Fundamentals of LED Video

Daktronics is recognized worldwide as the leading designer and manufacturer of large-screen LED displays. This booklet is intended to inform the marketplace of LED video display issues and combat false statements made regarding LED video technology. This document provides the facts about LED video technology and the reasons why Daktronics designs and manufactures its displays the way it does ... to provide the greatest value and utility for its customers.
LED Binning
The Facts

During the production process, light emitting diode (LED) manufacturers measure the brightness and color shade of individual LEDs and sort them according to similarity. Consistency in both brightness and color shade are critical when building an LED video display. A variance in either will produce a “grainy” or “pixelated” display image.

What Daktronics Does
The Facts

- Daktronics uses LEDs from leading suppliers with experience in the industry and only from suppliers capable of meeting Daktronics tight brightness and color specifications.

- Daktronics uses more LEDs for large-screen applications than any other manufacturer in the world.

- Daktronics contributes to the research and development efforts of LED suppliers spending significant time at their facilities reviewing processes, communicating market needs and discussing development paths.

Vendors’ Insight

“Daktronics is the #1 user of Nichia light emitting diodes in the LED video display market in America.”
Hideki Kaneguchi
Manager
Nichia Corporation

“Daktronics is an Avago Premiere Partner. Premiere Partners are long-term, high-volume Avago customers.”
Jovani Torres
Regional Manager
Avago (formerly Agilent) Technologies
LED Packaging
The Facts

Different LED types are available for building large-screen video displays. The two main types are through-hole LEDs and surface-mount technology (SMT) LEDs, also known as surface-mount device (SMD) LEDs. Each type is designed for different large-screen video applications.

Through-hole LEDs use a reflector cup and a lens package, that direct light to a specific area, not unlike a flashlight. Surface-mount LEDs do not have a directional reflector cup to focus the light to a specific area. Instead, it disperses light more evenly horizontally and vertically, providing a wider viewing angle when compared to through-hole LEDs. This characteristic makes SMT LEDs an excellent choice for most indoor applications and some outdoor applications with closer viewing distances. SMT LEDs are available in single color and three-in-one red, green and blue (RGB) packages. Three-in-one packages offer an additional benefit over the single color SMT, as it provides superior color blending at closer viewing distances.

What Daktronics Does
The Facts

• Daktronics uses the highest quality through-hole LEDs for most outdoor applications that require the highest brightness LEDs.

• Daktronics uses the highest quality single color and three-in-one SMT LEDs for many indoor applications.

• Daktronics leverages established relationships with LED manufacturers to use the best possible LEDs for each customer’s particular needs.
LED Lifetime
The Facts

The operational lifetime of an LED video display is determined by the lifetime of the light emitting diodes. Technically, a display is said to be at the end of its lifetime when its direct frontal brightness has dropped 50 percent. However, depending on the application, a display may operate in a satisfactory manner for years beyond the 50 percent point.

Three primary factors determine light emitting diode lifetime:

- the LED manufacturing process
- the approach to driving (powering) the LED
- the temperatures present during operation

Increasing the power applied to LEDs increases brightness but reduces lifetime. Increased exposure to higher temperatures shortens the lifetime of LEDs.

What Daktronics Does
The Facts

- Daktronics supplements data from premier LED vendors with in-house testing to formulate lifetime estimates.
- Daktronics optimizes pixel designs to gain maximum brightness without powering the LEDs beyond recommended levels.
- Daktronics provides active ventilation to prevent heat and humidity build-up and the accelerated aging associated with this condition.
Ventilation

The Facts

All electronic devices—including LED displays—require ventilation to maximize reliability and lifespan. The buildup of heat in an LED display will cause electronic components, including LEDs, to age more quickly and fail prematurely. Heat buildup causes accelerated LED aging resulting in a grainy image after time.

There are three primary ways to cool an LED display including heat sinks, forced air ventilation and air conditioning. Heat sinks are used in display designs in which air flow cannot be facilitated. Heat sinks provide the least amount of cooling and cannot reduce temperatures below the ambient temperature. Forced air ventilation provides additional cooling by replacing heated air with cooler air. Air conditioning provides the greatest amount of cooling.

Without forced air ventilation, temperatures inside an LED display cabinet can quickly exceed the recommended maximum for electronic components. The ventilation of displays that are operated for many hours each day is especially important.

What Daktronics Does

The Facts

• All Daktronics LED video displays use fans to force air through the display cabinet to reduce heat build-up.

• Daktronics closely evaluates the display environment and its intended use, to determine if additional ventilation, including air conditioning, is required.

An Analogy

Imagine sitting in a parked car with the windows rolled up on a breezy, sunny summer day. The temperature quickly rises and you become uncomfortable. If you roll down the windows, the breeze blows outside air through the car, cooling it considerably. To make the inside even cooler, you turn on the air conditioner, which forces cool air throughout the car.

LED manufacturers recommend that ventilation be strongly considered in display design.

“Thermal design of the end product is of paramount importance. The designer must consider how to manage heat in order to enhance the performance of the LEDs. If heat management is not considered, the lifetime of the LED will be significantly decreased or the LED will fail.”

