Using DLP® technology for stage-lighting systems

TEXAS INSTRUMENTS

Brandon Seiser
DLP® products
Product Marketing Engineer,
Texas Instruments

Stage-lighting systems have long been used to enhance the audience's experience during a performance, show or sporting event.

However, the inherent drawback with these systems is that they can inhibit a producer's flexibility when designing visual effects because they can only display a small number of patterns. DLP® technology has the ability to transform the stage lighting industry by breaking this barrier.

Designing a stage-lighting system with DLP technology can allow producers to dynamically program any pattern to display. Rather than relying on the physical filters used by current stage-lighting systems, DLP technology employs a programmable microelectromechanical systems (MEMS) device to direct light. This feature will unlock a producer's full creativity when designing visual effects and help deliver immersive, original and thrilling visual effects for the audience.

DLP technology background

Texas Instruments DLP technology is an award-winning MEMS technology that modulates light using a digital micromirror device (DMD). Each DMD can contain millions of independent mirrors, which switch either on or off to control the direction of light. **Figure 1** highlights these mirror movements. When the mirrors are switching in sync with color sequential illumination, DLP technology can create stunningly brilliant displays. DLP technology is used in many projection systems all over the world, ranging from large digital cinema projectors to automotive head-up displays (HUDs).

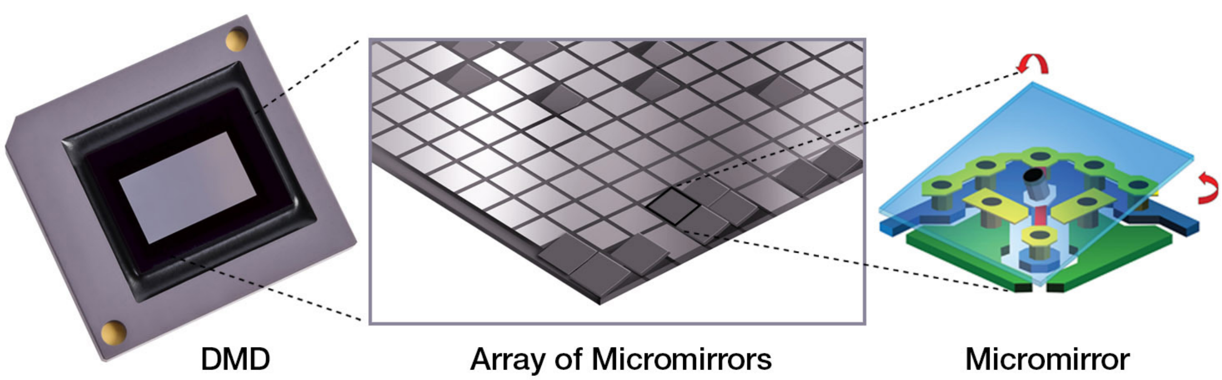

Figure 1. *A DMD can control each of its micromirrors individually.*

Enhancing stage-lighting systems with DLP technology

Current stage-lighting systems, like the system featured in **Figure 2**, can display a small number of stored patterns and have very limited color control.

Figure 2. *Traditional stage-lighting systems.*

Each new displayable pattern may require a special filter called a GOBO, which stands for "goes before the optics." Traditional stage-lighting systems typically place the filters between the illumination source and the optical path. Because each new pattern requires a different GOBO, the system must store these filters and have a mechanical system in place to change filters on demand.

The limited number of displayable patterns with GOBOs and their cumbersome mechanical switching systems have created the need for a new era of stage-lighting systems.

Stage-lighting systems designed with DLP technology can provide a cost-effective solution to these problems. Systems incorporating DLP technology can wirelessly program the DMD to display any image at any time, offering limitless pattern options for visual effects during a performance. When DLP technology-based systems are illuminated with only white light, the system can produce grayscale images and videos.

However, any DLP technology-based system can easily be converted to output full color by adding a color wheel into lamp systems, or by changing the illumination source to direct light-emitting diodes (LEDs) or laser-phosphor illumination source.

Figure 3 is an illustration of an optical path with a color wheel. DLP technology also provides a solution for dynamic image sizing, which can enable stage lighting units to serve multiple purposes during a performance.

