard Observer Response graph, developed by the CIE. We call this *tristimulus vision* because there are three types of receptors that individually send information to our brain and allow us to perceive different colors for the different mixtures of light energy within the visible spectrum.

Measuring color in a way that correlates well with human visual experience requires working in a calibrated color space, such as those defined by the CIE. This, in turn, necessitates making measurements with detectors whose response closely matches the CIE-defined *x*, *y*, and *z* tristimulus curves.

Tristimulus color measurement works similar to the human eye. Filtered light sensors receive light from the panel to be measured. The filter for each light sensor allows only a certain amount of each color of light to reach the sensor. The response of each of the filters is designed to match the response of one of the cone types in the average human eye.

IV. The Simplay Labs HD Panel Color Performance Program

Simplay Labs is committed to enabling optimal performance of HD products. We collaborate with retailers, content providers, and custom electronics professionals to enable consumers' passion for the HD lifestyle. We also work with manufacturers to ensure QoE results above and beyond simple protocol specifications, by delivering the best possible HD experience to the customer.

The Simplay Labs panel-level color performance verification program employs a combination of in-house tools and off-the-shelf test equipment, integrated with custom software, that include mathematics and realization programs, and digital filter design packages. Sophisticated custom test fixtures were developed to implement specific test plans for Simplay HD color performance testing.

Our testing environment makes use of processes that are accurate to the human-eye response at all frequencies of light, not just high output CRT frequencies. This fundamental program approach accurately measures all displays of the past, present, and future, regardless of SPD curves. It is this type of test environment that is the basis of the measurement specifications, procedures, and processes specified by the Simplay Labs panel-level color performance verification program

Our testing process evaluates HD panel color performance in a way that accurately represents the three types of cones in the human eye. This information allows us to compute a different measurement result for the different mixtures of light energy within the visible spectrum, in a way that duplicates the response of the human eye/brain combination. To accurately predict the response of the human eye to a combination of light energy at different frequencies, our tristimulus color measurement platform "sees" light the same way that the human eye sees it.

To evaluate the color transformations executed by a particular panel, one form of testing involves transmitting, via HDMI, a known color-bar pattern to the HD panel under test, and viewing the results. Panels that show colors landing outside the targets indicate incorrect color transformations.

Great care is taken by Simplay Labs test engineers when making these measurements to ensure that the sampling frequency, or integration time, of the test platform is synchronized with the scan frequency of the panel. All performance verification procedures include allowance for glare, and therefore provide a more accurate representation of color as perceived by the viewer. Measurements are made to ensure acceptable levels of constant channel chromaticity, spatial uniformity, and internal flare and channel independence. The testing specification also requires the averaging of multiple tests to avoid measurement errors.

Simplay Labs is the only one-stop organization offering a full suite of HD panel-level solutions, including color performance testing services, pre-testing R&D tools, product

development R&D consulting, and implementation technologies aimed at saving time and money in the development of new, high-performing display products (Figure 3).

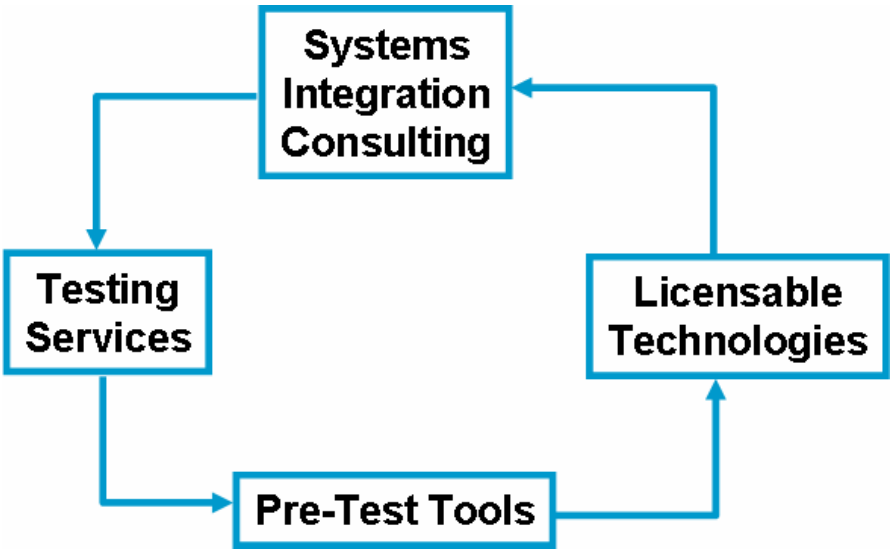

Figure 3. Simplay Labs Products & Services

HDTVs and HD Panels that have demonstrated adherence to the Simplay HD Color Performance Specification and passed testing by the Simplay HD Test Center are identified with the Simplay HD color logo, enabling consumers to buy CE equipment with the confidence their HD components have been verified for peak performance. Leveraging this branding component, the Simplay HD Testing Program is educating retail channels on the importance of HD panel-level color performance and how to identify high QoE devices. Now and going forward, the Simplay HD mark takes the guesswork out of shopping for HD, promising the perfect performance that consumers demand. Consumers will enjoy the performance of a lifetime from their home entertainment equipment.