UHD World Association
世界超高清视频产业联盟

Technical Requirements for Ultra-High Definition Mini/Micro Pixel Pitch LED Display

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Contents

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1. Scope

This document specifies key indicators, such as basic optical and display defects, related to large-size, ultra-high definition (UHD), mini/micro pixel pitch LED displays for indoor use, and provides the corresponding test methods. In addition, this document provides suggestions on the relationships between pixel pitches and chip sizes as well as common display sizes. This document applies to the design, development, selection, testing, and checking of UHD, mini/micro pixel pitch LED display systems.

2. Normative References

The following references are indispensable for the application of this document. For dated references, only the editions cited apply. For undated references, the latest editions of the referenced documents (including any amendments) apply.
SJ/T 11281-2017 Measure methods of light emitting diode (LED) panels
U/UWA 001-2022 Methods of measurement for UHD television

3. Terms, Definitions, and Abbreviations

The following terms and definitions are applicable to this document.

3.1 Pixel

The smallest imaging unit of the LED display.

[Reference: Section 3.6 of SJ/T 11141-2017]

3.2 LED lighting plate

A basic component formed by bonding/soldering discrete RGB LED chips or LED packages to a printed circuit board.

3.3 LED display box/module

A display unit whose lighting can be independently controlled, formed by combining several lighting plates and adding control circuits and structural components.

3.4 Ultra-high definition LED display

A display device consisting of LED boxes that receives, processes, and displays ultra-high definition video signals.

3.5 Mini/Micro pixel pitch LED display

A display device whose pixel pitch is no larger than 1.0 mm. The device has LED components that are matched by size to the pixel pitch and used to emit light.

3.6 Dot defect

A single pixel that does not display properly due to an open or short circuit.

3.7 Linear defect

Loss of control of the pixels in an entire row or column in the range of a driver chip.

4. General Structure of LED Displays

Unlike display devices such as LCD and OLED displays whose finished modules are completed in a factory at one time, the manufacturing process and installation of LED displays requires multiple combination methods to produce a finished module.

In terms of structure, the production of an LED display can be separated into the following sections, as illustrated in Figure 1.

a) Combining LED chips/LED packages to form LED lighting plates
b) Combining LED lighting plates to form LED display boxes
c) Combining LED display boxes to form an LED screen according to the final display size.

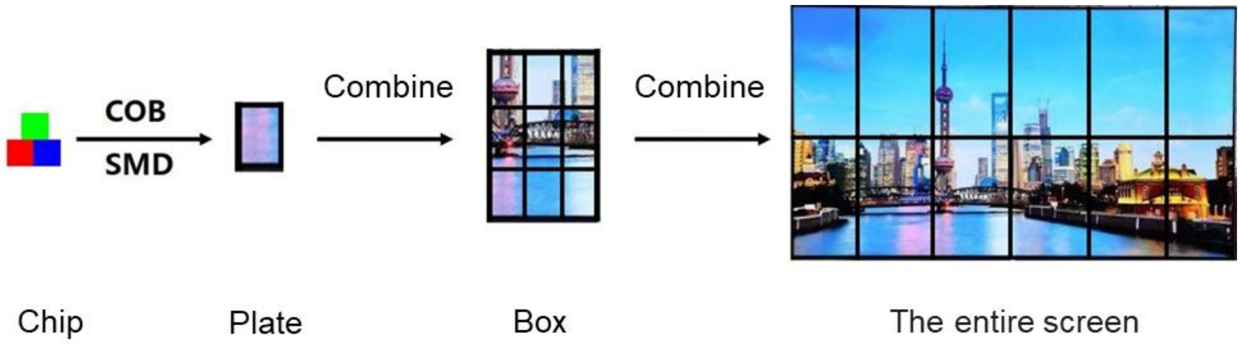

Figure 1: General structure of LED displays

5. Basic Requirements for Optical Performance

Table 1 lists the requirements for the optical performance of displays.

