TI DLP® Pico™ Technology for Smartphone Companion Projectors: A Pocket-sized Big Screen Experience

Texas Instruments

Jesse Richuso
Product Marketing Engineer
DLP® Products

This white paper explains how DLP® Pico technology can help solve the problem of developing a pocket-sized projector with high enough performance to appeal to smart phone and tablet users.

At a glance

1 **Smartphone companion projectors: a big-screen experience, anywhere**
Phone and tablet displays are relatively small, but a small accessory projector can make a big screen for sharing content.

2 **Technological advancements impacting smartphone companion projectors**
The evolution of RGB LED illumination and DLP Pico technology has enabled significant improvement in small projectors.

3 **DLP Pico technology for smartphone companion projectors**
Learn which DLP Pico chipsets are the best fit and how they are integrated into a system.

4 **Smartphone companion projector design and tradeoffs**
Find the right balance between performance, cost, size, and features to enable a successful product.

5 **Product development and supply chain**
From a new custom design to an existing third party solution, there are a variety of ways to develop a new smartphone companion projector.

The combination of widespread high-speed mobile data access and the high adoption rate of smartphones and tablets gives consumers the ability to stream video content easily and quickly. However, the portability of these devices limits their display sizes to a typical range of 4 to 10 inches diagonally, which is not ideal for extended viewing sessions or sharing content with multiple viewers. A pocket-sized solution to this problem is a smartphone companion projector that can create a big picture experience just about anywhere.

Smartphone companion projectors: a big-screen experience, anywhere

A smartphone companion projector, as shown in **Figure 1**, is a small, battery-powered projector that can display content from a mobile device. Smartphone companion projectors are small yet powerful enough to create a large image on a variety of surfaces, enabling people to gather and watch content together.

Figure 1. *Using a smartphone companion projector in a workplace setting.*

Smartphone companion projector benefits

There are three key benefits of smartphone companion projectors:

- **Shared big-picture experiences.** A larger image size enables a more comfortable extended viewing experience. Rather than having to gather around a small phone screen, a projected image enables more viewers to watch and be farther away from the display. While a smartphone screen is typically held at an arm's length or closer, a smartphone companion projector (see **Figure 2**) can create an image size as large as 50 inches diagonally in a dim room, enabling a viewing distance of 6 feet or more from the projection surface.

Figure 2. *An example of a smartphone companion projector.*

- **Portability.** Smartphone companion projectors are typically small enough to easily fit in a pocket or a bag, as shown in **Figure 3**. With such a small form factor, users can bring a big picture experience anywhere they go. Battery-powered smartphone companion projectors enable cable-free viewing experiences when a power outlet is not conveniently located.

Figure 3. *Smartphone companion projectors can act as portable displays for travelers.*

- **Flexible viewing surfaces.** Smartphone companion projectors can use a variety of surfaces as projection screens as long as the surface's color, uniformity and glossiness are acceptable. While the most common viewing surface is an interior wall, as shown in **Figure 4**, ceilings or home exteriors can also be used.

Figure 4. *Enable displays on blank walls with a smartphone companion projector.*

Technological advancements impacting smartphone companion projectors

Two types of technological advancement have improved the features and functionality of smartphone companion projectors: TI DLP® Pico™ technology and red-green-blue (RGB) LED illumination. Both of these types will be discussed in the following sections.

TI DLP Pico technology

With a 5.4-µm micromirror pitch and high optical efficiency, DLP Pico tilt-and-roll pixel (TRP) digital micromirror devices (DMDs) have enabled smaller, lower-power and higher-resolution pico projection systems (see **Figure 5**). The DLP Pico DLPC343x family of controllers, with package sizes as small as 7 mm by 7 mm and features such as **content-adaptive illumination control and local area brightness boost**, enables small printed circuit boards and enhanced performance for low-power applications.

The **DLP230GP** chipset, which includes a 0.23-inch 960 × 540 resolution DMD and a 7-mm-by-7-mm **DLPC3432** controller with a Mobile Industry Processor Interface (MIPI) Display Serial Interface (DSI) input, is particularly well suited for smartphone companion projectors.

