DLP5531-Q1 Light Engine Evaluation Module User's Guide

TI's DLP® technology offers the highest resolution available for automotive headlight applications and it's fully programmable. With more than one million addressable pixels per headlight, DLP technology exceeds the resolution of existing adaptive driving beam (ADB) technologies by serval orders of magnitude. 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 Light Engine Evaluation Module (EVM) allows for accelerated evaluation of the DLP5531-Q1 chipset with the inclusion of a DLP5531-Q1 light engine. 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 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 Light Engine EVM Overview

This user's guide presents an overview of the DLP5531-Q1 Light Engine 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 Light Engine EVM

The DLP5531-Q1 Light Engine EVM consists of three 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.
- Light Engine — Compact light engine designed to display images from the formatter board.

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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^2C, PROJ_ON, HOLD_BOOT, HOST_IRQ
J2	Host SPI
J3	Micro HDMI
J4	OpenLDI (Flex connector)
J5	Photodiode 1 (1)
J6	TPS99000-Q1 SPI Debug
J7	Photodiode 2 (1)
J8	HUD Driver Interface (1)
J9	LED Thermistor (1)
J10	Headlight Driver Interface
J11	Formatter Power

(1) 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 2 **Must be set to OFF position**
SW2 (1)	Host Port Checksum Select Off: CRC On: Checksum
SW2 (2)	Host Interface Select Off: Host SPI On: Host I^2C
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 Figure 1

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

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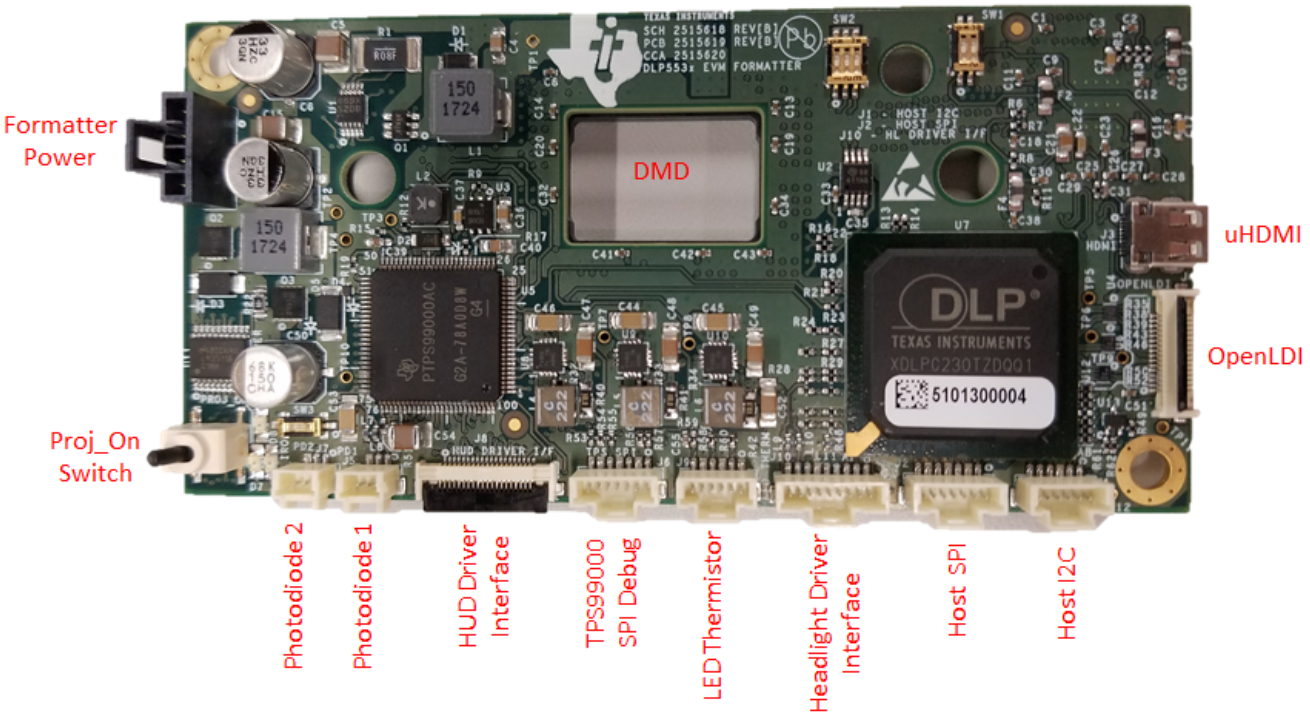

