*Design Guide: TIDA-080006*

# *405-nm DLP® Automotive Transparent Window Display Electronics Reference Design (0.3-in DMD)*

TEXAS INSTRUMENTS

## Description

This DLP3034-Q1 electronics reference design drives a DLP projector that can illuminate a phosphor film embedded inside glass to create a transparent window display. The phosphor film is transparent under normal conditions but turns into a colorful display when excited with 405-nm light from the DLP3034-Q1 projector.

## Resources

| | |
|---|---|
| TIDA-080006 | Design Folder |
| DLP3034-Q1 | Product Folder |
| DLPC120-Q1 | Product Folder |

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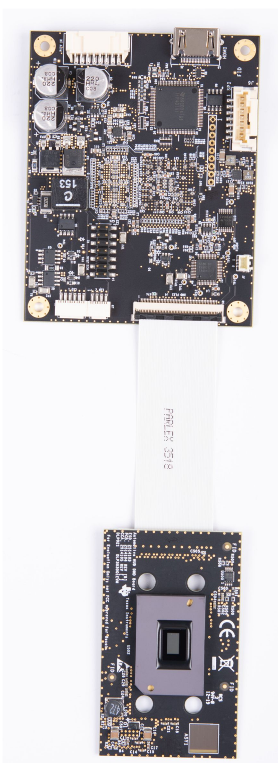
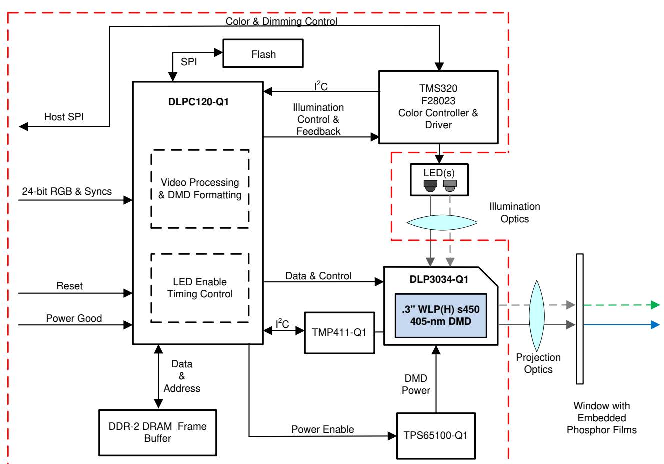


## Features

- Automotive-qualified DLP3034-Q1 chipset
- Supports 405-nm LED illumination
- Wide video graphics array (WVGA) (864 × 480) resolution
- 12-V input
- Current-controlled LED driver
  - Supports 1 or 2 LED color channels
  - Supports up to 4 A and 9 V per channel
- 50:1 dimming ratio
- –40°C to 105°C operation
- Compact PCB layout
- Reduced system cost

## Applications

- Transparent window display supporting:
  - Vehicle-to-vehicle communication
  - Vehicle-to-pedestrian communication
  - Robo-taxis
  - Ride hailing
  - Advertisement
  - Driver greeting and car diagnostics



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# 1 System Description

The fundamental components of this reference design include the DLP3034-Q1 0.3” WVGA 405-nm automotive digital micromirror device (DMD), the DLPC120-Q1 DMD controller, a current-controlled LED driver supporting either one or two channels, and the corresponding power supplies. These electronics are intended to be used to drive a projector that also encompasses a 405-nm LED, optical components to capture the LED light and to illuminate the DLPC3034-Q1 DMD, as well as a projection lens to direct the light to a window in a vehicle.

This projector should be paired with a transparent phosphor film which is embedded inside an automotive glass window. When the phosphor material is excited with 405-nm wavelengths from the projector, it emits visible light in all directions, thus enabling a transparent window to become a dynamic display. A full color display can be designed using multiple LEDs and films, with each LED emitting light at a specific wavelength that excites a corresponding phosphor film. There are several applications that can benefit from this projector and film technology.

There is a growing trend in the automotive industry towards autonomous vehicles, robo-taxis, and ride sharing. It is important for these vehicles to communicate with the outside world, while also supporting the original functions of the window and vehicle design. A transparent window display, enabled by this reference design and surrounding components, is one possible way to address these needs.