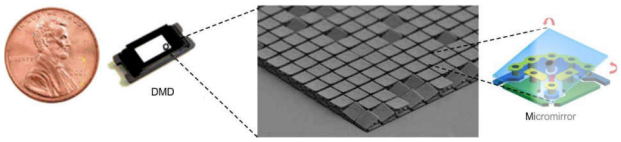

Figure 5. *A DLP Pico DMD.*

RGB LED illumination

Osram and **Luminus** LEDs with close éntendue matches to DLP Pico DMDs enable brighter, more efficient pico projection systems. For example, Osram CSLNM and Luminus SFT-10 1mm2 RGB LEDs match up well (with an f/1.7 illumination design) with TI's DLP230GP 0.23-inch quarter high-definition (qHD) DMD.

A three-channel optical design (with separate RGB LEDs) enables the highest possible optical efficiency for smartphone companion projectors, providing high brightness in products with small size and low power constraints.

DLP Pico technology for smartphone companion projectors

DLP Pico technology enables smartphone companion projectors to achieve the optimal combination of performance, size and battery life. **Table 1** describes five key features of DLP Pico technology and their associated benefits for smartphone companion projectors.

Features	Benefits
High optical efficiency	DLP Pico DMDs contain reflective and polarization-agnostic aluminum micromirrors, which enable bright smartphone companion projectors with relatively low illumination power consumption.
Small size, high resolution	DLP Pico DMDs, with micromirror arrays as small as 0.2 inches in diagonal, create high-resolution displays in mobile accessory form factors.
High contrast	Optical modules designed with DLP Pico DMDs can achieve full on-and-off contrast ratios of over 1000-to-1, depending on system optical design trade-offs. Higher contrast enables projection displays with more vivid colors and darker blacks.
DLP IntelliBright™ algorithms	The DLP IntelliBright image-processing algorithm suite helps optimize image brightness, contrast and power consumption. For more information, see ***TI DLP IntelliBright Algorithms for the DLPC343x Controller***.
Supplier ecosystem	A global supplier ecosystem of **optical module manufacturers**, system integrators and original design manufacturers (ODMs) eases the design process and enables product developers to go to market faster.

Table 1. *Key features of DLP Pico technology and associated benefits for smartphone companion projectors.*

A DLP Pico smartphone companion projector includes a DLP Pico chipset – a three-chip system comprises a DMD, a controller and a power-management integrated circuit (PMIC). **Figure 6** demonstrates the small size of an optical module which includes a DMD, LED illumination, and optical and mechanical components. The controller and PMIC are typically located on a nearby PCB that drives the optical module with illumination power and DMD control signals.

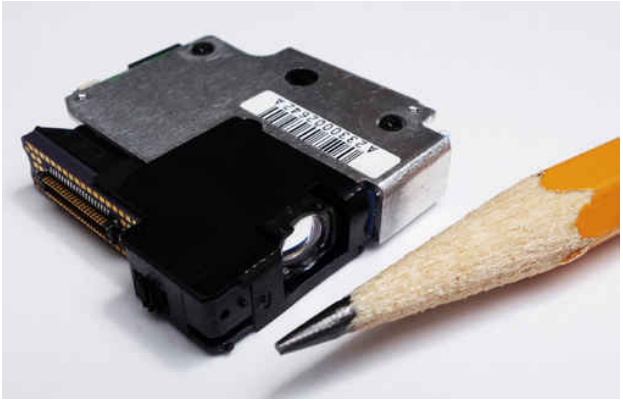

Figure 6. *An ultra-compact DLP2010 (0.2-inch 854 x 480 resolution) optical module with approximate dimensions of 30 mm by 30 mm by 6 mm.*

A 24-bit RGB parallel interface transmits video data, either from an external source or an onboard applications processor, to the DLP Pico controller, as shown in **Figure 7**. The **DLPC3430**, DLPC3432 and **DLPC3433** also support MIPI DSI for video input from mobile applications processors. I2C commands control the functionality of the DLP controller. The DLP PMIC not only manages DMD and controller power, but is also an LED driver for the RGB LEDs in the optical module.

DLP controller software and configuration files are stored in a flash memory chip that is typically included as a part of the optical module, either on a small board attached to the side or on a flex cable.

