

TI DLP® Pico™ technology for smart home applications



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Smart home applications and the Internet of Things (IoT) are changing our homes and bringing greater connectivity and intelligence to the devices that we use in day-to-day life. Integrating DLP Pico technology into these products can enhance their effectiveness and usability.

Integration of projection technology in smart home devices and appliances enables interactive, adaptive and reconfigurable interfaces which can replace buttons, tablets, LCD panels and mechanical knobs in virtually every room of the house.

The many separate devices and appliances which create a smart home differ from traditional home labor-saving machines by offering intelligence, connectivity and interactivity. Projection technology adds a powerful and effective way for these devices to present and interact with information using efficient and intuitive touch and gesture interfaces. Smart home applications require display technology that is embeddable, rugged and energy efficient. The projected images must work on varied surfaces such as walls, ceilings, counter tops and appliance surfaces. Brightness, contrast, color and detail must be sufficient to provide clear and pleasing images. Interactive displays and projection space allow for creative and powerful control features. DLP Pico technology provides the features and benefits which can make the smart home a flexible, reliable, and aesthetically pleasing place to live with enhanced functionality, comfort and energy efficiency.

Projection enabled by DLP Pico technology makes possible features such as:

- display on virtually any surface and any shape
- on-demand display
- high optical efficiency
- small form factor and high resolution

What is DLP Pico Technology?

Texas Instruments DLP Pico technology is a microelectro-mechanical systems (MEMS) technology that modulates light using a digital micromirror device (DMD). Each micromirror on a DMD represents a pixel on the screen (**Figure 1**) and is independently modulated, in sync with color sequential illumination, to create stunning displays. TI DLP technology powers the displays of products worldwide, from digital cinema projectors to projectors inside of tablets and smartphones. TI DLP Pico chipsets are a great fit for any display system that requires high resolution and high brightness with low power consumption in a compact size.

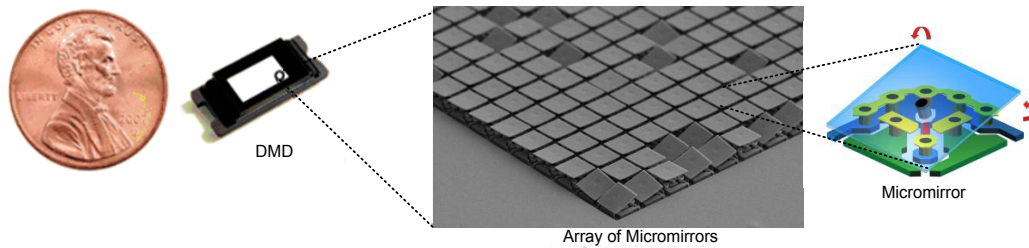


Figure 1. Digital Micromirror Device (DMD)

Technology trends in smart home

The concept of smart home is transforming the realm of home appliances, comfort and environment, monitoring and security, energy usage, entertainment, lighting and aesthetic enhancement. Residents can optimize home operations for daily/weekly schedules, energy usage (including seasonal and current weather), time of day, and security. Entertainment, information, lighting and aesthetics are also expanded and enriched through new capabilities. Remote monitoring and control of household functions is possible from anywhere in the world. Elderly and disabled persons benefit especially from the smart home by easier management of daily tasks and through enhanced nonintrusive monitoring and alerting.

It is noticeable that the primary driving factors of the growth and desirability of smart home applications vary by region. In Europe, the focus is on energy efficiency and home comfort. In North America the emphasis has been on utility, comfort and security. Smart home applications in Japan have promised enhancements to a safe and secure living environment, while also featuring discrete monitoring for an elderly population. In the rest of the world, smart home concepts help bridge the divide from non-developed or antiquated infrastructure to homes of the future. One example of this is the Smart Cities initiative in India.

Across the world it appears that multiple commercial players and government entities are driving the

smart home revolution. In the early stages the focus was primarily on energy management. Now the developments encompass security, utility and comfort as well.