## *1.1 Key System Specifications*

**Table 1. Key System Specifications**

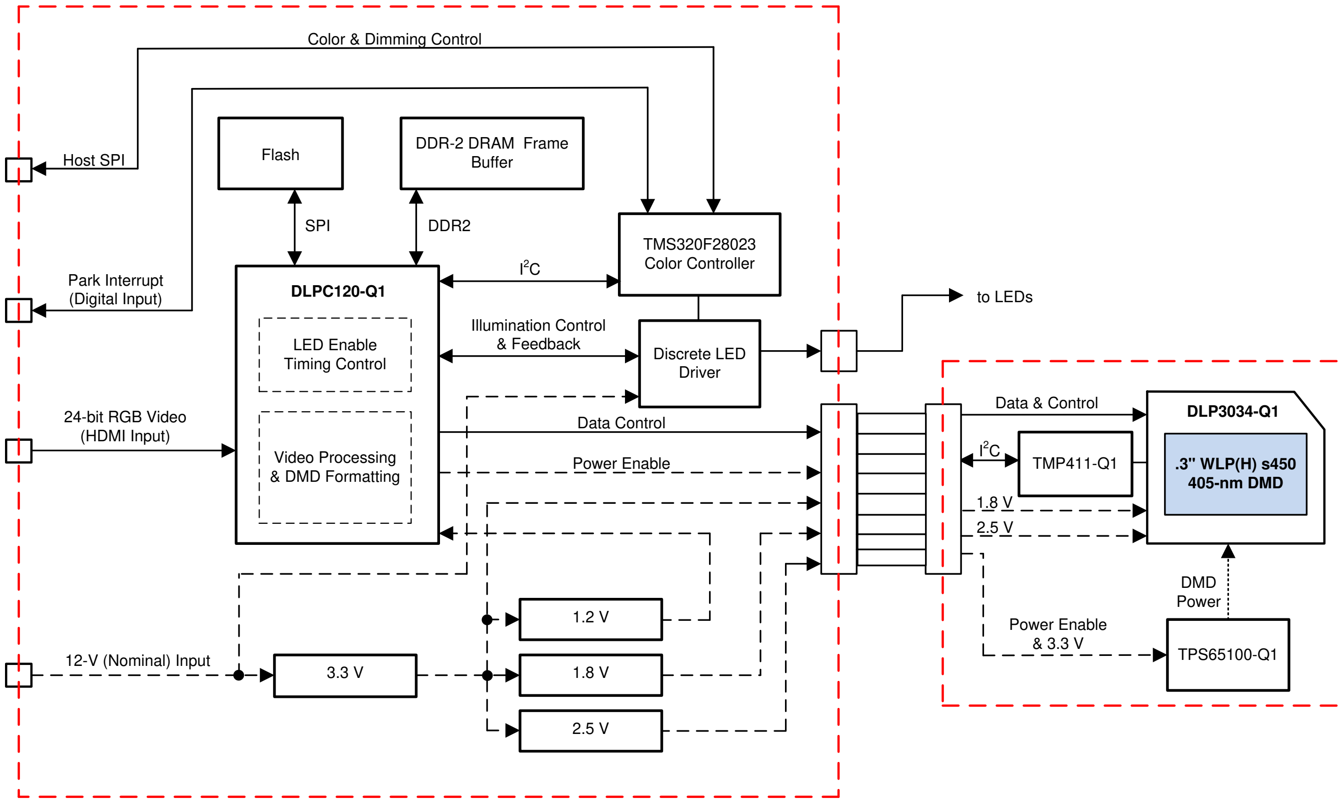
| PARAMETER | SPECIFICATIONS |
|---|---|
| Input power source | 12 V DC nominal, 8 V minimum to 18 V maximum |
| Power consumption | Power consumption depends on selected LED current. Depending on DMD sequence, duty cycle, number of LEDs, and other system parameters, power consumption for this chipset + LEDs is between 2 W and 36 W. For a single LED system driven at 95/5 duty cycle, 12-V input, and 4-A LED[1] current, the power consumption is 33.6 W. |
| Output signals | Single- or dual-channel LED drive |
| Temperature rating | The DLP3034-Q1 has an automotive temperature rating of -40°C to 105°C |
| Video input format | HDMI input de-serialized into 24-bit parallel RGB |
| SPI interface format | 100 kHz |
| Dimming ratio | 50:1 |

(1) This data assumes the CBM-25 LED from Luminus™.