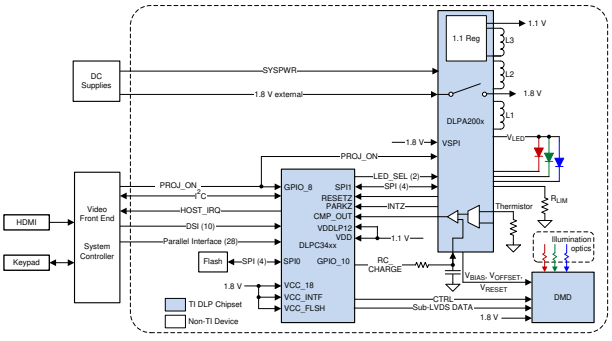

Figure 7. *Typical system block diagram for a basic mobile projector.*

Table 2 lists the various specifications of DLP Pico chipsets for smartphone companion projectors.

DMD Part Number	DLP2010	DLP230GP	DLP3010
Micromirror array diagonal	0.2 inches	0.23 inches	0.3 inches
Resolution	854 × 480	960 × 540	1280 × 720
Typical brightness range	Up to 200 lumens	Up to 300 lumens	Up to 350 lumens
Typical screen size in an office environment (1)	20-30 inches	20-35 inches	25-40 inches
Typical screen size in a dark home environment (1)	40-60 inches	40-70 inches	45-80 inches
DLP IntelliBright algorithms	Yes	Yes	Yes
MIPI DSI input interface supported	Yes	Yes	Yes
Reference design	**Ultra Mobile, Ultra Low Power Display Reference Design Using DLP Technology**	**Ultra Mobile, Low Power DLP Pico qHD Display Reference Design**	**Portable, Low Power HD Display with Increased Brightness Reference Design Using DLP Technology**
Display controller part number	**DLPC3430**	**DLPC3432**	**DLPC3433**
PMIC/LED driver part number	**DLPA2000 DLPA2005 DLPA3000**		

Table 2. *Compare recommended chipsets for smartphone companion projectors.*

(1) Assuming a required projected image brightness of 200 nits for an office environment and 50 nits for a dark home environment.

Smartphone companion projector design and tradeoffs

Several specifications affect the performance and usability of a smartphone companion projector. Optimizing these specifications and understanding the trade-offs between them are critical before starting product development.

Size and weight

A smartphone companion projector should be "pocketable," or at least small enough to easily fit in a bag without the additional weight being significant. The trade-off of a smaller, lighter projection system is typically lower brightness output given the use of smaller DLP chips (shown in **Figure 8**) and LEDs, as well as lower LED power consumption. A mobile accessory should find the right balance between size, weight, and performance. For example, a well-designed thermal management system can help improve brightness and reduce heat without increasing size and weight.

Figure 8. *Three different sizes of DLP Pico DMDs – the smallest has a micromirror array diagonal of 0.2 inches.*

Brightness

A higher brightness projector enables larger projected image sizes. A smartphone companion projector should be bright enough to create at least a 20-inch diagonal image size in a well-lit room and at least a 50-inch diagonal image size in a dark room, which is achievable with a brightness specification of at least 50 lumens. The **trade-offs of higher brightness** are typically increased size, weight and LED power consumption.

Resolution

The number of pixels displayed in the projected image determines the resolution. While higher resolution is generally preferable, lower resolution can still acceptable for video content. Productivity applications such as spreadsheets and presentations with small text typically demand higher resolutions to make smaller details visible. The trade-off of a higher-resolution projection system, all else equal, is higher cost.

Battery life

A smartphone companion projector should be able to operate for at least two hours on battery power, but preferably longer. To extend battery life, a lower brightness mode can be used or a larger battery can be included.

These **projection-specific design considerations** affect the usability and performance of a smartphone companion projector:

- **Throw ratio.** The throw ratio (see **Figure 9**) describes how large of a projected image a projector creates at a given distance from the projection surface. It is defined as the ratio of the distance between the projection lens and the projection surface to the width of the projected image. For smartphone companion projectors, throw ratios typically range from 1.0 (short throw) to 1.5 (standard throw). For example, a throw ratio of 1.5 would create a 2-foot-wide image from 3 feet away. Shorter throw ratios typically result in larger projection lenses and mirrors, and therefore larger overall optical modules.

