Design Guide: TIDA-020029
Digital Interface LED Driving Module Reference Design for Automotive Rear Light

TEXAS INSTRUMENTS

Description

This reference design offers a cost-effective solution for automotive rear-light applications such as interactive tail-light clusters, which may contribute in the future to of vehicle safety and increase vehicle design personalization. This reference design incorporates two linear LED drivers. By using a controller area network (CAN) physical layer (or a local interconnect network (LIN) optionally), the UART-based FlexWire interface of the LED drivers easily accomplishes long-distance, off-board communication without losing on EMI performance.

Resources

TIDA-020029	Design Folder
TPS929120-Q1	Product Folder
TCAN1042-Q1	Product Folder
TLIN1029-Q1	Product Folder

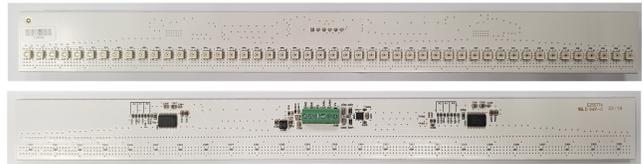Search Our E2E™ support forums

Features

- High pixel count, the design drives:
  - 48 LEDs (two per channel)
- Full feature set for each LED channel:
  - Diagnostics and protection
  - Pulse-width-modulation (PWM) dimming
  - Precise current setting
- UART-based FlexWire interface:
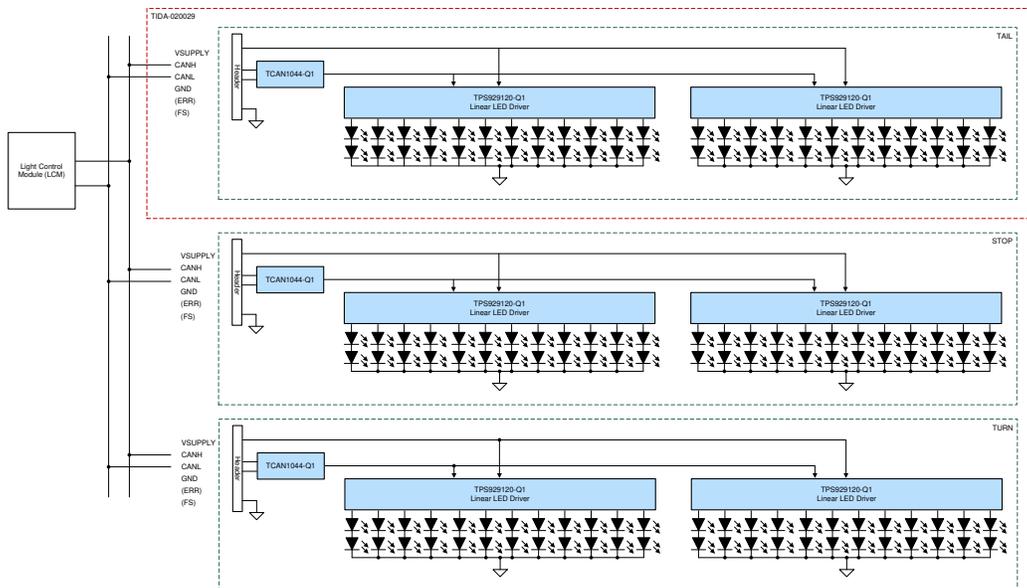 - Each FlexWire bus supports up to 17 devices

Applications

- Rear light- digital interface LED driving module
- Interior light - ambient lighting module

