



EDUCATION GUIDE **FREEFORM LED DISPLAYS**

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LED FREEFORM VIDEO DISPLAYS

A REVOLUTION IN THE LED VIDEO AND LIGHTING INDUSTRY

LED video and lighting are merging, creating a new realm of possibilities never before unleashed. With that, new challenges need to be considered to use the technology in creating displays, media facades and video sculptures.

LED specifications versus lighting specifications, contrast ratios, transparency and fill factor are all items that should be understood in order to blend with architecture and meet the expectation of the designer's vision. This guide provides the information to inform those in the field how best to use this available technology.





FAQ

WHAT ARE FREEFORM LED DISPLAYS?

Freeform LED displays wrap and cover architectural structures in multiple dimensions at both large and small scale. Freeform displays are made up of freeform LED elements. These displays run content ranging from color changes and effects to animations and full video. Types of freeform displays include channel letters, see-through displays and video sculptures.

WHAT ARE FREEFORM LED ELEMENTS?

A freeform LED element is the smallest component that constructs a freeform LED display. Elements come in several forms depending on the manufacturer. Common element forms include modules, pucks and sticks.

Depending on the element design, it may contain one pixel or it may contain several pixels. Puck elements typically consist of one pixel; stick elements often have an array of pixels along a single line. Square tiles also contain an array of pixels.



ARE FREEFORM ELEMENTS DAYTIME VIEWABLE?

Viewers can see freeform elements by day, depending on the product's manufacturer. Five factors create elements that are viewable in the daytime.

› **The brightness of the LED and pixels:**

The more intense an LED or pixel, the brighter it appears, and the brighter the LED or pixel, the more visible it is during the day. LEDs come from manufacturers in different intensities. In addition, a collective group of LEDs that form a pixel can have different intensities as well. Industry standards dictate that daytime viewable elements should have a brightness rating of 5,000 nits.

› **Contrast:**

A dark background color and strategically placed louvers give an element greater contrast. A light background color, such as white, will make the LEDs and pixels less viewable, especially when viewed in sunlight. Louvers added to the element above pixels or individual LEDs help shade the elements from sunlight, reducing the sun's ability to "wash out" the LED's brightness. The less contrast, the brighter the LEDs need to be to make the display visible during the day.

› **Element to element spacing:**

Element spacing determines collective intensity. The closer you space elements to one another, the more collective intensity they create to make an image visible during the day. The further you space elements from one another, the less intensity they create together.



› **Display background:**

Display background brightness also contributes to contrast. Many times freeform displays are transparent due to empty space between elements. The background behind the empty space affects how well individual elements stand out. For example, if the background is night sky or black, it increases the contrast between the elements. However, if the background is bright white or open sunlight, the contrast decreases between the elements.

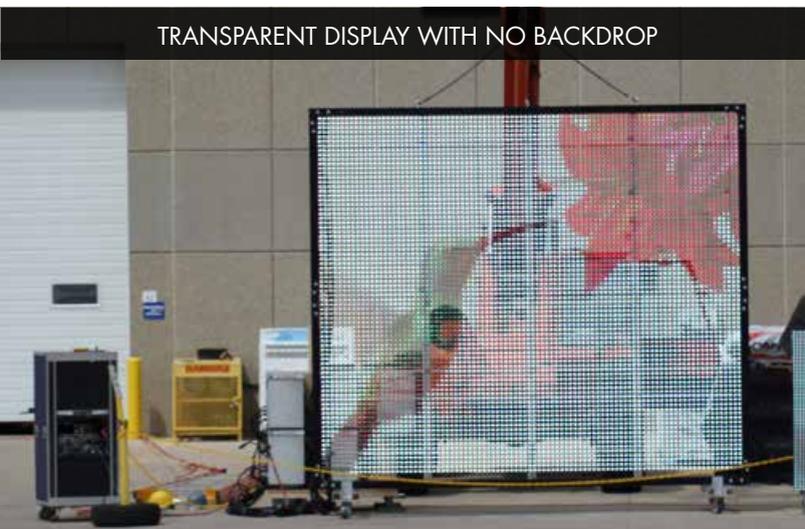
› **The angle in which sunlight reaches the display:**

Simply put, if sunlight shines directly on a display, viewers will have a harder time seeing the display than when direct sunlight is absent. If the display does not face the sun, viewers can see the display more easily during the daytime.