Technology developments in several areas give momentum to the spread of smart home concepts and applications. Global connectivity is enabling the “Internet of Things” (IoT) which is essential for these smart home applications, indeed forming the foundation for the smart home. Continuing this trend, projection technology can make smart home devices easier to use and enhance their effectiveness.

Role of projection technology in smart home

Traditionally, projection technology has served as the heart of a home theater installation. However, the smart home offers many more opportunities for projection technology to be used in novel roles.

Life style: projection used for improvement in lifestyle, home ambience

Smart home products may be aesthetically designed to fit with the home decoration and its furnishings. There is potential for a wide diversity of product concepts catering to the taste, style and culture of the owners and occupants of a smart home. There are already several examples of this trend, such as a light bulb with an embedded projector which fits a standard light socket, or a projector as part of a track light.



Figure 2. DLP projection enhances lifestyle

This type of projection-based lighting products offer several interesting use possibilities (Figure 2):

- Table lamp — content from personal devices like a smart phone can be shared.
- Light fixture — create special effects for various themes and moods.
- Framed picture — replace static picture with dynamic content.
- Child's room — provide soothing effects to calm an infant, or visual content to engage the child's attention, and even enhance education.

Smart home application developers incorporating projection displays can innovate and bring new, useful, and interesting products to market.

Control and monitoring: Projection as integral part of home security and control devices

An ultra-short throw* projection display (Figure 3) can provide an “on-demand” interactive control panel that can be used to monitor and configure smart home functions and devices. The projection-based panel can be reconfigurable and adaptive.

* An ultra-short throw projection display can provide a large image from a close distance (example: 15 inch wide display from a distance of 3-5 inches).

Integrating a projection device into a home monitoring product can bring about a paradigm shift in how such devices are used. An on-demand display-based human interface can enhance both the usability and the effectiveness of these devices.

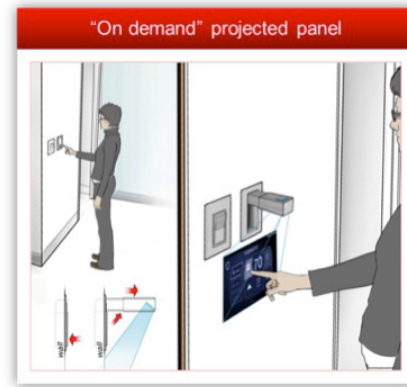


Figure 3. “On demand” projected panel

- A projection display can communicate wirelessly with a home climate control system (Figure 4) to display system status and provide control functions, show the temperature and humidity in any room, and provide local weather conditions and forecasts.
- A home security system can communicate with a display and warn about open doors or windows, or other security conditions (Figure 4).



Figure 4. Climate control system status and alarms

Utility and Appliances : Projection technology improves the utility of kitchen and household appliances

Smart kitchen, or connected kitchen, is a new and fast growing category. Several product concepts have been announced by the industry that use projection technology to produce an interactive display on a cooking surface or kitchen worktop. An example is a recipe reference which provides serving size calculations and online ingredient guides (**Figure 5**).



Figure 5. On the kitchen

Appliances

Similarly other kitchen or home appliances can benefit from the addition of projection functionality.



Figure 6. Dish washer

- Dish washer displays its status and any messages on the floor, while all controls are hidden (**Figure 6**).
- A microwave or oven displays a picture of the food being cooked on the front glass, along with any messages or warnings.

Why choose DLP technology?

Feature	Design benefit
Superior image quality	<ul style="list-style-type: none"> • High contrast and color gamut provides the most vibrant images • Film-like image; High fill factor (> 90%)
Flexibility and scalability	<ul style="list-style-type: none"> • Short and ultra short throw capable, any size, any surface, any resolution • Small and Compact optical engines can be integrated into appliances without compromising size and aesthetics. • Virtually any shape
High optical efficiency	<ul style="list-style-type: none"> • Low power for high brightness systems and minimal thermal design • Small and compact optical engines
Ecosystem	<ul style="list-style-type: none"> • Extensive supply chain, 3rd party optical modules and system integrators

