

# **DLP5531-Q1 Electronics Evaluation Module User's Guide**

TI's DLP® technology for automotive headlight applications is the only technology on the market that is both fully programmable and offers the highest resolution available. With more than one million addressable pixels per headlight, DLP technology exceeds the resolution of existing adaptive driving beam (ADB) technologies by more than 10,000 times. Automakers and Tier-1 suppliers can use this new programmable ADB solution to maximize brightness for drivers while minimizing the glare of oncoming traffic and reflections from high-gloss traffic signs. DLP technology works with any light source, including LED and laser illumination, and gives designers more precise light distribution on the road, with customizable beam patterns controlled by programmable software. Automakers and Tier-1 suppliers can partially or fully dim individual pixels with this solution, paving the way for the creation of headlight systems that allow drivers to keep their highbeams on in any condition.

The DLP5531-Q1 Electronics Evaluation Module (EVM) allows for evaluation of the DLP5531-Q1 chipset. This module brings together a set of components including the DLP5531-Q1, the DLPC230-Q1, and the TPS99000-Q1 to provide an efficient system for evaluation of high resolution headlight technology. When combined with optics, an input video source, and a computer or other means of control, the evaluation module can be used in a laboratory setting to demonstrate features such as:

- Adaptive Driving Beams
- Glare-Free Beam Steering
- Reflective Traffic Sign Dimming
- Pedestrian Dimming
- Symbol Projection
- OEM Branding

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## 1 DLP5531-Q1 Electronics EVM Overview

This user's guide presents an overview of the DLP5531-Q1 Electronics EVM and a general description of the main features and functions. It will also provide first steps for getting started as well as a description of system functions and configurations.

### 1.1 What Is in the DLP5531-Q1 Electronics EVM

The DLP5531-Q1 Electronics EVM consists of two subsystems:

- Formatter Board — Includes the DLP5531-Q1 DMD, the DLPC230-Q1 DMD Controller, and the TPS99000-Q1.
- Illumination Driver Board — Includes illumination drivers and provides power to the formatter board.

### 1.1.1 Formatter Board

The formatter board contains the following ports and switches, see [Figure 1](#).

**Table 1. Formatter Board Ports**

SCHEMATIC REFERENCE	FUNCTION
J1	Host I <sup>2</sup> C, PROJ_ON, HOLD_BOOT, HOST_IRQ
J2	Host SPI
J3	Micro HDMI
J4	OpenLDI (Flex connector)
J5	Photodiode 1 <sup>(1)</sup>
J6	TPS99000-Q1 SPI Debug
J7	Photodiode 2 <sup>(1)</sup>
J8	HUD Driver Interface <sup>(1)</sup>
J9	LED Thermistor <sup>(1)</sup>
J10	Headlight Driver Interface
J11	Formatter Power

