DLP® One Workshop - Automotive

July 11, 2018

DLP technology: automotive qualified

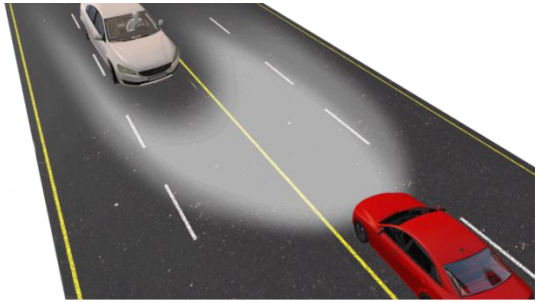
- Automotive qualified using industry standard testing
- Extended operating temperature -40 to 105 °C
- Hermetically sealed packaging
- PPAP documents available upon request
- In production and shipping in volume

DLP Technology for Automotive Applications

Augmented Reality Head-up Display

- **Wide** field of view, up to 12°
- **Farther** virtual images, up to 20m
- **Efficient** non-polarized imager
- **Vivid** image quality across temp

High Resolution Smart Headlight

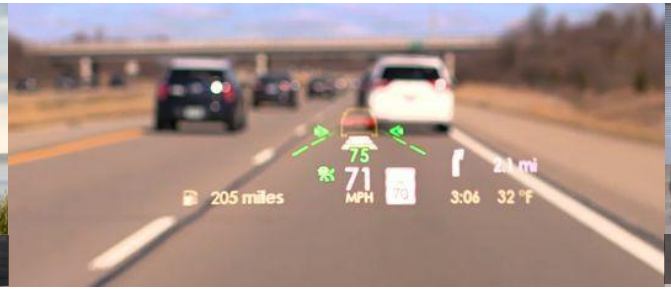


- **Glare-free** high beam
- **LASER** or LED illumination
- **Symbol** Projection
- **Fully** Programmable beam

Interior Display Applications

Lincoln brings DLP technology to their HUD systems


2017 Lincoln Continental




2018 Lincoln Navigator

> We'll be using a **DLP chip from Texas Instruments**, while many other automakers use a different technology that doesn't get quite as bright. **That's what sets us apart**.
>
> Anthony King
> Lincoln product design engineer
> *April '17 Ford Announcement*

From Lincoln:

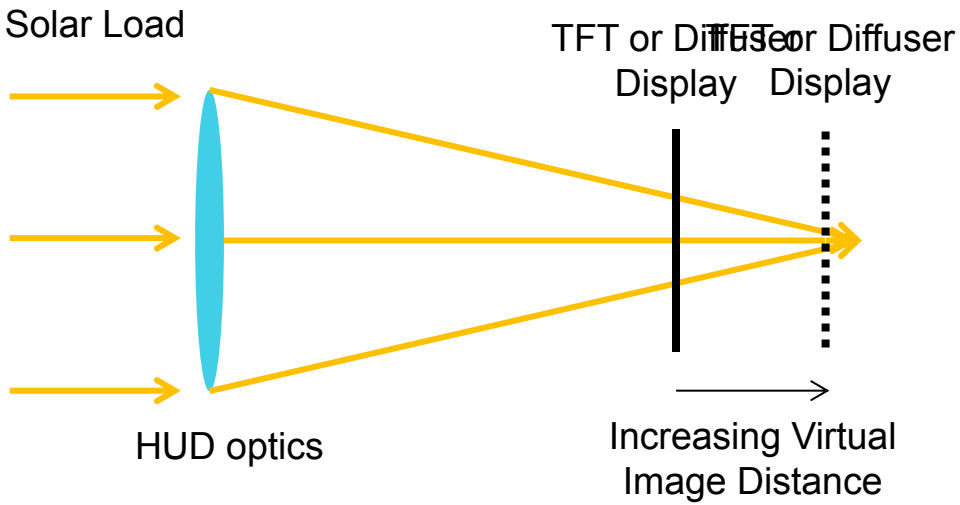
- ❑ Lincoln is the first manufacturer to use DLP technology in its head-up display.
- ❑ **DLP technology allows the display to be visible** in more ambient lighting conditions than its competitors, even while **wearing polarized sunglasses.**
- ❑ The HUD in the Lincoln Navigator has the brightest windshield-projected informational display and biggest display size in its class.

