DCI Digital Cinema Initiatives, LLC

DCI Memorandum Regarding Direct View Displays

Approved 27 June 2018
Digital Cinema Initiatives, LLC, Member Representatives Committee

1. Introduction

Direct view displays provide the potential for an improved high-quality image through significantly increased peak luminance and dynamic range.

The current Digital Cinema System Specification (DCSS) and Compliance Test Plan (CTP) were crafted with projection systems in mind. With the advent of direct view displays, the associated system architecture and performance characteristics differ from projection systems such that new specifications are necessary. This document broadly defines performance and security parameters that DCI intends to define for these types of displays in order to give manufacturers guidance while a complete set of requirements is developed. Parameters defined in this memo are tentative and subject to change.

These requirements will ensure interoperability of image content on the new generation of cinema displays while maintaining current DCSS compliant architecture.

DCI invites feedback on this memorandum from stakeholders in the cinema industry. Please send comments to dci.info@dcimovies.com with the subject line "Direct View Displays".

2. Definition of Direct View Display

A direct view display system is defined as a light emission display comprised of a combination of flat panel display cabinets conjoined so as to form a single large display. LED-based panels are typical, but the requirements herein apply to any image-forming display technology so comprised.

Definitions:

a. **Screen:** The complete direct view cinema display system including all pixels sufficient to display the entire image, and typically comprised of a plurality of Cabinets with a supporting structure, associated electronics and cabling.

b. **Cabinet:** The physical structure and associated electronics which contains a portion of the image area of a Screen. The emissive surface area of a Cabinet is typically comprised of a plurality of Modules.

c. **Module:** A component including an array of Pixels physically positioned so as to form the front display surface of a Cabinet. The Module is typically the smallest field-serviceable light-emitting component of a Screen.

d. **Pixel:** The smallest grouping of light emitting elements within a Module, and capable of broad-spectrum (not monochromatic) light emissions. A Pixel is often comprised of a triplet of red, green and blue light emitting diodes.

3. Draft Requirements for DCSS Compliance

a. Input Requirements

The Direct View Reference Display shall support:

DCDM image structures, and at a minimum, DCDM operational level 3, as defined in SMPTE ST 428-1.

HDR-DCDM (HDR Digital Cinema Distribution Master), with 12 bit image data formatted for SMPTE ST 2084 EOTF with CIE XYZ colorimetry at currently supported resolutions and frame rates.

b. Pixel Count

The sampling structure of the displayed picture (pixel count) shall be at least 4096 (4K) horizontal and 2160 vertical pixels. Image scaling at non-integer values *may* be utilized if it is clearly demonstrable that no artifacts result.

c. Pixel Visibility

The pixel structure should not be visible from a 1.0 screen height viewing distance.

The pixel pitch should be uniform across a Screen, including at Module boundaries.

d. Luminance Uniformity

DCI's intent is to require that the display shall not exhibit any perceptible inconsistency in luminance levels between pixels when viewed from any seat in the theater.

The specific variance in measured luminance between adjacent Modules that comprise a Screen shall not exceed tolerances that are currently under development.

e. Calibration White Point and Luminance

When the direct view display is sent a full frame image with the code values 2060 X', 2081 Y', 2116 Z', the chromaticity coordinates of the displayed image shall be x = 0.3127, y = 0.3290. These code values shall produce a displayed luminance of 100 cd/m^2.

When the direct view display is sent a full frame image with the code values 2081 X', 2081 Y', 2081 Z', the chromaticity coordinates of the displayed image shall be x = 0.3333, y = 0.3333. These code values shall produce a displayed luminance of 100 cd/m^2.

When the direct view display is sent a full frame image with code values 2748 X', 2771 Y', 2808 Z', the chromaticity coordinates of the displayed image shall be x = 0.3127, y = 0.3290. These code values shall produce a displayed luminance of 500 cd/m^2. This value shall represent the peak luminance requirement of the display. Behavior of code values exceeding this is undefined.

f. Minimum Active Black Level

The first code value that results in measurable light output from the display. This value is defined in Table 3 below.

g. Color Uniformity

The variance in displayed chromaticity between adjacent Modules that comprise a Screen shall not exceed tolerances that are under development at luminance levels above 1 nit.

h. Minimum Linear RGB Bit Depth Needed in the Reference Display

Displays must have a linear RGB bit depth sufficient to prevent visible contouring artifacts under all conditions. These requirements are anticipated to be consistent with the analysis contained in SMPTE EG 432-1, Annex F.

i. Off-Axis Uniformity (Luminance and Color)

Requirements are currently under development that will define the viewing angle that shall be supported and an acceptable Delta E threshold for luminance, chrominance and contrast.

j. Electro-Optical Transfer Function (EOTF)

The encoding transfer function shall be defined in terms of output-referred CIE XYZ tristimulus values produced by the display unit. The direct view display transfer functions are specified using 12 bit CIE XYZ encoding primaries and shall support both gamma 2.6 and SMPTE ST-2084 EOTF.

k. Color Gamut

In an additive display, the color gamut is a cuboid with vertices determined by the XYZ coordinates of the three primaries, the white point, and the black point. The color gamut primaries below define the minimum gamut for a Direct View Reference Display.

The cube in XYZ space defined by the black point and the following points expressed in Y,x,y.