Figure 1. DLP5531-Q1 EVM Formatter Board

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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	Fan
J5	Headlight Driver Interface
J6	Fan
J7	LED 0 - High current output up to 6 A, locking and keyed connector
J8	LED 1 - High current output up to 6 A, locking and keyed connector
J9	LED 2 - High current output up to 6 A, locking and keyed connector

Table 5. LED Driver Board Switches

SCHEMATIC REFERENCE / SIGNAL NUMBER	FUNCTION
SW1	Fan Enable On position is down in Figure 2

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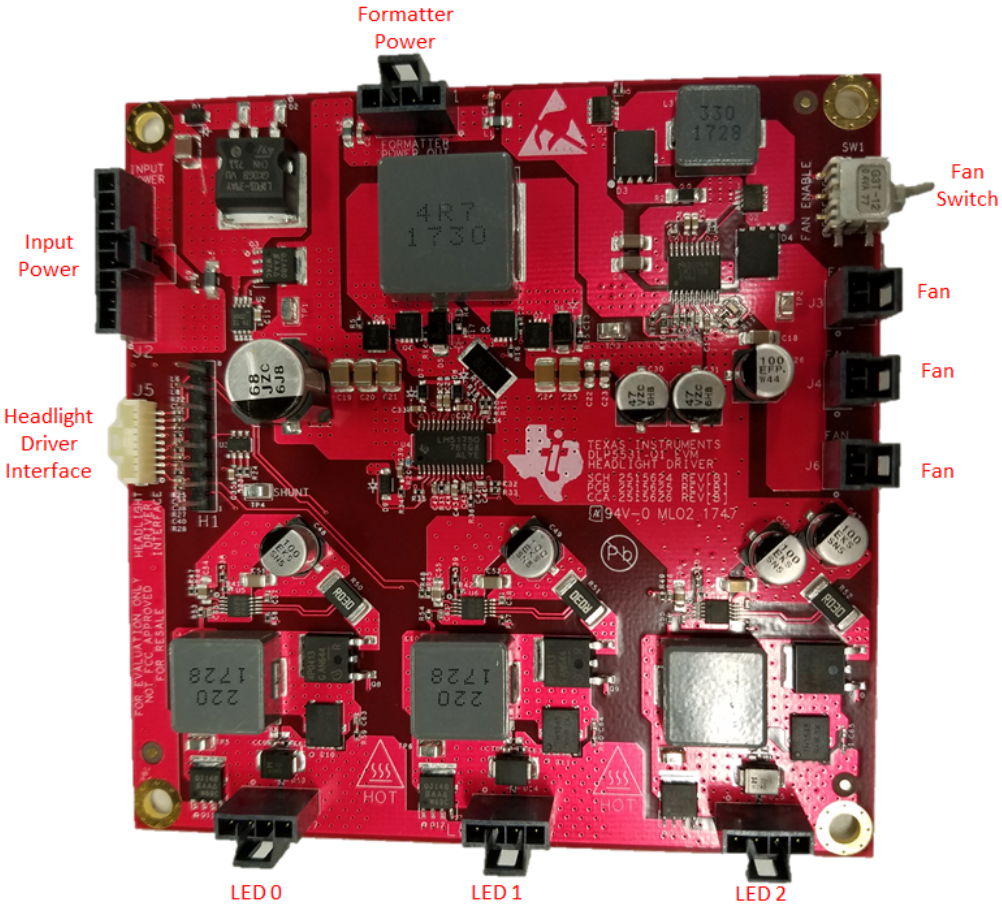

Figure 2. DLP5531-Q1 EVM LED Driver Board

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1.1.2 EVM Light Engine

The light engine included with the DLP5531-Q1 Light Engine EVM can expect to achieve the specifications listed in Table 6.