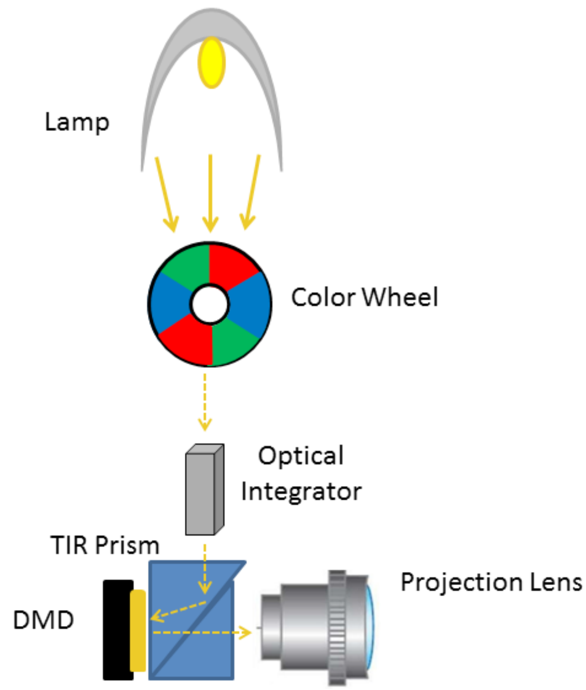

Figure 3. *An example of a color wheel inserted into the system's optical path.*

DLP technology can display new patterns just by repositioning its mirrors. Because all of the switching happens inside the DMD, a stage-lighting system designed with DLP technology eliminates all motors for pattern control. In current systems, each motor requires periodic maintenance and can reduce the system's field deployment length and deployment frequency.

Motor maintenance can become a major cost of owning a stage-lighting system, as some existing systems can have up to two motors per GOBO.

With the ability to display a limitless number of images or full color video and dynamically resize any image, DLP technology enables producers to create cutting-edge visual effects.

System considerations for stage lighting brightness

When selecting a DMD for a stage-lighting system, the most important requirement to consider is system output brightness. System output brightness is related to the thermal load placed on the DMD, and will determine which DMDs can withstand the thermal load of the system illumination source. For example, a 0.95-inch DMD will be able to produce a brighter image than a 0.65-inch DMD because the larger DMD can handle a larger thermal load from the illumination source. Different types of device packages and DMD size are two factors that will impact a DMD's thermal load. After specifying the required thermal load of the DMD, designers can specify other requirements such as aspect ratio and resolution.

Aspect ratio and resolution

Historically, stage-lighting systems were designed to display circular patterns. For circular patterns, selecting a DMD with a 4:3 aspect ratio is more optically efficient than a DMD with a 16:9 aspect ratio, as shown in Figure 4. This means that, for two systems with the same output brightness and image size, a 4:3 aspect ratio will produce a brighter circle than a 16:9 aspect ratio. However, if circles are not the intended display shape, the 16:9 aspect ratio can offer higher-resolution displays.

Resolution is an important factor in the design of a stage-lighting system with DLP technology. Image type and size are important considerations when creating a stage-lighting system with DLP technology because higher resolution allows more detail in a displayed image of the same size. Conversely, as the image size increases, the resolution must also increase to allow that same level of detail. A system meant to project very detailed patterns to the entire stage will require a higher resolution than a system that spotlights only simple shapes or characters.