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1 System Description

This reference design incorporates two linear LED drivers. By using a controller area network (CAN) physical layer (or a local interconnect network (LIN) optionally), the UART-based FlexWire interface of the LED drivers make it possible to avoid using a local microcontroller and still easily accomplish long-distance, off-board communication. The topology in this reference design offers a cost-effective solution for automotive rear-light applications such as interactive tail-light clusters.
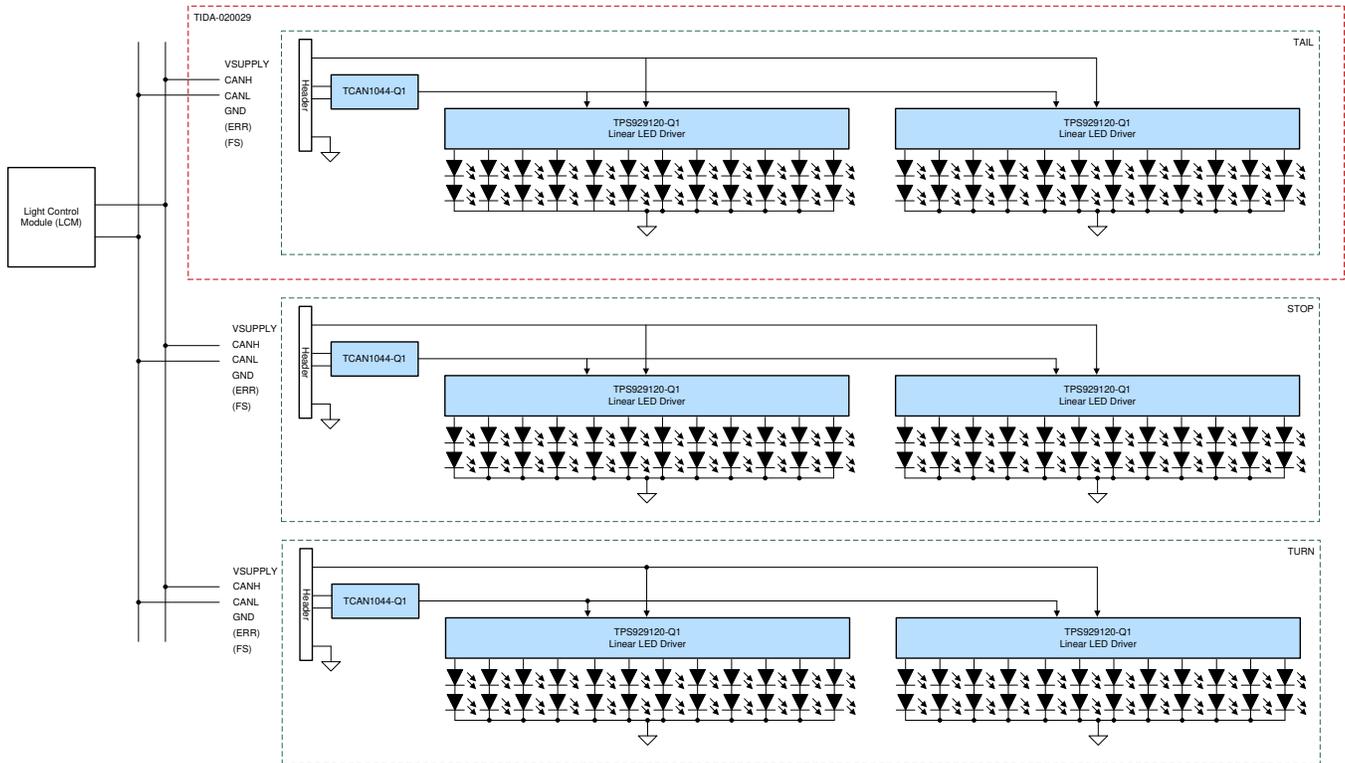
1.1 Key System Specifications

Table 1. Key System Specifications

PARAMETER	SPECIFICATIONS
DC input voltage range	4.5 V - 40 V
LDO output voltage	5 V
LED current	6 mA - 50 mA
Operating ambient temperature	-40°C to 85°C
PCB form factor	26.75 mm x 133.75 mm (2 layers)

2 System Overview

2.1 Block Diagram

Figure 1. TIDA-020029 Block Diagram

2.2 Design Considerations

To simplify this reference design and to increase flexiblity for use in a variety of applications, the board consists of two linear LED drivers that are connected to the same communication bus and use LIN or CAN transceiver for off-board communication. This board format has a simple connector interface, which allows this reference design to be evaluated with any selected MCU-Control board with a transceiver on it.

For ease of testing, the reference design board includes 48 LEDs with two on each output channel. Each channel can be controlled individually.