Table 6. Light Engine Performance Specifications

PARAMETER	MIN	NOM	MAX	UNIT
Peak Lux at 25 m (measured at center of image)		120		lx
Full On/Full Off Contrast (measured at center of image)		300:1		
Field of View (FOV)		14 × 7		Degrees

CAUTION

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

CAUTION

Do not stare at operating lamp. May be harmful to the eyes.

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1.1.3 Cables

The DLP5531-Q1 Light Engine EVM kit contains the following cables, see Figure 3.

Table 7. DLP5531-Q1 Light Engine EVM Cables

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

Figure 3. Cables Included in DLP5531-Q1 Light Engine EVM

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NOTE: For the DLP5531-Q1 Light Engine EVM kit, the LED power cable (E) has been modified to connect to the LED in the DLP5531-Q1 light engine provided in the kit. Also, the loose fan power cables (J) have been removed in the DLP5531-Q1 Light Engine EVM kit, as the fan power cable is connected to the fan on the light engine.

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1.2 Non-Optical Specifications

1.2.1 Electrical Specifications

Table 8. Electrical Specifications

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

(1) 8 A may be used, but care must be taken to ensure that individual components and the PCB do not exceed their maximum temperature.
(2) Care must be taken to ensure that individual components and PCB do not exceed their maximum temperature when driving high-power load.
(3) Some components are only rated to 85°C. Refer to Table 9 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 9. Please refer to the EVM bill of materials to review the temperature specifications of all components used in the EVM design.

Table 9. 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	Wurth	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

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Table 9. 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 Light Engine 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 Light Engine EVM, see Figure 4.

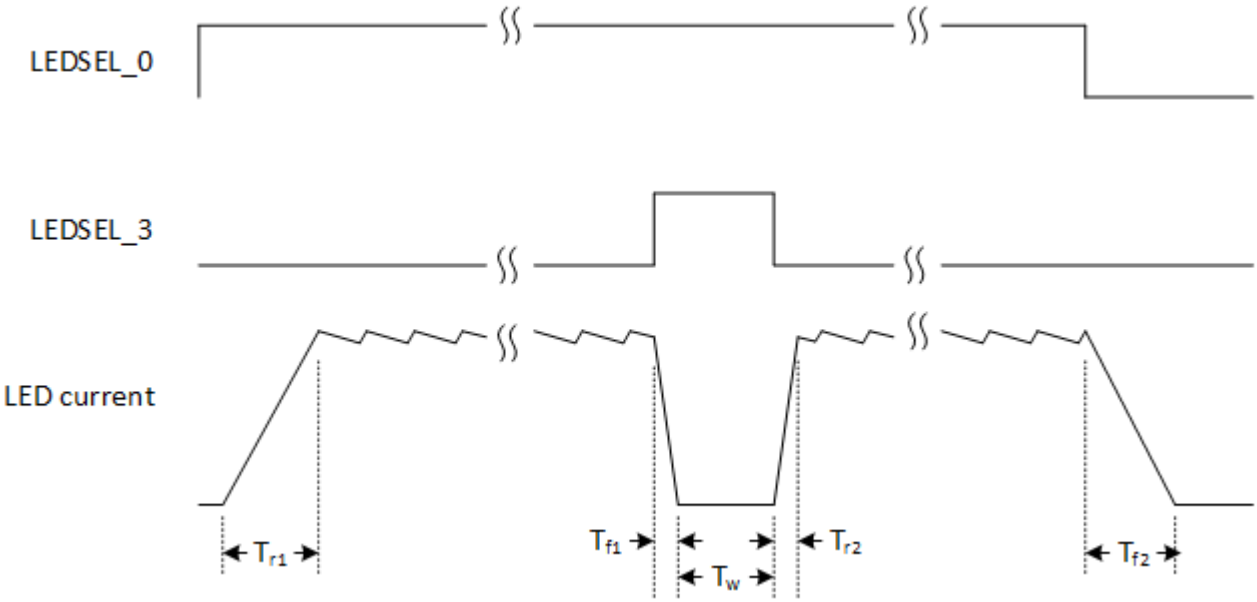

Figure 4. DLP5531-Q1 Light Engine EVM LED Driver Board Timing Specifications

The timing specifications are shown in Table 10.