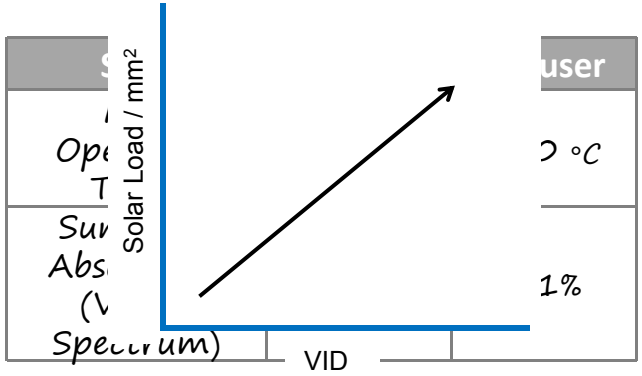
Source: Lincoln.com

Augmented Reality HUDs

- ❑ **Seeing significant activity around AR HUDs in Europe and China**
- ❑ **AR HUDs start deploying in 2020/2021**
- ❑ **AR specs: ~ 10 x 5° FOV, VID > 7.5m and a large eye box**
- ❑ **Why DLP Technology for AR?**
  - Solar load performance
  - Brightness / power efficiency
  - Supports HOE, waveguides, and LASERs
  - ADAS / primary display requirements
    - *Constant performance over temp, images viewable via polarized sunglasses, color saturation levels / high brightness*

AR virtual image distances > 7m

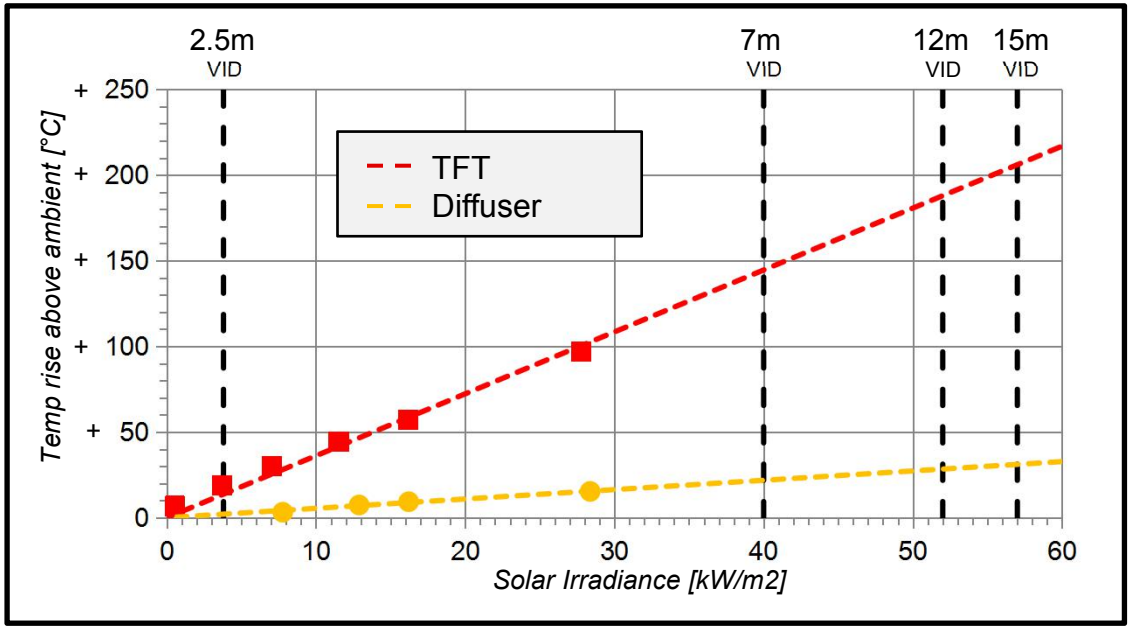




The longer the VID, the greater the HUD magnification resulting in higher surface temperatures

Sunlight study: temperature rise

Note: Off Axis sunlight is up to 3x worse peak irradiance and must be accounted for in thermal simulations