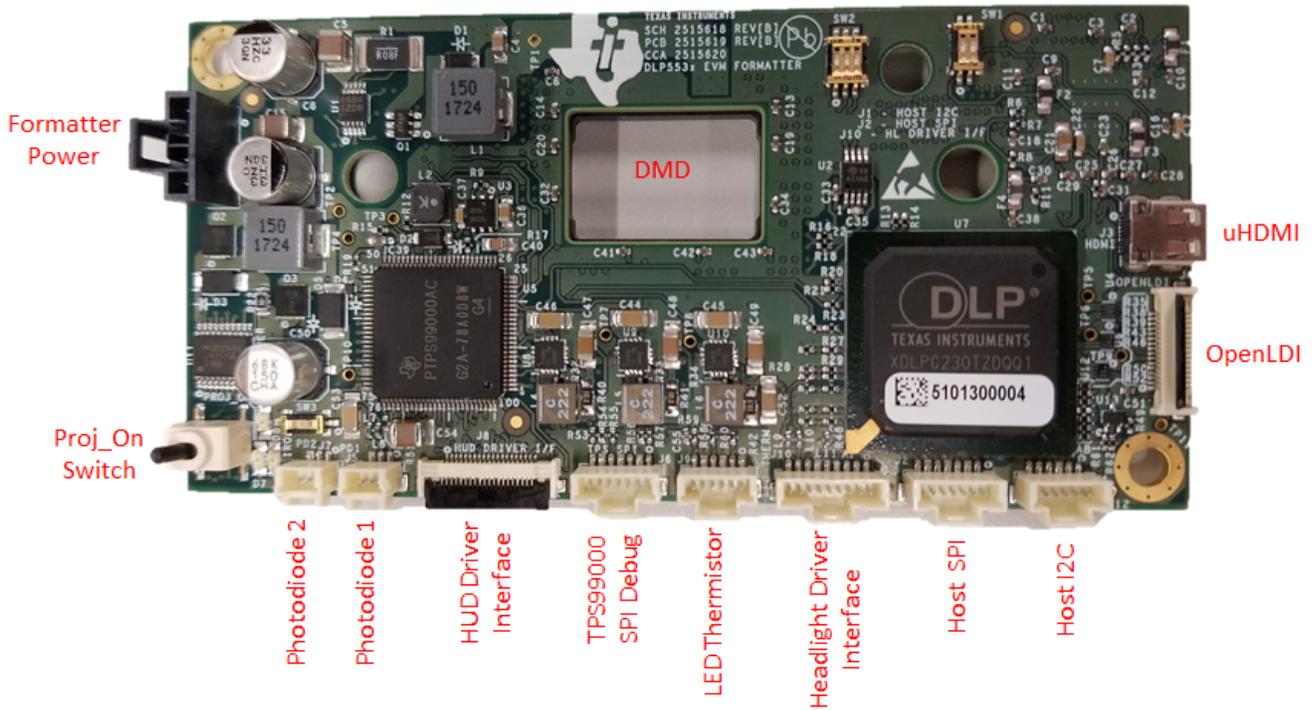
<sup>(1)</sup> Port unused for headlight application. Cable not provided.

**Table 2. Formatter Board Switches**

SCHEMATIC REFERENCE / SIGNAL NUMBER	FUNCTION
SW1 (1)	Spread Spectrum Enable Off: Disabled On: Enabled
SW1 (2)	Test Point 4 <b>Must be set to OFF position</b>
SW2 (1)	Host Port Checksum Select Off: CRC On: Checksum
SW2 (2)	Host Interface Select Off: Host SPI On: Host I <sup>2</sup> C
SW2 (3)	Host SPI Mode Off: Mode 0 or 3 On: Mode 1 or 2
SW3	Hold in Boot Off: Do not hold in boot (continue to main application) On: Hold in boot
SW4	PROJ_ON Off: Turn off system On: Turn on system On state is to the left in <a href="#">Figure 1</a>

**Table 3. Formatter Board LED Indicators**

SCHEMATIC REFERENCE	FUNCTION
D6 (Green)	Input power to Formatter Board (from LED Driver Board) Off: No power connected On: Power connected
D7 (Green)	PROJ_ON Off: System Off On: System On
D8 (Red)	HOST_IRQ Off: Interrupt not asserted On: Interrupt asserted



**Figure 1. DLP5531-Q1 EVM Formatter Board**

### 1.1.1.1 LED Driver Board

The headlight LED driver board contains the following ports and switches, see [Figure 2](#).

**CAUTION**



Hot surface. Contact may cause burns. Do not touch!

**Table 4. LED Driver Board Ports**

SCHEMATIC REFERENCE	FUNCTION
J1	Formatter Power
J2	Input Power
J3	Fan
J4	Headlight Driver Interface
J5	Fan
J6	Fan
J7	LED 0
J8	LED 1
J9	LED 2

**Table 5. LED Driver Board Switches**

SCHEMATIC REFERENCE / SIGNAL NUMBER	FUNCTION
SW1	Fan Enable On position is down in <a href="#">Figure 2</a> .

