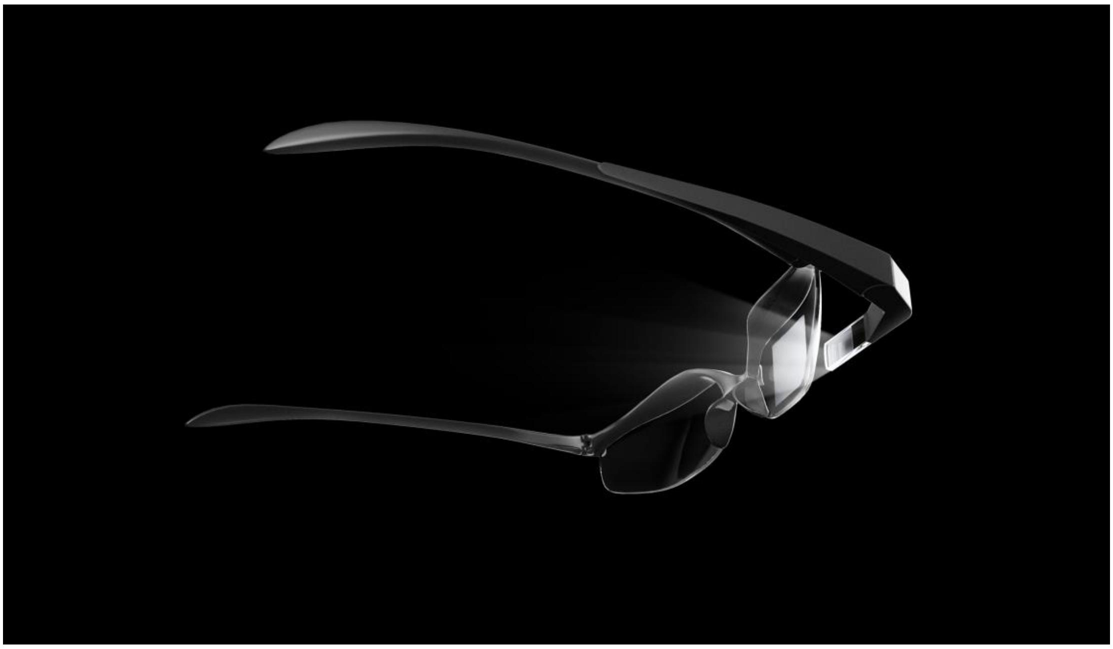
Guide to designing a device incorporating MEMS-based pico projection

By Carlos Lopez



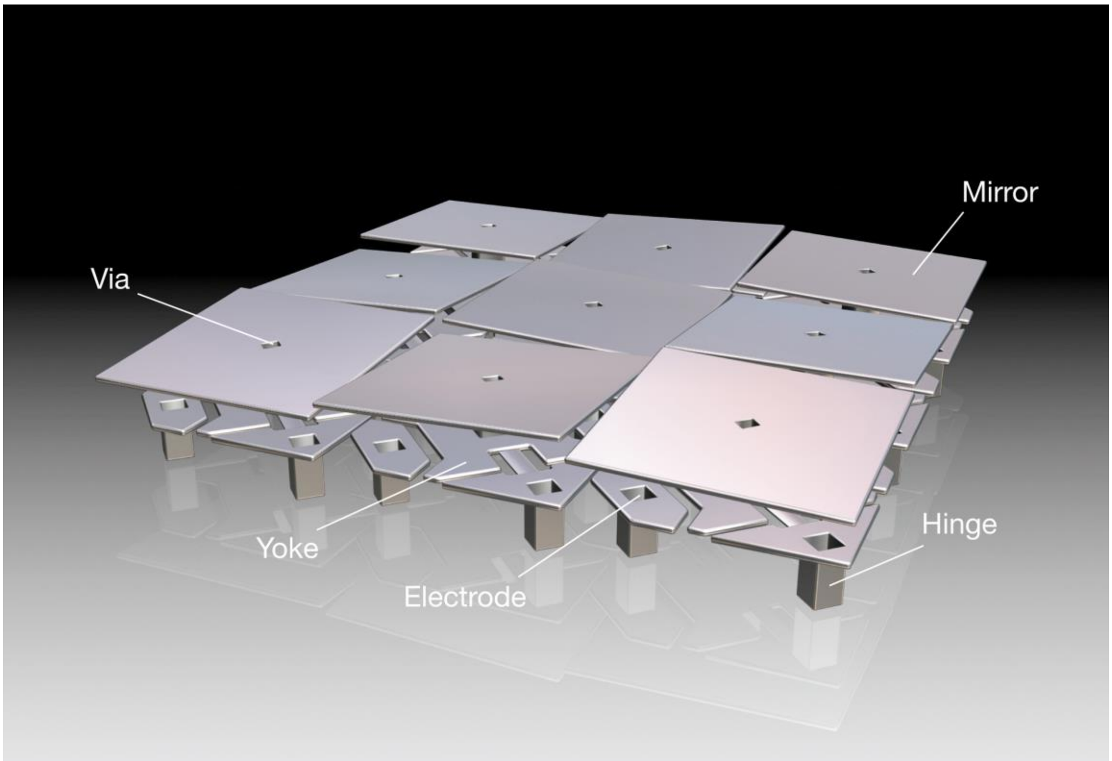
MEMS technology shown enabling a near eye display application