Table 1: Basic optical parameters and requirements

No.	Basic Parameter	Unit	Technical Requirement
1	Inherent resolution	Pixel	≥4K
2	Peak luminance	nit	≥600
3	Luminance uniformity	%	70/80/90
4	Chromaticity uniformity	Δuv	0.0015/0.0030/0.0045
5	Color gamut coverage	NTSC %	105/110/115
		DCI-P3 %	90/95/99

6	Half-luminance viewing angle	°	±75/85
7	Chromatic viewing angle	°	±75/80
8	Specular reflection	%	1/3/5
9	Black uniformity	ΔCIE	0.5/1/1.5
10	Grayscale gradient	Std	0.4/0.6/1.2
11	Gray level	bit	8/10
12	Frame rate	Hz	60/120
13	White balance Accuracy	(ΔX,ΔY)	(0.01, 0.01)/(0.02, 0.02)
14	Gamma Accuracy		2.2/2.3
15	Color accuracy	ΔE	0.05/0.04

6. Defect Types and Requirements (Pixel Out-of-control Rate)

Table 2 lists Pixel defect requirements of display screen

Table 2: Pixel defect requirements

No.	Basic Category	Sub-category	Unit	Requirement	
				SMD	COB
1	Dot defect (out-of-control dots)	Bright dot defect	PPM	100	40
2		Dark dot defect			
3		Flickering			
4	Linear defect ()	Horizontal line	Line	0	0
5		Vertical line			
6		Two paralleled lines			

7. Environmental Adaptation Requirements

Table 3 lists the basic requirements for environmental adaptation of displays.

Table 3: Environmental adaptation requirements

No.	Basic Parameter	Unit	Technical Requirement
1	Operating temperature	°C	-10–40
2	Storage temperature	°C	-40–55
3	Operating humidity	%RH	10–90

8. Recommended Relationships Between Pixel Pitches and Chip Sizes

Table 4 lists the recommendations for relationships between pixel pitches and chip sizes of displays.

Table 4: Recommended pixel pitches and matching chip sizes

Pixel Pitch (mm)	Tolerance (mm)	Chip Size (mil)					Lateral Chip Size (mil)		Tolerance (um)
		7*12	5*9	4*8	4*6	3*5	5*5	4*6	
P1.2	±0.1	√	√	√	√	√	√	√	±15
P0.9	±0.1		√	√	√	√	√	√	±15
P0.7	±0.1			√	√	√	√		±15
P0.6	±0.1			√	√	√			±10
P0.4	±0.1				√	√			±10

Note: The P1.2 data can be used as a reference.

9. Recommended Display Sizes (For Homes)

Table 5 lists the recommended display sizes for different resolutions.

Table 5: Recommended display size (unit: inch)

Resolution	Recommended Size			
	P0.9	P0.7	P0.6	P0.4
2K	81–83	65–68	54–59	39–43
4K	163–165	130–136	108–118	78–85
8K	N/A	N/A	217–236	156–170

Note: The size data for the 2K resolution can be used as a reference.

10. Measurement Methods

10.1 Measurement Conditions

Standard measurement conditions: Measurement should be done under the following temperature, humidity and air pressure conditions.

Environment temperature: 15°C–35°C, ideally 20°C

Relative humidity: 25%–75% RH

Air pressure: 86kPa–106kPa

Requirements for measurement probes: More than 500 pixels included

Measurement position: As shown in Figure 2, if the measurement position is just within the seam, the center position of the nearest lighting plate should be selected.

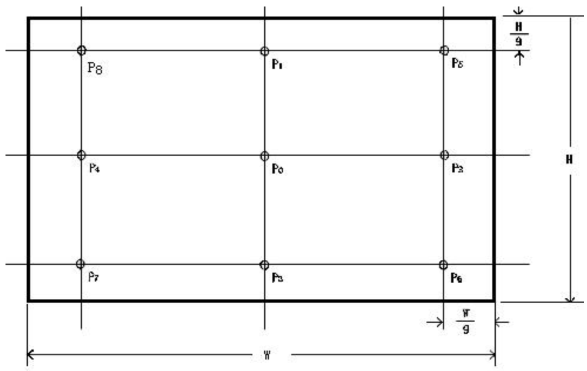

Figure 2: Distribution of 9-point measurement positions

Distance requirement: Generally, the non-contact measuring equipment should be 2 to 3 times the screen height from the screen.
Note: 16- or 25-point measurement can be used if necessary.

