

デザイン・ガイド: TIDA-010043

SpO₂ およびその他医療アプリケーション向け高効率大電流リニア LED ドライバのリファレンス・デザイン

概要

このリファレンス・デザインは、末梢毛細血管酸素飽和度 (SpO₂) およびその他医療アプリケーションに対応した、保護機能付き高効率 (ヘッドルーム制御) 大電流 (最大 1.5A) リニア (正確で高速) 発光ダイオード (LED) ドライバのリファレンス・デザインです。一般的な SpO₂ アプリケーションは、LED 経路で電流を駆動します。これらのドライバのほとんどは、アナログ・フロントエンド・デバイスと統合されており、標準値 100mA で動作します。人体および動物の広範な生理に対応するには、より大きな電流の駆動が必要とされます。このリファレンス・デザインを使うと自己較正が可能です。また、LED を最適に駆動するためルックアップ・テーブルを使用してヘッドルームを制御し、制御素子全体の消費電力を最小化できます。このデザインは 1.8V~4.2V の入力電圧範囲で動作し、最大 1.5A の LED 電流に対応できます。

リソース

TIDA-010043	デザイン・フォルダ
TPS63802	プロダクト・フォルダ
TPS2595	プロダクト・フォルダ
OPA365	プロダクト・フォルダ
OPA333	プロダクト・フォルダ
TLV7021	プロダクト・フォルダ
TMUX1119	プロダクト・フォルダ
CSD13202Q2	プロダクト・フォルダ
CSD13306W	プロダクト・フォルダ



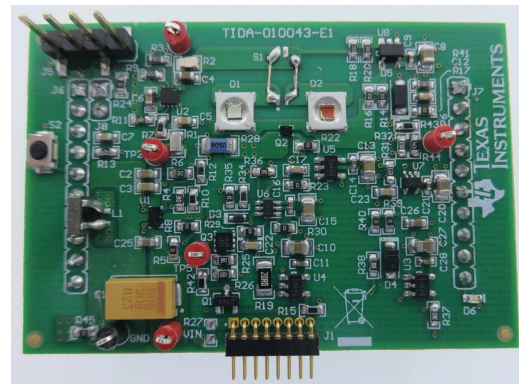
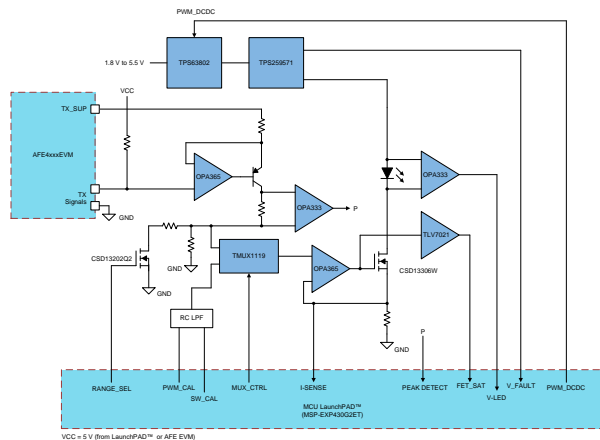
E2E™ エキスパートに質問

特長

- ヘッドルーム制御により LED を最適に駆動し、高い効率を実現
 - 内蔵の自己較正とルックアップ・テーブルによるヘッドルーム制御
 - LED の供給電圧を動的に調整し、プログラムされた電流レベルで最適の効率を実現
- 診断 (LED 開放、LED 短絡、LED 切断)、および eFuse を使用して電源を切断するフォルト保護機構
- 1.8V~5.5V の広い動作入力電圧範囲により、あらゆる種類のバッテリー入力に対応
- LED 電流の範囲をプログラム可能 (100mA~1.5A)
- LED 駆動のための AFE44xx シリーズ EVM と互換 (AFE4403 EVM でテスト済み)
- MSP430G2553 LaunchPad™ および 2 つのオンボード LED (緑色と赤色) でテスト済み

アプリケーション

- パルス・オキシメータ (血中酸素飽和度計)
- マルチパラメータ・メディカル・モニタ
- 内視鏡
- 外科用機器
- 医療用アクセサリ



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1 System Description

1.1 Introduction to Veterinary SpO₂ Application and Need for Higher LED Drive Current

Pulse oximetry is a non-invasive method of measuring the oxygen saturation of hemoglobin (SpO₂) in arterial blood. A typical saturation of peripheral capillary oxygen application drives current through light-emitting diodes (LEDs). Most of these drivers are integrated with analog front-end devices and work in the range of a few hundred milli-amperes up to approximately 250 mA. These currents are not strong enough for use with animals because animals have thicker and hairier skin compared to most driver's intended use with humans.

The oximetry can be done easily if the current through the LEDs is increased to 1.5 to 2 amperes. Higher the LED current, more is the penetration inside the animal body. This helps in getting good reflected signals for SpO₂ calculations.

1.2 Typical Applications

Any reference input current (e.g. from current output DAC) can be used to generate the boosted current output. Few applications are highlighted below.

The [pulse oximeter](#) measures blood oxygenation by sensing the IR and red-light absorption properties of deoxygenated and oxygenated hemoglobin. The oximeter is comprised of a sensing probe that attaches to the ear lobe, toe, or finger of a patient, and is connected to a data-acquisition system for calculation and display of the oxygen saturation level, heart rate, and blood flow. Light sources are typically LEDs, shine-visible red, and IR light. Deoxygenated hemoglobin allows more infrared light to pass through and absorbs more red lights. Highly oxygenated hemoglobin allows more red light to pass through and absorbs more IR light. The oximeter senses and calculates the amount of light at those wavelengths, proportional to the oxygen saturation, or desaturation, of the hemoglobin. The use of light in the absorbency measurement requires the designer to have a true light-to-voltage conversion using current as the input signal.

Veterinary pulse oximeters need higher current compared to human pulse oximeters. The higher currents for driving LEDs help in better penetration and receive enough signal for processing through thick animal skin.

[Multiparameter patient monitors](#) measure vital signs and sends them to a remote location through wired or wireless technology such as Bluetooth®, Bluetooth Low Energy® (BLE), Wi-Fi®, Sub 1-GHz, NFC/RFID, or to a local storage. These monitors have different modules to measure different vital signs.

This design can also be used for powering the light source in endoscopes, for driving LED and light source in optical blood analyzers (used for optical analysis), as light source for spectrometers, for medical lighting and for efficient and accurate current source for Medical lasers.

2 System Specifications and Design Features

This reference design realizes a protected- and headroom-controlled high-current LED driver for oximetry applications. The design features a small board which can power up from a single cell battery and sit on the MSP-EXP430G2ET board.

2.1 System Level Specifications

表 1 shows different characteristics and their specifications of the TIDA-010043 board.

表 1. Key System Specifications and Capabilities

CHARACTERISTICS	SPECIFICATIONS
Input voltage (VIN)	1.8 V to 5.5 V
VCC	5 V (from MSP-EXP430G2ET or AFE4403 EVM)
TX_SUP (from AFE4403 EVM)	5 V
Current limit on eFuse (TPS259571)	1.7 A
UVLO on eFuse (TPS259571)	1.2 V
LED current range (pulsed)	10 mA to 1.5 A
Calibration start	On power-up or reset (using switch S2)
Calibration steps	15
Time between each calibration step	100 ms
Number of LEDs supported	Two (green and red)
Interface to AFE4403 EVM	8-pin connector (50 mil – Part# 850-10-008-20-001000)
Interface to microcontroller board	J2 (100 mil – Part# 61301011821)
	J3 (100 mil – Part# 61301011821)
	J4 (100 mil – Part# PPTC021LFBN-RC)
Board dimensions	39.52 mm x 58.42 mm

3 System Overview

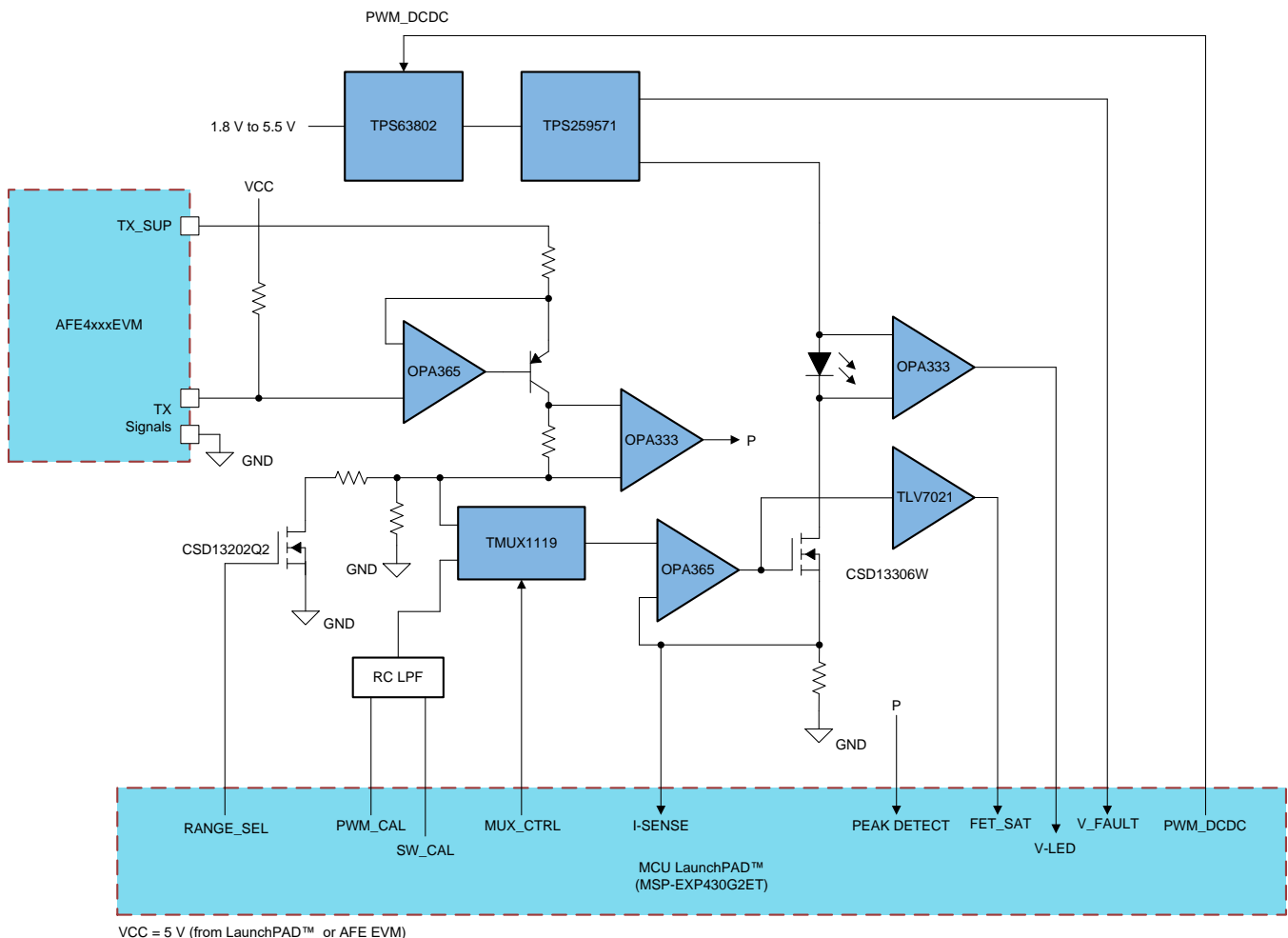
3.1 Block Diagram

Figure 1 shows the high-level block diagram for the TIDA-010043 design, which is a protected- and headroom-controlled high-current LED driver reference design for SpO₂ application. The design helps in boosting the current capability of existing LED drivers (integrated in analog front-end devices) and drives the high-current LEDs. The LED drive current signals (TX signals) from AFE are floating. The signals are referenced to ground and boosted to high current using two OPA365 devices and a MOSFET (CSD13660W). The MOSFET is set up as a linear current source and the LEDs are connected in series with it. The anode of the LED is supplied from a variable DC supply generated using TPS63802 and TPS259571.

