WHITEPAPER

LED display walls

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LED display walls have proven to be a highly effective means for communicating both entertainment and messages to large numbers of people. But how do they work? What are the key strengths and advantages of LED technology compared to other methods of producing large images? What kind of features do they offer? This whitepaper will answer these and other questions.

How LEDs and LED display walls work

LEDs are based on the phenomena of electroluminescence. Electrons moving across a semiconductor change to a lower quantum energy state, in the process emitting photons of a specific wavelength. The construction of an LED usually includes a lens that allows the resulting light to be emitted in an efficient manner in a given direction.

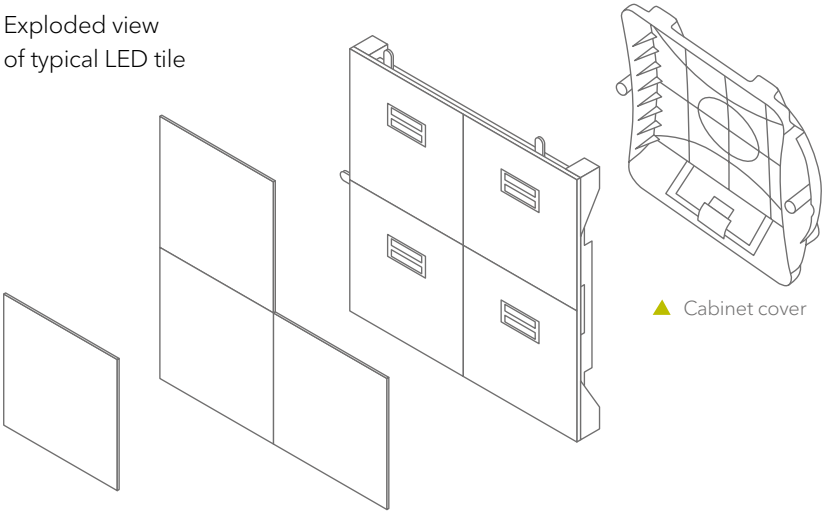
An LED display wall uses individual LEDs in three colors for each pixel: red, green and blue. The LEDs can be discreet devices or combined into a surface-mount device (SMD). Each color of LED, which is called a sub-pixel, receives its own drive signal based on video content, which allows in total, millions of colors to be generated. Typically, each tile is actually composed of a series of identical LED modules. The circuit boards of the modules are electrically connected such that each pixel receives its intended and unique RGB drive signals so that all pixels receive power from the tile's power supply. This modularity is an advantage during servicing because if an LED fails, only the module containing that LED needs to be replaced.

All of the modules in a tile are typically housed in a cabinet, which also contains a power supply for the tile as well as electronics to control each module and allow the connection of a video signal. Some tile designs place the power supply and control electronics in a separate enclosure that attaches to a frame that also holds the LED modules.

The tile's structure allows it to be hung from an external frame that enables larger arrays containing many tiles to be created. One or more separate control units, each connected to a given number of tiles, accept video signals from a variety of possible sources, typically over DVI or HDMI, and direct the correct portions of images to each tile.

The mechanical design of the tiles ensures that each aligns very accurately to its nearest neighbors, resulting in a seamless composite image that can contain anywhere from several thousand pixels to millions of pixels, depending on how many tiles are used and how many pixels each contains.

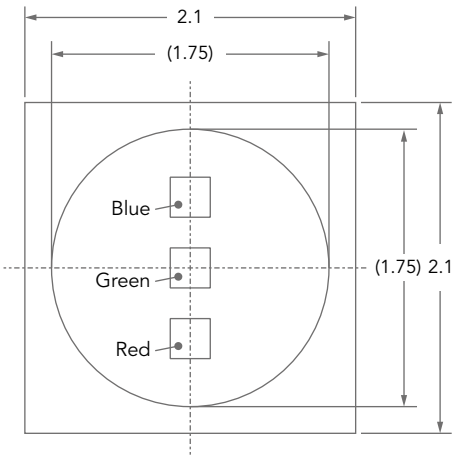
Exploded view of typical LED tile



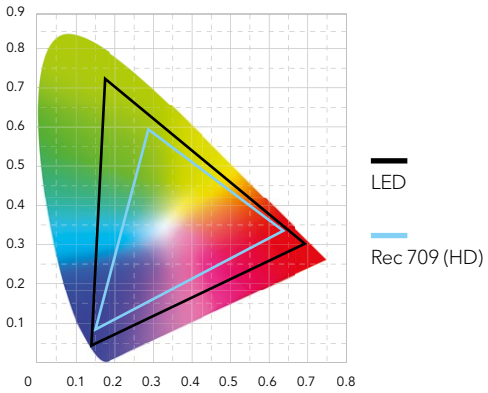
▲ Cabinet cover

▲ Modules, including: PCB board, pixels (3-in-1 SMD's) and driver IC's

▲ Cabinet (frame) including: power supply, receiver card and hub



▲ Typical surface mounted RGB LED device (SMD)



▲ Comparison of LED color gamut with standard HD gamut

Key strengths and advantages

As a light source, LEDs have a number of exemplary properties.