Digital Interface LED Driving Module Reference Design for Automotive Rear Light   3

2.3 Highlighted Products

2.3.1 TPS929120-Q1 Linear LED Driver

The TPS929120-Q1 is a 12-channel, 40-V high-side LED driver that controls the 8-bit output current and 12-bit PWM duty cycles. The device meets multiple regulation requirements with LED open-circuit, short-to-ground, and single LED short-circuit diagnostics. A configurable watchdog also automatically sets failsafe states when the MCU connection is lost, and, with programmable EEPROM, TPS929120-Q1 can flexibly be set for different application scenarios.

Figure 2. TPS929120-Q1 Block Diagram

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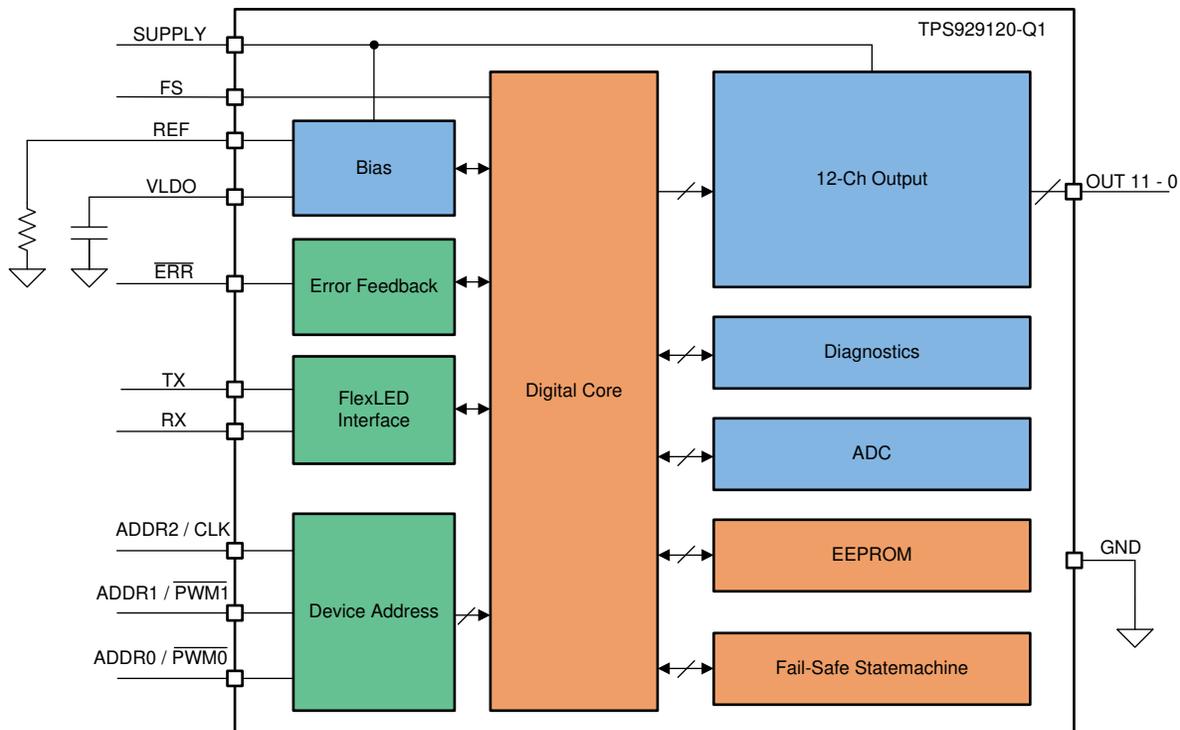
2.3.2   TCAN104x-Q1 CAN Transceiver

This CAN transceiver family meets the ISO11898-2 high-speed CAN (Controller Area Network) physical layer standard. All devices are designed for use in CAN FD networks up to 2 Mbps (megabits per second). Devices with part numbers that include the *G* suffix are designed for data rates up to 5 Mbps, and versions with the *V* suffix have a secondary power supply input for I/O level shifting the input pin thresholds and RXD output level. This family has a low power standby mode with a remote wake request feature. Additionally, all devices include many protection features to enhance device and network robustness.

