WHITE PAPER

LED Displays in Movie & TV Production

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Macroblock

LED DISPLAYS IN MOVIE & TV PRODUCTION

Along with their increasing use in applications such as digital billboards, scoreboards, retail signage and the like, LED displays are increasingly landing roles in movies. The parts they play have typically focused on their use as theater screens, replacing projectors and the white backdrop.

More and more, though, they're appearing in the productions themselves.

Many of us have thrilled to the latest science-fiction television shows and the blockbuster action films, where the action takes place on some far-off, exotic world. Or think of a period piece, where the story takes place in 1920s New York, with realistic backdrops enhancing the effect. Or maybe a war film, where behind the actors are scenes of destruction.

The effects can be awe-inspiring, allowing us to get lost in the story. So awe-inspiring, in fact, that we don't give much thought to how those effects are created.

That's where LED displays come in.

Creating the effect

In the early days of film, those worlds were typically created either with painted sets or movies projected on a screen behind the actors. Think of an Alfred Hitchcock film such as 1959's North by Northwest, where a drunken Cary Grant attempts to maneuver a speeding car down a winding mountain road. The effect was created by having Grant sit in a stationary car with road scenes projected on a screen behind him. Looking back, it's kind of amusing.

More recently, those effects are created with a "green screen," technically called chroma key, where actors play their parts in front of a blank green or blue screen, and the background details are filled in later. The green screen technique initially became popular in TV weather reports, where the weatherman appears to be standing in front of a map of the country (but is actually standing in front of a blank screen). It's now common throughout the film and television industries.

Although green screen effects are a dramatic advancement compared with a projected background, it does have its limitations. If the lighting isn't perfectly balanced, it can appear fake, ruining the suspension of disbelief required to become fully immersed in the story. Changing the background perspective as the camera moves can be difficult. In addition, an effect called "spill" can occur, where green light is reflected on the actors. That's especially true if they're wearing a shiny costume.

And from the actors' point of view, it can be difficult to imagine being part of a world that's not there.

The "virtual set"

Green screen effects and projected backgrounds have certainly served as a valuable tool for filmmakers, but that's about to change. A recent evolution in set design offers the potential to reshape the way movies are made, and at the heart of the revolution are LED displays.

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Instead of using a projected background or a green screen with effects filled in later, an LED display positioned behind the action can create that background in real time.

One of the most prominent examples of the technique is the Disney+ series "The Mandalorian," based on characters from the Star Wars universe. According to the film industry publication American Cinematographer the set, dubbed The Volume, consisted of a curved, 20'-high-by-180' LED video wall, and included 1,326 individual LED screens of a 2.84mm pixel pitch. The wall created a 270-degree semicircular background with a 75'-diameter performance space. Topping that was an LED video ceiling, set directly onto the LED wall. Behind the cameras were two 18'-high-by-20'-wide flat panels of 132 more LED screens.

During the filming process, background scenes were displayed on the LED wall.

"The Volume allows us to bring many different environments under one roof," Visual effects supervisor Richard Bluff of visual effects company Industrial Light & Magic told the publication. "We could be shooting on the lava flats of Nevarro in the morning and in the deserts of Tatooine in the

afternoon. Of course, there are practical considerations to switching over environments, but we [typically did] two environments in one day."

An LED backdrop offers a number of advantages compared with a green screen. Along with being virtually indistinguishable from reality, an LED backdrop offers better lighting compared with a green screen and is easier for the actors to "get into" the scene.

Because the background can be filmed along with the main action, the costs of adding those effects in later can be mostly eliminated. It also does away with the need to guess where set elements will be filled in on the green screen, and features such as lighting or layout can be changed quickly.

Although creating the LED backdrop does involve a significant up-front investment, much of that is offset by not having to locations and to build sets. And of course, it can always be used as a green screen if needed.

Display considerations

LED displays promise to change the way movie and television productions are created, but the effects are only as good as the video walls on which they're shown. And those displays are constantly improving.

Just a few decades ago the pixel pitch, or the distance between individual pixels in an LED display, was in the range of 12 mm, making them suitable primarily for viewing from a distance. Today, the pixel pitch of some displays is in the range of .6 mm or smaller, making them comparable in resolution to an LCD display.