First is brightness. Indoor LED display walls today can achieve peak brightness of up to 12,000 nits (cd/m2), although levels for indoor models are typically less than 2,000 nits. While high-brightness is crucial for an outdoor display that needs to compete with direct sunlight, it is also a boon to an indoor display that needs to be noticed in a busy environment.

Other methods of creating large images either can't achieve image brightness levels comparable to LED display walls or can do so only with a considerable increase in system complexity. LCD panels, for example, are typically less than 1,500 nits, with most below 700 nits. In the case of projection displays, where image brightness is almost arbitrary but scales with image size for a given lamp or other light source, achieving brightness levels rivaling LED display walls for a specific combination of lamp and image size may require multiple projectors.

The ability of LED display walls to handle high levels of ambient illumination is another strength. This is a consequence not only of the high-brightness typical of LED tiles but of high contrast ratios. The result is an outstanding perceived level of black, resulting in a high-contrast image even in elevated levels of indoor ambient light.

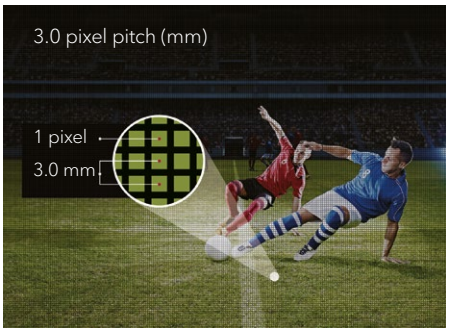
A further strength of LED display walls is a very large achievable color gamut, which is the range and purity of the colors a display can reproduce. The red, green and blue LEDs used in LED display walls all emit a much narrower range of wavelengths than a broad-spectrum, white-light source like a lamp. This allows more deeply saturated colors to be reproduced as well as increasing the range of reproducible colors.

Another strength of LED display walls is the long life. The useful lifetime of a display's light source is often defined as the number of hours to reach half of the initial brightness. By this measure LEDs, whether used only as a light source or employed directly as pixels in an LED display wall, typically last much longer than lamps.

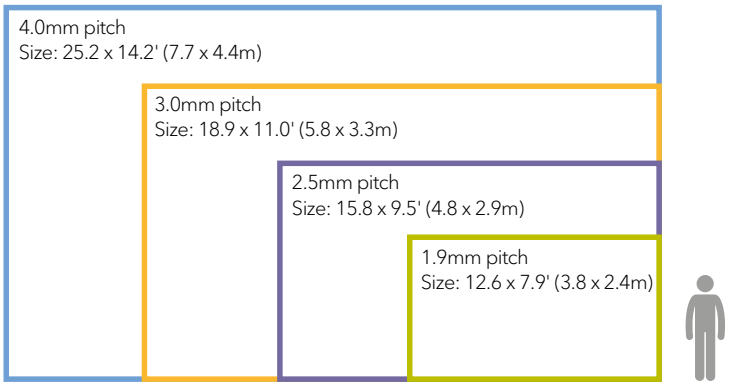
All displays consume power and require cooling but not all display technologies are the same in this regard. LED display walls consume energy more efficiently than most other display technologies. The improvement in efficiency can be as high as 400% or more, depending on which displays are being compared. This translates into less heat as well as less audible noise resulting from the cooling required to dissipate that heat. In fact, some LED tiles run cool enough to not require fans, provided there is adequate space behind them and appropriate HVAC.

An important image parameter for any display is the pitch or distance between its pixels. The lower the number the closer that observers will able to get to an image before discerning its individual pixels. A lower number also means that a given number of pixels can be packed into a smaller area, or conversely that more pixels can be achieved within a given area. However, small pixel pitches aren't right for every application. For very large displays in particular, an overly small pitch may result in many more pixels than are needed for a given application. Fortunately, LED tiles are available
in a broad range of pixel pitches from as large as 20mm to as small as 1mm, with the smaller pitches primarily for indoor use.

Also very important is the fill factor of individual pixels. This is the ratio of the area of the light-producing element within a pixel (in this case the LEDs



▲ Visual illustration of pixel pitch



▲ Recommended display size to achieve 1920 x 1080 resolution (estimate to be used as a guideline only)

themselves) to the total area of the pixel. The higher the fill factor, the smoother the image and the closer observers can approach the display without pixels becoming obvious.