Figure 3. TCAN104x-Q1 Block Diagram

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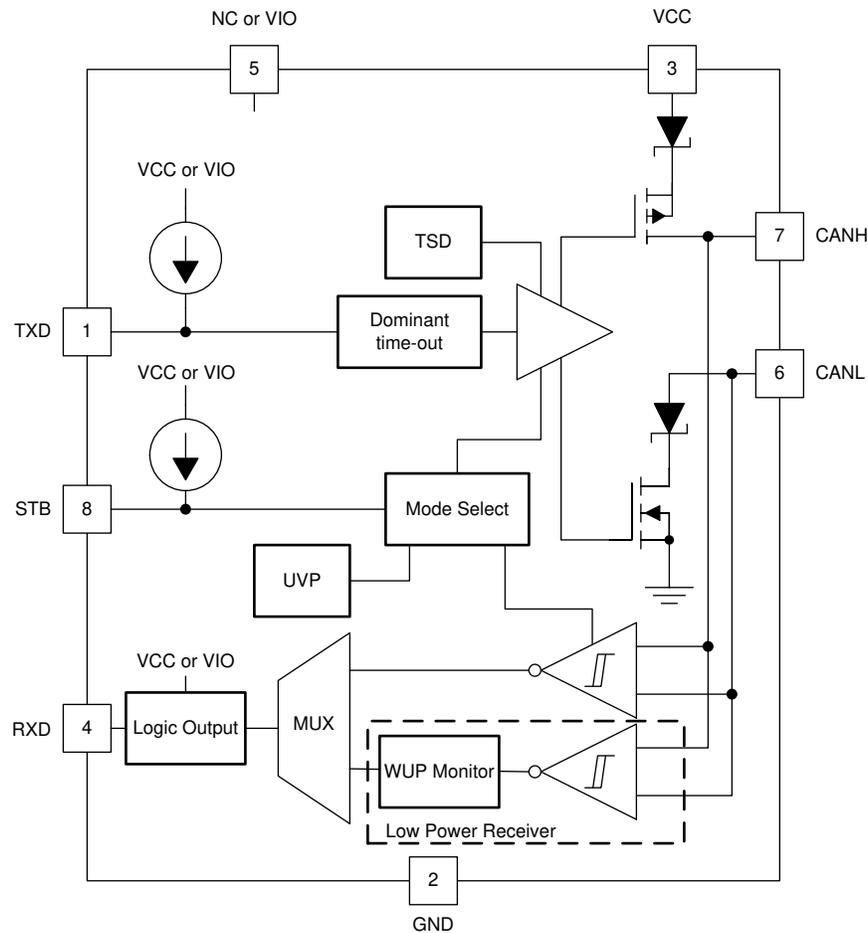
2.4   System Design Theory

This reference design uses a two-layer printed circuit board (PCB) where the LEDs are placed on the top layer and all of the other components are placed on the bottom layer. The PCB integrates 48 LEDs with two LEDs on each channel that can be controlled individually. The PCB is not intended to fit any particular form factor and has dimensions of 26.75 mm x 133.75 mm. The primary objective of the design with regards to the PCB is to make a solution that is compact while still providing a way to test the performance of the board. The size of the solution can be further reduced in this design. Figure 4 shows a 3D rendering of the PCB.

Because each FlexWire bus can support 16 devices, it is possible to use them on one communication bus in up to 8 reference designs.

Figure 4. 3D Render of TIDA-020029
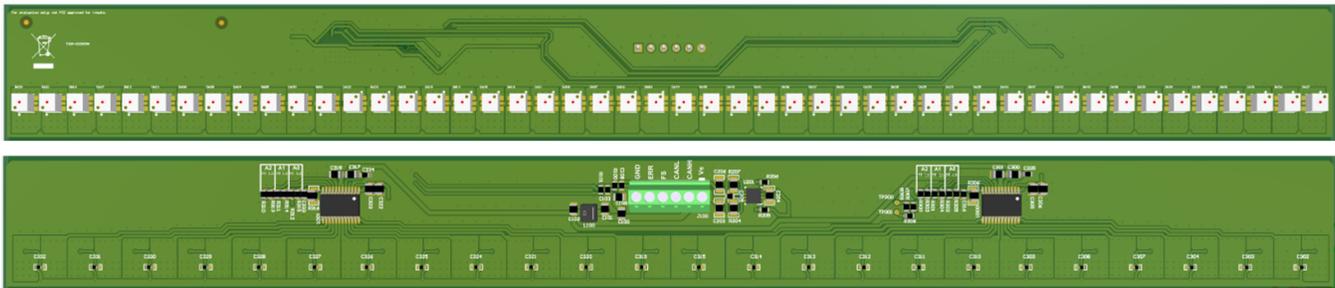
2.4.1   TCAN1044-Q1 Automotive High Speed CAN Transceiver