Over the last few years, millions of products incorporating pico projection have shipped, and developers are innovating new applications for this rapidly growing display category. Ideal applications for pico projection include near eye display, interactive digital signage, head mounted display, ultra short throw (UST) TV, standalone portable projectors and embedded projection in smartphones, tablets and laptops. New uses continue to emerge; for example, you might be able imagine a design for a thermostat using a display powered by gesture recognition or interactive touch.

After a developer formulates a unique and effective idea on how to use pico technology in their application, they are faced with several factors to consider. As noted in the block diagram further below, these include selection of display technology, light source, optics and software. A well-chosen combination of these variables can result in an end product with optimal power and light efficiency, capable of delivering large, bright, high-quality images.

Imaging Technology

Designers are faced with imaging technology options, the most important being selection of a device that most efficiently utilizes light. There are two different optical path architectures in the marketplace: transmissive and reflective. Reflective technologies utilize an array of microscopic mirrors to create the image without fundamentally altering the light, in turn maximizing light efficiency (see diagram below).



Reflective MEMS micromirror array

In contrast, other technologies employ transmissive or a hybrid of transmissive and reflective systems, requiring polarization of light to control the intensity of each pixel. Transmissive methods incur significance light loss, thus reducing optical efficiency.

Another consideration for the selection of display technology is the ability to tilt micromirrors. Microelectromechanical systems' (MEMS) superstructures tilt the micromirrors toward or away from the optical path to create each display pixel. Tilting mirrors allow the device to more efficiently capture light without worrying about polarization, resulting in higher brightness at lower system power.

Switching speed is a third sub-consideration for the selection of display technology. For this use-case, the developer should consider a technology that can switch as quickly as possible, as this will allow the design to instantaneously control the light path and color sources for the system. The faster switching speed not only provides better colors but also better image quality, as there is less motion blur, resulting in a better viewing experience. As a point of reference, Texas Instruments DLP® (Digital Light Processing) Pico™ devices can switch each pixel/micromirror up to 3000 times per second.