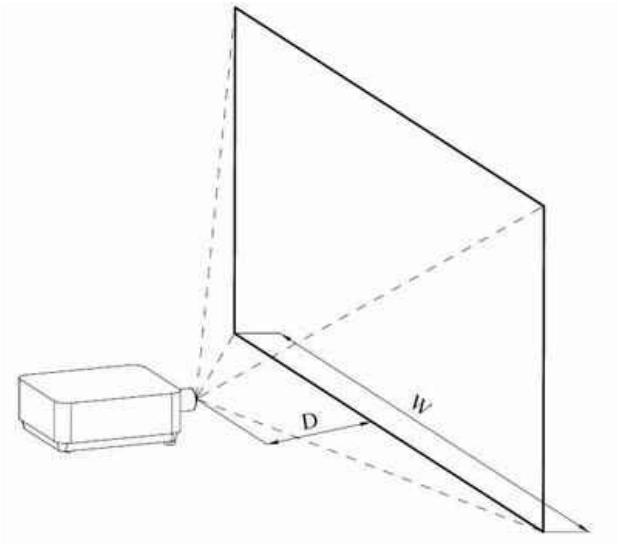

Figure 9. *Throw ratio*

$$\text{Throw ratio} = \frac{\text{d}}{\text{w}} \quad (1)$$

where

- d is the distance from the projector lens to the image
- w is the horizontal width of the image

- **Offset.** Offset (see **Figure 10**) describes the path of the projected light once it exits the projection lens. 0% offset describes a projector that sends light equally up and down after it exits the projection lens. 100% offset describes a projector that sends the top of the image up and keeps the bottom of the image coincident with the projection lens axis. 100% or higher (tilted upwards) offset is most common, because it avoids sending the bottom part of a projected image into the surface on which the projector is resting. However, 0% offset optical designs enable thinner optical designs and the offset can be compensated for with a projector tilt mechanism and digital keystone correction.

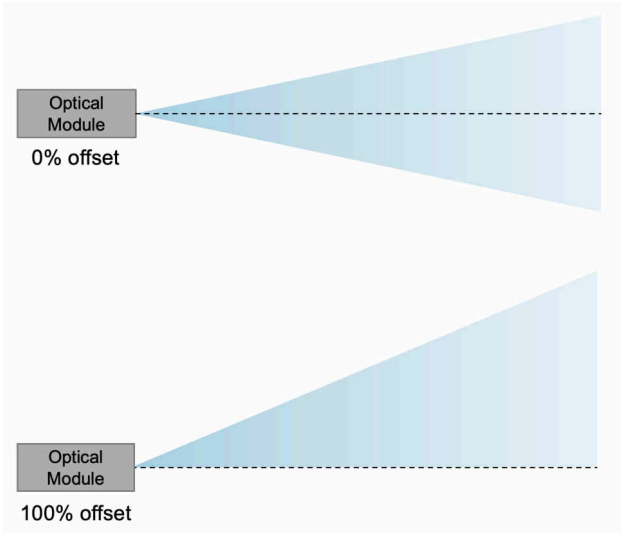

Figure 10. *Comparison of 0% offset and 100% offset.*

- **White point and color temperature.** RGB LEDs produce variable white points and color temperatures (the relative mix of RGB light that creates white and intermediate colors), which optical module manufacturers can adjust and program into different user-adjustable modes (vivid, standard, cinema) in a final product. The brightness specification of an optical module can vary depending on the white point. If color accuracy is a key requirement of the final product, a target white point can be specified to the optical module manufacturer.
- **Thermal management.** A heat spreader or planar copper-fin heat sink is physically sized to achieve a certain brightness specification, given the constraints of the maximum heat load on the DMD, the maximum available illumination drive current and the minimum efficiency of the illumination source. Once the optical module manufacturer's heat-sink solution is known, an appropriate amount of passive or active cooling (such as a fan) can keep the DMD and the illumination source within their respective recommended operating temperature ranges.