Table 10. LED Driver Board Timing Specifications

PARAMETER	VALUE
T_{r1}, T_{f2}	<50 µs
T_{f1}, T_{r2}	<2 µs
T_w	minimum = 1 µs

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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 11.

Table 11. 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 Light Engine EVM and PC.

2.1 Kit Assembly Instructions

When assembling the DLP5531-Q1 Light Engine EVM, it is helpful to start by connecting the cables to the formatter board (attached to the light engine) to the LED driver board. Once all of the cables are connected, the light engine can be mounted. To mount the light engine, attach the light engine to the light engine stand. After the light engine is mounted on the stand, the stand can be mounted on the mounting plate of the LED driver board. A diagram of all connections is shown in Figure 5. The full light engine assembly is shown in Figure 6.

1. Connect the Headlight Driver Interface cable to the Formatter Board (J10) and the LED Driver Board (J5).
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 the LED Driver Board LED2 port (J9). The LED connector is located between the heat pipes and heat sink of the DMD. This connector is above the formatter board.
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).

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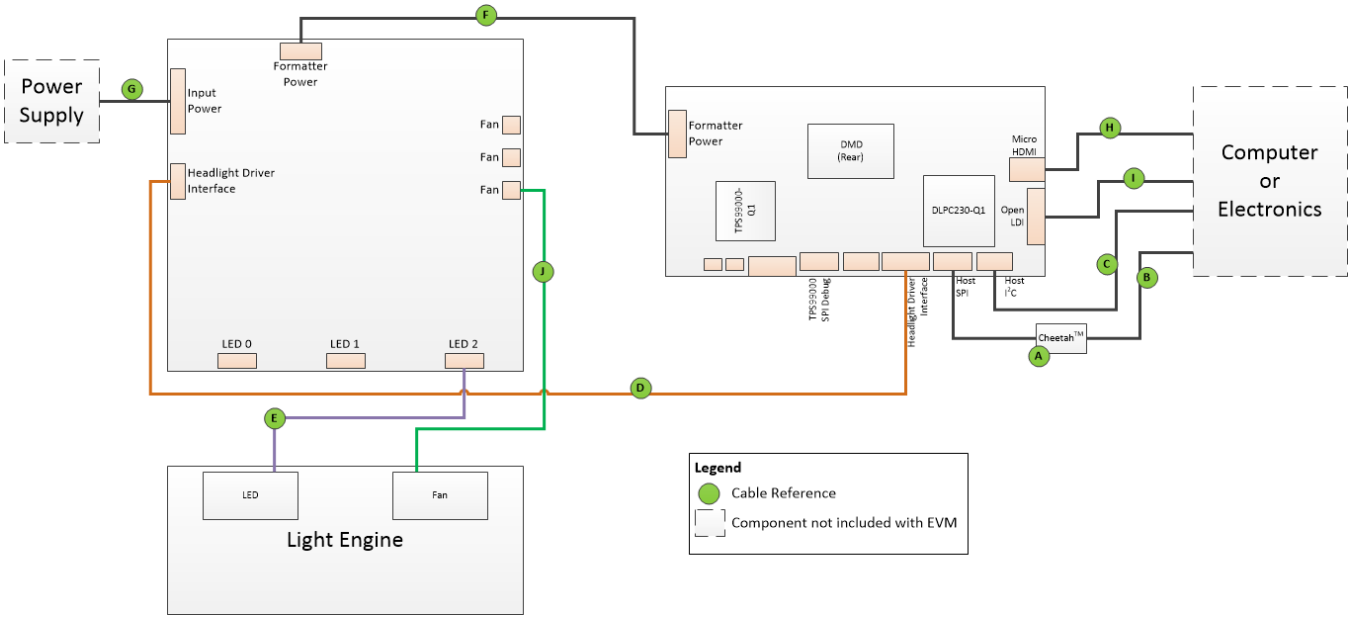