The design also highlights some more important features like range selection for LED current (using the MOSFET CSD13202Q2), LED current sensing (using the OPA333), peak-detection for comparing with look-up table (using the OPA333), and switching between calibration mode and normal functionality, which is implemented using the TMUX1119.

The design is tested with the MSP430G2553 LaunchPad™ (MSP-EXP430G2ET) and AFE4403 EVM.

Figure 1. TIDA-010043 Block Diagram



3.2 Highlighted Products

Key features of the highlighted devices are mentioned in the following sections.

3.2.1 TPS63802

The TPS63802 is a high-efficiency buck-boost converter with output current capability up to 2 A. This device limits the peak current at 4.5 A in boost-mode and 3.5 A in buck-mode. The device is adjusted to the programmed output voltage. The device remains in a 3-cycle buck-boost mode when the input voltage is approximately equal to the output voltage. The transitions happen seamlessly and avoid unwanted toggling within the modes. The TPS63802 comes in a 2 mm x 3 mm package. The device works with tiny passive components to keep the overall solution size small.

3.2.2 TPS259571

The TPS2595xx family of eFuses (integrated FET hot swap devices) is a highly integrated circuit protection and power management solution in a small package. The devices provide multiple protection modes using very few external components and are a robust defense against overloads, short circuits, voltage surges, and excessive inrush current. Output current limit level can be set with a single external resistor. It is also possible to get an accurate sense of the output load current by measuring the voltage drop across the current limit resistor. Applications with particular inrush current requirements can set the output slew rate with a single external capacitor. Overvoltage events are quickly limited by internal clamping circuits to a safe fixed maximum, with no external components required.

3.2.3 OPA365

The OPAx365 zero-crossover series, rail-to-rail, high-performance, CMOS operational amplifiers are optimized for very low voltage, single-supply applications. Rail-to-rail input or output, low-noise (4.5 nV/ $\sqrt{\text{Hz}}$) and high-speed operation (50-MHz gain bandwidth) make these devices ideal for SpO₂ applications. The OPA365 (single version) is available in the micro-size SOT23-5 (SOT-5) and SOIC-8 packages.

3.2.4 OPA333

The OPAx333 series of CMOS operational amplifiers use a proprietary auto-calibration technique to simultaneously provide very low offset voltage (10 μV , maximum) and near-zero drift over time and temperature. These miniature, high-precision, low-quiescent current amplifiers offer high-impedance inputs that have a common-mode range 100 mV beyond the rails, and rail-to-rail output that swings within 50 mV of the rails. Single or dual supplies as low as 1.8 V (± 0.9 V) and up to 5.5 V (± 2.75 V) can be used. These devices are optimized for low-voltage, single-supply operation.

3.2.5 TMUX1119

The TMUX1119 is a complementary metal-oxide semiconductor (CMOS) single-pole double-throw (2:1) switch. Wide operating supply of 1.08 V to 5.5 V allows for use in a broad array of applications from medical equipment to industrial systems. The device supports bidirectional analog and digital signals on the source (Sx) and drain (D) pins ranging from GND to VDD. All logic inputs have 1.8-V, logic-compatible thresholds, ensuring both TTL and CMOS logic compatibility when operating in the valid supply voltage range. Fail-safe logic circuitry allows voltages on the control pins to be applied before the supply pin, protecting the device from potential damage.

3.2.6 TLV7021

The TLV7021 is single-channel, micro-power comparator that features low-voltage operation with rail-to-rail input capability. The device is available in an ultra-small, leadless package measuring 0.8 mm × 0.8 mm, making it applicable for space-critical designs. It offers an excellent speed-to-power combination with a propagation delay of 260 ns and a quiescent supply current of 5 μ A. This combination of fast response time at micro-power enables power-conscious systems to monitor and respond quickly to fault conditions. With an operating voltage range of 1.6 V to 5.5 V, these comparators are compatible with 3-V and 5-V systems.

3.2.7 CSD13202Q2

This 12-V, 7.5-m Ω NexFET™ power MOSFET has been designed to minimize losses in power conversion and load management applications. The SON 2 × 2 offers excellent thermal performance for the size of the package.

3.2.8 CSD13306W

This 8.8-m Ω , 12-V, n-channel device is designed to deliver the lowest on resistance and gate charge in a small 1- × 1.5-mm outline with excellent thermal characteristics and an ultra-low profile.

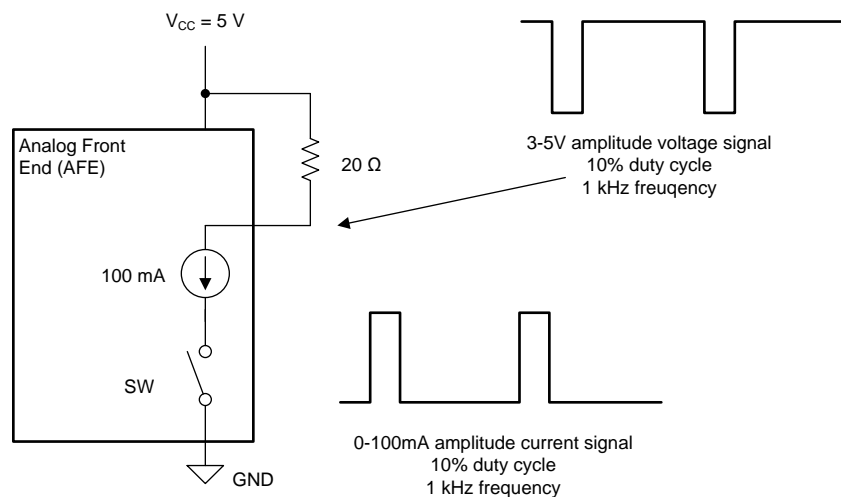
3.3 System Design Theory

This section explains the design theory and equations, if required, for each of the devices used in the design.

3.3.1 Understanding the LED Current Pattern

Typically, analog front-end devices, such as the AFE4403, integrate LED drivers with switches to turn on and turn off the LED drivers. As shown in [Fig 2](#), assume that the AFE has an integrated 100-mA current source and the switch SW is switching at a 1-kHz frequency with 10% duty cycle. The 0- to 100-mA current signal will generate a voltage waveform (3-V to 5-V amplitude) across a 20-ohm resistor. This voltage is floating. A circuit is needed to convert the voltage into a ground-referenced voltage signal.

Fig 2. AFE Current Signal Conversion to Voltage Signal

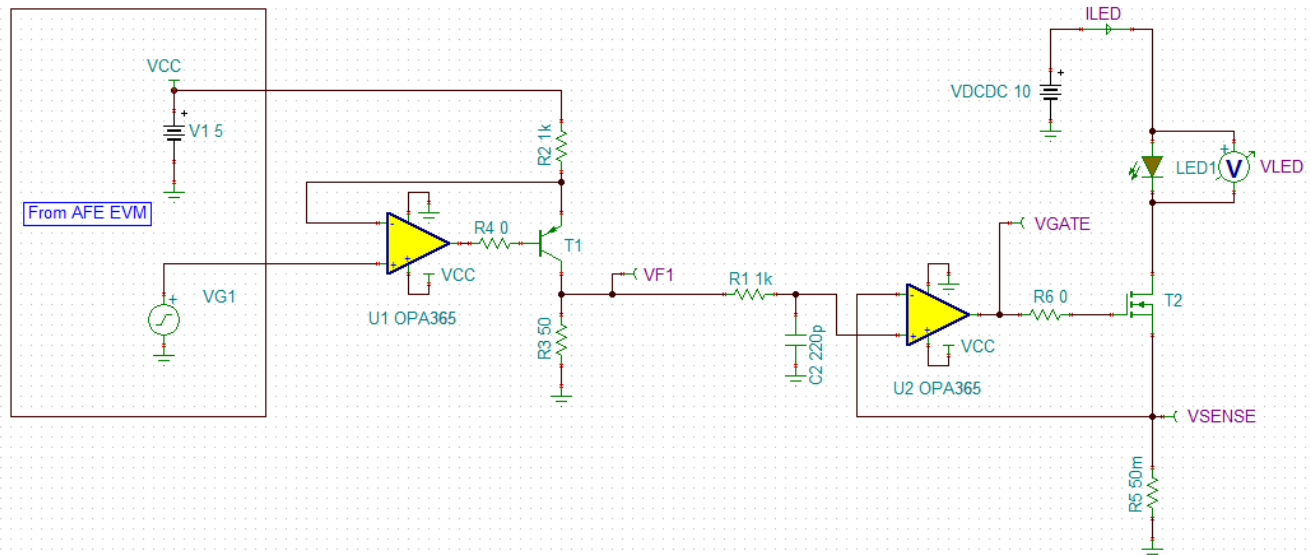


3.3.2 Conceptual Explanation of the Design

[Fig 3](#) shows the TINA-TI simulation for the high-level concept of the circuit. The component designators may differ from actual designators in the Altium schematic of the TIDA-010043.

VG1 is the voltage signal, which is derived from LED driver current signal as shown in [Fig 2](#). The input to first OPA365 (U1) is floating (3 V to 5 V) and switching at 1 kHz. This stage, along with transistor T1, is used to level shift and make the voltage signal ground referenced and not floating. VF1 is the voltage output referenced to ground. The second-stage operational amplifier (op-amp) OPA365 is used to boost the current to approximately 2 A by using the MOSFET as a linear current source. The VDCDC is representing voltage coming from buck-boost converter and eFuse.

図 3. TINA Simulation for the High-Level Concept of the TIDA-010043



With VF1 fixed at 100 mV, VDCDC is swept from 0 V to 10 V. 図 4 shows that when VSENSE reaches 100 mV, the VGATE changes state and the MOSFET current source comes out of the linear region.

図 4. DC Transfer Characteristics for Simulated Circuit (VDCDC Swept From 0 V to 10 V)