Temp Increase @ 12m VID	
TFT	+ 190°C
Diffuser	+ 34°C

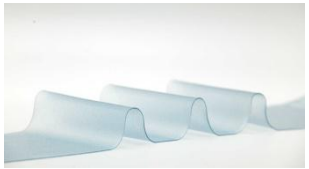
DLP Technology Advantages:

- No performance derating
- No turn off over temp
- Improved reliability & lifetimes

TFT Panel Temperature rise is ~ **6x higher** than the DLP Diffuser
(*IR/UV solar irradiance filtered out)*

DLP technology: interior automotive applications

DLP projector: 1 to 2 liters in size



Emissive phosphor & holographic films

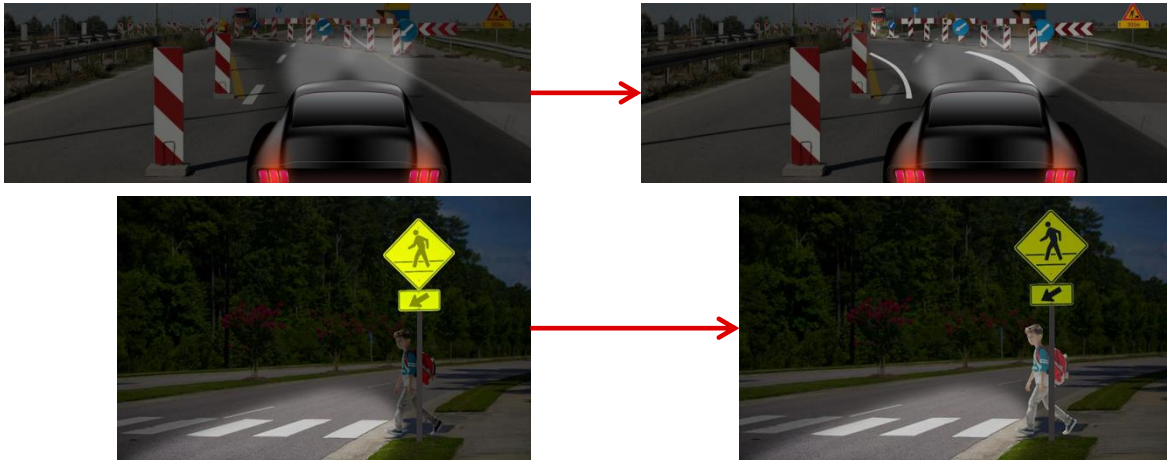
DLP3030-Q1 Evaluation Modules

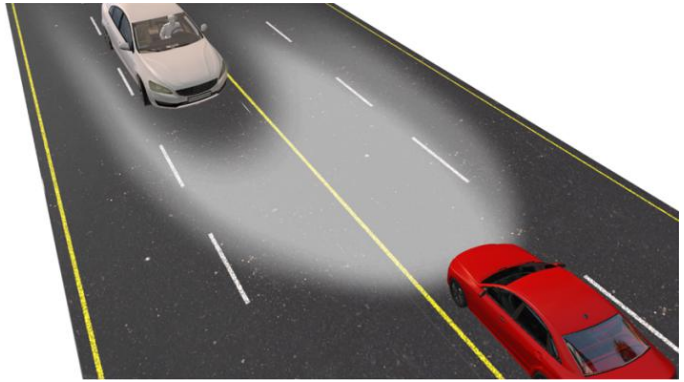
Options	EVM	Good choice if…
1 Electronics only		• Designing a PGU or Projection module • Need electronics to drive a PGU optics module • Part number: **DLP3030Q1EVM** • Available now for $1,999
2 Electronics + PGU		• You are designing a HUD • Need to benchmark different PGUs w/ your HUD design • Part number: **DLP3030PGUQ1EVM** • Available now for $6,500
3 Combiner HUD Demo		• Need a quick path to a functional DLP HUD prototype • Need to demonstrate DLP technology performance • Part number: **DLP3030CHUDQ1EVM** • Available now for $25,000

