DLP® Pico™ technology for smart speaker displays

TEXAS INSTRUMENTS

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Smart speakers are becoming a common fixture in households worldwide as consumers continue to adopt IoT solutions to leverage the connected world. With on-demand virtual assistant capability and quality audio performance, incorporating display functionality is a logical next step for these "out all of the time" devices.

However, displaying visual content in a small speaker can be a challenge. It can be difficult to package tablet-to-small-TV-size displays into compact, aesthetically pleasing form factors, but TI DLP Pico technology offers large projection displays from small devices.

The advent of smart speakers

Smart speakers were originally designed as wireless audio playback devices with several types of connectivity. They now come in many shapes and portable sizes, with different levels of audio performance. The defining feature of a smart speaker is a user's ability to give voice commands and get a response from a virtual assistant. Furthermore, smart speakers can communicate with other appliances in the home, positioning the device as a hub for home automation, as well as an always-on/on-demand source of information.

The market for smart speakers and smart displays is estimated to continue its high growth trajectory. Juniper Research predicts that devices like the Amazon Echo, Google Home, Apple HomePod and Sonos One will be installed in a majority of U.S. households by the year 2022. They add that 70 million households will have at least one of these smart speakers, with the total number of installed devices topping 175 million. Although other consumer products like TVs, automobiles, phones and tablets will continue to incorporate virtual assistant technology, the desire to have an "always-on" device positioned in the home is one primary growth driver.

The role of display projection in smart speakers

Adding a display to a smart speaker is a natural extension of its functionality. Similar to how center console displays are proliferating in automotive environments, consumers will benefit from a similar visual experience in a home information/entertainment device. Currently, the way users request content from a smart speaker differs

Figure 1. *50-cc optical engine size examples.*

from their interaction with a smartphone or tablet. Since voice commands are the primary mode of requesting content from a smart speaker, a simplified user interface is needed to efficiently communicate results. Displayed images need to be simple, with minimal need for touch interaction, while also providing an image large enough to be viewable from a distance.

Smart displays will likely be located near high-traffic areas such as the kitchen or family room and should be aesthetically pleasing while looking nonintrusive. Incorporating tablet-size flat-panel displays (approximiately 7 to 10 inches) adds to clutter and limits where consumers can put their smart speaker. However, the ability for pico projection to generate a large image from a small device and turn any surface into a display addresses these challenges. Imagine being able to generate a crisp and stunning 20- to 40-inch image from an optical module approximately 45 mm by 75 mm by 15 mm (just over 50 cc), as the examples show in **Figure 1**.

Furthermore, pico projection offers several options:

- Ultra-short throw projection.
- Standard throw projection.
- Surface projection.
- Free-form projection.
- Interactivity.

These options offer flexibility in the type of surface used for a smart display, and smart displays can even be designed for dual use, such as surface projection and ultra-short throw projection in a single device. Smart speaker developers incorporating pico projection can innovate with these options to bring new, differentiated and enhanced products to market. **Figure 2** illustrates various projection display options for smart speakers.