10.2 Inherit Resolution

Measuring equipment: A CCD dimension measuring system
Measured images: Powered off
Measurement position: Board edge and pixel pitch
Method:

1) Measure the length of the LED board and the horizontal distance between pixels. Divide the two values to obtain the horizontal resolution.
2) Measure the height of the LED board and the vertical distance between pixels. Divide the two values to obtain the vertical resolution.
3) Intrinsic resolution = Horizontal resolution x Vertical resolution

10.3 Peak Luminance

Refer to Section 5.2.7.2 of SJ/T 11281-2017.
Measuring equipment: A luminance meter or colorimeter
Measured images: Pure white images (externally input pure white signals)
Measurement position: Center of the display
Measurement method: Measure the luminance of the center point.

10.4 Luminance Uniformity

Refer to Section 5.2.7.3 of SJ/T 11281-2017.
Measuring equipment: Brightness/ whiteness colorimeter
Measurement images: Pure white images
Measurement position: Nine positions of the 9-point measurement or the center of each box
Measurement method: Measure the luminance at the nine points of the display, and calculate the luminance uniformity of the display using formula (1); or measure the luminance at the center of each box, and calculate the luminance uniformity of the display using formula (1).

$$L_J = 1 - \frac{\left|L_i - \bar{L}\right|_{max}}{\bar{L}} \times 100\% \quad \cdots\cdots (1)$$

10.5 Chromaticity Uniformity

Refer to Section 5.8 of SJ/T 11141-2019.
Measuring equipment: Brightness/ whiteness colorimeter
Measured images: Pure white images

Measurement position: Nine positions of the 9-point measurement or the center of each box

Measurement method: Measure the chromaticity at the nine points of the display, or measure the chromaticity at the center of each box, and calculate the chromaticity uniformity of the display using formula (2). Select the maximum value of Δu'v' at each point.

$$\Delta u'v' = \sqrt{\Delta u'^2 + \Delta v'^2} \quad \cdots (2)$$

10.6 Color Gamut Coverage

Measuring equipment: Brightness/ whiteness colorimeter

Measured images: Pure red, pure blue, and pure green images

Measurement position: Center of the display

Measurement method: Display R, G, and B signals respectively. Use a colorimeter to measure the color coordinates (xr, yr), (xg, yg), and (xb, yb) of the center point of the display.

The NTSC color gamut coverage is calculated as follows:

The formula for calculating color gamut area:

$$S = \frac{\left|(xr - xb)(yg - yb) - (xg - xb)(yr - yb)\right|}{2} \quad \cdots (3)$$

The formula for calculating the NTSC color gamut coverage:

$$G_{NTSC} = \frac{S}{0.157} \times 100\% \quad (4)$$

The DCI-P3 color gamut overlap ratio is calculated as follows:

1) Inclusion (as shown in Figure 3): Use formulas (3) and (5) to calculate the gamut overlap ratio.

$$G_{DCI-P3} = \frac{S}{0.152} \times 100\% \quad (5)$$

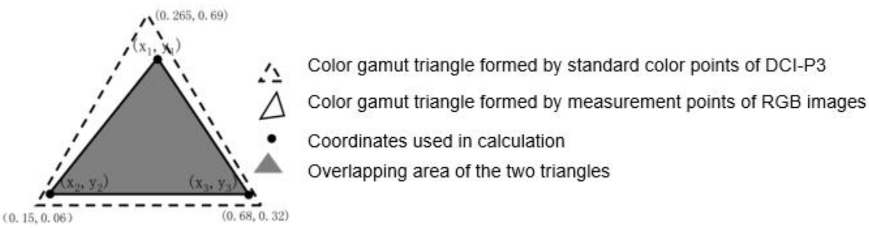

Figure 3: The overlapping part is included.

2) Internal tangent (as shown in Figure 4): Use formulas (3) and (5) to calculate the gamut overlap ratio.

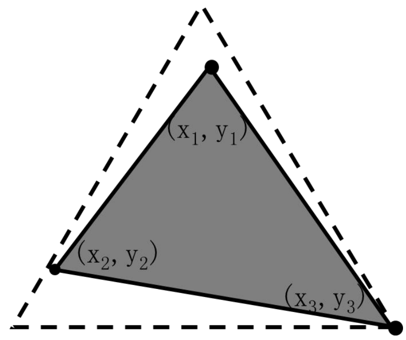

Figure 4: The overlapping part is an internal tangent.