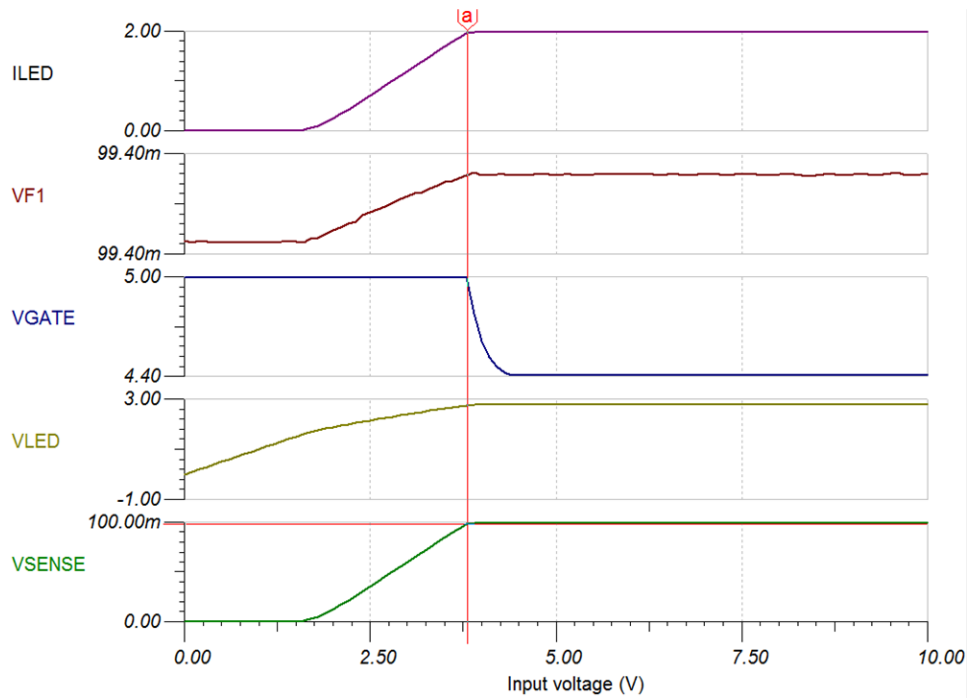
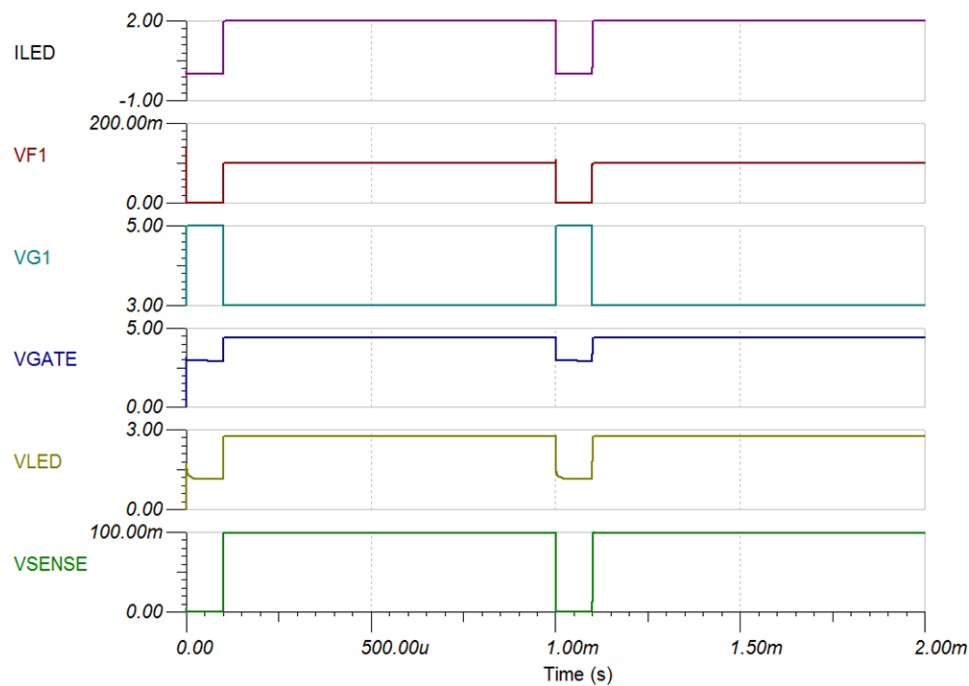


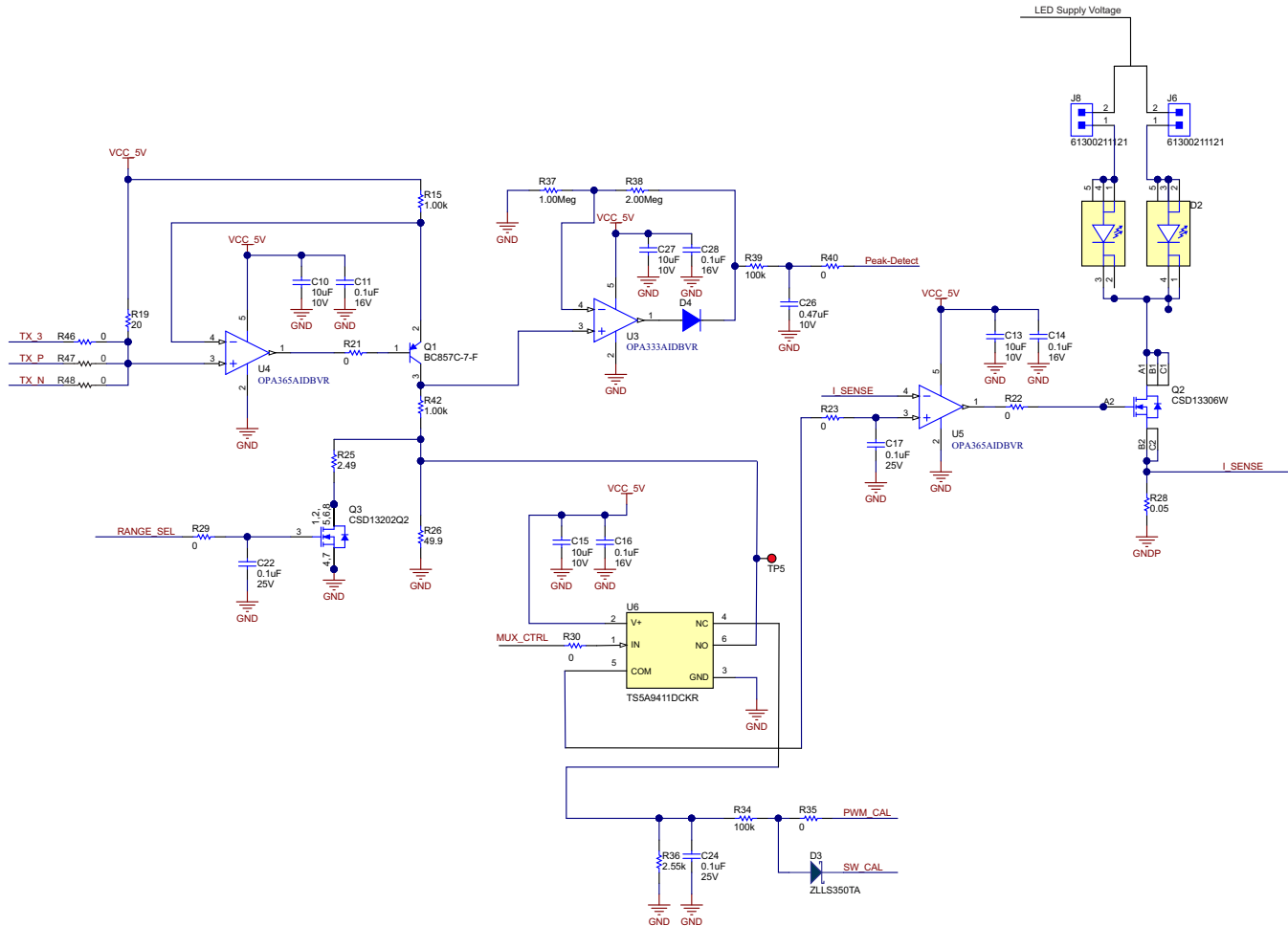
図 5 shows the transient response of the circuit shown in 図 3.

図 5. Transient Waveforms for Simulated Circuit


3.3.3 Function of the Circuit

図 6 shows the schematic of the design. There are two major parts of the schematic. The first section is the calibration section and the other section is for normal functioning. The calibration routine starts at every power cycle or if SW_X (S2) is pressed on the TIDA-010043 board.

Figure 6. Schematic Showing Signal Chain Devices

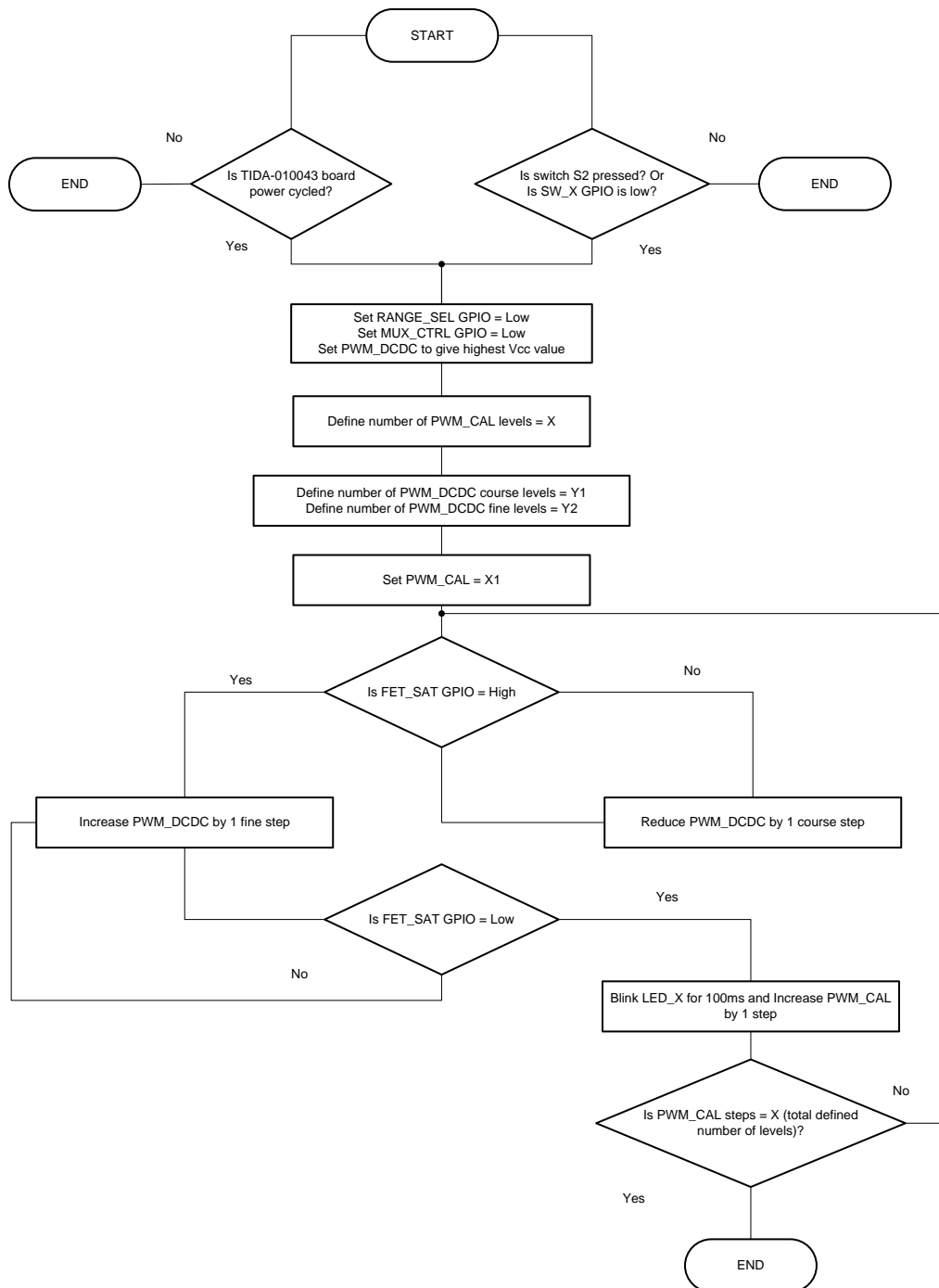


For the calibration process, a voltage is set using PWM_CAL at the non-inverting terminal of op-amp U5 (OPA365) which sets the ISENSE flowing through the LED. The MUX_CTRL is set to low which means S2 and D pins are connected internally. The op-amp U5 and MOSFET Q2 (CSD13306W) are set up as a linear current source. The current through LEDs (D1 or D2 based on which jumper is connected – J8 or J6) is dependent on ISENSE voltage. The voltage across the LED will vary based on the current flowing through it, and the drop across the MOSFET will also vary based on $R_{DS(on)}$ of the MOSFET. To ensure that the power across the LED is optimized, the anode voltage of the LED should be dynamically decided. To achieve this, the PWM_DCDC signal is used. This signal generates variable PWM to set the feedback of the buck-boost converter TPS63802. Once the ISENSE voltage is set, the PWM_DCDC signal is swept to generate different voltage levels at the anode of the LED, same as the output of the eFuse device TPS259571.

For any LED, the TIDA-010043 follows this calibration process and saves the LED voltage and current levels in a look-up table. These values are used for functional testing. Op-amp U3 (OPA333) is used for detecting the peak of the signal and then comparing it with the value in the look-up table. This way, optimum supply voltage and currents for the LED can be set.

Figure 7 shows the flowchart for the calibration routine.