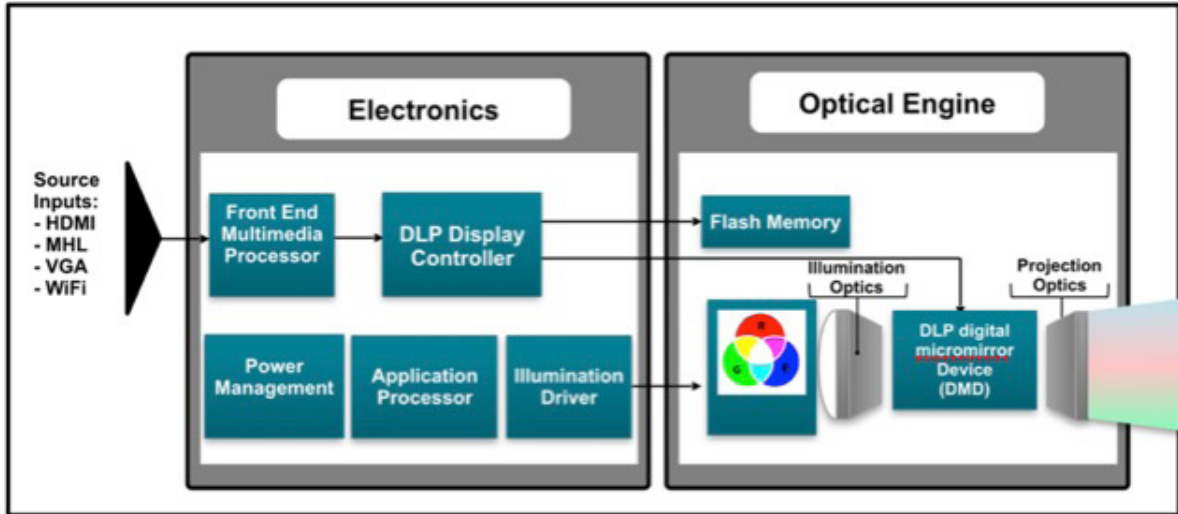


Figure 7. Block diagram of a typical DLP Pico display system

System and electronic considerations for smart home

Figure 7 shows the block diagram of a typical DLP projection system. There are two main partitions which provide the projection functionalities.

The electronics partition contains the DLP controller chip, a power management block, and the illumination driver chip. It may also have an application processor and a front end interface processor. In addition to managing the projection system, the application processor could also support gesture control, interactivity, or other features.

The optical partition contains the DLP DMD, the illumination devices (usually LEDs), the optical elements (lenses, filters, and so forth), and the associated mechanical components. These components are integrated into a compact and rugged assembly known altogether as an optical engine. The size and form factor of the optical engine depends on specifications such as resolution, brightness, throw ratio, as well as other design factors. Optical engines are available from [online suppliers](#) and manufacturers who make up the DLP Pico ecosystem.

DLP Pico ecosystems

Developers can leverage the extensive network of third-parties supporting the [DLP Pico ecosystem](#). Depending on their requirements, they can engage with a design house to build a custom projection system, buy an optical engine from an optical engine supplier (OEM) or source a finished projection subsystem from a system integrator.

Unique requirements for smart home

Projection surface

A surface may not be *ideal* for projection due to its color, pattern, or surface curvature (for example, kitchen counter tops or wall paper). This problem can be overcome by additional brightness and algorithms to compensate for surface geometry, color and pattern.

Retrofitting

Often, equipment needs to be retrofitted into an existing location and wiring environment. The projection surface may not be naturally aligned with the projection lens. This problem can be addressed through keystone correction and zoom functions. A tilt-and-roll adjustment for the projection module can also be helpful.

Size and form factor

The required size and form factor are another system design consideration. Projection modules need to integrate into existing appliances while maintaining an aesthetic appearance. The size of the optical engine depends primarily on its brightness, resolution, and throw ratio. The DLP Pico optical engine can be compact enough to be integrated into a smart phone or tablet, so that it need not compromise the form factor or design aesthetics of any appliance. At the other end of the spectrum, they can light up a 100-inch wide surface with a vivid image.