Figure 5. Cable Connections

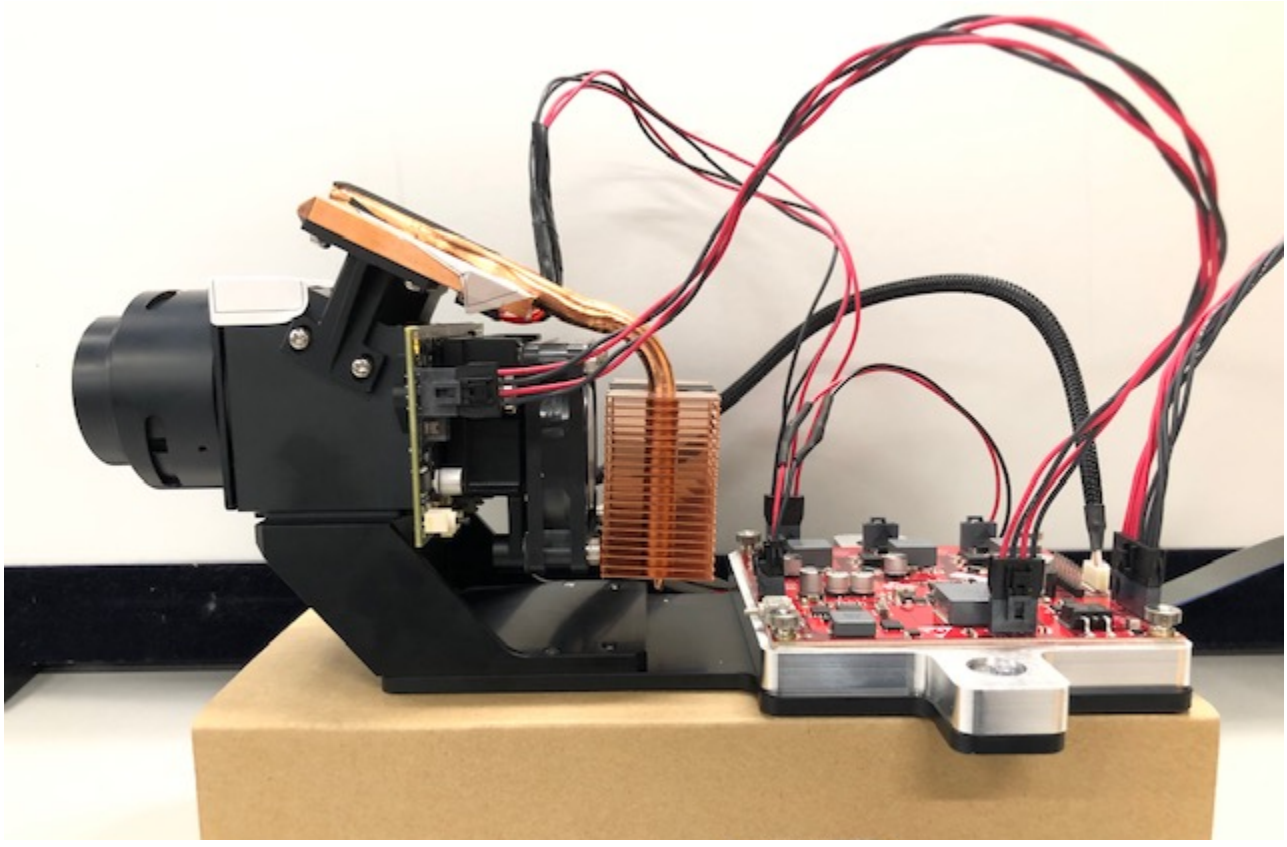

Figure 6. Assembled DLP5531-Q1 Light Engine EVM

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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