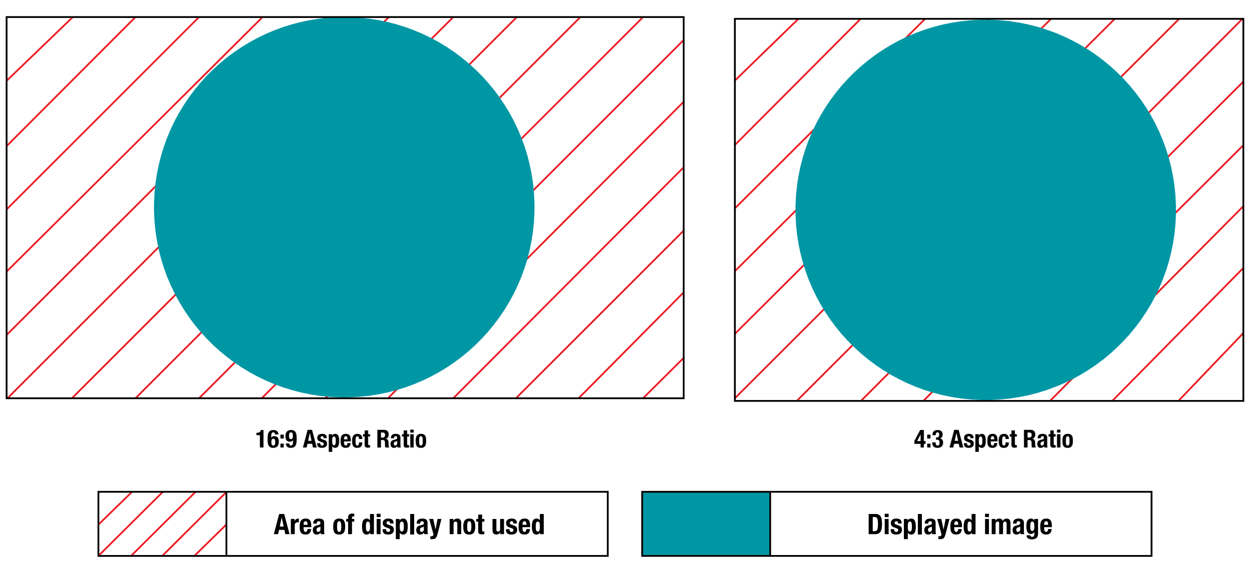

Figure 4. *A circle displayed using 4:3 and 16:9 aspect ratios.*

Physical dimensions

Current stage-lighting systems can be very large, and require special supports hung from the ceiling of the performance hall. To limit system size, a DLP technology-based stage-lighting system needs to keep the size of the DMD in mind, as the diagonal size of the DMD is the main driver of overall system size. This is because as the size of the DMD increases, the size of the optical engine increases proportionally. The optical engine is a major component in a DLP technology-based system and consists of the DMD printed circuit board (PCB), optical path and illumination source.

DLP technology offers different size DMDs that are available in the same resolution. This is due to different pixel sizes. For example, the 0.47-inch 1080p DMD and 0.65-inch 1080p DMD both deliver 1080p resolution, but come in different array diagonals. This gives system designers flexibility when optimizing a DLP technology-based system for physical size without sacrificing display resolution.

Illumination source

DLP technology is illumination source-agnostic, meaning that the DMD is compatible with lamps, LEDs and lasers. This enables designers to strategically select an illumination source to optimize their system for brightness, cost or size.

System elements for stage lighting using DLP technology

There are many elements in a system utilizing DLP technology. Each of the key elements have been highlighted in the list below. Refer to **Figure 5** for a visual representation of these elements in a complete system.