Although that shrinking pixel pitch has greatly improved the resolution of the displays it does create challenges that need to be overcome to make them suitable for video applications. Concerns that need to be addressed when using LED displays in video productions include:

- **Adjustable screen brightness**
  For different scenarios, the brightness of screen is needed to adjust to meet requirements.
- **Refresh rate**
  - » **Refresh rate at high brightness** - According to the "10 times refresh" theory, the refresh rate for LED displays needs to be more than 10 times the camera shutter speed for images taken

by the camera to be free of lines and defects. A typical camera has a shutter speed of about 1/200 second, so the refresh rate of an LED display in a broadcast application needs to be greater than 2,000Hz or bright lines will appear in the image.

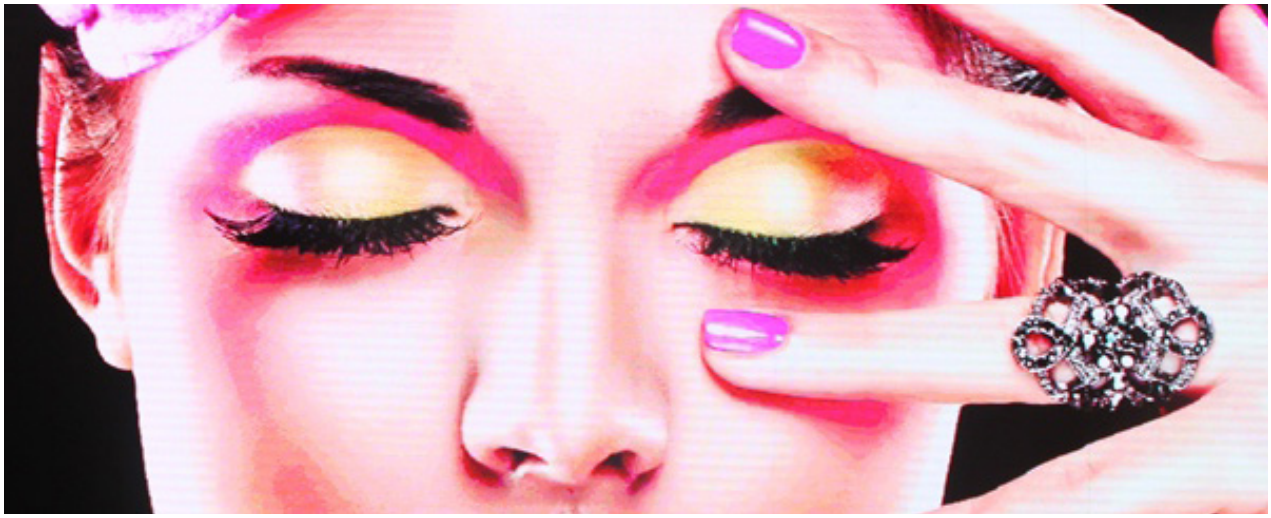
Low refresh rate results in bright lines

» **Refresh rate at low brightness** - Most fine-pitch LED displays today use PWM-based driver chips, which have the characteristics that the refresh rate at low-grayscale levels is lower than that at high-grayscale levels. As a result, when showing a low-grayscale image on the LED screen black streaks appear on the picture taken by the camera, greatly affecting the visual experience.

Low refresh rate causes the scan line problem

- **Grayscale output issues**

  The loss and discontinuity of pixel data at low grayscale levels greatly reduces the smoothness of images, causing them to appear unclear to viewers. There are two causes of this problem. The first is that the grayscale data of the video source is compressed. This leads to a loss of a certain amount of grayscale and is likely to cause blocky images. The second is that the grayscale output bit number of the LED display is too low. Therefore, the jump span of each level at low grayscale is too large, thereby causing discontinuity.



Low grayscale causes the discontinuity problem

- **HDR**

  If the LED display has a higher grayscale output, such as 16 bits, it can decrease discontinuity problems and lead to a better visual performance. Viewers can see more details, especially under low brightness conditions. In addition, when the video source is HDR, an LED displays would

perform better with 16-bit grayscale output and a higher refresh rate. This kind of opulent image quality will bring a photorealistic performance making it well suited for movie backdrop use.