Exterior Lighting applications

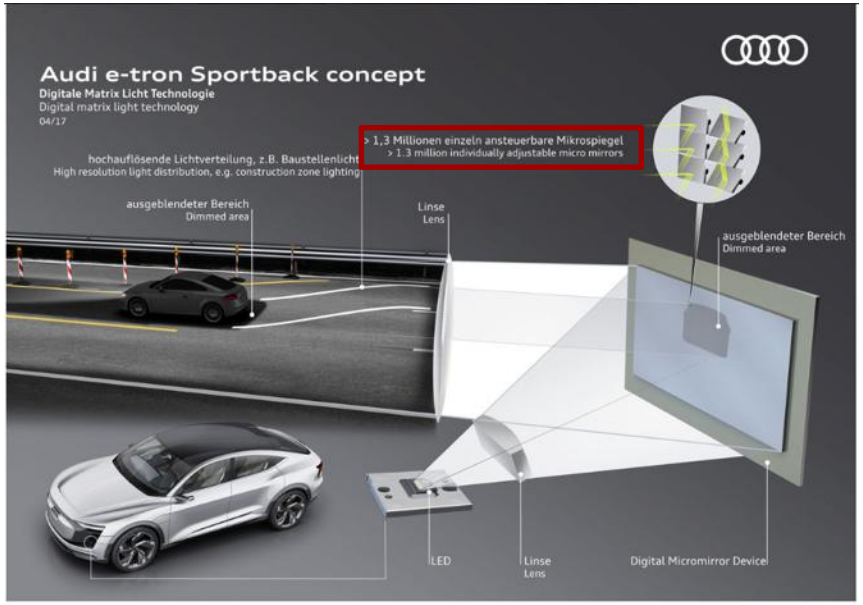
DLP Technology Enables New Light Functions

- **High Resolution**
  - ADB = Adaptive Driving Beam
  - Glare-Free Beam Steering
  - Reflective Traffic Sign Dimming
  - Pedestrian Dimming
  - Fully programmable
- **Driver Assistance**
  - Augmented Night Vision
  - Construction Light Projection
- **Car2X: Communication with Environment**
  - Added Value in Absence of Engine Noise of EV
  - Warnings
  - Safety Signs
- **Animation**
  - Leaving Home / coming Home Light (Welcome Light)
  - OEM Branding (Logo, Showroom)





OEM High Resolution Headlight Announcements



04/18/17 | Illustration

Audi e-tron Sportback concept

Digital matrix light technology

Image No: A172941
Copyright: AUDI AG

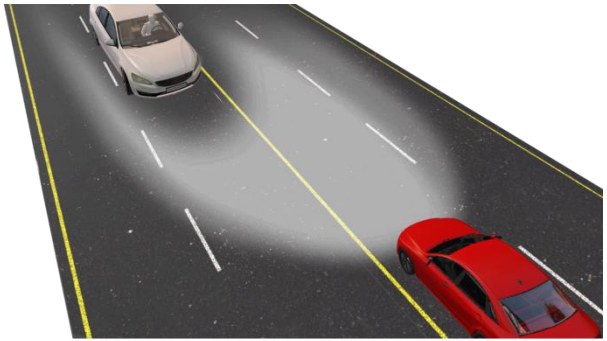
https://www.audi-mediacenter.com/en/press-releases/the-architecture-of-e-mobility-audi-e-tron-sportback-concept-7637

"With a resolution of over one million pixels per headlamp, DIGITAL LIGHT not only creates ideal light conditions for every driving situation; it also extends the visual support from our driving assistance systems",

http://media.daimler.com/marsMediaSite/en/instance/ko/World-premiere-in-the-Mercedes-Maybach-S-Class-DIGITAL-LIGHT-the-light-of-the-future-hits-the-road.xhtml

DLP Technology in Digital Headlights

High Resolution Smart Headlight



- **Glare-free** High Beam
- **LASER** or LED Illumination
- **Symbol** Projection
- **Fully** Programmable Beam