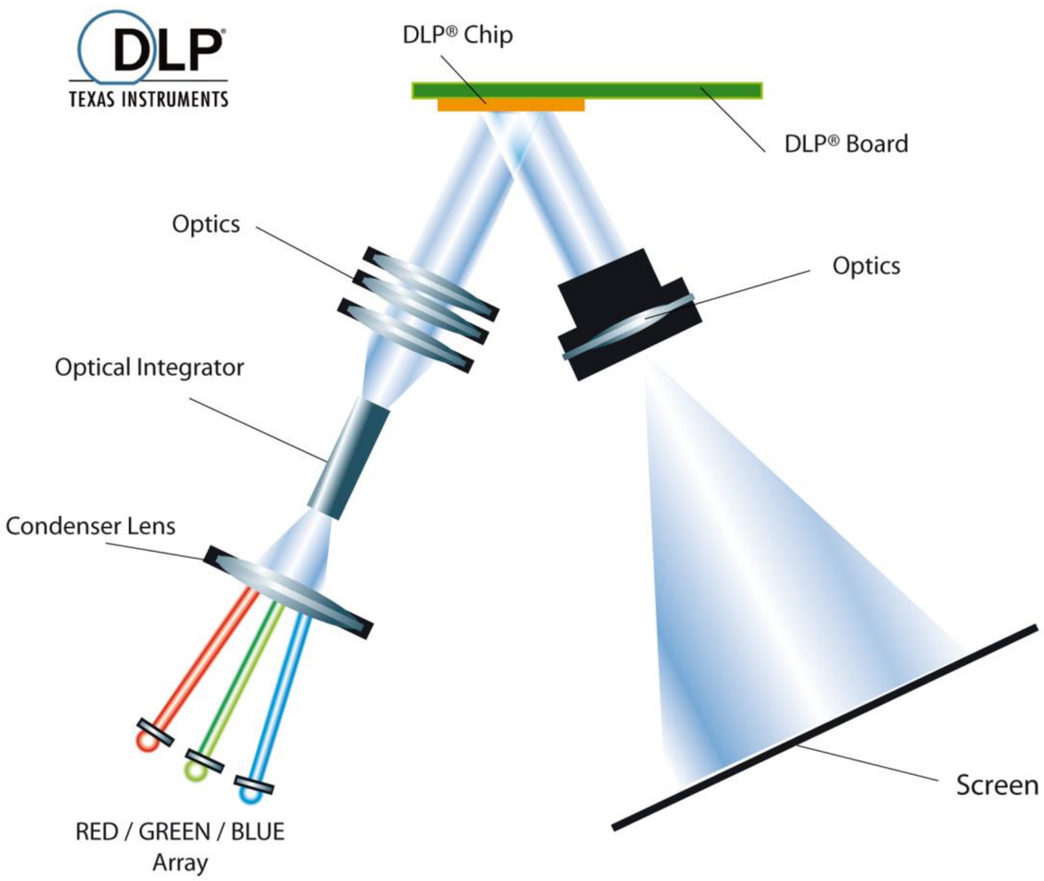
Light Sources

When considering light sources, there are three primary options: lamps, LEDs and lasers.

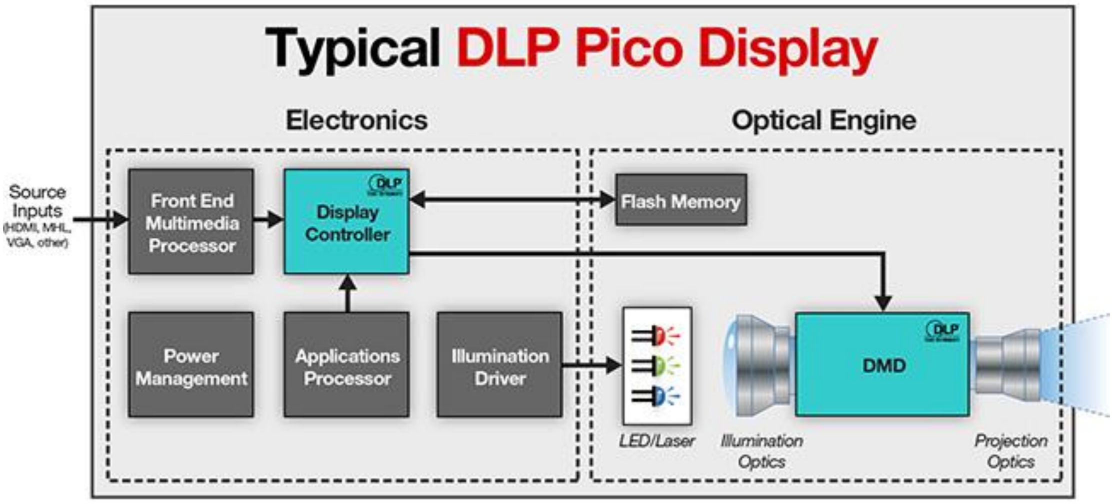
Lamps are commonly used in conference room and home theater projectors, where high lumen levels (1000L to 2000L) are required.

For pico projectors, the most common light sources used are LEDs, specifically individual red, green and blue LEDs. The benefit of LEDs is that they provide the best tradeoff between cost, size, brightness (lumens per watt) and reliability.

Laser illumination has the benefit of high flux density (in lumens) from a small size, as well as highly-saturated colors. Laser illumination is an attractive option for pico projector applications requiring hundreds of lumens and where the cost of lasers can be accommodated.



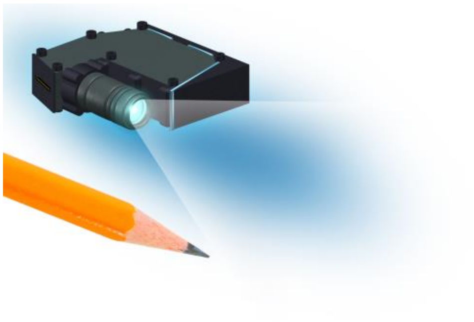
Typical pico display system



Optical Engines

Creating an optical engine design involves numerous trade-offs, each of which has an effect on size, cost and optical efficiency. There is an existing, mature network of Optical Engine Manufacturers (OEMs) that can supply fully-tested, off-the-shelf (OTS) designs for most pico projection applications.