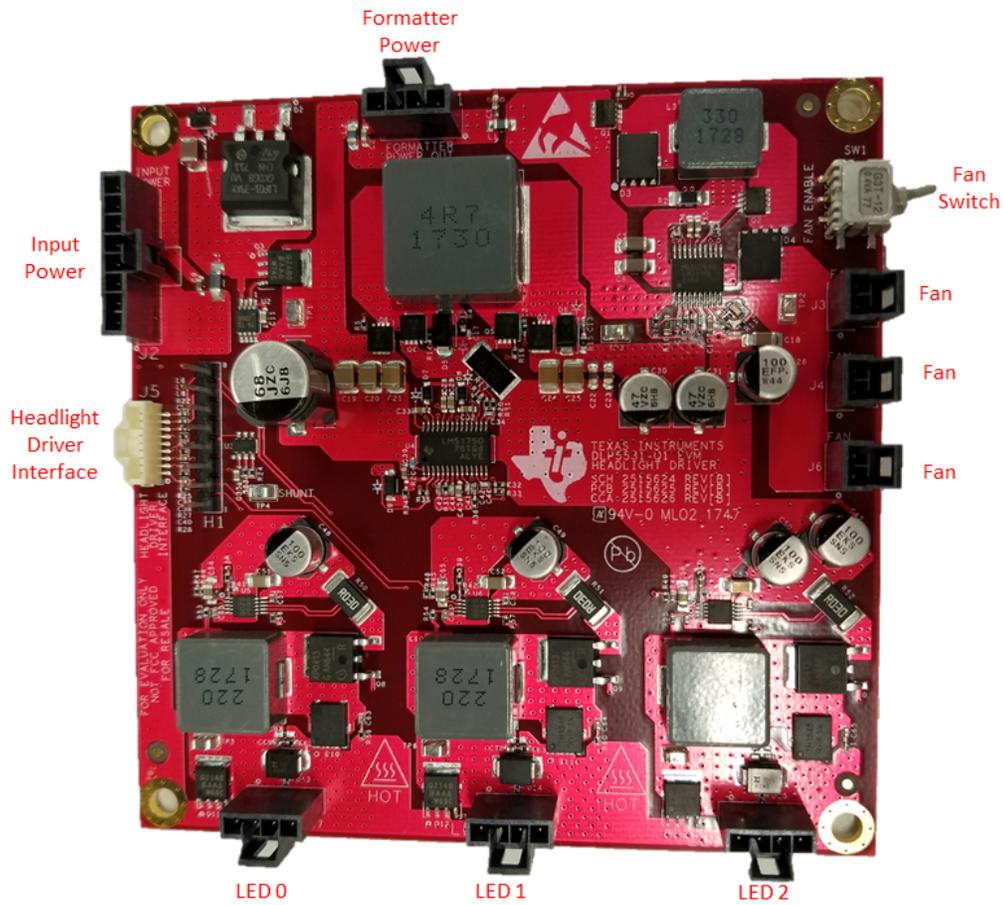


Figure 2. DLP5531-Q1 EVM LED Driver Board

### 1.1.2 Cables

The DLP5531-Q1 Electronics EVM kit contains the following cables, see [Figure 3](#).

NAME	REFERENCE	QUANTITY
Cheetah™ SPI Host Adapter	A	1
Host SPI Cable	B	1
Host I <sup>2</sup> C Cable (Includes PROJ_ON, HOLD_BOOT, HOST_IRQ signals)	C	1
Headlight Driver Interface Cable	D	1
LED Power Cable	E	3
Formatter Power Cable	F	1
Input Power Cable	G	1
Micro HDMI Cable	H	1
OpenLDI Flex Cable	I	1
Fan Power Cable	J	3



Figure 3. Cables Included in DLP5531-Q1 Electronics EVM

## 1.2 Specifications

### 1.2.1 Electrical Specifications

**Table 6. Electrical Specifications**

PARAMETER	MIN	NOM	MAX	UNIT
<b>INPUT</b>				
Voltage	8	12	18	V
Power			96	W
<b>LED DRIVER OUTPUT LOAD</b>				
Voltage (Per LED Channel)	3		12	V
Current (Per LED Channel)			6 <sup>(1)</sup>	A
Power (Sum of All LED Channels)			72	W
<b>FAN LOAD</b>				
Voltage		12		V
Current (Sum of All Fan Channels)			1	A
<b>TEMPERATURE</b>				
Operating DMD Temperature <sup>(2)</sup>	−40		105 <sup>(3)</sup>	°C

<sup>(1)</sup> 8 A may be used, but care must be taken to ensure that individual components and the PCB do not exceed their maximum temperature.

<sup>(2)</sup> Care must be taken to ensure that individual components and PCB do not exceed their maximum temperature when driving high-power load.

<sup>(3)</sup> Some components are only rated to 85°C. Refer to [Table 7](#) for a list of these components.