# 2 System Overview

## 2.1 Block Diagram

**Figure 1. TIDA-080006 Block Diagram and Board Partition**




## 2.2 Design Considerations

### 2.2.1 Support for Multiple LEDs

The DLP3034-Q1 automotive DMD has been optimized for illumination sources centered around 405-nm wavelengths. However, it is possible that the DMD can support other illumination wavelengths as well—see the *DLP3034-Q1 0.3 WVGA 405-nm DMD for Automotive Interior Display* data sheet. This reference design is intended to drive either one or two LEDs. To switch from between the two, it simply requires the removal or installation of three different resistors, as Table 2 shows. Note that while the reference design can drive up to two channels, the DLP3034-Q1 and DLPC120-Q1 chipset is capable of driving up to three channels.

**Table 2. Configuration for Single- or Dual-channel LED Drive(1)**

| NUMBER OF COLOR CHANNELS SUPPORTED | R8 | R103 | R104 |
|---|---|---|---|
| One Color | Optional | Install | Remove |
| Two Color | Remove | Remove | Install |

(1) Refer to the corresponding schematic design for component names R8, R103, and R104.

### 2.2.2 Input Voltage vs. RMS LED Current

In this reference design, there is simply a TI ideal diode circuit between the input voltage and the LED driver, without a regulator to fix the voltage to the driver. Tests have shown that variations to the input voltage level have an impact on the waveform of the LED current. Specifically, a higher input voltage results in a higher switching frequency and higher ripple of the LED current, which means the RMS value is higher. For LEDs which generally have a direct relationship between RMS current and optical power output, this means that a varying input voltage may also vary the brightness of the display in this application. This effect is most severe at lower LED currents. See the *Test Results* for the data of testing with this reference design.

If the customer-application deems that this variation is likely to occur and the performance is unacceptable, TI recommends adding a pre-regulator between the input voltage and the LED driver to stabilize the voltage seen by the LED driver.

### 2.2.3 Input Video Configuration

This reference design includes two boards: the *Controller board* and the *DMD board*. Connect these boards with a 50-pin flat flex connector, ensuring that the cable is correctly installed and the clamp is properly closed on the connectors of both boards.

Connect a power cable to the appropriate connector. Additionally, connect the LEDs. In a projector module, care should be taken to ensure that the DMD and LEDs are correctly mounted to the optical system. If the electronics are tested on their own, then TI recommends wearing eye protection to prevent direct exposure to the raw light from the LED. Also note that the LEDs may get hot, so an appropriate heatsink is recommended.

After the boards have been connected and all cables installed, 12 V can be applied. With the proper DLPC120 firmware installed, provided by the *TI Applications* team, the system will default to 4-A current for each LED.

## *2.3 Highlighted Products*

### 2.3.1 DLP3034-Q1

The DLP3034-Q1 device is the automotive DMD component that is central to this system. It serves as the display panel inside the projector.

### 2.3.2 DLPC120-Q1

The DLPC120-Q1 device is the automotive DMD controller component that is responsible for driving the DLP3034-Q1 DMD.

# 3 Hardware and Test Results

## 3.1 Required Hardware

This reference design includes two boards: the *Controller board* and the *DMD board*. Connect these boards with a 50-pin flat flex connector, ensuring that the cable is correctly installed and the clamp is properly closed on the connectors of both boards.

Connect a power cable to the appropriate connector. Additionally, connect the LEDs. In a projector module, care should be taken to ensure that the DMD and LEDs are correctly mounted to the optical system. If the electronics are tested on their own, then TI recommends wearing eye protection to prevent direct exposure to the raw light from the LED. Also note that the LEDs may get hot, so an appropriate heatsink is recommended.

After the boards have been connected and all cables installed, 12 V can be applied. With the proper DLPC120 firmware installed, the system will default to 4-A current for each LED.

## 3.2 Testing and Results

### 3.2.1 Test Setup

The hardware was configured exactly as described in the *Required Hardware* section. The *Automotive Control Program* tool was used to module the LED current for each of the conditions shown in the *Test Results* section. An oscilloscope was used to measure two signals: LED forward voltage and LED current (with probe).

### 3.2.2 Test Results

Testing has shown that LED RMS current varies with input voltage at lower output current levels.