If any factors are ignored, daytime viewing may be affected. Therefore, customers should ask manufacturers questions regarding daytime viewing to gain a thorough understanding of display capabilities.

An easy way to prove daytime visibility is through a product demonstration in the outdoor conditions in which the display will operate.

TRANSPARENT DISPLAY WITH NO BACKDROP



TRANSPARENT DISPLAY WITH BLACK BACKDROP



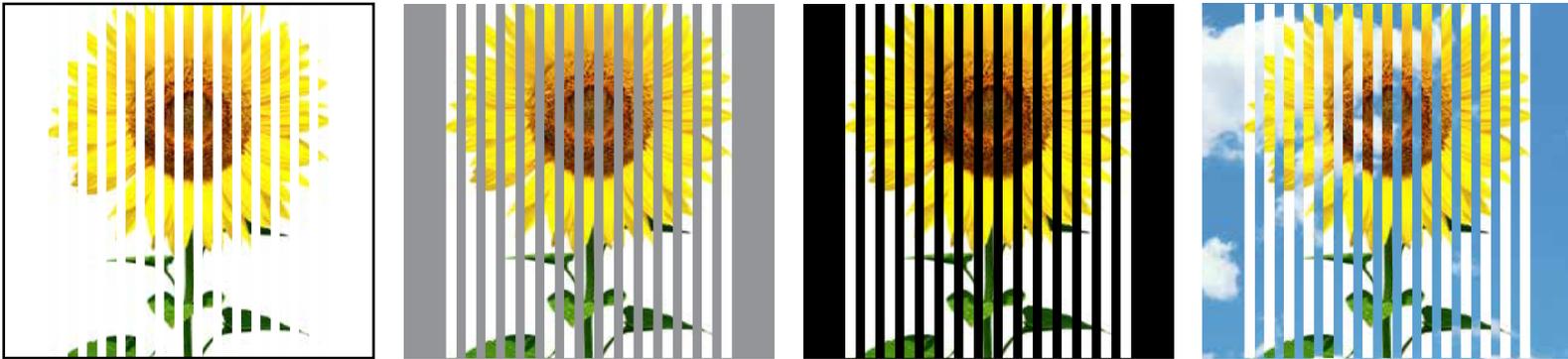
HOW DOES CONTRAST AFFECT DISPLAY VIEWABILITY?

The greater the contrast, the better the display image's viewability. Contrast is the brightness ratio of light to dark values in an image. This determines display readability. Adjusting the contrast on a video monitor or TV shows this effect.

When contrast increases, colors appear more vibrant and images become easier to see. When contrast reduces, the image appears light and washed out.

This may happen to freeform displays when a dark color background, such as a dark wall or the nighttime sky, is absent between each panel.

The lighter and brighter the background color, the lower the contrast becomes because the difference between the lit pixel and the background becomes less and less.



A note about contrast: Contrast is critical to an LED display's viewability. The contrast ratio provided in most manufacturer specifications does not reflect how the actual display will perform in use.

No industry standard for display contrast ratio exists, and each manufacturer determines its own measurement method. Most manufacturers measure contrast under ideal conditions where the difference between the LEDs off state and on state measure at maximum.