The TCAN1044x-Q1 devices are high-speed controller area network (CAN) transceivers that meet the physical layer requirements of the ISO 11898- 2:2016 high speed CAN specification providing an interface between the CAN bus and a CAN protocol controller.
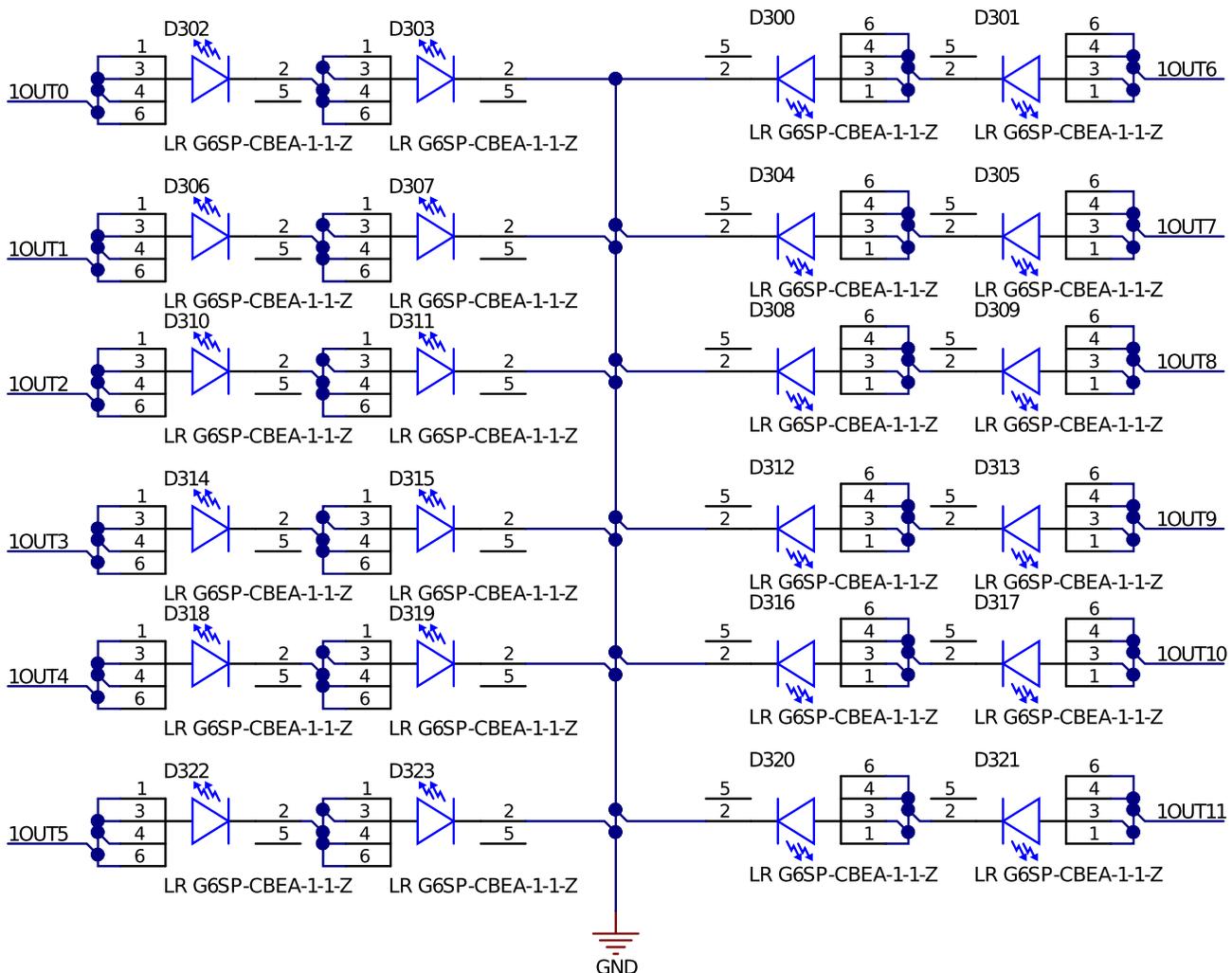
Figure 5. TCAN1044-Q1 CAN Transceiver Schematic
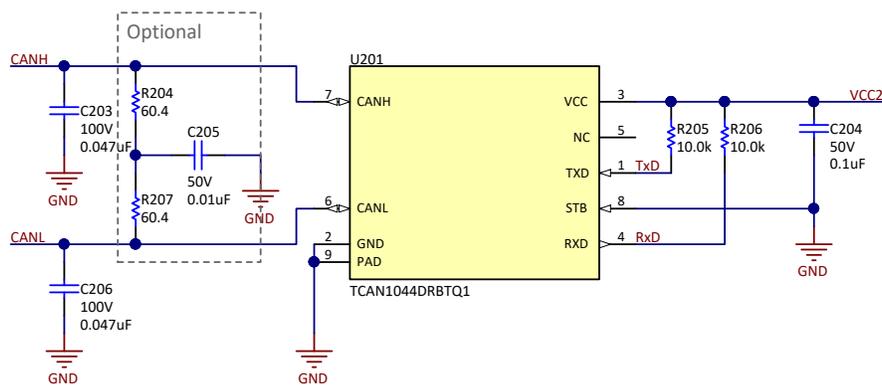
In this reference design, a CAN transceiver is supplied by 5 V on the VCC pin from the internal LDO of the TPS929120-Q1 device. The pull-up resistor R205 and R206 are required for the UART interface between the TCAN1044-Q1 and TPS929120-Q1. For the CAN transceiver in this design, the standard input filter is used.