Nichia Corporation
Thermal Management of LEDs
LED Application Note
October 31, 2003
www.nichia.co.jp
Factory Calibration
The Facts

LED binning alone is not enough to ensure a uniform (non-grainy) display image. Daktronics goes a step further by performing a proprietary “full-depth” factory calibration of each module during the manufacturing process.

What Daktronics Does
The Facts

- Every individual LED is balanced for uniform brightness (luminance) and color shade (wavelength).
- Each LED pixel (picture element) on each module is calibrated to match the other pixels on the module.
- Every module on every display is balanced for uniform color temperature, also known as white point, to match the other modules in the display.
- Daktronics modules are calibrated in a specially designed chamber to ensure consistency of each LED.
- Daktronics has been refining its calibration processes for nearly a decade, while many companies are just beginning to explore similar calibration methods.

Daktronics fully calibrates each module in a display before it leaves the factory, ensuring a display with a uniform appearance.
Field Calibration

The Facts

As a display ages, LEDs slowly begin to lose brightness. The challenge lies in that LEDs dim at slightly different rates. This difference can, in time, result in a grainy display image.

“Automatic” calibration systems balance only module brightness. They cannot identify or adjust for the differences that occur between individual LEDs over time. Daktronics solves this problem by offering a unique field calibration service at the pixel level that restores a display to its factory uniformity levels. The only way to properly calibrate an aging LED display site is to measure the light output at its actual location in actual use conditions.

What Daktronics Does

The Facts

- Daktronics is the only LED display manufacturer providing this service to the marketplace.
- Daktronics first used this unique process (illustrated below) in 1998 and has perfected it over several years of use.
- Through this unique process, Daktronics restores each LED, pixel and module to original factory uniformity levels.

Simplified Field Calibration Diagram

1. Light sensing device measures precise light output display
2. Data from light sensing device relayed to controller
3. Controller sends calibration instructions to display pixels
Color Depth
The Facts

Grey-scale values (shades of red, blue and green) are the basis for determining the overall color capability of an LED video display. Dimming values, on the other hand, simply indicate the extent to which overall display brightness can be turned down in low light conditions. Color depth (grey-scale values) is a much more important factor than overall display brightness (dimming values) in the quality of images shown on an LED display.

Although unrelated, some manufacturers combine grey-scale values with dimming values (among others) to put what appears on paper to be a more impressive color specification. Combining grey scale and overall dimming values is deceiving. If Daktronics were to use the deceptive practice of combining color depth with overall display dimming, up to 144 quadrillion colors could be claimed. The table below shows the resulting color capability without adding overall display brightness.

What Daktronics Does
The Facts

- Daktronics displays have the capability to show up to 4.4 trillion shades of color with true 14-bit color depth.
- Daktronics products are most often judged to offer superior image quality during side-by-side comparisons.

Color Depth Chart
Grey scale only—does not include overall display dimming

<table>
<thead>
<tr>
<th>Bits per Color</th>
<th>Resulting Shades of Grey (Red, Green, Blue)</th>
<th>Resulting Color Capability</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-bits</td>
<td>256</td>
<td>16.7 million</td>
</tr>
<tr>
<td>10-bits</td>
<td>1,024</td>
<td>1.07 billion</td>
</tr>
<tr>
<td>12-bits</td>
<td>4,096</td>
<td>68.7 billion</td>
</tr>
<tr>
<td>14-bits</td>
<td>16,384</td>
<td>4.4 trillion</td>
</tr>
</tbody>
</table>
Overall Display Dimming
The Facts

For maximum effectiveness, a display must have the capability to adjust brightness levels for correct intensity and high contrast according to ambient light conditions during any time of day. During lower light conditions at night, a display that is too bright due to inadequate adjustment may be worse than a display that is too dim. An overly bright display can be distracting and difficult to read, which can damage market acceptance and result in stricter sign codes.

A good display control system should have multiple dimming control methods including automatic dimming as determined by ambient light conditions, scheduled dimming that can be preset to adjust at scheduled times and manual dimming that instantly adjusts the brightness. Scheduled dimming is required when an auto dimming system must be overridden to meet certain conditions or as sign codes require.

What Daktronics Does
The Facts

- Daktronics provides automatic, scheduled and manual display dimming.

- Daktronics uses a light sensor for automatic display dimming. As ambient light levels go down, the display automatically dims to the proper levels.

- Daktronics control systems offer display operators the ability to quickly and easily change the overall display brightness.

- Daktronics uses five bits of data for 32 different levels of brightness, from nearly off to full brightness (100 percent).
**Display Refresh Rate**

**The Facts**

Refresh rate describes the number of times the display image is updated over the course of one second. If individual LED modules are not updated at exactly the same time, a flickering checkerboard pattern can appear on the display. Modules may appear to bounce back and forth between states of high and low brightness. This is especially apparent when a display is shown on television. Many display manufacturers just increase the refresh rate to mask the difference in brightness between modules less noticeable. Daktronics solves this problem, not by masking, but by refreshing all modules in perfect unison.