### 1.2.2 Component Temperature Ratings

The boards and most of the board components are rated to operate between −40°C to 105°C, including the DLP5531-Q1, the DLPC230-Q1, and the TPS99000-Q1.

Some components on board, such as switches, connectors, and indicator LEDs, do not meet this temperature rating. The specifications for all EVM components which are not rated between −40°C to 105°C are listed in [Table 7](#). Please refer to the EVM bill of materials to review the temperature specifications of all components used in the EVM design.

**Table 7. EVM Components Which Are Not Rated for −40°C to 105°C**

Board	Reference	Part Number	Manufacturer	Description	Temperature Minimum (°C)	Temperature Maximum (°C)
Formatter	D6, D7	LTST-C171KGKT	Lite-On	LED, GREEN 0805	−55	85
Formatter	D8	LTST-C171KRKT	Lite-On	LED, RED 0805	−55	85
Formatter	J3	685119248123	Würth	CONN MICRO HDMI RIGHT ANGLE	−40	85
Formatter	SW1	CVS-02TB	Copal Electronics Inc	SWITCH DIP SLIDE 2-POS 1 MM 6 V	−40	85
Formatter	SW2	CVS-03TB	Copal Electronics Inc	SWITCH DIP SLIDE 3-POS 1 MM 6 V	−40	85
Formatter	SW3	CVS-01TB	Copal Electronics Inc	SWITCH DIP SLIDE 1-POS 1 MM 6 V	−40	85
Formatter	SW4	GT12MSCBE	C&K Comp	SWITCH, SPST, GULL	−30	85
Formatter	U4, U6, U12, U503, U505	PCMF2HDMI2SZ	Nexperia	COMMON MODE CHOKE 4LN SMD ESD	−40	85

**Table 7. EVM Components Which Are Not Rated for –40°C to 105°C (continued)**

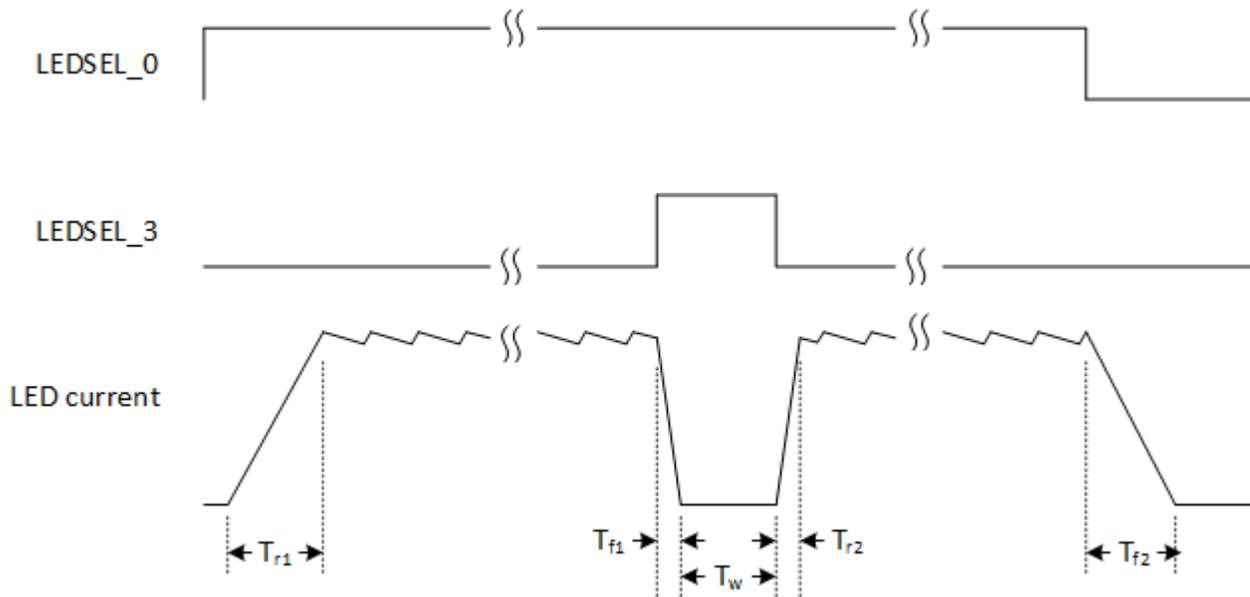
Board	Reference	Part Number	Manufacturer	Description	Temperature Minimum (°C)	Temperature Maximum (°C)
Formatter	U504	TFP401AIPZPRQ1	Texas Instruments	IC PANELBUS DVI RCVR 100-HTQFP	–40	85
LED Driver	SW1	G3T12AH-R	NKK Switches	SWITCH, SPDT, 28 V, 100 mA	–30	85

The Formatter and LED Driver PCBs have a UL flame rating of 130°C maximum.