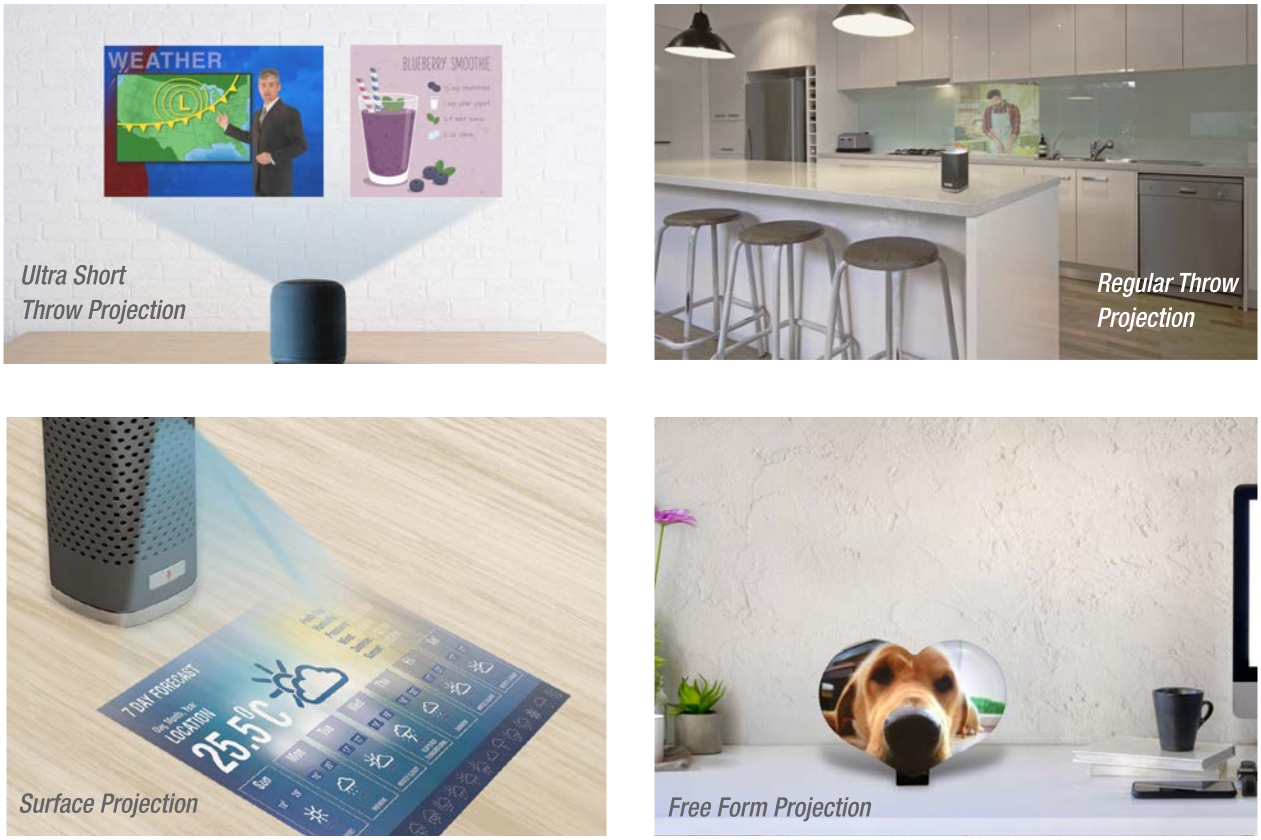

Figure 2. *Examples of pico projection options.*

How does TI DLP technology work in smart speakers?

At the core of DLP technology is the digital micromirror device (DMD), which is a microelectromechanical systems (MEMS) technology that modulates light. Each micromirror on a DMD creates one or more pixels on the displayed image and is independently modulated in sync with color-sequential illumination to create a wide variety of high-performance smart speaker displays.

TI DLP Products' TRP micromirror technology (**Figure 3**), combined with its adaptive DLP IntelliBright™ algorithms, enables developers to increase brightness in a device as it consumes less power. DLP chipsets built on the TRP architecture can incorporate twice the number of pixels and deliver 30 percent greater optical efficiency and up to 50 percent power savings on a frame-by-frame basis than previous TI architectures of comparable resolution.

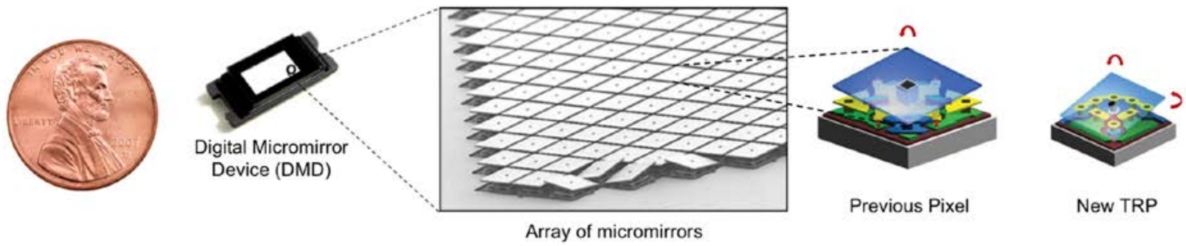

Figure 3. *TI DLP TRP technology*

Table 1 illustrates the design benefits of TI DLP technology in smart display design.