2.4.2   TPS929120-Q1 Linear LED Driver

This section describes how to design with the TPS929120-Q1 linear LED driver. Figure 6 shows the schematic for one linear LED driver used in this reference design.

Figure 6. TPS929120-Q1 Linear LED Driver Schematic

Each channel of the TPS929120-Q1 is capable of sinking a maximum of 75 mA. In this reference design, two LEDs (OSRAM LR G6SP) are in series connected to each channel shown in Figure 7, meaning that both LEDs apply the same current and the same dimming level (PWM value). The DC current can be programmed using an external resistor R616 connected between the REF pin and GND. In this design, the maximum LED current is set to 50 mA.

Figure 7. Schematic of 24 LEDs

Every TPS929120-Q1 has an unique address used for the communication on the FlexWire bus. Each FlexWire bus supports a maximum of 16 slave devices. The TPS929120-Q1 has 3 pinouts, including ADDR2, ADDR1, and ADDR0, for device address configuration. There are additional 4-bit EEPROM registers to program the slave address of the TPS929120-Q1. The EEPROM register EEP_INTADDR sets the device slave address by either address pins setup or internal EEPROM register code. On this reference design board, external pull-up and pull-down resistors are available that are already connected to the ADDRx pins (R610, R611, R612, R613, R614, R615) to set the unique address for each individual device on the communication bus. Either a pull-up or a pull-down resistor should be removed from each address pin.

3   Hardware, Software, Testing Requirements, and Test Results

3.1   *Required Hardware and Software*

This reference design must be connected to a 12-V power supply and to a communication bus. Figure 8 shows the default test setup of this reference design. In this test setup, an MSP430 LaunchPad™ is used as a master device, which is also connected to the same communication bus through a TCAN1044-Q1 device.