The DLP5531-Q1 Electronics EVM is not a production design. It is intended for evaluation only.

### 1.2.3 Driver Requirements

The DLP5531-Q1 chipset, used with LED illumination, requires illumination modulation. This illumination modulation turns off the light output during micromirror reset, which improves system contrast. For the system timing specifications of the DLP5531-Q1 Electronics EVM, see [Figure 4](#).



**Figure 4. DLP5531-Q1 Electronics EVM LED Driver Board Timing Specifications**

The timing specifications are shown in [Table 8](#).

**Table 8. LED Driver Board Timing Specifications**

PARAMETER	VALUE
$T_{r1}, T_{f2}$	<50 $\mu$ s
$T_{f1}, T_{r2}$	<2 $\mu$ s
$T_w$	minimum = 1 $\mu$ s

### 1.2.4 Video Specifications

The following resolutions are programmed in the Extended Display Identification Data (EDID). Some video sources may not support all resolutions.

- 1152 × 1152
- 1152 × 576
- 576 × 288

The input source specifications in the EDID of the EVM are outlined in [Table 9](#).

**Table 9. Typical Timing for Supported Source Resolutions**

Horizontal Resolution	Vertical Resolution	Horizontal Blanking				Vertical Blanking				Vertical Rate (Hz)	Pixel Clock (MHz)
		Total	Sync (Pixel Clocks)	Back Porch (Pixel Clocks)	Front Porch (Pixel Clocks)	Total	Sync (Lines)	Back Porch (Lines)	Front Porch (Lines)		
1152	1152	80	8	32	40	33	8	22	3	60	87.59
1152	576	80	8	32	40	17	8	6	3	60	43.83
576	288	322	8	154	160	181	8	158	15	59.98	25.26