When representing a 500 nits P3 D65 color volume:

Red (114.48, 0.6800, 0.3200)

Green (345.8693, 0.2650, 0.6900)

Blue (39.6435, 0.1500, 0.0600)

Peak White (500, 0.3127, 0.3290)

l. Color Accuracy

Within the minimum color gamut, all colors shall be accurately reproduced. The tolerances listed below can be used to verify the color primaries of the minimum gamut.

The following points are expressed in x,y.

Red (0.6800 ± .005, 0.3200 ± .005)

Green (0.2650 ± .01, 0.6900 ± .01)

Blue (0.1500 + 0.005/ - 0.015, 0.0600 + 0.01/ - 0.02)

m. Grey Scale Tracking

Using the black-to-white gray step-scale test pattern, the entire step-scale appears neutral without any visible color non-uniformity. The black-to-white gray step-scale test pattern is centered on the display and occupies a rectangle sized 20% of the screen height by 80% of the screen width. The background is defined by code values [1000, 1015, 1040], which define a luminance of 5.0 cd/m2 and chromaticity coordinates x = 0.313, y= 0.329. Each step is 8% of the screen width and is defined by the code values in Table 2.

Using the black-to-dark gray step-scale test pattern, the entire step-scale appears neutral without any visible color non-uniformity. The black-to-dark gray step-scale test pattern is centered on the display and occupies a rectangle sized 20% of the screen height by 80% of the screen width. The background is defined by code values [37, 38, 40], which define a luminance of 0.020 cd/m2 and chromaticity coordinates x = 0.313, y= 0.329. Each step is 8% of the screen width and is defined by the code values in Table 3.

Table 2 – Black-to-white gray step-scale test pattern code values, luminance values, and chromaticity coordinates (all measurements are made in the center of the display)

	Input Code Values			Output Chromaticity Coordinates		Output Luminance
Step Number	**X'**	**Y'**	**Z'**	**x**	**y**	**Y,** cd/m^2
1	472	481	496	0.3126	0.3292	0.50
2	603	614	632	0.3122	0.3292	1.00
3	758	771	792	0.3121	0.3293	2.00
4	1000	1015	1040	0.3124	0.3291	5.00
5	1211	1227	1255	0.3128	0.3288	10.00
6	1444	1462	1492	0.3128	0.3291	20.00
7	1783	1803	1836	0.3126	0.3292	50.01
8	2060	2081	2116	0.3127	0.3291	100.10
9	2350	2372	2408	0.3127	0.3292	200.21
10	2748	2771	2808	0.3126	0.3293	500.43

Table 3 – Black-to-dark gray step-scale test pattern code values, luminance values, and chromaticity coordinates (all measurements are made in the center of the display)

	Input Code Values			Output Chromaticity Coordinates		Output Luminance
Step Number	**X'**	**Y'**	**Z'**	**x**	**y**	**Y,** cd/m^2
1	25	26	27	0.3106	0.3331	0.0010
2	37	38	40	0.3121	0.3277	0.0020
3	60	62	65	0.3095	0.3296	0.0050
4	86	88	92	0.3133	0.3281	0.0100
5	121	124	129	0.3129	0.3293	0.0202
6	185	189	196	0.3138	0.3291	0.0501
7	250	255	265	0.3129	0.3279	0.0998
8	332	339	351	0.3121	0.3289	0.1997

n. Contouring

Contouring is the appearance of steps or bands where only a continuous or smooth gradient is expected. Because contouring is a function of many variables, it is important to look at a series of test patterns with shallow gradations to simulate naturally occurring gradations in images. Examples include horizons, particularly at sunset or sunrise, and the natural falloff around high intensity spotlights, particularly if diffused by atmosphere or lens filtration. These test pattern ramps have a step width of no less than four pixels with an increment of one code value per step and are placed on a background equal to the minimum value in the ramp, so that the eye is adapted for maximum sensitivity.

Since dynamic fades to black are widely used in real-world content, a dynamic test pattern that fades slowly to black is another useful approach.

o. Temporal Artifacts

Temporal artifacts such as flicker and lag (on moving highlights) can significantly impair the quality of a displayed image. Although it is difficult to measure and quantify these parameters, the

goal should be to minimize the visibility of flicker and lag, such that they do not distract from the presentation.

p. Spatio-Temporal Aliasing

The display shall be free of artifacts caused by the pixel multiplexing used in the display device.

q. Stereoscopic Display Requirements

DCI intends to specify requirements for calibration white point and luminance, minimum active black level, color gamut and color accuracy, etc., in order to avoid multiple stereoscopic deliverable requirements.

r. Sound Considerations

Direct view displays present a unique impediment to accurate screen sound localization and dialog reproduction, potentially altering the intended sound imaging characteristics of the soundtrack. DCI recognizes that sound reproduction is an integral part of the theatrical experience. While not a display device requirement, direct view display manufacturers must develop solutions that enable the sound mix to be experienced as the filmmakers intended.

s. Security Architecture Requirements:

Existing DCI security requirements were crafted with media blocks and projectors in mind. DCI intends to maintain the same security objectives but clarify how they apply to the system architecture utilized by direct view displays. In particular, type 2 SPB (projector SPB) requirements will be revised to accommodate the unique characteristics of direct view displays, enabling front-servicing/replacement of Modules without forcing a security event alert.

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