Design considerations

The specification for the projector will depend on several factors like the desired image size, the type of the display surface, the form factor required for integration into the end equipment and the distance between the projection unit and the display surface. The final specification may involve trade-offs among the following key requirements:

Brightness

The total lumens of output from the projector will depend on the desired size of the image and the ambient light condition. If the projection surface has some color or patterns (a kitchen counter top, for example) it may be necessary to increase the brightness by an additional 20-30%. **Table 1** provides suggested brightness values for the projector based on [image size and different ambient light conditions](#).

Resolution

The required resolution depends primarily on the content or information to be displayed. A 720p (1280x720) or 1080p (1920x1080) resolution may be preferred if content is a picture or video. A WVGA (854 x480) or 720p resolution is adequate for the display of generic information like text messages and graphic symbols.

Image diagonal (inches)	Suggested projector light output (lumens)			DLP Pico DMD diagonal size (inches) and part number suggestions
	Dark room (50 nits)	Dim room (100 nits)	Well-lit room (200 nits)	
80-100"	300-450	550-900	1100-1750	>0.5" Class (DLP Enterprise Solution)
60-80"	150-300	350-550	650-1100	0.45"-0.47" Class DLP4501 or DLP4710
50-60"	110-150	250-350	450-650	0.3" Class DLP3010
40-50"	80-110	150-250	300-450	0.2" Class DLP2010
30-40"	40-80	80-150	150-300	
20-30"	20-40	40-80	80-150	
10-20"	5-20	10-40	20-80	
5-10"	<10	<10	<20	

Ambient lighting environment and suggested image brightness intensity in nits. 1 nit = 1 cd/m²

Table 1. Display diagonal vs suggested projector light output (lumens)

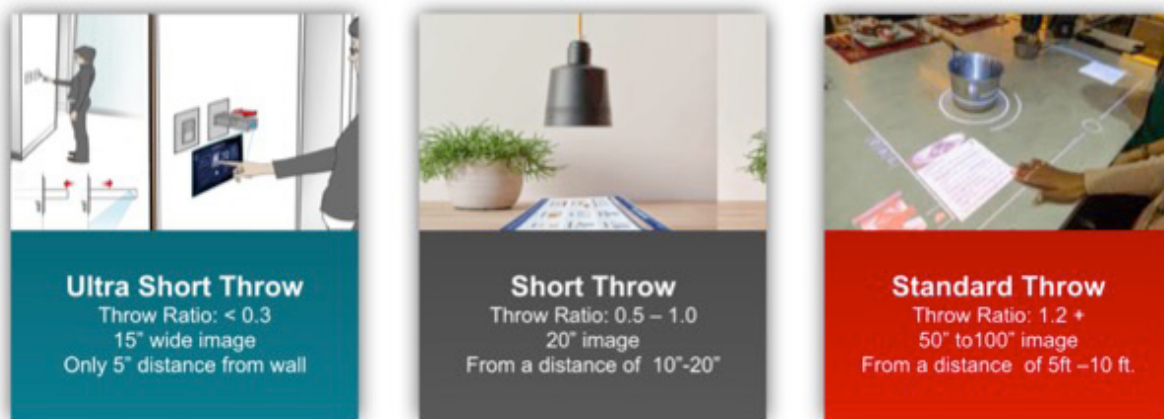


Figure 8. Different throw ratios offer different possibilities

Throw ratio

A projector's throw ratio is defined by the ratio of the distance between the projection lens and the screen to the width of the projected image. The required throw ratio depends on the appliance and the allowable space.

Size and Form factor

The size and form factor of a projection system is critical for fitting into standard home appliances and devices. DLP Pico chipsets have been designed to enable a very compact and small projection engine. In addition, the high brightness efficiency of DLP technology enables a very bright projector in a very small form factor.