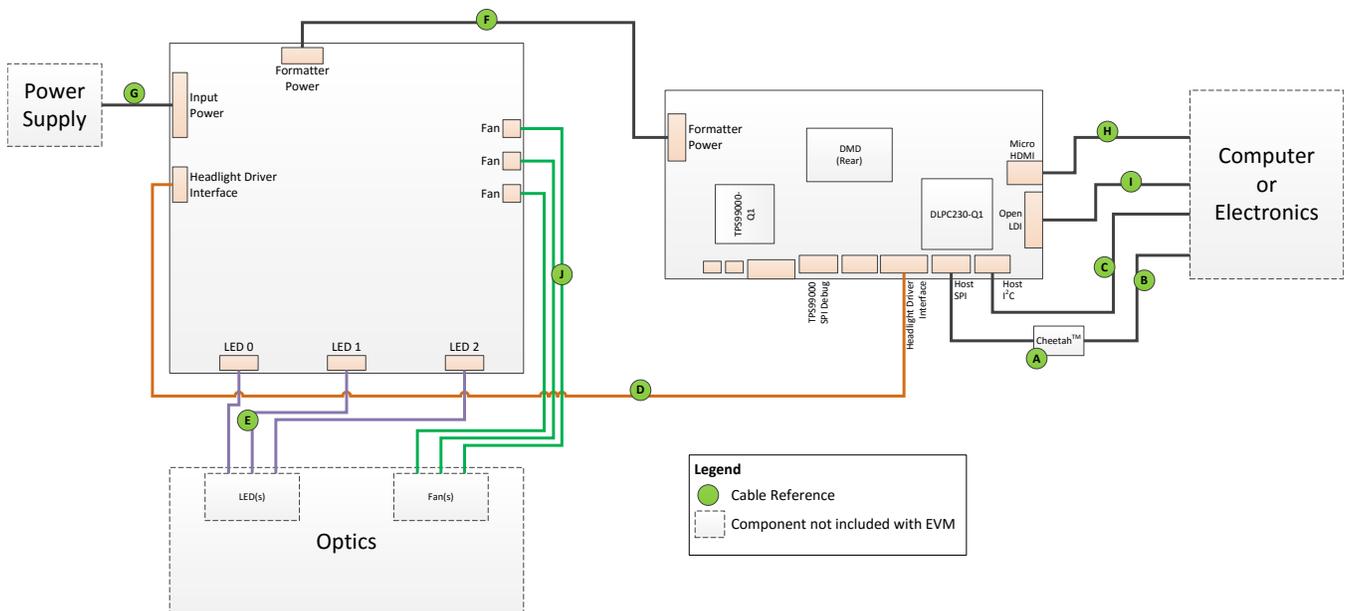
## 2 Quick Start

Use the following instructions to setup your DLP5531-Q1 Electronics EVM and PC.

### 2.1 Kit Assembly Instructions

A diagram of all connections is shown in [Figure 5](#).

1. Connect the Headlight Driver Interface cable to the Formatter Board (J10) and the LED Driver Board (J4).
2. Connect the Host SPI cable to the Formatter Board (J2) and the Cheetah adapter. Connect the Cheetah adapter's USB cable to PC.
3. Connect the Formatter Power cable to the Formatter Board (J11) and the LED Driver Board (J1).
4. Connect the LED power cable to any of the LED Driver Board LED ports (J7, J8, J9). Note that some ports may be disabled by flash setting. LED 0 (J7) is used by default.
5. Connect the Fan Power cable to any of the LED Driver Board fan ports (J3, J5, J6). Confirm the fan switch on the LED Driver Board (SW1) is in the ON position.
6. Connect the Micro HDMI cable to the Formatter Board (J3). Connect the Micro HDMI cable to PC HDMI port.
7. Connect the Power Input cable to the LED Driver Board (J2).