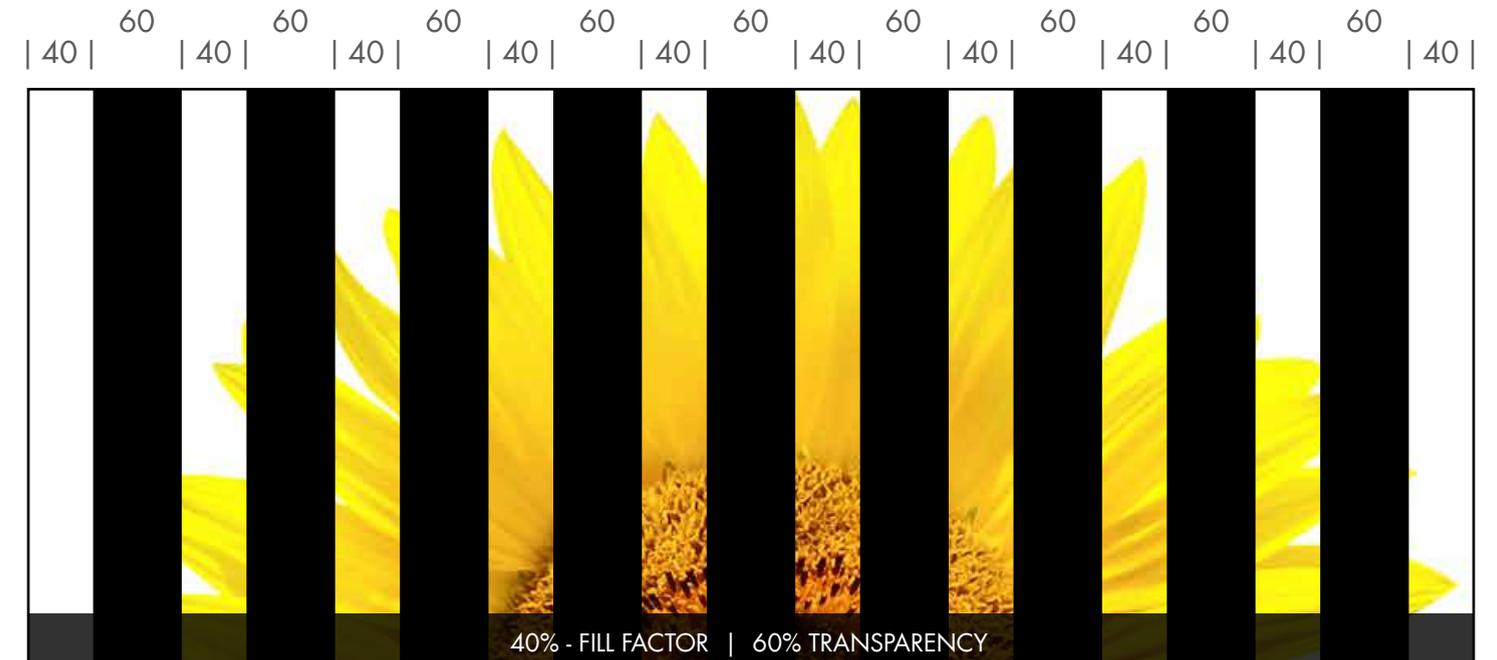
In real installations, the display surface will reflect some ambient light, decreasing the contrast ratio, and increasing the importance of louvers and element background color.

HOW DO TRANSPARENCY AND FILL FACTOR AFFECT ONE ANOTHER?

Transparency and fill factor are inversely related; as one increases, the other decreases. Transparency is the percentage of space not occupied by elements, or seen as an equation:

$$\text{Transparency} = \frac{\text{Total Display Area} - \text{Element Fill Area}}{\text{Total Display Area}}$$

As transparency increases and fill factor decreases, contrast may be sacrificed, especially if the display background is bright. If the background is dark, contrast may not be lost at all.