Figure 7. Calibration Flowchart



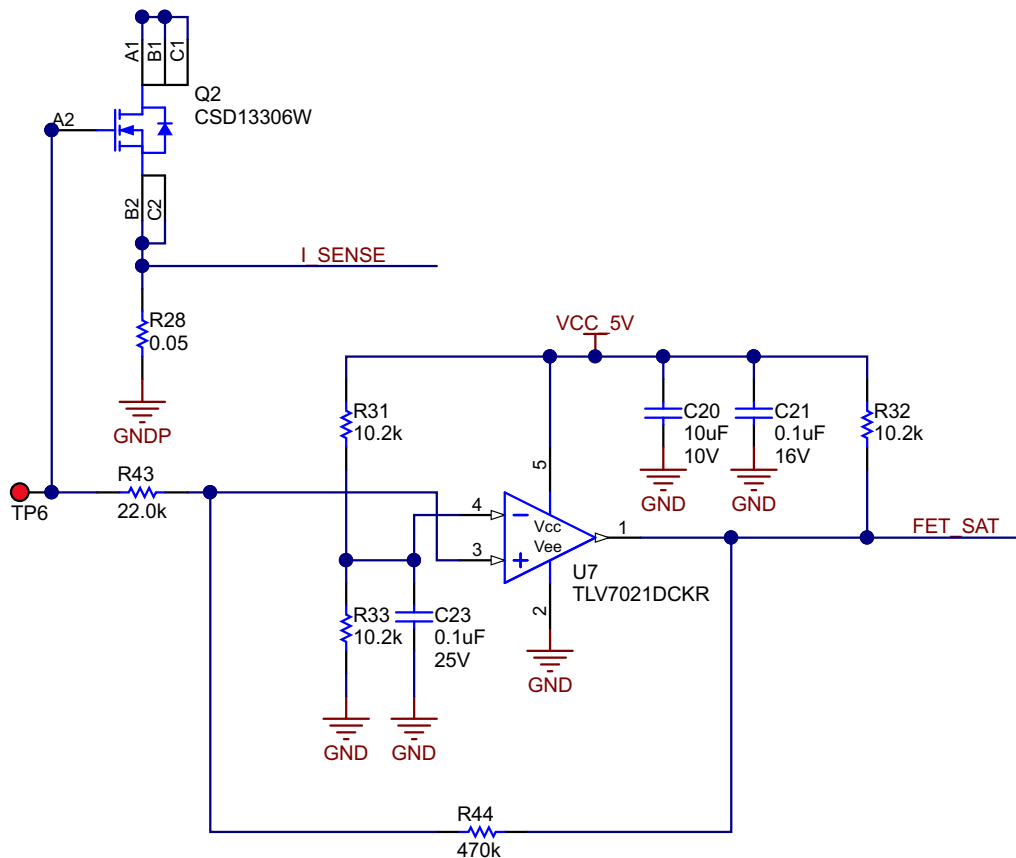
The TX_N, TX_P, and TX_3 signals are LED current signals from the AFE4403. Op-amp U4 (OPA365) and transistor Q1 (BC857) are used for shifting the reference for the switching input voltage signal. Once the current is referenced to ground, it passes through multiplexer U6 (TMUX1119). Because the calibration process is already over, the MUX_CTRL signal is set to high so that D and S1 pins can be connected with each other.

MOSFET Q3 (CSD13202Q2) is used for selecting the LED current range. When RANGE_SEL pin is set low, Q3 is off. This gives LED current range up to 1.5 amperes. When RANGE_SEL pin is set high, Q3 is turned on and R25 is connected in parallel with R26 (for example, . 2.49 || 49.9). This gives lower current through the LED.

3.3.4 Comparator With Hysteresis to Get MOSFET Saturation Signal

When the calibration is performed, the gate voltage of the MOSFET is considered as the deciding factor when current source starts to saturate. This signal is provided to the microcontroller through a comparator (TLV7021) with hysteresis. The threshold of the comparator is set at $V_{CC}/2$, or 2.5 V.

図 8. Comparator to Get MOSFET Saturation Signal for Calibration and Normal Function

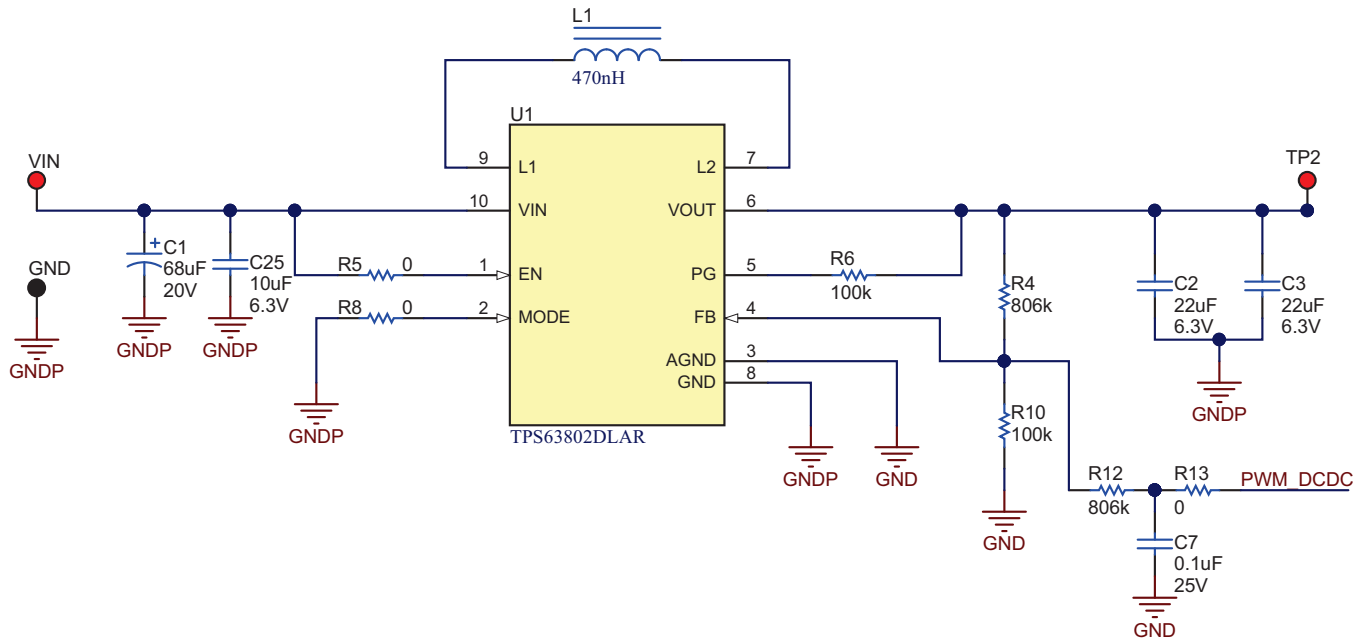


3.3.5 Designing Buck-Boost Converter Circuit TPS63802

The TPS63802 is a buck-boost converter which can accept input voltage from 1.8 V to 5.5 V and generate a constant voltage between these values.

The calculations for input capacitor, output capacitor, and inductor are taken from the [TPS63802 high current, high efficiency single inductor buck-boost converter data sheet](#).

図 9. Buck-Boost Converter TPS63802 Circuit



The calculations of feedback resistors are important because the feedback voltage is controlled using PWM_DCDC signal from microcontroller. 式 1 and 式 2 show the calculations for the feedback resistors .

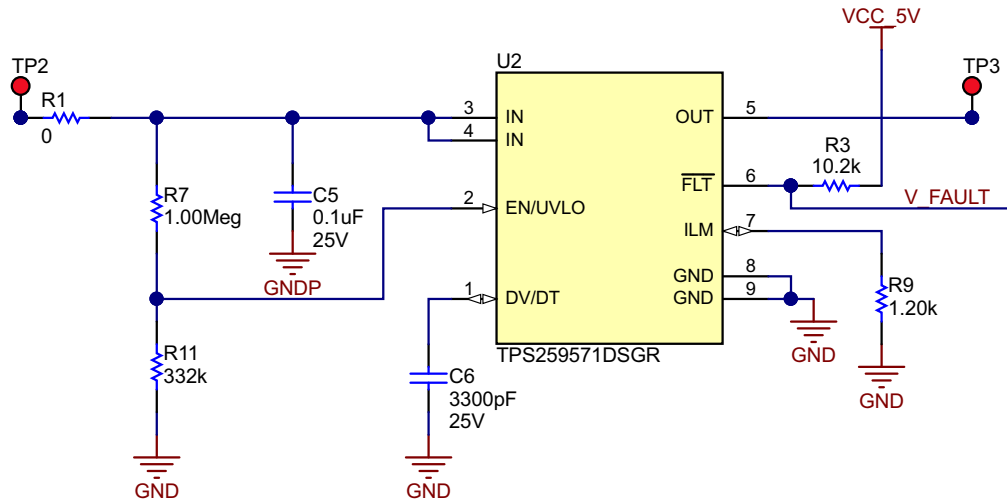
$$R_{12} = R_4 \left(\frac{V_{CTRL-max} - V_{CTRL-min}}{V_{OUT-max} - V_{OUT-min}} \right) = 1M \times \left(\frac{3 - 0}{5 - 1.6} \right) = 882 \text{ k}\Omega \text{ (Selected } 866 \text{ k}\Omega) \tag{1}$$

$$R_{10} = \frac{V_{FB} \times R_4 \times R_{12}}{(R_{12} \times V_{OUT-max}) - (R_4 \times V_{CTRL-min}) - V_{FB} (R_4 + R_{12})} = \frac{0.5 \times 1M \times 866 \text{ k}}{(866 \times 5) - (1M - 0) - 0.5(1M + 866 \text{ k})} = 127.4 \text{ k}\Omega \tag{2}$$

3.3.6 Designing eFuse Circuit TPS259571

The TPS259571 is an eFuse device which has under-voltage lock-out (UVLO) and current limit feature. The UVLO is set using resistors R7 and R11 and using 式 3. The current limit is set using resistor R9 connected on pin ILIM of TPS259571 and 式 4.

図 10. eFuse Circuit



$$V_{IN} = \frac{V_{UVLO}(R_7 + R_{11})}{R_{11}}$$

$$5 = \frac{1.2(1M + R_{11})}{R_{11}} \text{ gives } R_{11} = 315 \text{ k}\Omega$$

(3)

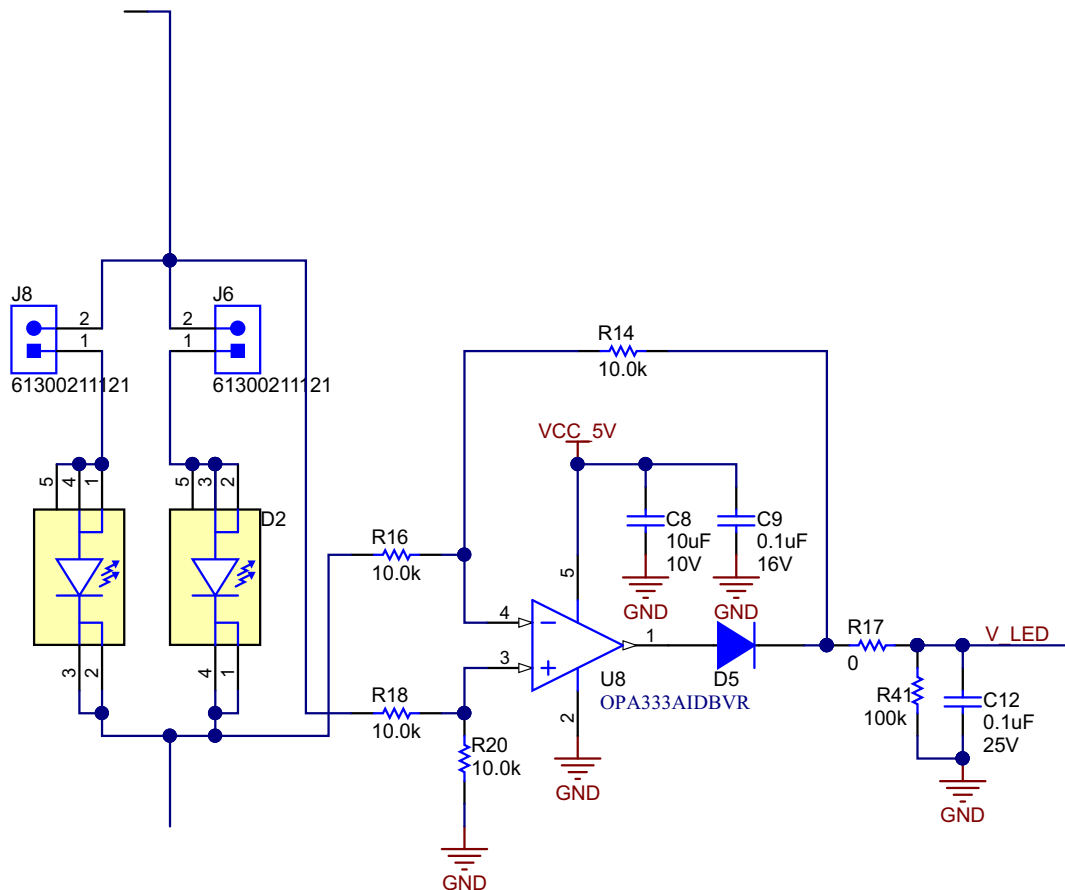
$$R_{ILIM} = \frac{2000}{I_{LIMIT} - 0.04} = \frac{2000}{1.7 - 0.04} = 1.2 \text{ k}\Omega$$

(4)

3.3.7 Sensing LED Voltage

図 11 shows the measurement circuit to monitor the voltage across LEDs. The two LEDs are green (LZ1-00G102-0000) and red (LZ1-00R102-0000). These are connected to the circuit one at a time using jumpers J8 and J6. To see if the LED is open or short, it is important to know the voltage across it. U5 (OPA333) is used as difference amplifier (with unity gain) with peak detector. V_LED signal at the output of amplifier is provided as a signal to the microcontroller.