3) External tangent (as shown in Figure 5): Calculate the coordinates (x1, y1) and (x2, y2) of the two newly generated intersection points, together with a measured coordinate (x3, y3), to replace (xr, yr), (xg, yg), and (xb, yb) respectively in formula (3). Use formulas (3) and (5) to calculate the gamut overlap ratio.

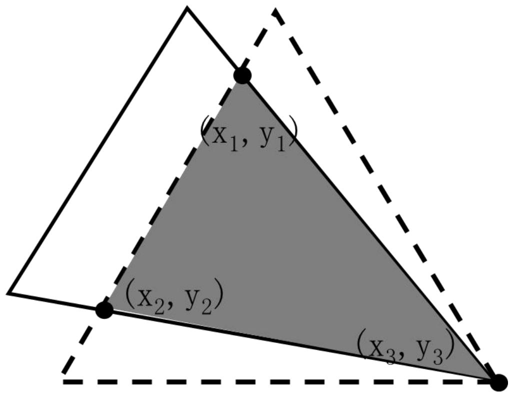

Figure 5: The overlapping part is an external tangent.

4) Intersection: Calculate the color gamut overlap area based on the two overlapped triangles.
The overlapping part is a triangle (as shown in Figure 6). Calculate the coordinates (x1, y1) and (x2, y2) of the two newly generated intersection points, together with a vertex coordinate (x3, y3) of the DCI-P3, to replace (xr, yr), (xg, yg), and (xb, yb) respectively in formula (3). Use formulas (3) and (5) to calculate the gamut overlap area.

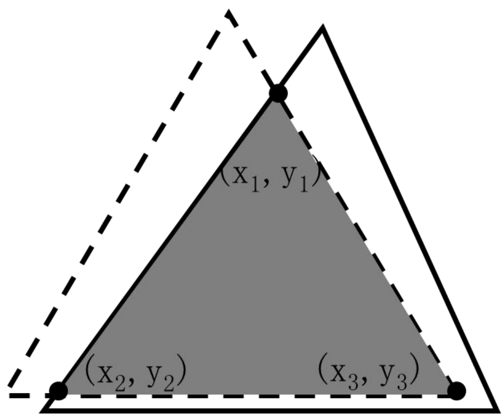

Figure 6: The overlapping part is a triangle.

5) The overlapping part is a pentagon (as shown in Figure 7). Calculate the coordinates of the four newly generated intersection points (x1, y1), (x2, y2), (x3, y3), and (x4, y4), together with the coordinates (x5, y5) of a measurement point. Use formula (6) to calculate the overlapping area, and then calculate the color gamut overlap ratio using formula (5):

$$S = \frac{\left| x1y2 + x2y3 + x3y4 + x4y5 + x5y1 - x1y5 - x2y1 - x3y2 - x4y3 - x5y4 \right|}{2} \quad \text{.....(6)}$$

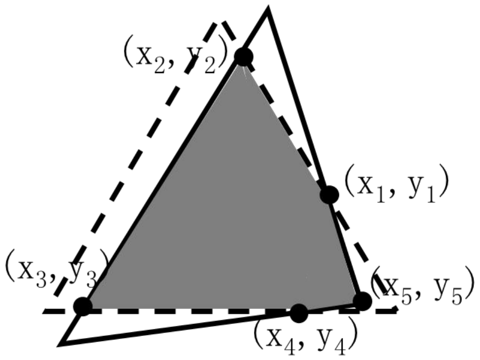

Figure 7: The overlapping part is a pentagon.

10.7 Half-luminance Viewing Angle

Both horizontal and vertical luminance viewing angles should be measured.

Measuring equipment: Brightness/ whiteness colorimeter

Measured images: Pure white images

Measurement position: Center of the display

Measurement method: Take the luminance of 0 degree as the reference. The deflection range of the luminance meter is ±85 degrees. Take the viewing angle when the luminance is reduced to 1/2 the reference luminance.

10.8 Chromatic Viewing Angle

Both horizontal and vertical chromatic viewing angles should be measured.

Measuring equipment: Brightness/ whiteness colorimeter

Measured images: 9 specific images as shown in Table 6

Measurement position: The colorimeter should be able to move in an arc with a radius of 3 times the display height. Keep the observation point at the center of the display P0 (as shown in Figure 2) unchanged.