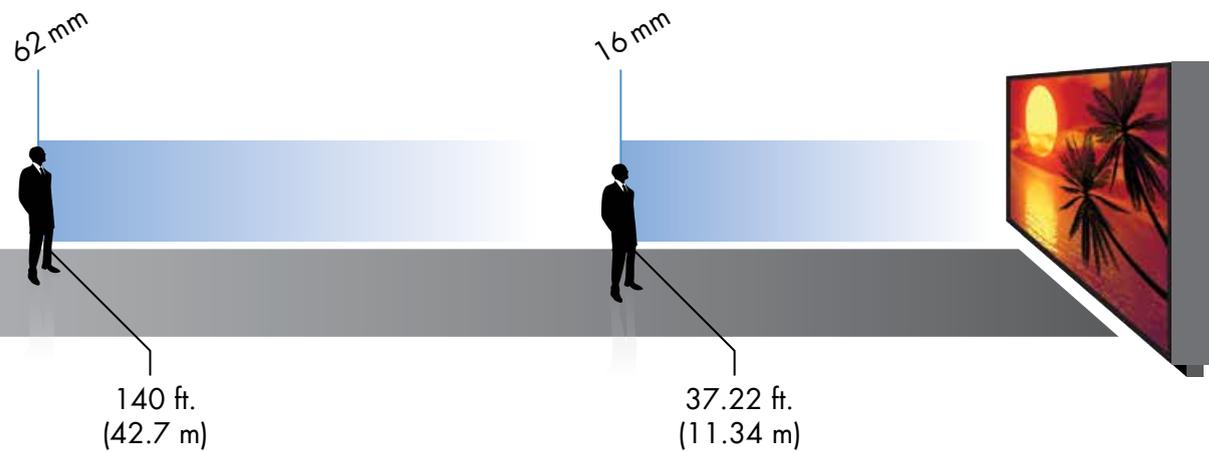
WHAT'S THE OPTIMAL VIEWING DISTANCE OF A FREEFORM LED DISPLAY?

Optimal viewing distance is determined by the greater of two measurements: the distance between individual pixels, often referred to as pixel pitch, or the physical center-to-center distance between individual elements.

Optimal viewing distance is the point at which colors from individual pixels begin to blend with the surrounding pixels.

Minimum viewing distance is based on the shortest distance at which an individual perceives pixels blending together.

Maximum viewing distance is based on the longest distance at which an individual can still accurately view the image.



HOW DO YOU MEASURE THE BRIGHTNESS OF A FREEFORM LED DISPLAY?

The industry standard measurement for display intensity is nits (cd/m^2). To be daylight visible, a display must have at least 5,000 nits.

Since freeform displays may have a varying pixel pitch over the entire display, the correct way to state individual element brightness is candelas per element or candelas per pixel.

If you know the pixel spacing, any manufacturer can determine the display nit rating.

All manufacturers should be able to provide measurements in candelas per element or candelas per pixel.

A candela is a measurement of luminous intensity emitted by a light source in a particular direction. A nit is equivalent to one candela per meter squared (cd/m^2).

Other measurements, which are typically used to rate light and lamps, may include a lumen, a measurement of the perceived power of light, and lux, the number of lumens per meter squared (lm/m^2).

If a manufacturer gives you these ratings, ask for them in either candelas per element or candelas per pixel.



HOW DO FREEFORM ELEMENTS MOUNT TO STRUCTURES?

Freeform element mounting methods and hardware varies depending on the manufacturer. Elements should be capable of mounting from either the front or the rear and should work with standard mounting hardware. Ask for mounting details from individual manufacturers.

WILL SIGNAL AND ELECTRICAL CABLES FROM THE FREEFORM ELEMENTS BE VISIBLE?

Some element manufacturers have designed their elements to hide cables, making display installation appear almost cable free. Other manufacturers do not have this capability designed in their product, and their displays may have cables exposed.

All elements require power and signal sources, and currently this requires cables for transmission between each element.

Additionally, some elements are designed with more than one cable between each element which makes hiding cables more difficult.

Typically when it comes to hiding cables, fewer cables are better. Fewer cables also alleviate confusion during display setup and repair.

HOW DO I KNOW IF FREEFORM ELEMENTS CAN WITHSTAND OUTDOOR CONDITIONS?

The electronics of outdoor freeform elements require protection from the environment. Therefore, electronics should have gasketing, coating and other measures to prevent corrosion.

Manufacturers may measure freeform element's weather tightness through Ingress Protection (IP) ratings. IP ratings measure an element's ability to keep out foreign substances, specifically dust and water.

An IP rating consists of two numbers; the first number relates to the intake of solids and the second refers to the intake of liquids.

The higher the IP rating, the better the element repels dust and water. For example, by referring to this chart, an element rated as IP-67 doesn't intake dust and can be immersed in one meter of water for 30 minutes and still run.