DLP Pico chipset feature	Design benefit for smart displays
Image quality	• High contrast and color gamut provides the most vibrant images • Film-like image: high fill factor (>90%) • Resolution options from nHD (640 x 360) to 4K
Flexibility and scalability	• Short and ultra-short throw capability, any size image, on any surface, of any resolution • Compact optical engines can be integrated into various industrial designs without compromising size and aesthetics • Virtually any shape
High optical efficiency	• Low power even for high-brightness systems • Minimal thermal designs required, including fan-free designs with up to 100-lumen brightness performance (see **Figure 4**) • Small and compact optical engines
Ecosystem	• Extensive supply chain, including third-party optical modules and system integrators

Table 1. *DLP technology benefits*

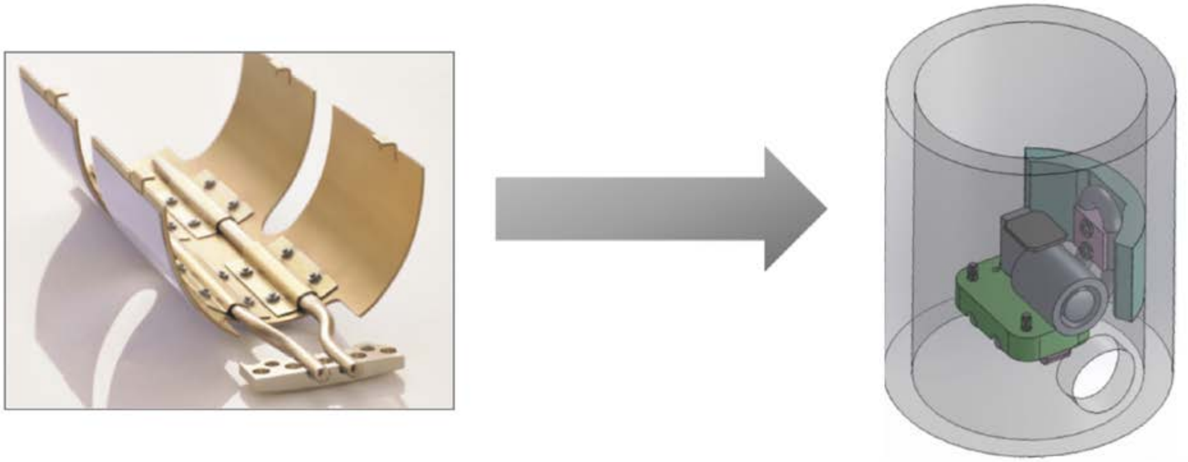

Figure 4. Example of a passive, "silent" fan-free 100-lumen thermal design for a smart display

System and electronic considerations for smart speakers

Figure 5 shows the block diagram of a typical DLP products projection system. This system is composed of two main subsystems:

- The electronics subsystem contains the controller chip, a power-management block and the illumination driver chip. It may also have an application processor and a front-end interface processor.
- The optical subsystem contains the DMD, illumination devices (usually LEDs), optical elements (lenses, filters, etc.), and associated thermal and mechanical components. These components are integrated into a compact and rugged assembly known as an optical engine. The size and form factor of the optical engine depend on specifications such as resolution, brightness and throw ratio, as well as other design factors.