- **Contrast**

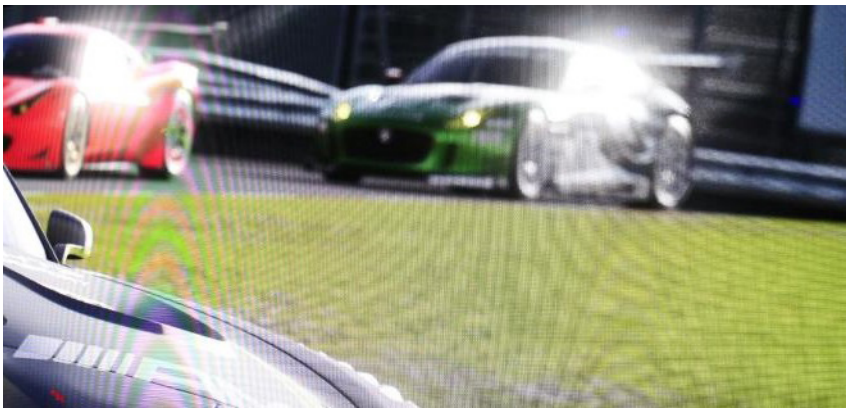
  Insufficient contrast causes a loss of image detail and results in images without multiple layers, similar to a painting without depth and color.

Low contrast, losing image detail

High contrast, remaining image details

- **Moiré**

  Moiré patterns are large-scale interference patterns that can be produced in an image when an opaque ruled pattern with transparent gaps is overlaid on another similar (but not identical) pattern.



Moiré

- **Heat and power consumption**

  LED displays are notorious for using a great deal of energy and generating a large amount of heat that can drive up costs and shorten display life.

Addressing the challenges

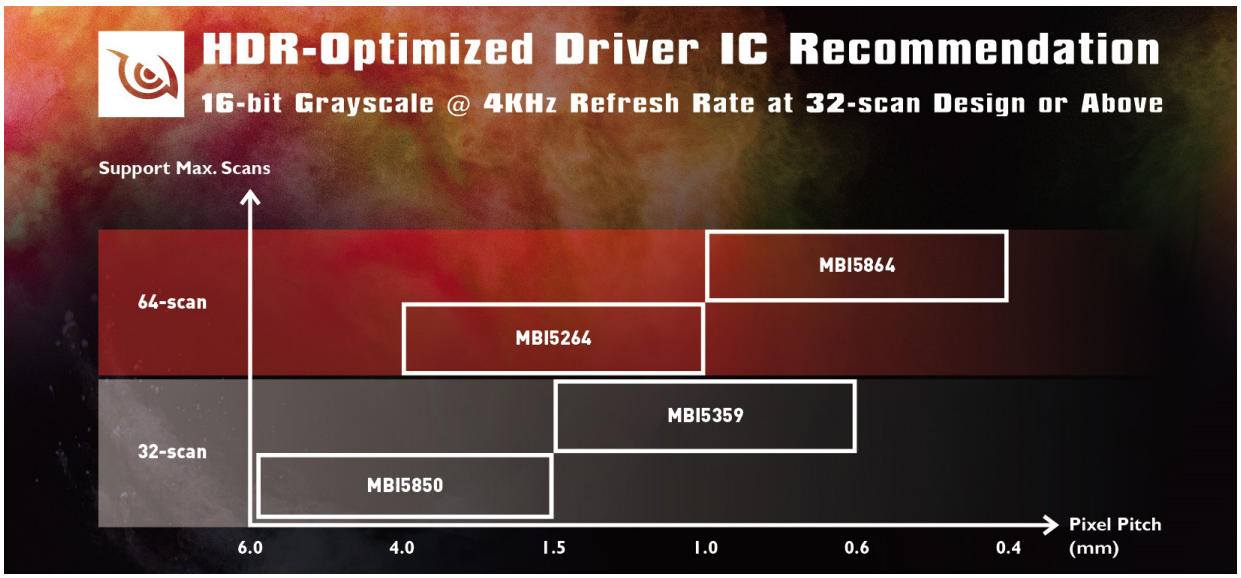
Although the challenges of LED displays can be complicated, they're not insurmountable. Many, in fact, can be addressed by using the right driver ICs, the integrated circuits responsible for creating the image seen on the display.

Taiwan-based technology company Macroblock has created a line of driver ICs that solves many of these challenges, and more. Macroblock provides LED driver ICs for commercial LED display applications including indoor, outdoor, VMS and message signs.

Most Macroblock driver ICs include a "current gain" function for screen brightness adjustment. As we know, LED's brightness is determined by the current. Therefore, lowering or increasing the LED driver current can achieve display brightness adjustment. Because using current gain to adjust brightness has the advantage of not resulting in grayscale loss problems, the current gain function has been widely applied to various LED displays that require brightness adjustment.

For high refresh rate and high grayscale output considerations, Macroblock has a series of driver ICs that can achieve 16-bit grayscale at 4KHz refresh rate at the same time, including its MBI5251 (max. 8-scan design), MBI5850, MBI5359, MBI5264 and MBI5864 driver ICs.