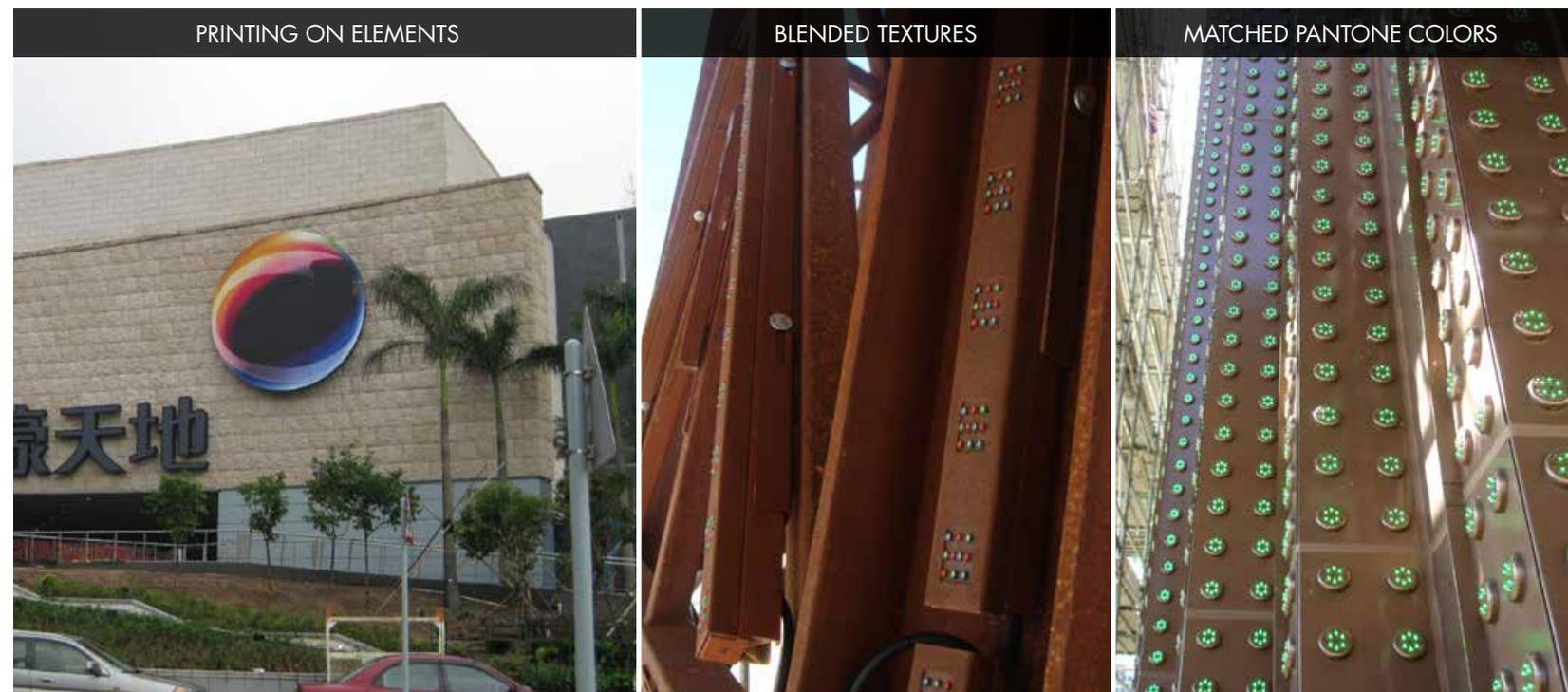
First Number		Second Number	
0	No protection	0	No protection
1	Protected against large objects up to 50 MM, such as a human hand	1	Protected against vertically dripping water
2	Protected against small objects up to 12.5 MM, such as fingers	2	Protected against dripping water angled up to 15 degrees
3	Protected against objects up to 2.5 MM, such as tools	3	Protected against dripping water angled up to 60 degrees
4	Protected against objects up to 1 MM, such as wires	4	Protected against water splashing from all directions
5	Dust protected – Protected against access of enough dust to interfere with the satisfactory operation of the equipment	5	Protected against water jets from all directions
6	Dust tight – Totally protected against the intake of dust	6	Protected against strong water jets from all directions
		7	Protected against immersion (between 15 MM and 1 M in depth)
		8	Protected against submersion

CAN LED ELEMENT EXTERIORS MATCH BACKGROUNDS TO FORM A STATIC DISPLAY DURING THE DAY?