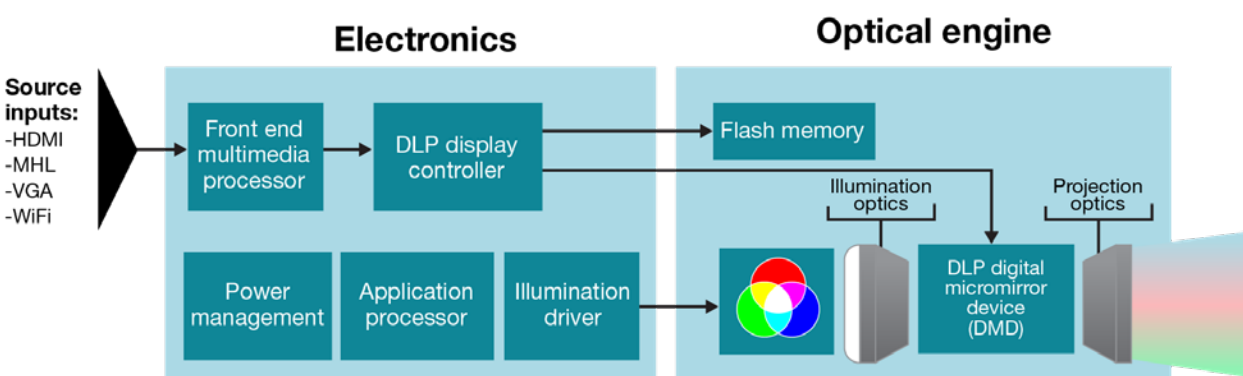

Figure 5. DLP Pico projection system block diagram.

Unique requirements for smart speakers

Here are some of the considerations for designing smart speakers with displays.The exact projector specification will depend on factors like the desired image size, 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.

- **Projection surface.** Some surfaces, like kitchen countertops or wallpaper, may not be ideal for projection due to their color, pattern or surface curvature. It's possible to overcome this problem with additional brightness and algorithms to compensate for surface geometry, color and pattern.
- **Size and form factor.** The required size and form factor are additional system design considerations. Projection modules need to integrate into uniquely shaped and aesthetically pleasing smart spearker designs. The size of the optical engine you use depends primarily on its brightness, resolution and throw ratio. The DLP Pico optical engine can be compact enough to be integrated into a smart speaker. As described earlier, there are existing 100-lumen designs that are as small as 50 cc.
- **Brightness.** The total lumens 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 (like on a kitchen countertop), it may be necessary to increase the brightness by an additional 20–30%. **Figure 6** provides suggested brightness values for the projector based on image size and different ambient light conditions.

Suggested projector light output (lumens)

Image diagonal (inches)			
80-100	300-450	550-900	1100-1750
60-80	150-300	350-550	650-1100
50-60	110-150	250-350	450-650
40-50	80-110	150-250	300-450
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
Target brightness intensity	Dark room (50 nits)	Dim room (100 nits)	Well-lit room (200 nits)

DLP Pico DMD diagonal size (inches) and part number suggestions
>0.5" class (DLP enterprise solution)
0.45"-0.47" class DLP4501 or DLP4710
0.3" class DLP3010
0.2" class DLP2010

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

Figure 6. *Suggested brightness values for given environments.*

- **Resolution.** The required resolution depends primarily on the information content displayed, as well as the desired image size. Something as low as nHD (640 x 360) can be good for simple graphics and videos, while qHD (960 x 540), 720p (1280 x 720) or higher may be a better fit for a more robust display.
- **Throw ratio.** A projector's throw ratio is defined as 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 placement of the product relative to the image surface. A long-throw projection lens is typically defined as having a throw ratio greater than 2-to-1. A long-throw lens would be used in situations where the display surface is a long distance from the projection module. A short-throw projection lens is typically defined as having a throw ratio from 0.8-to-1 to 1-to-1, and an ultra-short-throw projection lens is typically defined as having a throw ratio less than 0.5-to-1. Short-throw and ultra-short-throw lenses could be used in situations where the projection surface is very close or right next to the projection module. A normal throw projection lens is typically defined as having a throw ratio equal to or greater than 1.2-to-1.

Value-added features

Several features can enhance the effectiveness of a projection display and add value to the smart speaker.