Figure 8. Hardware Test Setup

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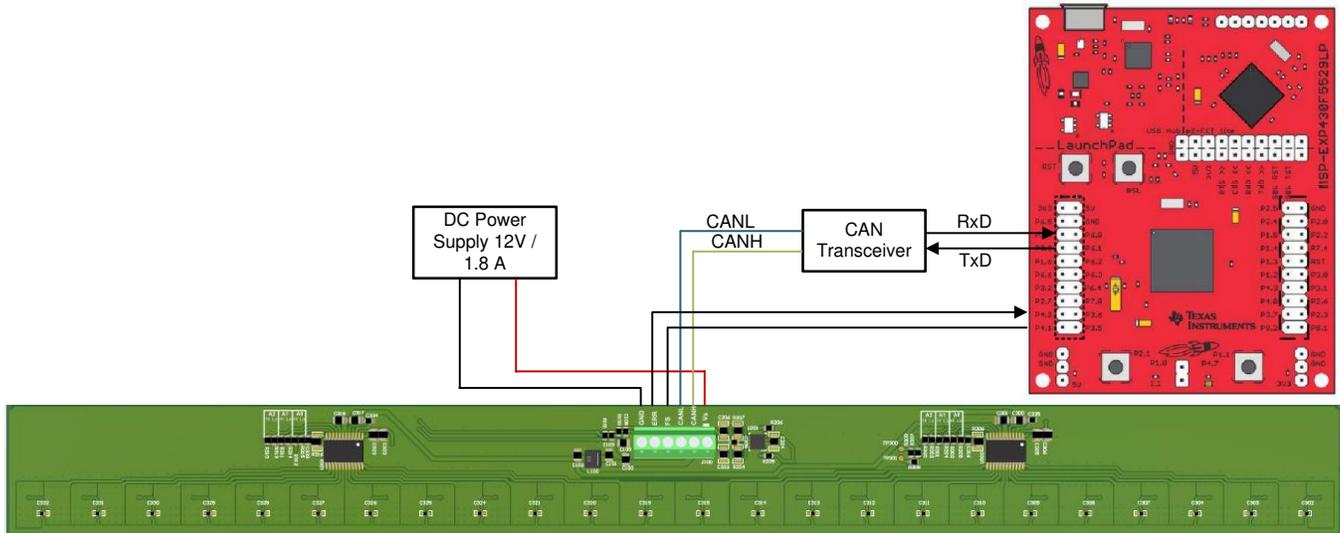
3.1.1   Software

Special testing software was created for this design that controls the LED drivers through the UART (FlexWire). The software is structured in such a way that the MCU first initializes both TPS929120-Q1 and then sets the values for the set of registers so that all 48 LEDs (24 channels, 2 LED-Drivers) can represent various patterns, such as sequential turn light, dimming light, and running light, where the output channels are switched on one after the other. The flow chart in Figure 9 shows the simplified structure of the software.

Figure 9. Software Flow Chart
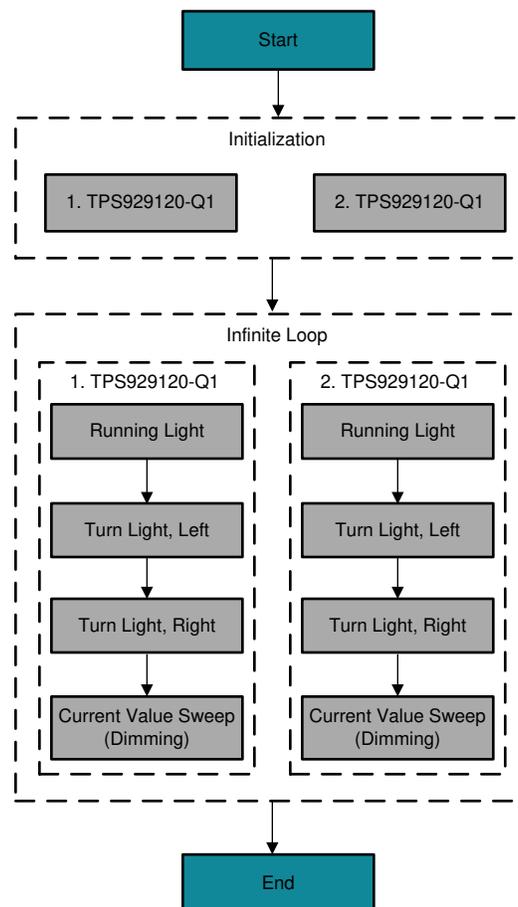
3.2 Testing and Results