Using an existing OTS design is the fastest way to get to market. If there isn't an OTS design that meets a developer's needs, OEMs are fully capable of creating semi-custom or custom designs.



Typical size of an optical engine

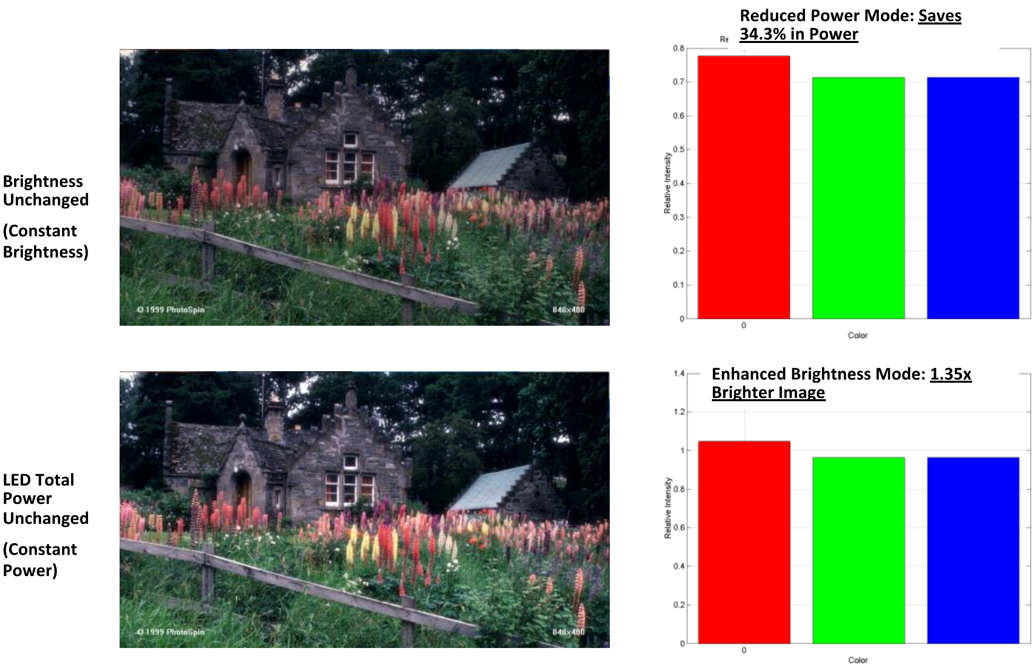
Algorithms to increase battery life, image quality and brightness

For most pico projectors, achieving efficiencies for battery operation is critical. An important aspect of managing power comes through utilizing algorithms to analyze the image on a frame-by-frame basis. By doing so, the intensity of each LED can be optimized for each frame. For example, a blue sky will not need much red and green, while a red sunset won't need much blue and green. This can provide savings in power consumption of up to 50 percent without compromising image quality or brightness, and in many cases actually improves both.

For example, TI's suite of DLP IntelliBright™ algorithms can be tuned by the device manufacturer to intelligently provide the optimal brightness, power consumption and contrast, according to the specific usage of the device.

The first algorithm in the suite is called Content-Adaptive Illumination Control (CAIC). This algorithm operates by adjusting red, green and blue illumination strength on a frame-by-frame basis. The algorithm can be configured to maintain "constant image brightness" (which results in lower power consumption) or to maintain "constant illumination power" (which results in higher image brightness). This enables developers to select their desired amount of brightness boost versus power savings.

CAIC Simulation Examples



The second algorithm is Local Area Brightness Boost (LABB), which identifies 'dark areas' and 'light areas' within a frame. The gain is then adjusted for the darker parts of the image to give a more balanced and realistic picture.

Local Area Brightness Boost Simulations

LABB=enabled *LABB=disabled*

Furthermore, adding an ambient light sensor to a pico projector enables the algorithms to adjust the image brightness to suit varying ambient light conditions. This further maximizes battery life and optimizes the viewing experience.

By exploring these guidelines and pragmatically selecting image technology, light sources, optics and software implementation, developers can create innovative and exciting world-class applications incorporating pico projection.

MEMS shown enabling embedded smartphone projection

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