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

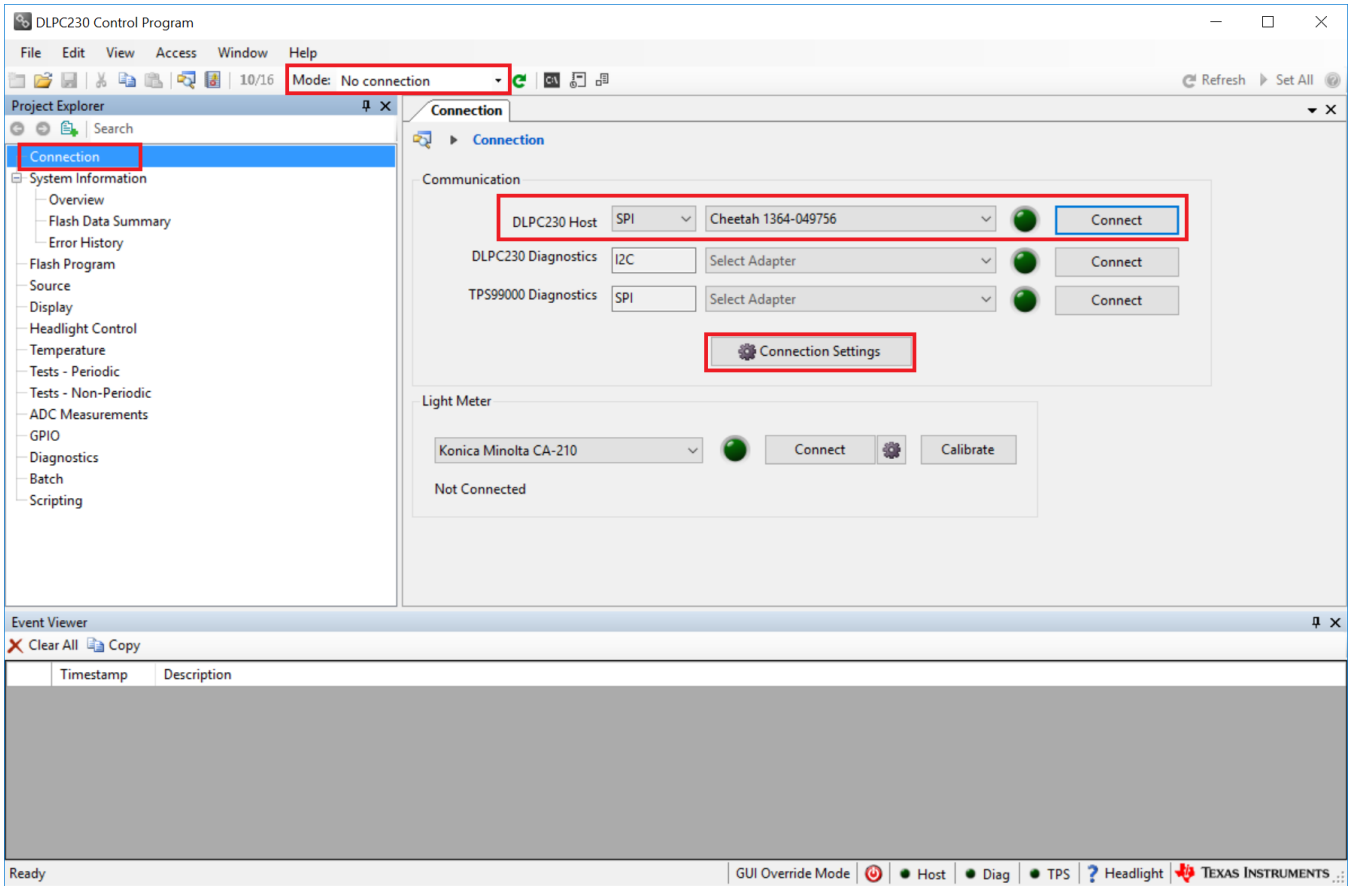

Figure 7. Connecting to the DLPC230-Q1 Device Using the DLPC230-Q1 Automotive Control Program #1

5. 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.