**Figure 2. LED RMS Current vs. Input Voltage at Different Current Amplitude Levels**

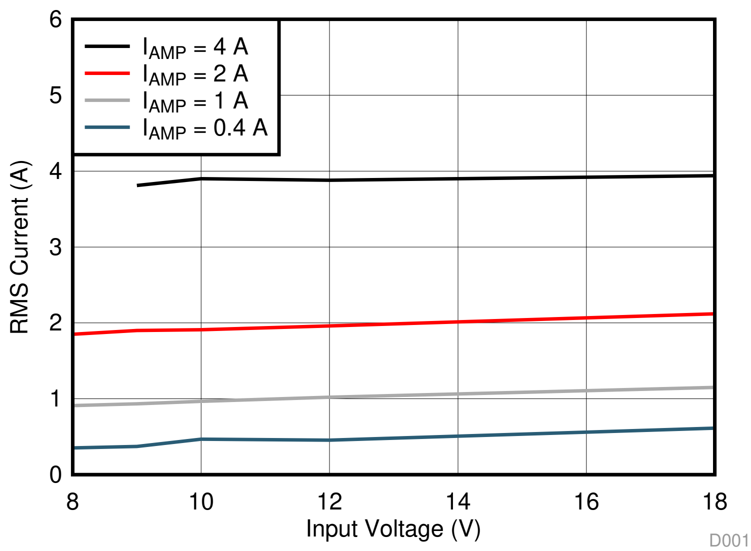


**Table 3. Percent Change in LED RMS Current With Varying Input Voltage**

| CURRENT AMPLITUDE (A) | PERCENT DROP FROM 18 V TO 10 V |
|---|---|
| 4.0 | 1% |
| 2.0 | 11% |
| 1.0 | 19% |
| 0.4 | 31% |

The oscilloscope captures in Figure 3 through Figure 6 show the signals justifying the data in Figure 2 and Table 3. Table 4 serves as a legend of the signals in the oscilloscope captures.

**Table 4. Oscilloscope Capture Signal Description**

| PROBE CHANNEL # | COLOR | SIGNAL |
|---|---|---|
| 2 | Cyan | LED $V_F$ |
| 4 | Green | LED Current |