図 11. LED Voltage Measuring Circuit



3.3.8 Connecting the TIDA-010043 With LaunchPad™

図 12 shows the connectors used for connecting the TIDA-010043 to the MSP-EXP430G2ET board.

図 12. Connectors

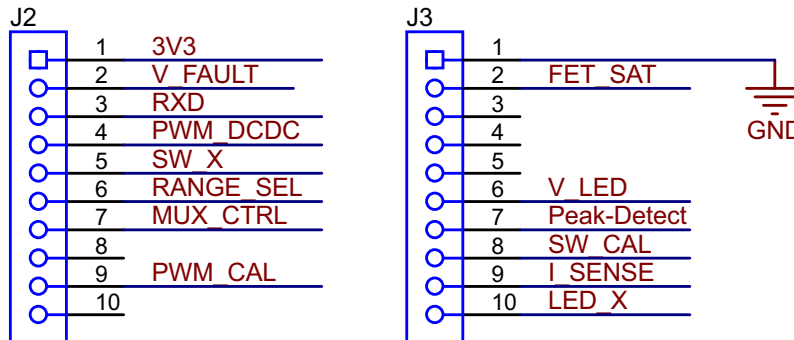


表 2 lists the functions of the pins used from the MSP-EXP430G2ET board.

表 2. Connections Between the TIDA-010043 and LaunchPad™

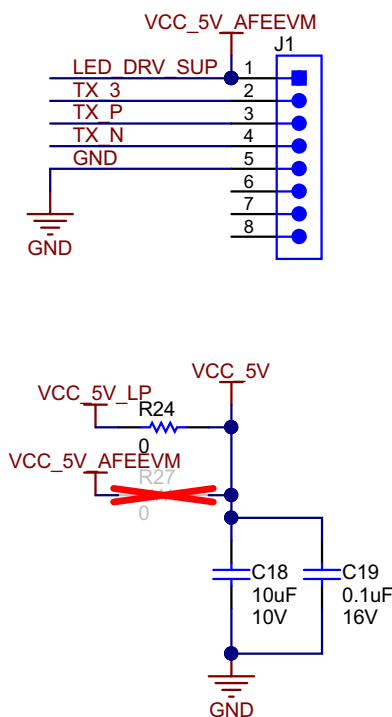
MSP-EXP430G2ET BOARD PIN NUMBER	FUNCTION	TIDA-010043 CONNECTOR PIN NUMBER	FUNCTION	COMMENTS
J1 – Pin 1	3V3	J2 – Pin 1	3V3	3.3-V supply
J1 – Pin 2	P1.0	J2 – Pin 2	V_FAULT	Fault flag from TPS259571 device
J1 – Pin 3	P1.1	J2 – Pin 3	RXD	Data receive (optional)
J1 – Pin 4	P1.2	J2 – Pin 4	PWM_DCD C / TXD	PWM for TPS63802 buck-boost converter device and TXD (optional)
J1 – Pin 5	P1.3	J2 – Pin 5	SW_X	Switch for reset and calibration
J1 – Pin 6	P1.4	J2 – Pin 6	RANGE_S EL	Range selection GPIO
J1 – Pin 7	P1.5	J2 – Pin 7	MUX_CTR L	Mux control GPIO
J1 – Pin 9	P2.1	J2 – Pin 9	PWM_CAL	Calibration PWM signal
J2 – Pin 11	P2.3	J3 – Pin 10	LED_X	LED indication for calibration
J2 – Pin 12	P2.4	J3 – Pin 9	ISENSE	Sense voltage
J2 – Pin 13	P2.5	J3 – Pin 8	SW_CAL	Optional GPIO for enabling software calibration (not used in the design)
J2 – Pin 14	P1.6	J3 – Pin 7	Peak Detect	Peak detect signal for ADC input of the microcontroller
J2 – Pin 15	P1.7	J3 – Pin 6	V_LED	LED voltage
J2 – Pin 19	P2.6	J3 – Pin 2	FET SAT	MOSFET saturation signal for calibration
J2 – Pin 20	GND	J3 – Pin 1	GND	Ground
J3 – Pin 21	5V	J4 – Pin 1	VCC_5V_L P	5 volts VCC for the devices used on TIDA-010043
J3 – Pin 22	GND	J4 – Pin 2	GND	Ground

注: Connector J5 on the TIDA-010043 board is optional and can be used for TXD/RXD functionality.

3.3.9 Interfacing the TIDA-010043 With the AFE4403 EVM

The AFE4403 EVM is connected to the TIDA-010043 (for providing current signals for driving LEDs) using connector J1 as shown in [Figure 13](#). The supply voltage VCC for all the ICs on the TIDA-010043 is set to 5 V and can come from either the MSP-EXP430G2ET board or from the AFE4403 EVM. The two resistors R24 and R27 can be mounted based on the VCC selection.

Figure 13. Interfacing the TIDA-010043 Board With the AFE4403 EVM



4 Hardware, Software, Testing Requirements, and Test Results

4.1 Required Hardware and Software

4.1.1 TIDA-010043 Board Picture

Figure 14 and Figure 15 show the top and bottom views of the TIDA-010043 printed-circuit board (PCB) respectively. The important sections are highlighted with yellow boxes and captions.

Figure 14. TIDA-010043 PCB - Top View

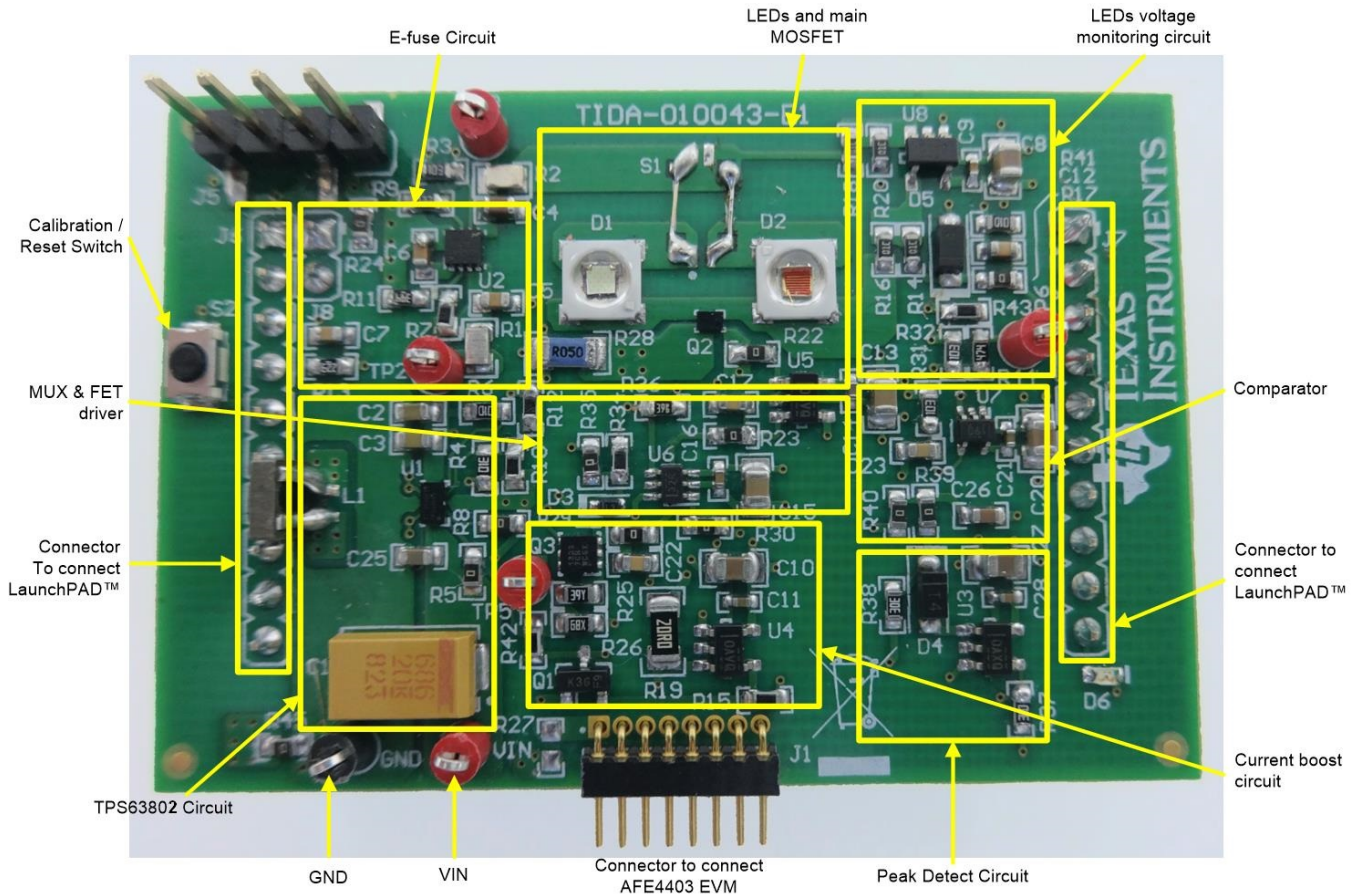
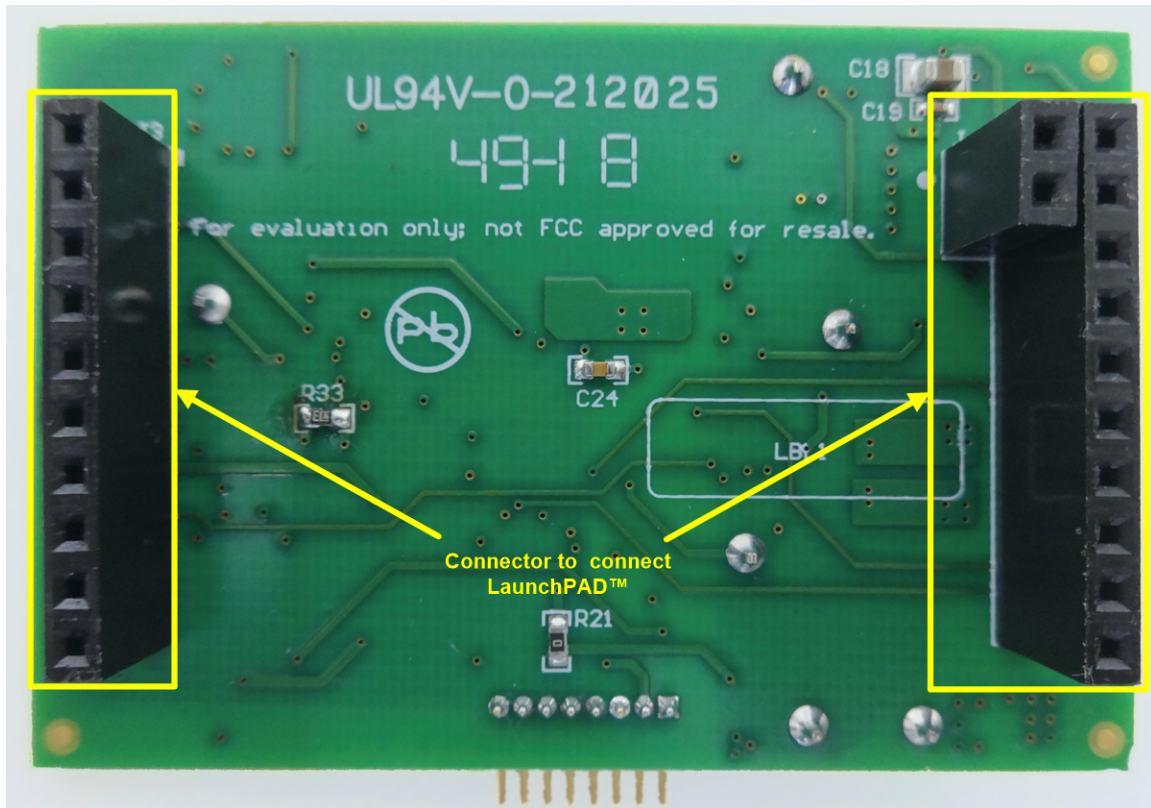