- **Interactivity.** Interactivity can turn a projected image into a virtual tablet. Depending on the use case, a simple gesture control may suffice, or a highly accurate multitouch capability may be required. There are multiple technologies that can be integrated with projection systems to provide an effective user interface including stereo vision, structured light and time of flight.
- **Keystone correction.** The space constraints of a projection system often prevent the centering and alignment of the projector with respect to the projection surface, resulting in a geometric distortion that resembles a keystone. Keystone correction compensates for this distortion and enables 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 speakers.

DLP chipsets for smart speaker applications

DLP chipsets are available in a broad range of sizes and resolutions to suit different display diagonals, brightness requirements and pixel densities (resolution). **Figure 7** shows the available DLP chipsets. Each DMD requires the matching controller chip and power-management IC to complete the chipset.

The smart smart speaker market is growing rapidly and the addition of display, or smart display, will enhance the user experience and value. DLP Pico technology offers very exciting opportunities to provide differentiated display options. Below are some resources to help you learn more.

DLP Pico product portfolio for smart speakers

DMD part #	DLP2000	DLP2010	DLP230GP	DLP230KP	DLP230NP	DLP3010	DLP3310
							
Micromirror array diagonal size	0.20”	0.21”	0.23”	0.23”	0.23”	0.31”	0.33”
Display resolution	640x360	854x480	960x540	1280x720	1920x1080	1280x720	1920x1080
Typical brightness range (lumens)	Up to 50	Up to 150	Up to 200	Up to 200	Up to 200	Up to 300	Up to 400
Projected image diagonal size[1]	Up to 15”	Up to 25”	Up to 30”	Up to 30”	Up to 30”	Up to 40”	Up to 45”
Typical illumination power consumption range	1-3W	1-20W	1-20W	1-20W	1-20W	5-40W	5-30W
Optical modules in production	Yes	Yes	Yes	Yes	Coming soon	Yes	Yes
Controller part # and (package size)	DLPC2607 (7x7mm)	DLPC3430 (7x7mm) DLPC3435 (13x13mm)	DLPC3432 (7x7mm)	DLPC3434 (7x7mm)	DLPC3436 (7x7mm)	DLPC3433 (7x7mm) DLPC3438 (13x13mm)	DLPC3437 (13x13mm)
Controller video input interface	Parallel RGB	Parallel RGB MIPI DSI	Parallel RGB MIPI DSI	Parallel RGB	Parallel RGB	Parallel RGB MIPI DSI	Parallel RGB
Frame refresh rate	Up to 60hz	Up to 240hz	Up to 240hz	Up to 60hz	Up to 60hz	Up to 120hz	Up to 60hz
Chipset power consumption	<200mW	<200mW	<250mW	<250mW	<250mW	<350mW	<600mW
DLP IntelliBright™ Algorithms		✔	✔	✔	✔	✔	✔
Keystone correction		✔	✔	✔	✔	✔	✔

[1]Assumes a well lit room with an image brightness requirement of 200 nits

Figure 7. *DLP Pico product portfolio for smart speakers.*

Evaluation modules (EVMs) are available for purchase to quickly begin assessing and developing with the DLP Pico chipsets. Developers can also leverage the DLP Pico ecosystem, which consists of an extensive network of third-party design houses, optical module makers and system integrators that enable them to source fully-formed projection systems.

Additional resources

- Learn more about DLP Pico technology:
  - Get started using DLP Pico technology.
  - Learn more about our products and data sheets.
- Evaluate DLP Pico technology with an EVM:
  - **DLP Pico Tools**
- Download a reference design to speed product development using DLP Pico schematics, layout, bill of materials and test reports:
  - Ultra Mobile, Ultra Low Power Display Reference Design Using DLP Technology.
  - Portable, Low Power HD Projection Display Using DLP Technology.
  - Mobile 1080p Display Reference Design Using DLP 0.33-Inch Micromirror Array.
  - Compact Full HD 1080p (Up to 16 Amps) Projection Display Reference Design Using DLP Pico Technology.
- Find DLP Pico optical modules and design support.
- Check out TI’s E2E™ Community to search for solutions, get help, share knowledge and solve problems with fellow engineers and TI experts.

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