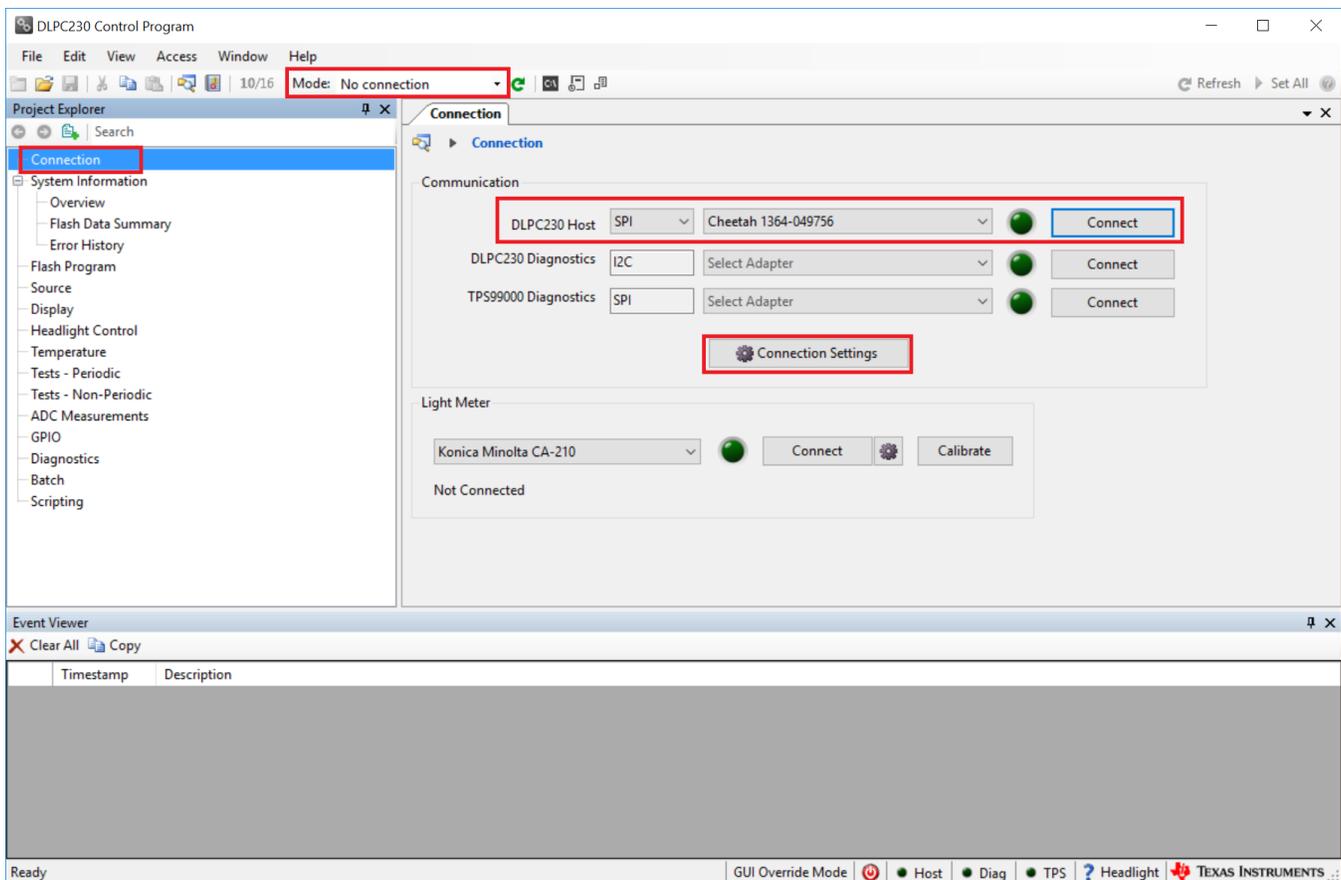
**Figure 5. Cable Connections**

## 2.2 Power-Up

1. Connect input power cable to a power supply that meets input power specifications defined in [Section 1.2](#). The red cable for the V+ terminal and black cable for the V- terminal.
2. Turn on the supply power. Once powered up, a Formatter Board LED indicator (D6) should illuminate green.
3. Turn the PROJ\_ON switch (SW4) ON. The ON position is towards the perimeter of the board, and OFF is towards the DMD. A Formatter Board LED indicator (D7) should illuminate green.