Yes, but not all manufacturers have this capability. The most advanced manufacturers can customize element exteriors to match Pantone or specific logo colors.

In addition, they can blend exteriors into textures, such as brick, and can print complex imagery on element surfaces.

Furthermore, they can offer protection from color fading, helping the element exteriors to maintain their color throughout their lifetime.



HOW DO IMAGES ON FREEFORM DISPLAYS MAINTAIN INTEGRITY AND AVOID DISTORTION ACROSS UNEVEN SURFACES?

Pixel mapping maintains image integrity by making images as true-to-life as possible and preventing optical distortion.

Image integrity is important for see-through and sculpture displays that run animations and video content.

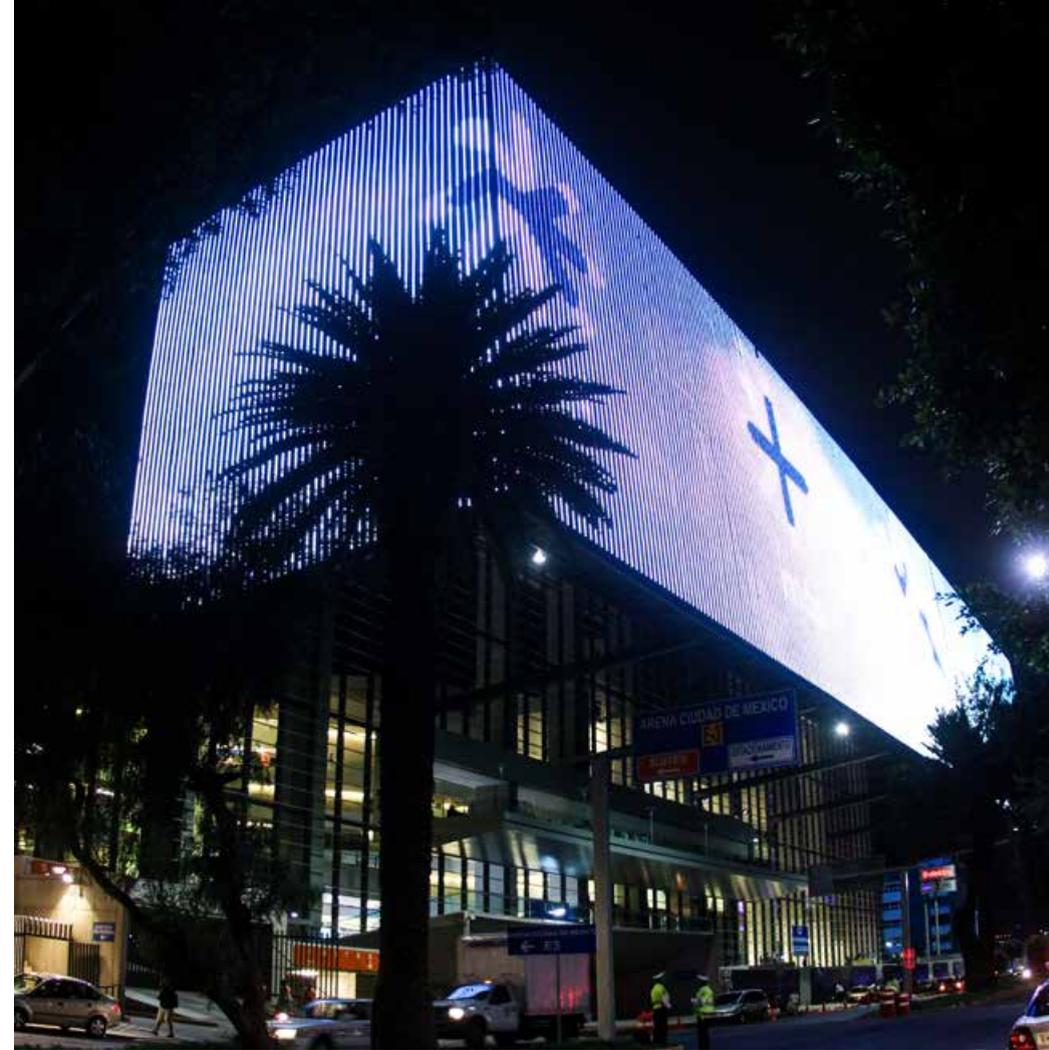
Pixel mapping takes an individual pixel from an image and charts it to a specific pixel on a display.