**Figure 3. 4-A LED Amplitude at 18-V Input Voltage**

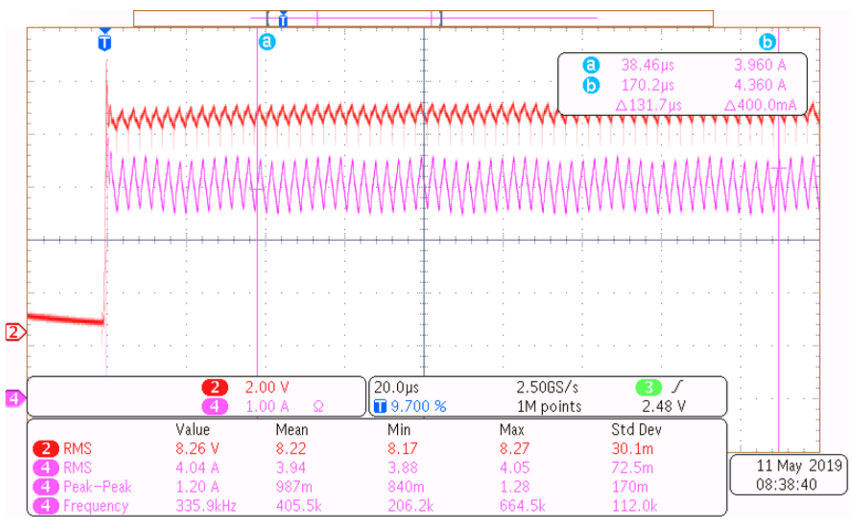



**Figure 4. 4-A LED Amplitude at 10-V Input Voltage**

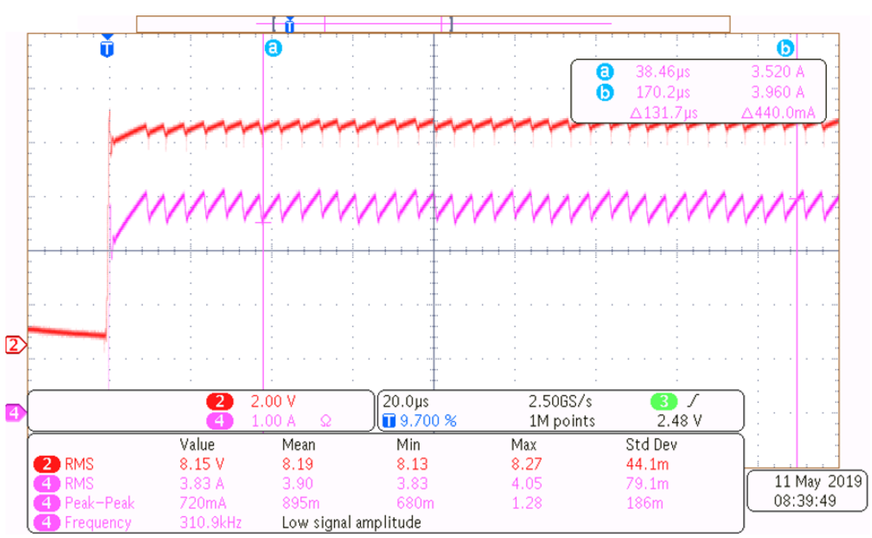


**Figure 5. 0.4-A LED Amplitude at 18-V Input Voltage**

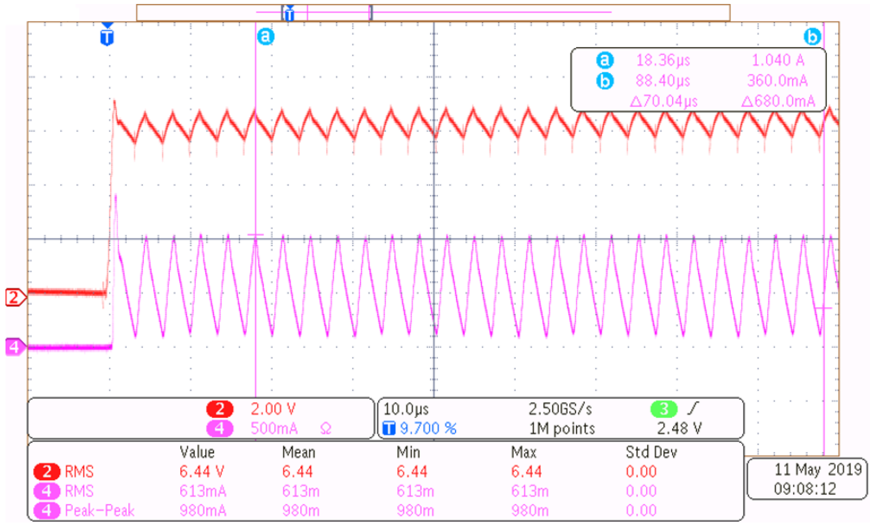
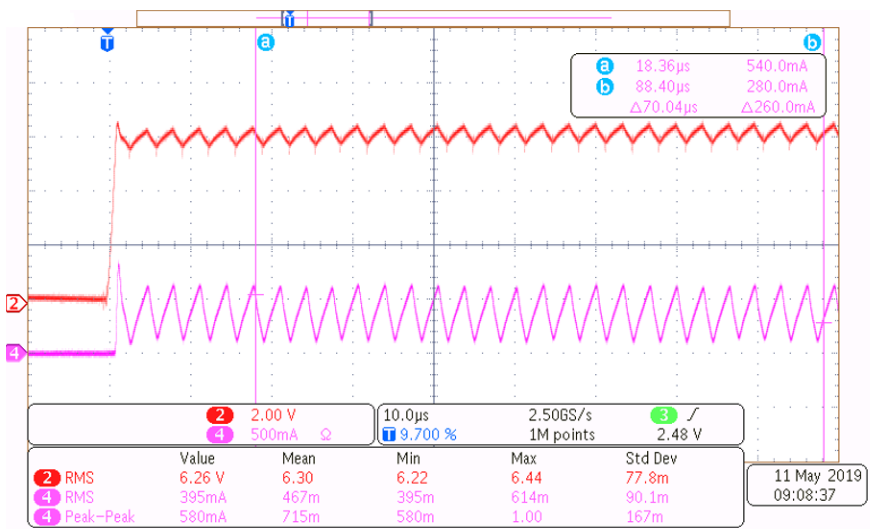



**Figure 6. 0.4-A LED Amplitude at 10-V Input Voltage**



# 4 Design Files

## 4.1 Schematics

To download the schematics, see the design files at TIDA-080006.

## 4.2 Bill of Materials

To download the bill of materials (BOM), see the design files at TIDA-080006.

## 4.3 PCB Layout Recommendations

### 4.3.1 Layout Prints

To download the layer plots, see the design files at TIDA-080006.

## 4.4 Altium Project

To download the Altium Designer® project files, see the design files at TIDA-080006.

## 4.5 Gerber Files

To download the Gerber files, see the design files at TIDA-080006.

## 4.6 Assembly Drawings

To download the assembly drawings, see the design files at TIDA-080006.

# 5 Software Files

To download the software files, see the design files at TIDA-080006.

# 6 Related Documentation

1. Texas Instruments, *DLP3034-Q1 0.3 WVGA 405-nm DMD for Automotive Interior Display Data Sheet*
2. Texas Instruments, *DLPC120-Q1 Automotive DMD Controller Data Sheet*

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