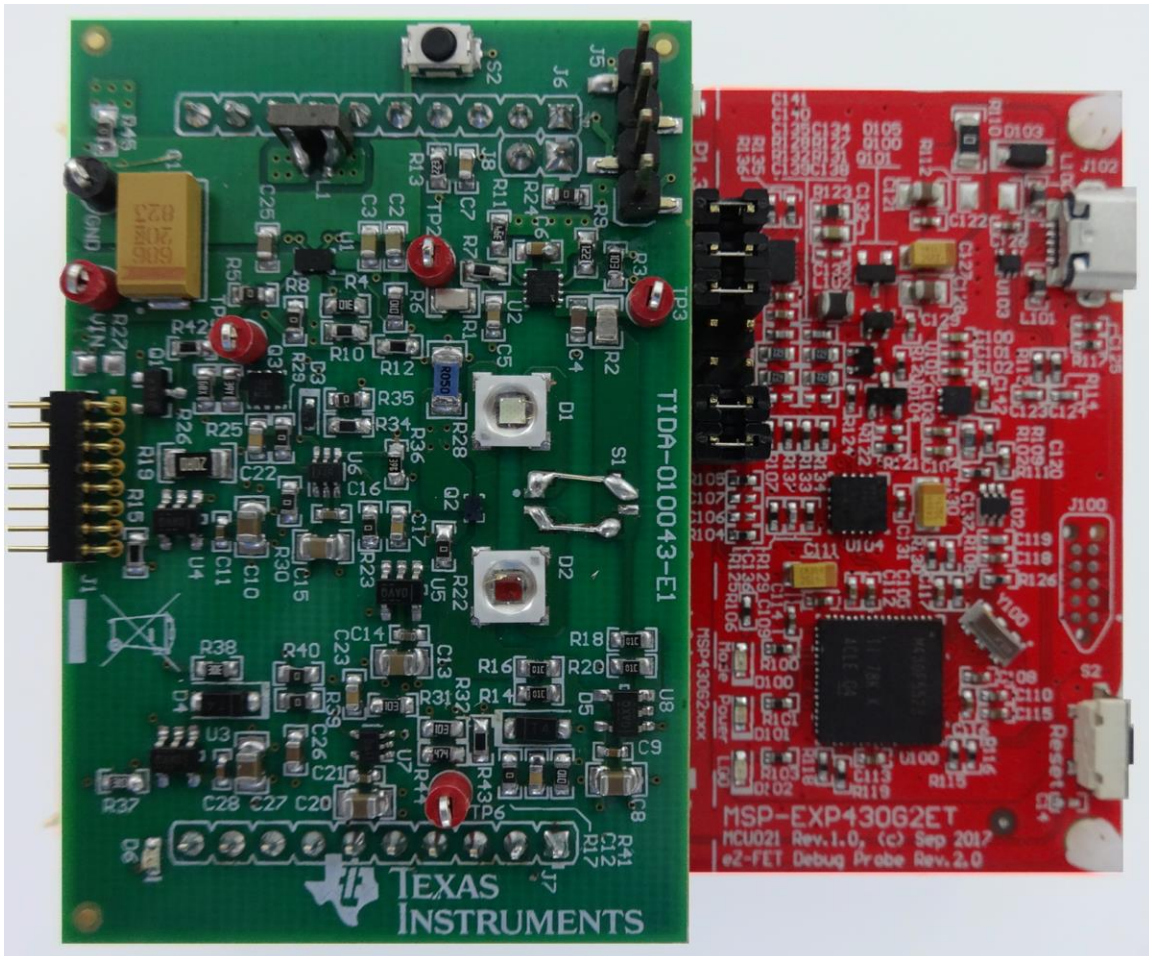
図 15. TIDA-010043 PCB - Bottom View



4.1.2 Connecting the TIDA-010043 Board to the MSP-EXP430G2ET

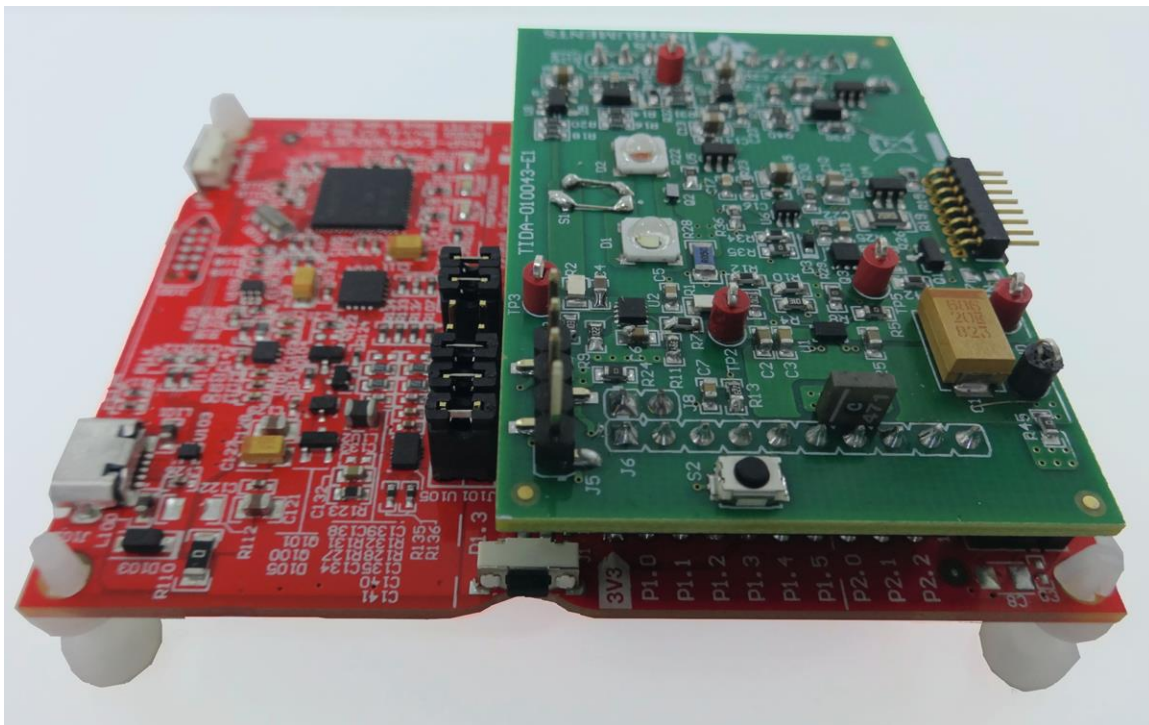
☒ 16 shows the top view of the TIDA-010043 board connected to the MSP-EXP430G2ET.

☒ 16. The TIDA-010043 Connected to the MSP-EXP430G2ET (Top View)



☒ 17 shows the side view of the TIDA-010043 board connected to the MSP-EXP430G2ET.

☒ 17. TIDA-010043 Connected to the MSP-EXP430G2ET (Side View)



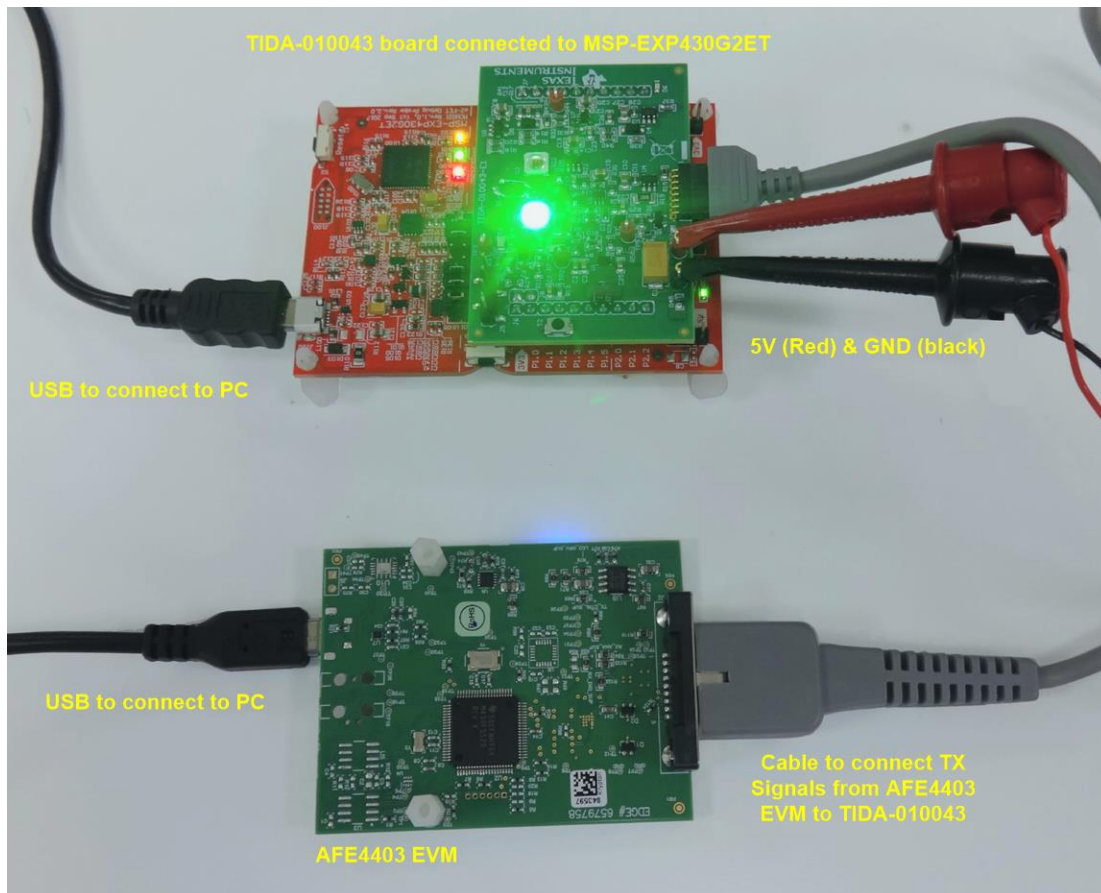
4.2 Testing and Results

This section shows the test setup and test results for the TIDA-010043 board (see [Figure 19](#)).

4.2.1 Test Setup

The TIDA-010043 board is connected on the MSP-EXP430G2ET board. The TIDA-010043 board is powered using 1.8-V to 5.5-V variable power supply. The AFE4403 EVM is connected to the TIDA-010043 board using cable as shown in [Figure 18](#). The MSP-EXP430G2ET and AFE4403 EVM are both connected to the PC for programming.