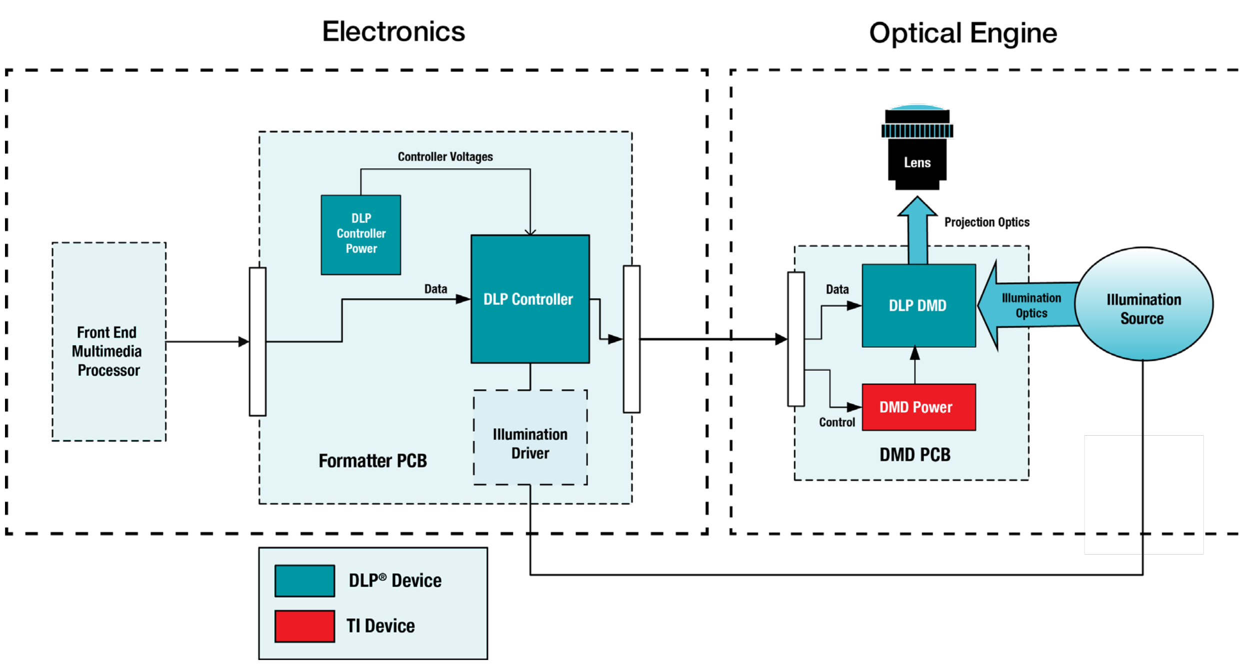

Figure 5. *Typical DLP technology display system block diagram.*

Front-end multimedia processor. The front-end multimedia processor converts incoming data to the correct format for the DLP controller. This unit can also contain customized functionality such as Wi-Fi® or Bluetooth® connectivity to easily send data to the stage-lighting system.

Formatter PCB. The formatter PCB is home to the DLP controller and all of the other required electronics to accept the data from the front-end multimedia processor. The DLP controller converts the data from the front-end multimedia processor and drives a series of images to the DMD to display the desired content. Other components such as the front-end multimedia processor and illumination source driver (and accompanying electronics) may also be located on this board.

DMD PCB. The DMD PCB contains the DMD chip and all required electronics to drive the DMD chipset – including the interface between the DLP controller and DMD chipset to send and receive data. The DMD chip uses the data from the DLP controller to create an image.

Illumination source and optics. In addition to all of these electronics (front-end multimedia processor, formatter PCB and DMD PCB), an illumination source and optical path are required to create a complete DLP display system. The illumination source, optics and DMD PCB are the three major components of an optical engine.

Optical module manufacturers (OMMs) in the DLP Products ecosystem currently create a wide variety of optical engines, which come in many different sizes, use many different DMDs and achieve a large spectrum of brightness levels using different illumination sources.

The availability of optical engines allows end-equipment producers to accelerate a product development cycle without requiring specialized expertise and resources.

DLP chipsets for stage lighting

Table 1 provides a brief overview of several DLP chipsets that can be designed into a stage-lighting system. (See ti.com/dlp to view all DLP chipset offerings.) The brightness estimations are made assuming image-quality requirements for stage lighting and systems optimized for maximum brightness. Over design considerations can be made to optimize a design for any particular specification.

The DLP chipset portfolio can address every segment of the stage lighting market to enhance the visual experience of performances at venues of all sizes. DLP technology allows for maximum design flexibility, enabling innovation in stage lighting. Please see the below resources to learn more about designing a system with DLP technology.

Specifications	0.65-inch Wide XGA (WXGA)	0.65-inch 1080p	0.95-inch Super XGA (SXGA+)	0.95-inch 1080p
Resolution	1280 x 800	1920 x 1080	1400 x 1050	1920 x 1080
Aspect ratio	16:9	16:9	4:3	16:9
Pixel pitch (µm)	10.8	7.6	13.7	10.8
Typical brightness (American National Standards Institute [ANSI] lumens)	1,500-8,000	1,500-8,000	3,000-15,000	3,000-15,000
DMD part number	DLP650LE	DLP650NE	Contact TI	Contact TI
Controller part number	DLPC4422	DLPC4422	DLPC4422	DLPC4422
DMD driver part number	DLPA200	Integrated solution	DLPA200	DLPA200
Power-management integrated circuit (PMIC) part number	DLPA100	DLPA100	DLPA100	DLPA100

Table 1. *DLP chipsets for stage lighting.*

Related websites

- Learn more about DLP technology:

"How to Display Video and Control Light Using TI DLP Technology" video.

DLP Products – getting started.

- Download a design from the TI Designs reference design library to accelerate product development using DLP technology schematics, layout files, bill of materials and test reports:

4K UHD High Brightness Display Reference Design Using TI DLP Technology.

Low-Latency, High-Speed TI DLP Digital Projection Reference Design.

- Get familiar with TI's E2E™ Community DLP Products and MEMS forum to search for solutions, get help, share knowledge, and solve problems with fellow engineers and TI experts.

IMPORTANT NOTICE FOR TI DESIGN INFORMATION AND RESOURCES

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265