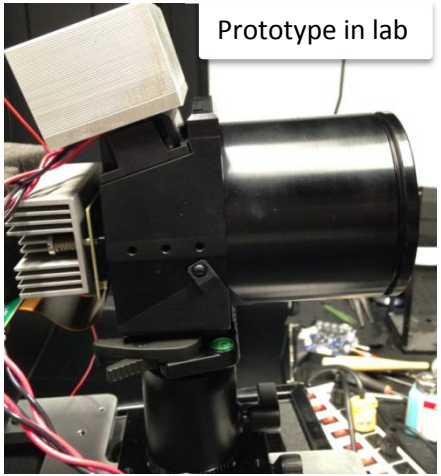
Benefits of DLP Technology

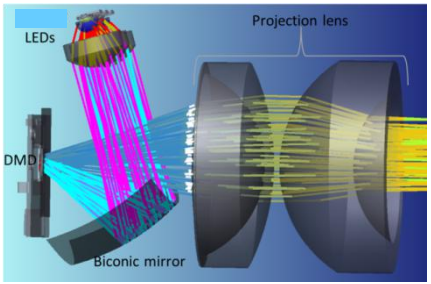
Feature	Design Benefit
Automotive qualified	First DLP Chipset engineered specifically for Automotive Applications
Highest Resolution	Delivers >1.3M Pixels per Headlight for most versatile Projection – Enables Transition from Lighting to Communication (Car2X)
Fully programmable	Supports all Kinds of dynamic Adjustments, e.g. different geographic Regions, Leveling, Cut-off Lines / Kinks
Small Form Factor	Allows compact Optics supporting Minimum Projection Lens Height for stylish Vehicle Design
Light Source agnostic	Flexibility for Designers, allowing to select LED or Laser Illumination

DLP5531-Q1 DLP HL prototype using custom optics

	Measured performance
Field of view	14°x7°
Peak Illuminance @ 25m	111 lx
Peak illuminance in the masked region @ 25m	0.42 lx
Peak Intensity	69375 Cd
Peak intensity in the masked region	263 Cd
Brightness at screen	1028 lm
FOFO contrast	263:1
Resolution	>10 pixels / °
Power consumption	~46 W

- 2600lm out of 2 white LEDs
- 95% sequence efficiency
- All measurements are performed at room temperature
- Headlight cover loss is not included

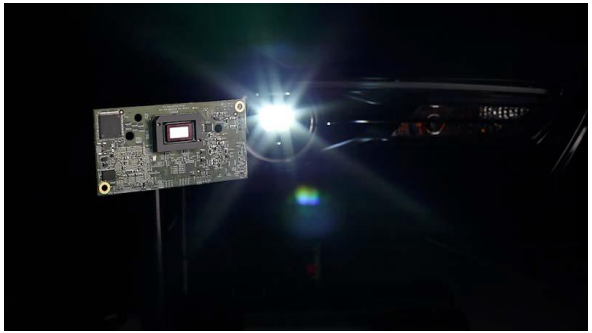


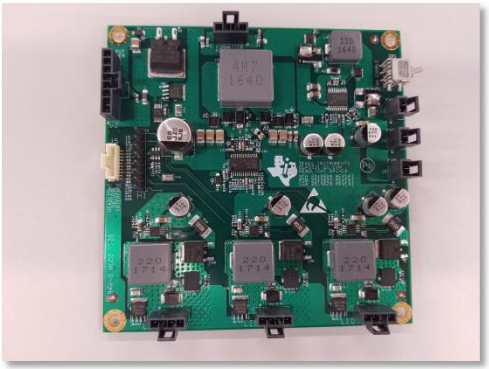


Optical layout

DLP5531Q1EVM - Headlight EVM

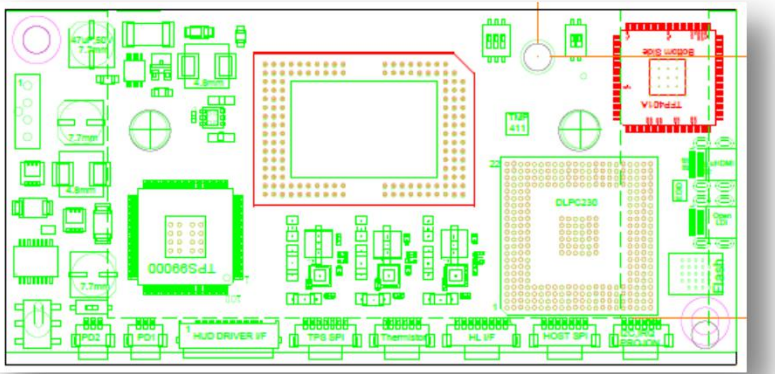
- Evaluation Module (EVM) for DLP553X-Q1 will include electronics serving the HUD and Headlight applications
- EVM is available for Purchase