The ratio of pixel mapping can be 1:1, one display pixel for each image pixel; 1:2, one display pixel for every two image pixels; and so on.

Not all manufacturers offer pixel mapping, and some manufacturers' pixel mapping is better than others, especially if you chart pixels on an uneven surface.

Superior pixel mapping systems take a standard, rectangular image source and apply it to the display area, accounting for any gaps between pixels and compensating for curved and irregular surfaces.

This allows content to appear custom-tailored to fit the freeform display, giving audiences a top-quality viewing experience.



GLOSSARY

ANIMATIONS:

- 1) Motion graphics that bring a display to life
- 2) Content comprised of motion graphics

COLOR CHANGE:

A display effect in which one color changes immediately to another.

COLOR WASH:

A display effect in which colors change gradually from one to another.

CONTRAST:

- 1) Difference in visual properties that makes an image on a display distinguishable from other objects in the background.
- 2) The range of light-to-dark values of an image that are proportional to the voltage difference between the black and white voltage levels of the video signal. The contrast control is an adjustment of video gain.

CONTRAST RATIO:

Ratio between the nit measurement taken when a screen displays a blank video signal and a full, white video signal or is turned off and when the screen displays a full white color.

CONTROL BOX:

Device that converts a display signal protocol into a pixel/element signal protocol.

DAYLIGHT VISIBLE:

Showing content in direct sunlight that is readable anywhere within the display's recommended viewing distance. A display that is shaded by another object is not in direct sunlight. Color wash and color change content is less likely to be seen as daylight visible because of poor display pixel contrast. Video, text, and animation content are better for daytime viewing.

DYNAMIC:

Ability to change content in real-time.

ELEMENT:

Component consisting of one or more pixels.

FILL FACTOR:

The percentage of display space occupied by elements.

FREEFORM VIDEO:

Video displays capable of wrapping and covering architectural structures in multiple larger-scale or small-scale dimensions.

HIGH-END VIDEO:

Content for a display comprised of a standard video signal that has not been altered or reduced in quality (i.e. uncompressed video).

LED MESH:

- 1) Nearly transparent LED display that can be seen through the front when the display is not running. The display can also be seen through from the back at all times.
- 2) An LED mesh display must consist of a regular repeating pattern pixel layout and does not have fill factor of 100% - does not have a transparency of 0%.

LED VIDEO:

Video displayed on a device that uses LEDs to emit light.

PIXEL:

Single group of LEDs containing at least one blue, one red and one green LED capable of showing any color within the display's color range.

PIXEL MAPPING:

The ability to directly place video content onto a display so it is properly scaled and audience viewable.

PUCK:

Individual LED pixel element that has a similar shape as a hockey puck.

RGB/COLOR DEPTH:

Determined by the number of levels of each color of LED can produce. For example, if an LED display processor can create 1,024 shades of each color (red, green and blue), then it uses 30-bit color which includes $10,243 = 1$ billion colors.

STICK:

- 1) Linear-shaped LED element consisting of one to two rows of several pixels.
- 2) Multiple LED pixels that are configured in one or two rows running the length of a linear-shaped element.

TRANSPARENCY:

The percentage of space in an LED display not occupied by elements, or seen as an equation:

$$\text{Transparency} = \frac{\text{Total Display Area} - \text{Element Fill Area}}{\text{Total Display Area}}$$

VIDEO CAPABLE:

An LED display which has the means to run live or pre-recorded video.



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