**What Daktronics Does**

**The Facts**

- Daktronics LED modules refresh at precisely the same moment, thereby eliminating this problem entirely, creating a consistent “flicker-free” image.

- Daktronics refreshes its video at a rate that provides superior images for fans at the site as well as those watching on television. Synchronized refreshing of images is also very important to advertisers who promote products and services on video displays.
Pixel Designs
The Facts

An LED pixel (picture element) requires a red, a green and a blue light emitting diode (the three primary colors of light) to produce the full-color spectrum. However, some display manufacturers employ a controversial practice of sharing LEDs across multiple pixels to lower manufacturing costs. Display manufacturers selling virtual, dynamic or dual pixels do not provide a red, green and blue LED in every pixel, but instead share the light from a single LED, most often the blue LED, across multiple red and green LEDs.

Most confusing is the fact that these display manufacturers publish pixel spacing and resolution information as if every pixel had a dedicated red, green and blue LED. In reality, it is not rare for one of these displays to have as few as one blue LED for every four red and green LEDs.

What Daktronics Does
The Facts

- Each Daktronics pixel consists of a red, green and blue LED devoted exclusively to that pixel. Daktronics counts only the true number of pixels and does not exaggerate the pixel count (resolution) with virtual pixels.

- Daktronics powers its LEDs at a level that helps increase LED lifetime. It does not overdrive (overpower) individual light emitting diodes in order to share the light output among multiple pixels.

- Because Daktronics processes video signals differently, its LED displays do not suffer from the color problems associated with sharing a single LED between multiple pixels.
High-Definition Content

The Facts

Large-screen video displays are comprised of tiles populated by clusters of red, green and blue light emitting diodes (LEDs). These tiles are then stacked within a frame to form the video display. It is the number of LED clusters—pixels—that determine the resolution of the video display. For instance, it would not be uncommon for an LED video display size of 224 pixels high by 304 pixels wide. This ratio is far from the 720p standard that is 720 pixels high by 1,280 pixels wide or the 1080i standard of 1,080 pixels high by 1,920 pixels wide.

There is a benefit to delivering HD content to virtually any large-screen video display regardless of display resolution. The perceived improvement in image quality will be minimal for smaller screens but worth considering for screens with 250 or more pixels of display height. The image improvement is credited to a number of factors including the manner in which large-screen video display video processors adjust the incoming signal to fit the display and the simple fact that much more image data is available in the signal—more points from which the processor can pull data. While a large-screen video display may not technically be a true HD display in terms of resolution, the availability of an HD feed can substantially elevate the final image quality.

What Daktronics Does

The Facts

- Daktronics control systems are designed to accommodate both SD (standard definition) and HD (high definition) signals.

- Daktronics has installed many systems that incorporate the HD aspect ratio of 16:9 (width to height).

- ProStar® displays that are 250 pixels tall and greater will experience image improvement when displaying HD signal. Displays with pixel length of 320 or greater will also see image improvement when displaying HD signal.
Remote Display Control
The Facts

Several applications, such as a network of billboards, require the ability to run a display from a different location. This is possible with the Daktronics Venus® 7000 controller, which runs multiple displays from any location.

The remote Venus application “talks” to a display through an Internet, network or dial-up connection. Each remote location contains an optional control computer to edit content and an additional computer in a durable, weather-sealed case at the sign location. The main control station sends user-specified information to each remote computer (located at a sign) via the system’s connection.

The best remote connection depends on the display type and individual needs. Because the files sent to full-color displays are very large, they need a high-speed, powerful connection, such as an Internet setup with a cable or DSL modem. Dial-up connections are only a viable option for monochrome displays, as the files for these display types tend to be smaller. ISDN and wireless are other options for full-color display connections.

Daktronics also controls displays remotely for clients from its corporate headquarters. Services can include creating and uploading content and schedules, as well as display monitoring.

What Daktronics Does
The Facts

- Daktronics uses either Internet, network or dial-up connection to remotely control displays.
- Customers may choose to hire Daktronics to control the display on their behalf.
LED Video Industry

The Facts

Since the advent of high-brightness red, green and blue light emitting diodes in the mid 1990s, many firms have entered the large-screen LED video industry, and many have failed after unsuccessful installations. To be successful in the industry, a company must provide dependable displays capable of showing high-quality imagery, control systems that make creation and management of content appropriate for the needs of each particular customer, and ongoing support for the product for many years.

Daktronics Position

The Facts

- Daktronics was founded in 1968 and is focused on large-screen displays and scoreboards using LED technology.
- Daktronics is recognized as the world’s leading designer and manufacturer of large-screen LED video displays by the independent research firm iSuppli Corporation.
- Daktronics LED video displays are manufactured at the company’s facilities in Brookings, S.D., U.S.A.
- Daktronics is a financially stable, publicly traded company that will be around for years to come to support its display systems.
- Daktronics has sold and installed more than 4,300 large-screen LED displays since 1997.