- **Focus method.** Adjusting the position of the projection lens will focus a smartphone companion projector at the intended projection surface distance. It is possible to adjust the position manually using a focus mechanism or a stepper motor, or by using an external autofocus solution such as camera or depth-sensing solution in combination with a stepper motor. Although an autofocus solution may provide a better user experience, it costs more to integrate.

Connectivity options

Connectivity between a smartphone companion projector and a mobile device, such a smartphone and tablet, is a key design consideration. Connection methods include:

- Wireless connectivity – Many smartphones, tablets and laptops have wireless connectivity standards that a smartphone companion projector can incorporate. For example, Android phones (see Figure 11) and tablets use Google Cast, while Windows 10 PCs use Miracast.
- Modular attachment – It is possible to design a smartphone with an external electronics interface to enable modular attachments (see **Figure 11**). A modular attachment makes connecting a smartphone companion projector fast and easy, with the potential for convenient features such as automatic power-on and battery power-sharing between the two devices.

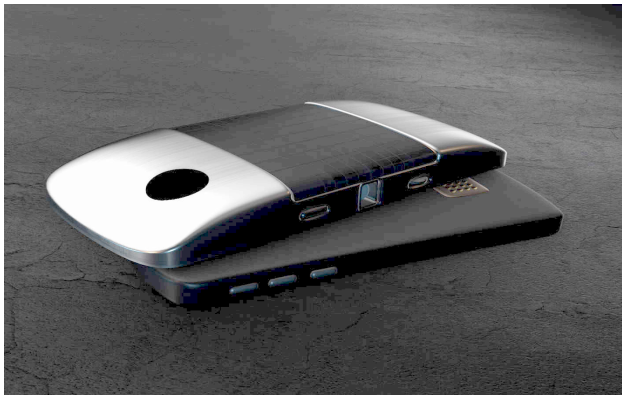

Figure 11. *Modular projector.*

- Built-in cable – If wireless connectivity or a modular connection is not possible, a built-in cable can provide a quick and easy connection to a phone. For example, it is possible to hide a permanently attached USB Type-C® or micro-High-Definition Multimedia Interface (HDMI) cable in a compartment or slot on the side of the product that users can pull out quickly.
- USB Type-C – The USB Type-C interface can deliver both power and data over one cable with a small, reversible connector (see **Figure 12**). A smartphone companion projector with a USB Type-C interface can not only receive video; it can also can receive power from some mobile computing devices, enabling a compact and lightweight battery-free projector design.

Figure 12. *USB-C can support both video and power output to a smartphone companion projector.*

- HDMI – HDMI is the current standard for wired video interfaces and is found on most projectors today. Many mobile computing devices can either directly output HDMI or do so with an adapter. HDMI ports can also accommodate popular streaming sticks, such as Chromecast, Amazon Fire TV or Roku, turning a standard smartphone companion projector into a mobile streaming display.

Product development and supply chain

There are several options when it comes to developing or sourcing a smartphone companion projector product:

- **White-label product from a smartphone companion projector ODM.** A consumer electronics brand seeking to add a product to its portfolio can find a complete system ready for production. An ecosystem of DLP Pico projector ODMs can supply a smartphone companion projector that matches the performance and cost targets of the brand. Limited customization of the product may be available.
- **Custom product from a system integrator.** A smartphone companion projector system integrator can develop a new product from the ground up with customizable features such as audio performance, connectivity and product functionality.
- **Custom product from a system integrator.** A smartphone companion projector system integrator can develop a new product from the ground up with customizable features such as audio performance, connectivity and product functionality.
- **New product design.** For companies that want to design a completely new product themselves, an **optical module manufacturer** can supply an optical module, the core subsystem of a smartphone companion projector. The rest of the product can be designed around it. Learn more about **how to get started with product development.**

Conclusion

Designing a projector that is appealing as a mobile companion to smartphones and tablets is challenging. It requires finding the right balance between performance, battery life, portability, features, and cost.

DLP Pico technology helps make designing a smartphone companion projector easier, with chipsets that enable high performance and low power in a small form factor. In addition, third party optical module and projection system suppliers can help quickly make product concepts become reality.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

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