Figure 18. Testing the TIDA-010043 With the AFE4403 EVM



4.2.2 Calibration Waveform

Each of the calibration waveforms below shows how PWM_CAL and PWM_DCDC signals are used for the calibration process. The FET_SAT signal is monitored on each calibration state.

図 19. Calibration Waveforms for Green LED (Pink = PWM_CAL, Blue = PWM_DCDC, Green = FET_SAT)

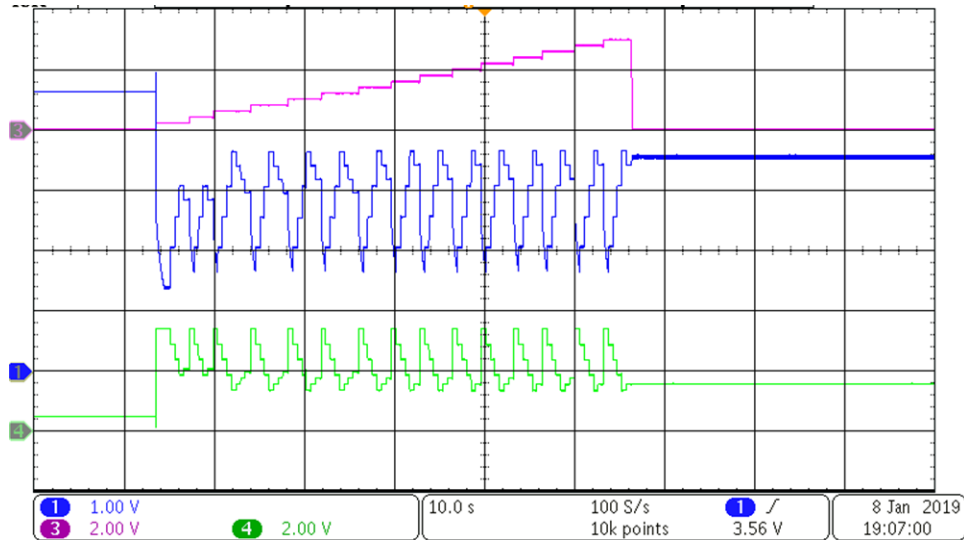


図 20. Calibration Waveforms for Red LED (Pink = PWM_CAL, Blue = PWM_DCDC, Green = FET_SAT)

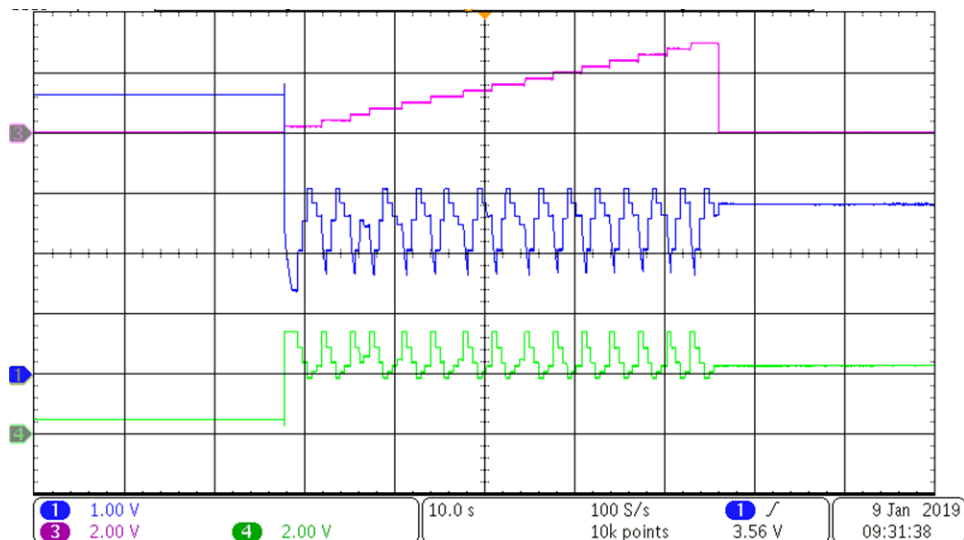
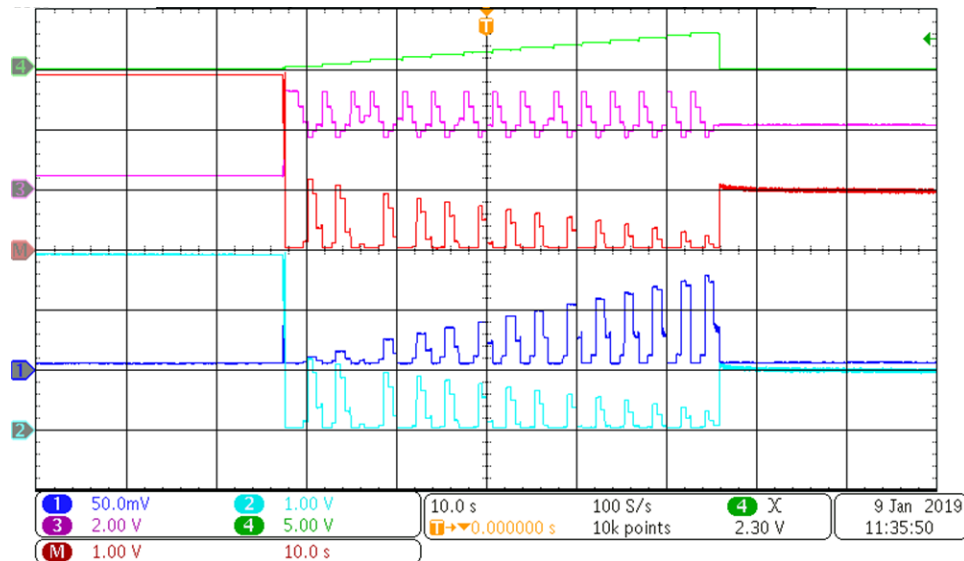


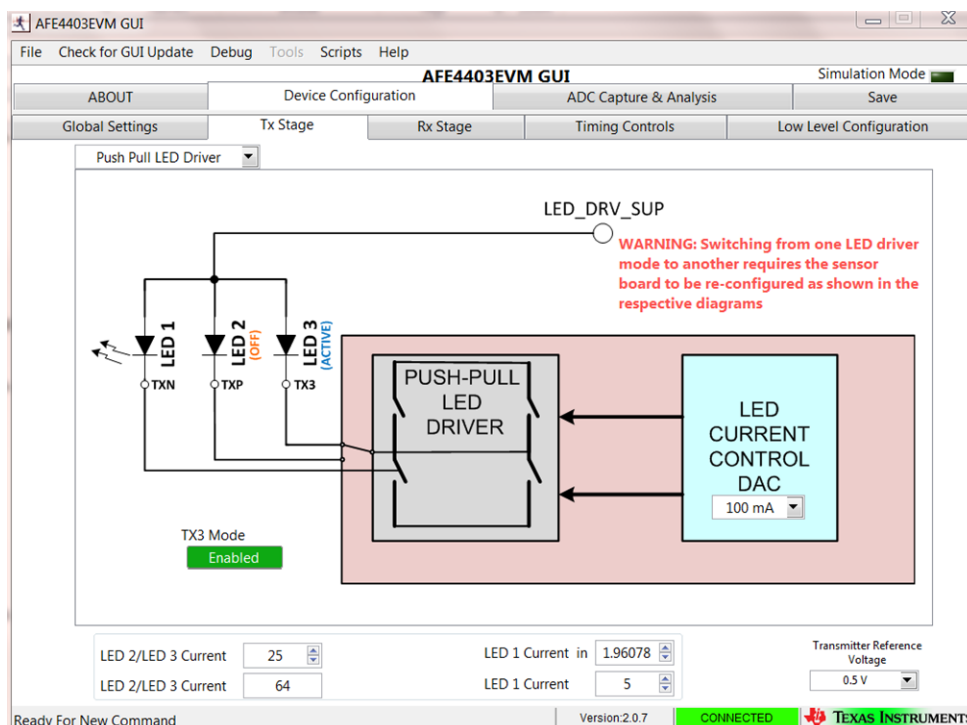
図 21. Calibration Graphs Showing PWM_CAL (Green), PWM_DCDC (Pink), Vdrain of MOSFET (Light Blue), Vsource of MOSFET (Dark Blue), VDS of MOSFET (Red)



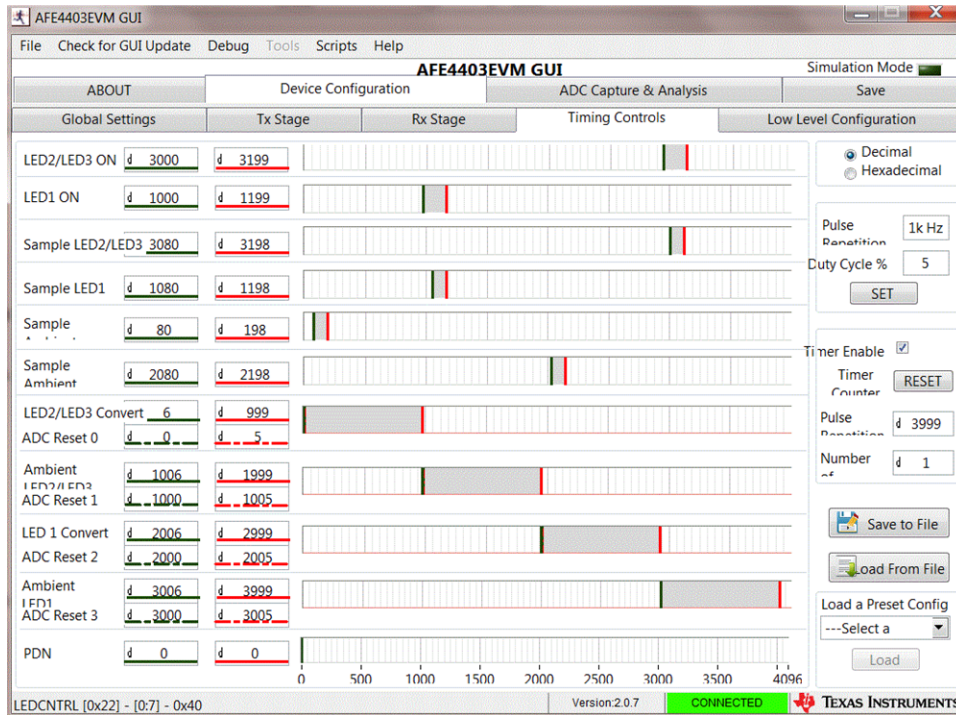
4.2.3 Setting Up Current in AFE4403 EVM GUI

Once the calibration process is complete, the board can be tested with current input signals from the AFE4403. Before testing the TIDA-010043 board, it is important to set up the current signals from the AFE4403. The parameters which need to be set are LED current, LED driver configuration, pulse repetitive frequency, and duty cycle of the current signal. 図 22 and 図 23 show screen shots of the AFE4403 EVM GUI. For more details on the GUI, see the [AFE4403](#).