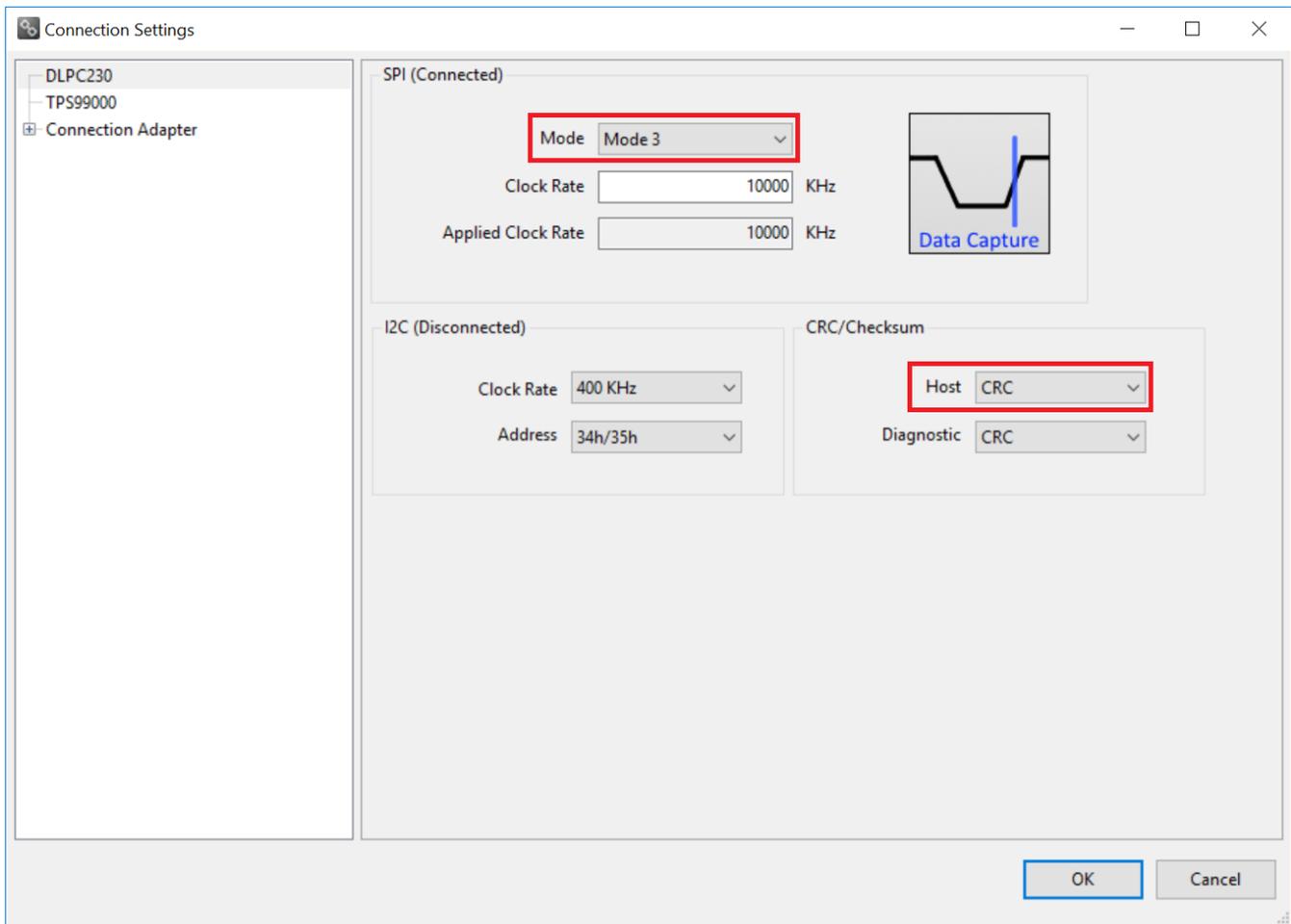
### 2.2.1 Software Setup

- Download and install the DLPC230-Q1 Control Program (<http://www.ti.com/mysecuresoftware>).
- Install Total Phase Cheetah USB adapter (<http://www.totalphase.com/products/usb-driverswindows>).
- Use the DLPC230-Q1 Control Program to connect to the system using the Cheetah USB to SPI adapter and turn the system on.
- To connect, set the DLPC230-Q1 Host to SPI and select the Cheetah from the drop down menu.



**Figure 6. Connecting to the DLPC230-Q1 Device Using the DLPC230-Q1 Automotive Control Program**

- Select "Connection Settings" to confirm the SPI configuration matches the Formatter Board switch settings described in [Table 2](#). Specifically, SPI mode and CRC/Checksum may vary based on switch settings. Press "OK" once configuration is complete.



**Figure 7. Connecting to the DLPC230-Q1 Device Using the DLPC230-Q1 Automotive Control Program**

- Click the Connect button. The green circle should then light up to indicate that connection was successful to the Cheetah Adapter.

### 3 LED Driver

Section 1.2 defines the LED driver load specifications.

The LED brightness can be controlled through PWM output from the DLPC230-Q1. Using the DLPC230-Q1 Automotive Control Program "Headlight Control" tab, the PWM slider bars (PWM0, PWM1, and PWM2) control the current through each LED driver channel. Note that the PWM control may exceed the maximum current specification of some LEDs in certain LED configurations. Table 10 provides reference conversions from PWM level to drive current for commonly used current levels.

**Table 10. LED PWM Drive Current Conversion Reference**

PWM LEVEL	DRIVE CURRENT (A)
0	See <sup>(1)</sup>
256	2
512	4
768	6
1024	8

<sup>(1)</sup> Some current will continue to flow through the LED with a PWM level of 0 and light output may still be visible. To fully remove LED current, the system must be set to standby mode.

## 4 Optics and Mechanics

Optics and mechanics are not included in the DLP5531-Q1 Electronics EVM.

The EVM includes a heat sink and thermal pad, which are attached to the LED driver board. A DMD heatsink is recommended, but is not included in the DLP5531-Q1 Electronics EVM.

## 5 Programming Flash Steps

1. Using the DLPC230-Q1 Automotive Control Program, which is connected to the EVM, navigate to the "Flash Program" tab.
2. Using the folder icon, select an Image File (.bin) and open it.
3. Click "Program and Verify Flash Memory."

Note that if the device is in Display mode, it will automatically be switched to Standby during programming.

## 6 SPI & I<sup>2</sup>C Timing

For more information on SPI and I<sup>2</sup>C specifications, see the DLPC230-Q1 data sheet.

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