3.2.1 Thermal Performance

Figure 10 and Figure 11 show the thermal behavior of the TPS929120-Q1, when all channels are outputting maximum current that is set by an external resistor at TPS929120-Q1.
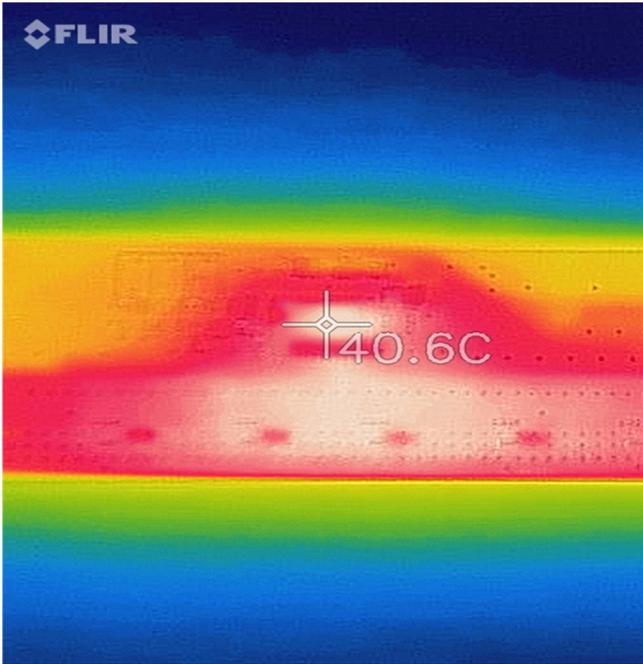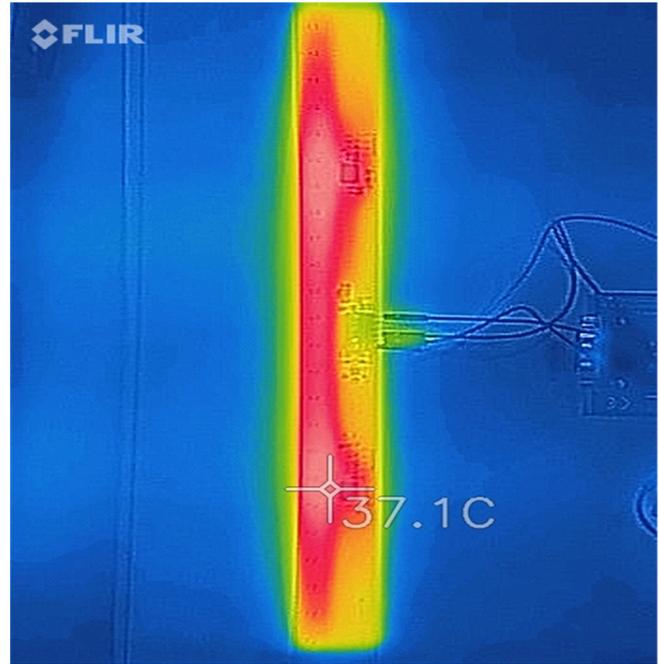
Figure 10. TPS929120-Q1

Figure 11. TIDA-020029 With Two TPS929120-Q1

4 Design Files

4.1 *Schematics*

To download the schematics, see the design files at TIDA-020029.

4.2 *Bill of Materials*

To download the bill of materials (BOM), see the design files at TIDA-020029.

4.3 *PCB Layout Recommendations*

4.3.1 Layout Prints

To download the layer plots, see the design files at TIDA-020029.

4.4 *Altium Project*

To download the Altium Designer® project files, see the design files at TIDA-020029.

4.5 *Gerber Files*

To download the Gerber files, see the design files at TIDA-020029.

4.6 *Assembly Drawings*

To download the assembly drawings, see the design files at TIDA-020029.

5 Software Files

To download the software files, see the design files at TIDA-020029.

6 Related Documentation

1. *TPS929120-Q1 12-Channel Automotive 40-V High-Side LED Driver Data Sheet*
2. *TCAN1042-Q1 Automotive Fault Protected CAN Transceiver With CAN FD Data Sheet*

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