Measurement method:

1) Display the nine images in full screen in sequence, change the angle from the horizontal direction, and calculate $\Delta u'v'$.
2) Find the left and right angles of each color with a chromatic aberration of 0.020. The sum of the left and right angles is the chromatic viewing angle of the color.
3) Take the minimum value among the nine viewing angles as the horizontal chromatic viewing angle value.

4) Measure the vertical chromatic angle in the same way.

Table 6 Parameter settings of nine color signals

No.	(a) When the range is 0–255 (analog interface input)			(b) When the range is 16–235 (digital interface input)			Color example
	R	G	B	R	G	B	
1	115	82	68	115	87	74	Dark skin
2	194	150	130	183	145	128	Light skin
3	56	61	150	64	69	145	Blue
4	70	148	73	76	143	79	Green
5	175	54	60	166	62	68	Red
6	231	199	31	214	187	43	Yellow
7	187	86	149	177	90	143	Magenta
8	8	133	161	23	130	154	Cyan
9	122	122	121	121	121	120	Gray

10.9 Specular Reflection

Specular reflection is measured to assess the severity of glare on the display in ambient light.

Measuring equipment: A reflection meter

Measured images: Powered off

Measurement position: 9 points

Measurement method:

1) Turn off the power supply of the LED display.
2) Measure the Specular Component Include (SCI) and Specular Component Exclude (SCE) at the 9 points of the LED display with the reflection meter.
3) Record the SCI and SCE at each point.
4) Specular reflection = SCI – SCE.
5) Take the maximum of the specular reflection as the reflection of the display.

Note: When measuring, the long side of the meter should be parallel with the short side of the display.

10.10 Black Uniformity

Measuring equipment: A reflection meter

Measured images: Powered off

Measurement position: 9 points

Measurement method: When the display is in black screen mode, select nine points on the display as the test points and use the center of the screen as the reference point to measure the other eight points.

ΔE is the relative chromatic aberration with the reference point. The maximum value of ΔE is used.

10.11 Grayscale Gradient

Measuring equipment: Brightness/ whiteness colorimeter

Measured images: 255 evenly distributed levels of grayscale images from pure white to pure black

Measurement position: Center of the display

Measurement method: Measure all data across the full grayscale range, calculate the dE2000 chromatic aberration between two adjacent gray levels, calculate the std values between all dE2000 chromatic aberrations, and show the result in std value.

10.12 Gray Level/Frame Rate

Refer to SJ/T 11281-2017 5.3.1 and SJ/T 11281-2017 5.3.2.

10.13 White Balance Correction

Measuring equipment: Brightness/ whiteness colorimeter

Measured images: 255 evenly distributed levels of grayscale images from pure white to pure black

Measurement position: Center of the display

Measurement method:

1) Measure the luminance and chrominance data of 0–255 gray levels using a luminance meter and colorimeter.
2) Use the color coordinates (x, y) of the grayscale L128 as a reference, calculate the difference between x and y of the grayscale L20–L255 with x and y of the grayscale L128 respectively, and take the absolute value.
3) The result is the maximum of absolute values.

10.14 Gamma Correction

Measuring equipment: Brightness/ whiteness colorimeter

Measured images: 255 evenly distributed levels of grayscale images from pure white to pure black

Measurement position: Center of the display

Measurement method:

1) Measure the luminance and chrominance data of 0–255 gray levels using a luminance meter and colorimeter.
2) Calculate the local gamma curve based on the luminance and calculate the gamma value using the least-squares method (the gamma standard is 2.2, ranging from 2.0 to 2.4).

10.15 Color Accuracy

Measuring equipment: Brightness/ whiteness colorimeter

Measured images: 9 specific images as shown in Table 6

Measurement position: P0 at the central observation point of the display (as shown in Figure 2)

Measurement method:

1) Display nine colors in full screen on the display calibrated by an authoritative measurement organization, and measure the color coordinates.

(x0, y0) i(i=1–9) are used as the reference for each color, and the recommended value is shown in Table 7.

2) Display nine colors in full screen in sequence on the display, and measure the color coordinate values $(x, y)_i$.