Zoom

Variable image size capability (zoom) may be required when the projection function has to be retrofitted into existing fixtures such as a light track or home monitoring devices. It will help to resize the image for a given distance to the projection surface for projection. There are three commonly used broad categories of projector based on throw ratio: standard throw (1.0 -1.6); short throw (0.5 - 1.0); and ultra-short throw (<math>< 0.5</math>). **Figure 8** illustrates use cases for various throw ratios.

Value added features

There are several features which can enhance the effectiveness of a projection display and add value to the appliance or device into which it is incorporated.

Interactivity

Interactivity is a critical component of the use interface of a product. Depending on the end user and the specific use case, a simple gesture control may suffice, or a highly accurate multitouch capability may be required. There are multiple candidate technologies which can be integrated with projection systems to provide an effective user interface.

Table 2 provides a high level comparison of some of the leading interactive technologies.

For a majority of use cases, time of flight technology may be a sufficient fit for smart home applications. For cost sensitive appliances which can utilize a simpler gesture interface, a low cost solution based on ultrasound or IR may be preferred. However, when a high precision gesture and touch sensitive interface is required, a multi-touch solution based on an IR laser curtain may be necessary.

	Stereo vision	Structured light		Time of flight
		Fixed pattern	Programmable pattern	
Cost	Low	Mid-high	High	Medium
Depth accuracy	Low (mm-cm)	Mid-high (mm-cm)	High ($\mu\text{m-cm}$)	Medium (mm-cm)
Response time	Medium (limited by S/W)	Slow (limited by camera speed)	Slow (Limited by camera speed)	Fast (limited by sensor speed)
Distance range	Mid-range	Short to Mid-range (depends on illumination power)	Short to Mid-range (depends on illumination power)	Short to long range (depend on laser/ led power power)
Low light performance	Weak	Good	Good	Good
Bright light performance	Good	Weak/fair	Weak/fair	Good
Software Complexity	High	Low/medium	Medium	Low

Table 2. Comparison of interactive technologies

Keystone correction

Often the space constraints of a projection system prevent the centering and alignment of the projector with respect to the projection surface, resulting in a geometric distortion which resembles a keystone. Keystone correction compensates for this distortion, and allows for the design of a more compact device or appliance. Most projectors have a vertical keystone correction capability to correct for a projector that is not centered in the vertical plane. However, when a projector cannot be centered in the horizontal plane, horizontal keystone correction may be desired as well.

Projection Surface correction

In some cases the desired display surface may have irregular surface geometry (contouring). Advanced

image processing capabilities enable the correction of the projected image to compensate for this contouring and appear undistorted. Similarly, adaptive corrections for surface color and pattern can significantly enhance the effectiveness of the projection function in smart home applications.

DLP chipsets for smart home applications

Texas Instruments offers DLP projection chips of different sizes and resolutions to suit different display sizes, brightness requirements, and pixel densities (resolution). **Table 3** shows the available DLP chipsets. Each DMD requires the matching controller chip and power management IC (PMIC) to complete the chipset.