Certain LED drivers from Macroblock include a "Dynamic+ Power Saving" function helps save power when an LED display shows "low gray level" or "low grayscale" content. Depending on the



LED driver IC recommendation

grayscale level of the content, Dynamic+ Power Saving can reduce power consumption by as much as 10 percent when displaying either still images or full-motion content and bring a lower surface temperature.

In addition, the makeup of the LEDs themselves is changing. Over the past decade or so LEDs have typically been manufactured using surface mount technology, with the LED mounted on a hard epoxy layer. That allowed for ever-shrinking pixel pitches and helped drive increased energy efficiency.

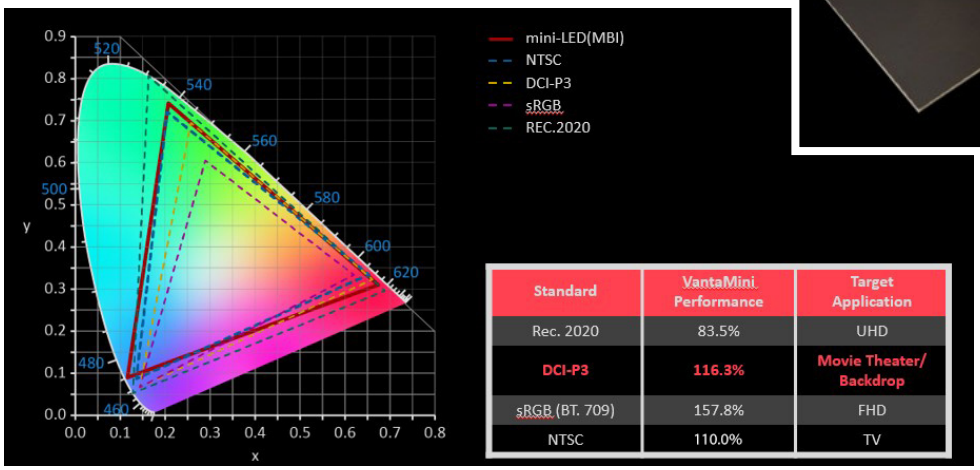
In recent years, though, a new breed of “flip chip” LEDs have begun appearing on the market. Without getting too bogged down in the details, flip-chip LEDs are manufactured using high-precision mass transfer technology and a sophisticated housing process, which offers several advantages over SMD modules. Those include:

- Enhanced shock and vibration resistance
- Superior heat dissipation
- Superior light performance

Macroblock is one of the companies that have introduced a mini-LED module solution leveraging flip-chip technology. Macroblock’s solution, dubbed VantaMini, feature pixel pitches as low as 0.625 mm and offer a higher contrast, overall superior image quality and longer life span than an LED using surface mount technology.

VantaMini

As shown in the graphic below, the VantaMini offers a wider color space compared with traditional displays.



Standard	VantaMini Performance	Target Application
Rec. 2020	83.5%	UHD
DCI-P3	116.3%	Movie Theater/ Backdrop
sRGB (BT. 709)	157.8%	FHD
NTSC	110.0%	TV

In addition, the wider viewing angle of the VantaMini compared with a surface mount design offers a wider viewing angle (170°) that helps avoid color shift.

A glimpse of the future

The goal of any movie or television production is to create worlds that, to the viewer, appears as real as possible.

The use of LED displays in film and television promise to expand the possibilities for creating those worlds, while at the same time lowering costs and shortening production time. Chances are it's just a matter of time before LED displays reshape the entertainment industry.

Solving the moiré issue

One issue that could potentially be addressed with an LED display using flip-chip modules is that of moiré, a problem that occasionally cropped up when filming The Mandalorian. According to comments made in an article appearing in the trade journal FX Guide, the production team occasionally shot the background slightly soft to reduce moiré patterns that might expose the LED wall. Because the background was out of focus, the team often found it necessary to replace it in post-production.

The displays used in filming The Mandalorian featured a pixel pitch of 2.84mm. Because VantaMini uses flip-chip LEDs that are package-free and of a much smaller pixel pitch, they offer the potential to reduce or eliminate moiré issues. That does not mean, however, that the entire LED screen should use the smallest pixel pitch solution. Doing so would increase costs dramatically, and it doesn't make sense when considering viewing distance. For VantaMini, deployers can replace parts of large pixel pitch modules with finer pixel pitch modules for close shots as needed and then restore them as before. This solution brings convenience to movie industry applications and decreases the need for green screens.

Source: Macroblock