3) Calculate the color coordinate difference $\Delta E=\sqrt{\Delta x^2+\Delta y^2}$ of each color, and take the average value as the color accuracy value of the display.

4) Fill the measurement results in Table 7.

Table 7 Values of reference color coordinates and measurement results of color accuracy

No.	Reference Color Coordinate Values		Color Accuracy Measurement Results		ΔE	Color Example
	x_0	y_0	x	y		
1	0.3934	0.3724				Dark skin
2	0.3735	0.3696				Light skin
3	0.1889	0.1124				Blue
4	0.3026	0.5237				Green
5	0.5257	0.3199				Red
6	0.4274	0.4966				Yellow
7	0.3639	0.2356				Magenta
8	0.2151	0.2760				Cyan
9	0.3094	0.3431				Gray
Color Accuracy Value						

10.16 Defect

Measurement equipment: An imaging luminance meter

Measured images: Pure R, G, B, and W color images

Measurement position: Full screen

Measurement method:

1) Use dark-field signals (low gray levels) to drive the full screen, and manually or automatically calculate points lit in R, G, B, and W images on the display. These points are bright dot defects and are recorded as bright dots. More than two consecutive bright dots are recorded as a bright line.

2) In the preceding situation, the dots with unstable luminance are the R, G, B, and W flickering defects, which are recorded as flickering dots.

3) Use pure R, G, B, and W image signals, and manually or automatically calculate points that should be but are not lit as dark defects in R, G, B, and W images on the display. These points are dark dot defects and are recorded as dark dots. More than two consecutive dark dots are recorded as a dark line.
4) In the preceding situation, a point that causes other colors to light up under a single color drive is a crosstalk defect and is recorded as a crosstalk point.

Appendix A. Chrominance Difference Curve Across the Full Grayscale Range

(Informative)

Figure A.1 shows the color representation across the full grayscale range from 0 to 255.
It can be seen from the figure that the color coordinates below 20 gray levels vary greatly, and its accuracy cannot be used for reference.

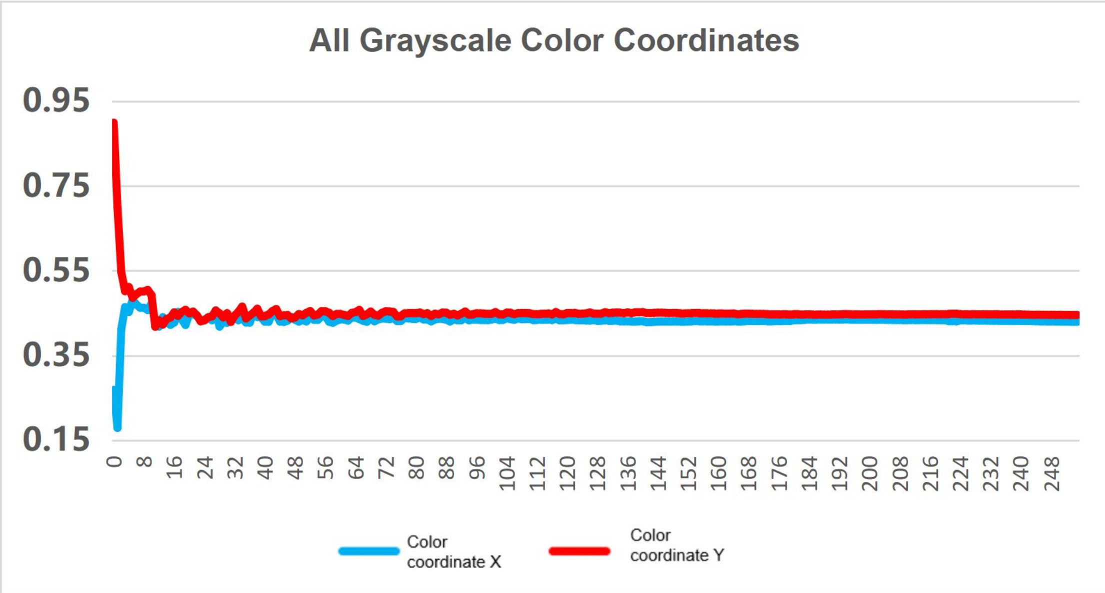

Figure A.1 Example of color coordinates across the full grayscale range