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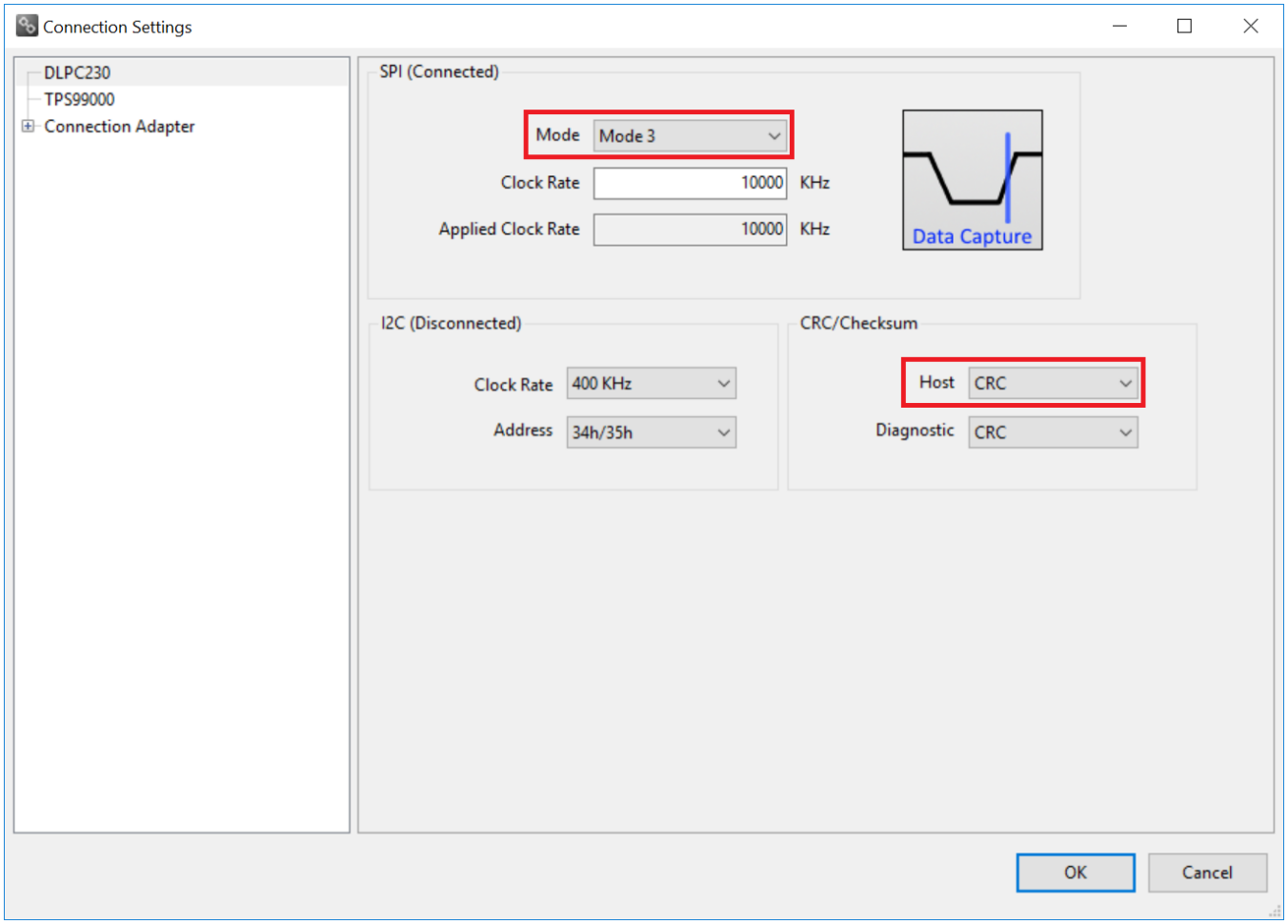

Figure 8. Connecting to the DLPC230-Q1 Device Using the DLPC230-Q1 Automotive Control Program #2

6. 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 12 provides reference conversions from PWM level to drive current for commonly used current levels. The LED used in the DLP5531-Q1 Light Engine EVM has a maximum current rating of 6 A. Because of this maximum current (6 A), the user of the DLP5531-Q1 Light Engine EVM must not set the PWM level over 768. If the user selects a PWM value over 768, the LED can be permanently damaged.

Table 12. LED PWM Drive Current Conversion Reference

PWM LEVEL	DRIVE CURRENT (A)
0	See (1)
256	2
512	4

(1) 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.

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Table 12. LED PWM Drive Current Conversion Reference (continued)

PWM LEVEL	DRIVE CURRENT (A)
768	6
1024	8

4 Optics and Mechanics

Both optics and recommended heat sinks (DMD and LED) are included with the DLP5531-Q1 Light Engine EVM. These heat sinks have been designed to operate the DLP5531-Q1 DMD and LED within their data sheet specifications.

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^2C Timing

For more information on SPI and I^2C specifications, see the DLPC230-Q1 data sheet.

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Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (December 2019) to A Revision	Page
• Added maximum PWM value to achieve maximum current for LED used in Light Engine	16

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