LED Driver Board

EVM Front Side with DMD mounted

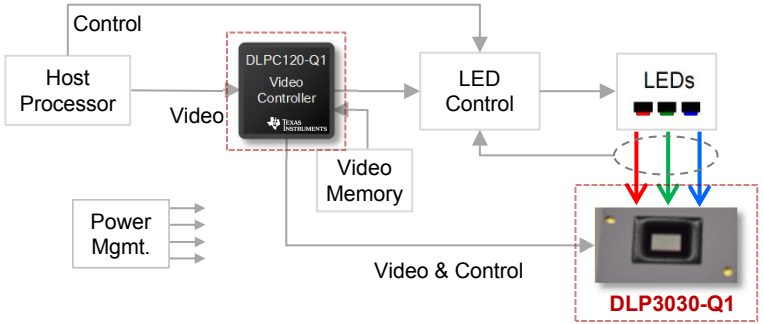


EVM Back Side

Automotive qualified chipsets

DLP3030-Q1 Chipset

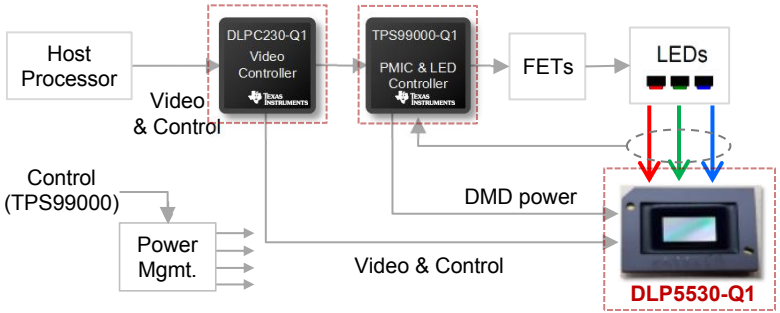
- 0.3” DMD (864 x 480 resolution)
- -40 to 105 °C operation
- 60Hz video refresh
- Supports up to 5000:1 dimming ratio
- RGB video interface



DLP5530-Q1 Chipset

- 0.55” DMD (1152 x 576 resolution)
- 3x mirror array area vs. DLP3030-Q1
- RGB or OpenLDI video interface
- On-chip:
  - Video memory + diagnostics
  - LED dimming controller
  - DMD power management

Calendar RTM: 2Q18



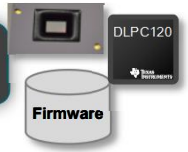
Auto DLP Chip Set Roadmap

Prod | Sampling | Concept

DLP3000-Q1
0.3" DMD (0.4MP)

- Chipset Components:
  - DLP3000 (DMD)
  - DLPC120 (Digital Companion)
- 854 x 480 WVGA Resolution
- 16:9 Aspect Ratio
- WFOV HUD up to 12°
- AR capable, VID up to 20M
- -40C to 90 °C DMD
- In Production

DLP3030-Q1
0.3" DMD (0.4MP)



- Chipset Components:
  - DLP3030 (DMD)
  - DLPC120 (Digital Companion)
  - Firmware
- 60% smaller DMD Package
- Key Improvements:
  - Increased Operating Range to 105C
  - Instant Turn-on at -40C
- Released

DLP5530-Q1
DLP5531-Q1
0.55" DMD (1.3MP)

- Chipset Components:
  - DLP553x (DMD)
  - DLPC230 (Digital Companion)
  - TPS99000 (Analog Companion)
  - Firmware
- 1152 x 576 Resolution
- 2:1 Aspect Ratio
- On-Chip LED Control & Video RAM
- On-Chip DMD Power Management
- OpenLDI and 24-bit RGB I/F
- -40 to 105°C DMD
- **Samples now**, RTM 3Q18

Future Focus

- 125°C DMD Capability
- Wider/Full FOV
- Optimized Brightness
- Improved Contrast

Performance

Time

Thank you!