DMD part number	DLP2000	DLP2010	DLP230GP	DLP230KP	DLP230NP	DLP3010	DLP3310	DLP4710
Micromirror array diagonal size (inches)	0.20"	0.21"	0.23"	0.23"	0.23"	0.31"	0.33"	0.47"
Display resolution	640x360 nHD	854x480 WVGA	960x540 qHD	1280x720 720 p	1920x1080 1080 p	1280x720 720 p	1920x1080 1080 p	1920x1080 1080 p
Micromirror pitch	7.6 µm	5.4 µm	5.4 µm	5.4 µm	5.4 µm	5.4 µm	5.4 µm	5.4 µm
Micromirror orientation	Square	Square	Square	Square	Square	Square	Square	Square
Typical brightness (lumens)	Up to 50	Up to 150	Up to 200	Up to 200	Up to 200	Up to 300	Up to 400	Up to 1500
Typical image diagonal size	Up to 30"	Up to 50"	Up to 60"	Up to 60"	Up to 60"	Up to 80"	Up to 80"	Up to 140"
Typical illumination power consumption	1-3 W	1-10 W	1-10 W	1-10 W	1-10 W	1-20 W	10-30 W	20-120 W
Optical modules in production	Yes	Yes	Coming Soon	Yes	Coming Soon	Yes	Yes	Yes
Controller GPN	DLPC2607	DLPC3430 DLPC3435	DLPC3432	DLPC3434	DLPC3436	DLPC3433 DLPC3438	DLPC3437 2 required	DLPC3439 2 required
Frame refresh rate	Up to 60 Hz	Up to 240 Hz	120 Hz	60 Hz	60 Hz	Up to 120 Hz	Up to 60 Hz	Up to 60 Hz
DLP IntelliBright™ Algorithms*	—	•	•	•	•	•	•	•
Keystone correction (1D vertical)	—	•	•	•	•	•	•	—
Evaluation module (EVM)	Order on TI.com	Order on TI.com	—	—	—	Order on TI.com	Order on TI.com	Order on TI.com
TI reference design	TIDA-01473	TIDA-00325	TIDA-080002	—	—	TIDA-01571	TIDA-080000	TIDA-01226
PMIC GPN								
DLPA1000 (up to 1 A)	•	—	—	—	—	—	—	—
DLPA2000 (up to 750 mA)	—	•	•	•	•	•	—	—
DLPA2005 (up to 2.4 A)	—	•	•	•	•	•	—	—
DLPA3000 (up to 6 A)	—	•	•	•	•	•	•	•
DLPA3005 (up to 16 A)	—	—	—	—	—	—	—	•

Table 3. DLP Pico display chipset portfolio and EVMs (tools)

*Texas Instruments DLP® IntelliBright™ technology is a suite of image processing algorithms designed to intelligently manage brightness, contrast, and power consumption.

Next steps

1. Learn more about DLP Pico technology:
 - a. Getting started with TI DLP Display Technology: <http://www.ti.com/lit/pdf/dlpa059>
 - b. Products and datasheets: <http://www.ti.com/dlp-chip/display-and-projection/pico-chipsets/products.html>
2. Evaluate DLP Pico technology with an easy to use evaluation module (EVM):
 - a. DLP2000 EVM: <http://www.ti.com/tool/dlpdlcr2000evm>
 - b. DLP2010 EVM: <http://www.ti.com/tool/dlpdlcr2010evm>
 - c. DLP3010 EVM: <http://www.ti.com/tool/dlpdlcr3010evm-g2>
 - d. DLP3310 EVM: <http://www.ti.com/tool/dlpdlcr3310evm>
 - e. DLP4500 EVM: <http://www.ti.com/tool/dlpc6401displayevm>
 - f. DLP4710 EVM: <http://www.ti.com/tool/dlpdlcr4710evm>
3. Download a reference design to speed product development using DLP Pico schematics, layout files, BOM and test reports.
 - a. DLP2010: [Ultra Mobile, Ultra Low Power, Low Power Display using DLP® Technology](#)
 - b. DLP230GP: [Ultra Mobile, Low Power DLP Pico qHD Display Reference Design](#)
 - c. DLP3010: [Portable, Low Power HD Projection Display using DLP® Technology](#)
 - d. DLP3310: [Mobile 1080p display reference design using DLP® 0.33 inch micromirror array](#)
 - e. DLP4710: [Portable, Low Power Full HD Projection Display using DLP® Technology](#)
4. Optical Modules and design support:
 - a. Contact ODMs for production-ready optical modules:
<http://www.ti.com/dlp-chip/display-and-projection/pico-chipsets/buy-optical-engine/optical-module.html>
 - b. Contact Design Houses for custom solutions:
<http://www.ti.com/dlp-chip/display-and-projection/pico-chipsets/buy-optical-engine/design-houses.html>
 - c. Buy production ready optical modules online:
<http://www.ti.com/dlp-chip/display-and-projection/pico-chipsets/buy-optical-engine/optical-module.html>
5. Contact your local TI salesperson or TI distributor representative: www.ti.com/general/docs/contact.tsp
6. Check out TI's E2E community to search for solutions, get help, share knowledge and solve problems with fellow engineers and TI experts: <http://e2e.ti.com/support/dlp>

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