Another strength of LED display walls is the perceptually seamless nature of the images. The tiles of an LED display wall are designed in such a way that they touch each other without increasing the distance between the pixels from one tile to the next. Moreover, the nature of the area surrounding the LEDs in a typical tile makes it difficult from a normal viewing distance to see where the tiles join.

Configuration options

A wide variety of LED display tiles are available in the market. These are fundamentally divided into indoor and outdoor models. Pixel pitch is a further point of differentiation. What all of these products have in common is extreme modularity. The small form factor of typical LED tiles makes it easy to create a display wall of arbitrary size, aspect ratio and shape.

LED tiles are also typically quite thin, often with a depth of less than 10cm. One intriguing consequence is the ability to mount the tiles along a curve. Depending on the radius of curvature and the model of tile, convex curves as well as concave curves can be accommodated. The small sizes typical of LED tiles offer considerable flexibility in the size and the shape of a display wall.

One of the most important choices when choosing an LED display wall is the pixel pitch. The best pixel pitch depends on both the desired pixel count in the final image and the expected distance of viewers. As an example, the above graphic illustrates the display wall sizes required to achieve a full HD (1920 x 1080) image for a range of pixel pitches. To achieve a UHD image (3840 x 2160) – sometimes called "4K" – simply double each linear dimension in the diagram. Other aspect ratios and final image resolutions are, of course, possible.

With respect to the optimal viewing distances for different pixel pitches there are no hard and fast rules. Nevertheless, Table 1 lists some recommendations.

The best pixel pitch for a given application is one for which the pixels are not obtrusively obvious at the typical viewing distance yet still allows the display wall at its intended resolution to subtend a significant portion of the viewer's field of vision for maximum impact.

Table 1: Suggested optimal viewing distances*

Christie Velvet LED display pixel pitch	Optimal viewing distance: Pixel pitch x 8	Optimal viewing distance from LED display: (approx.)
1.9mm	1.9 x 8	15 feet
2.5mm	2.5 x 8	20 feet
3mm	3 x 8	24 feet
4mm	4 x 8	32 feet

* To calculate optimal viewing distance in meters instead of feet, the formula is pixel pitch x 2.5. (Estimate to be used as a guideline only)

A complete solution

There is more to an LED display wall than just the LED tiles. Typically, a number of external control units are also required, each unit responsible for a subset of the tiles in the wall. Each control unit accepts video signals from source devices and provides a separate video output for each subgroup of tiles. Most solutions include a video processor and universal routing switches, as well as content management and collaboration systems.

Media server options

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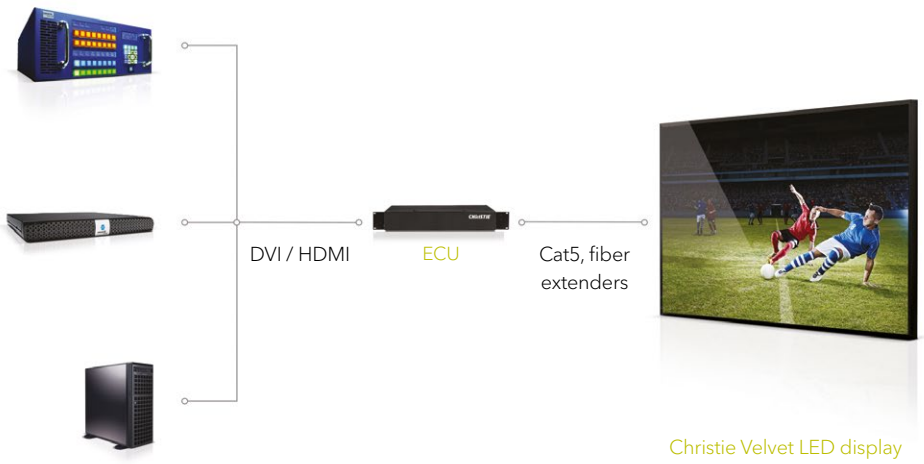
Unmatched 20 megapixel v
processing matrix switchinc
integrated source monitorir

Christie Phoenix
Network distributed open c
system for simultaneous en
display of audio-visual data

Third-party media server



▲ LED display wall solution components

Conclusion

Compared to other image-display technologies, LED display walls enjoy a number of advantages with respect to brightness, color gamut, service life, power consumption and form factor. They are also uniquely adaptable to a wide variety of applications with differing requirements for size, shape, viewing distance and environment.

As an image-display technology, the LED display wall may be one of the new kids on the block but it is already distinguishing itself. The future for LED display walls looks bright.

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