図 22. Setting Up LED Drivers and LED Current for the AFE4403



23. Setting Up Pulse Repetition Frequency and Duty Cycle of Current Signal From the AFE4403



24. Waveforms at PRF = 100 Hz and Duty Cycle = 25% (Dark Blue: TX_3 Input From AFE4403, Pink: Peak-Detect Signal, Light Blue: Voltage Signal Across R25)

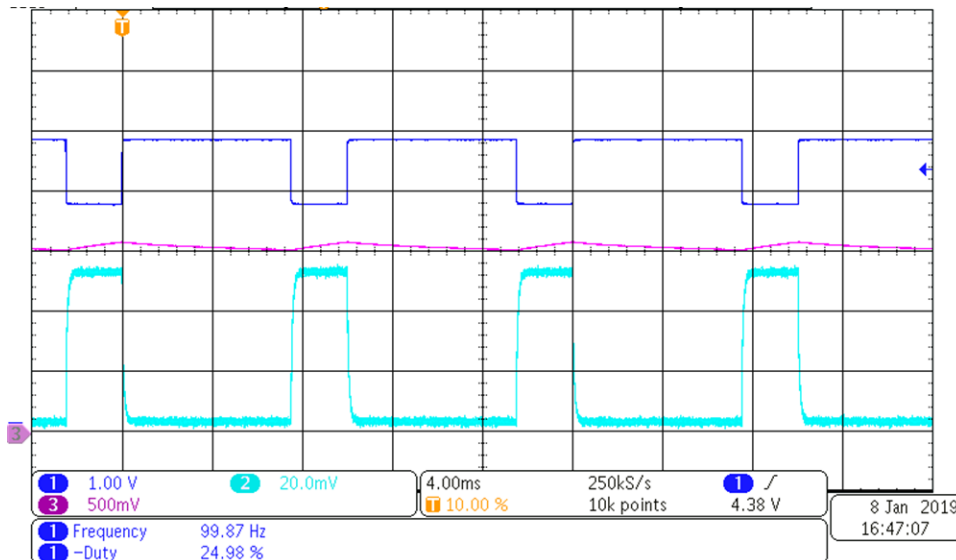


図 25. Waveforms at PRF = 100 Hz and Duty Cycle = 5% (Dark Blue: TX_3 Input From AFE4403, Pink: Peak-Detect Signal, Light Blue: Voltage Signal Across R25)

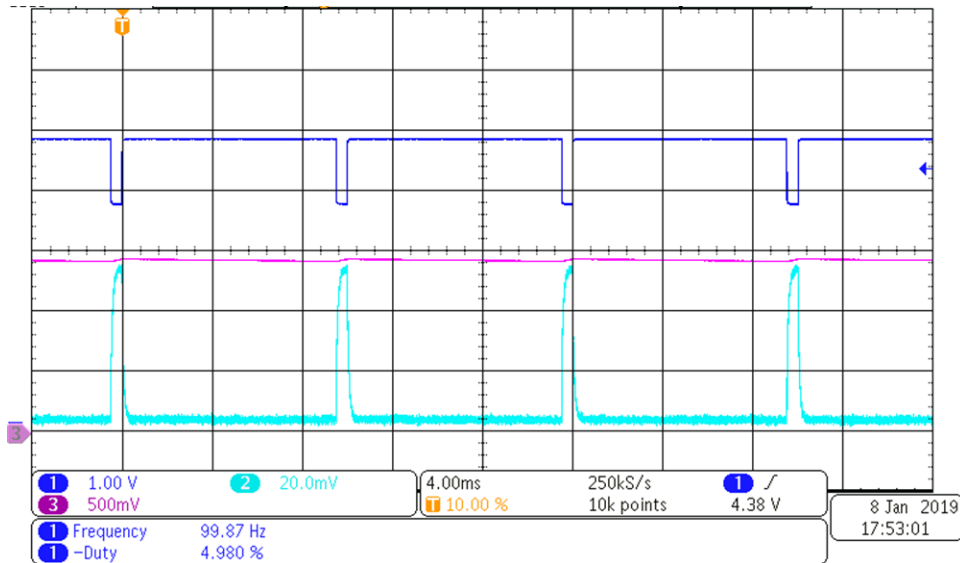


図 26. Waveforms at PRF = 500 Hz and Duty Cycle = 25% (Dark Blue: TX_3 Input From AFE4403, Pink: Peak-Detect Signal, Light Blue: Voltage Signal Across R25)

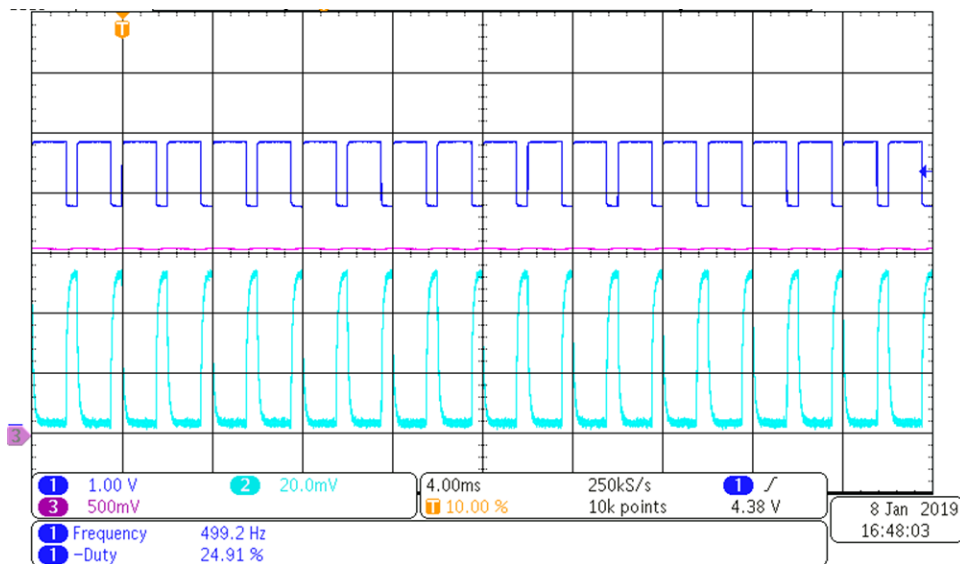


図 27. Waveforms at PRF = 500 Hz and Duty Cycle = 5% (Dark Blue: TX_3 Input From AFE4403, Pink: Peak-Detect Signal, Light Blue: Voltage Signal Across R25)

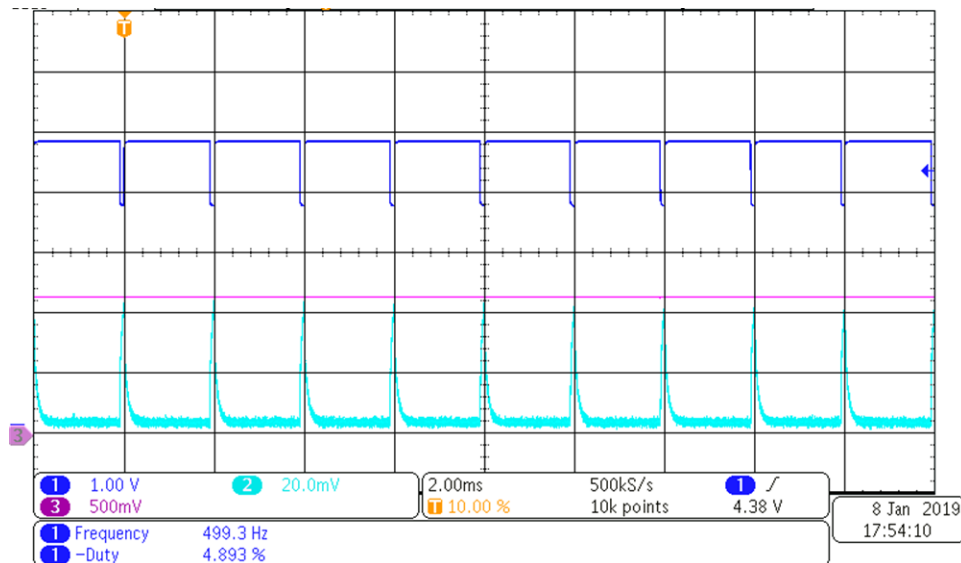
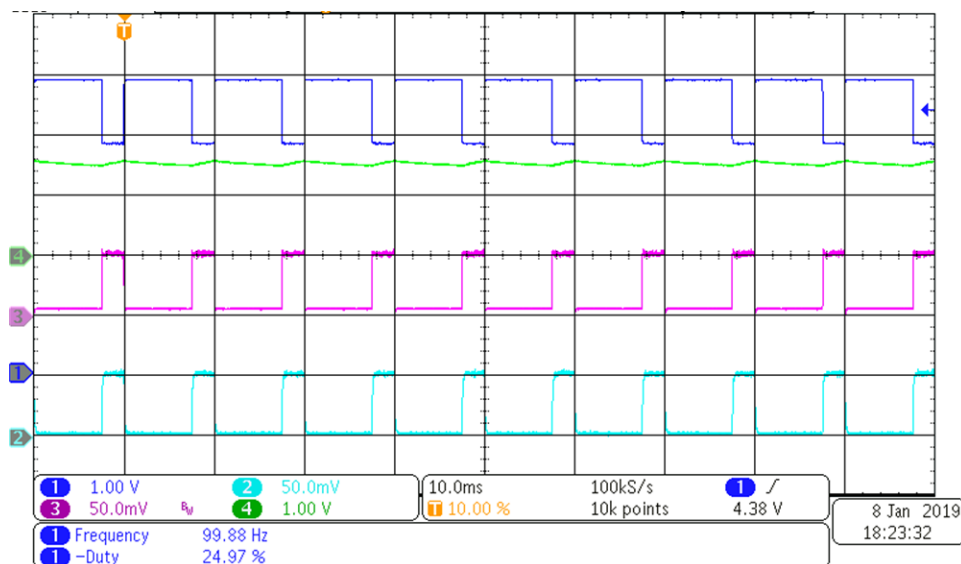
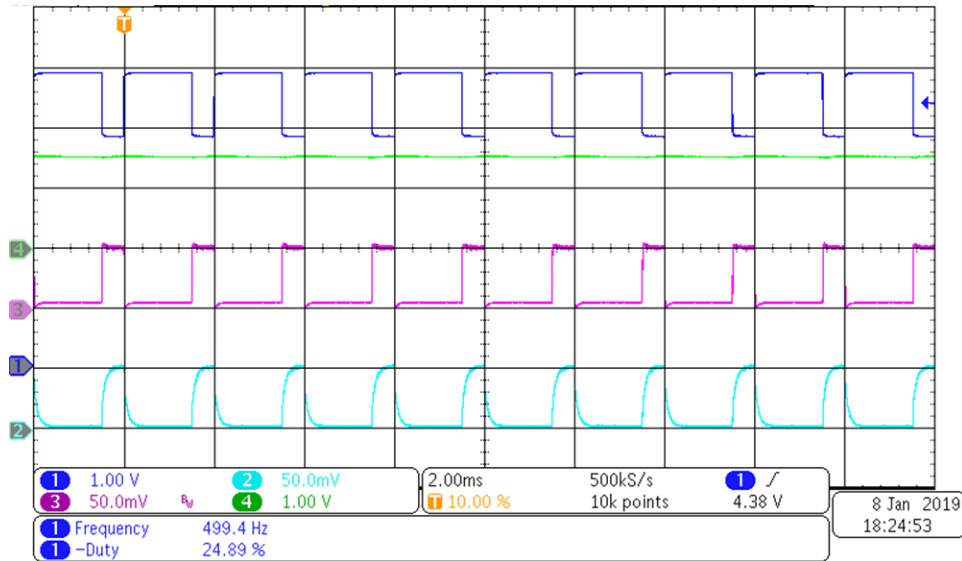


図 28. Waveforms at PRF = 100 Hz and Duty Cycle = 25% (Dark Blue: TX_3 Input From AFE4403, Green: Peak-Detect Signal, Pink: I_SENSE Signal, Light Blue: Voltage Signal Across R25)



29. Waveforms at PRF = 100 Hz and Duty Cycle = 25% (Dark Blue: TX_3 Input From AFE4403, Green: Peak-Detect Signal, Pink: I_SENSE Signal, Light Blue: Voltage Signal Across R25)



5 Design Files

5.1 Schematics

To download the schematics, see the design files at [TIDA-010043](#).

5.2 Bill of Materials

To download the bill of materials (BOM), see the design files at [TIDA-010043](#).

5.3 PCB Layout Recommendations

Device specific layout guidelines for each individual TI part used in this design can be found in the corresponding data sheets. [Fig 15](#) and [Fig 16](#) show the top and bottom views of the TIDA-010043 PCB respectively. The important sections are highlighted with red arrows and captions.

5.3.1 Layout for Main Board

図 30. Top Layer of the TIDA-010043 Board

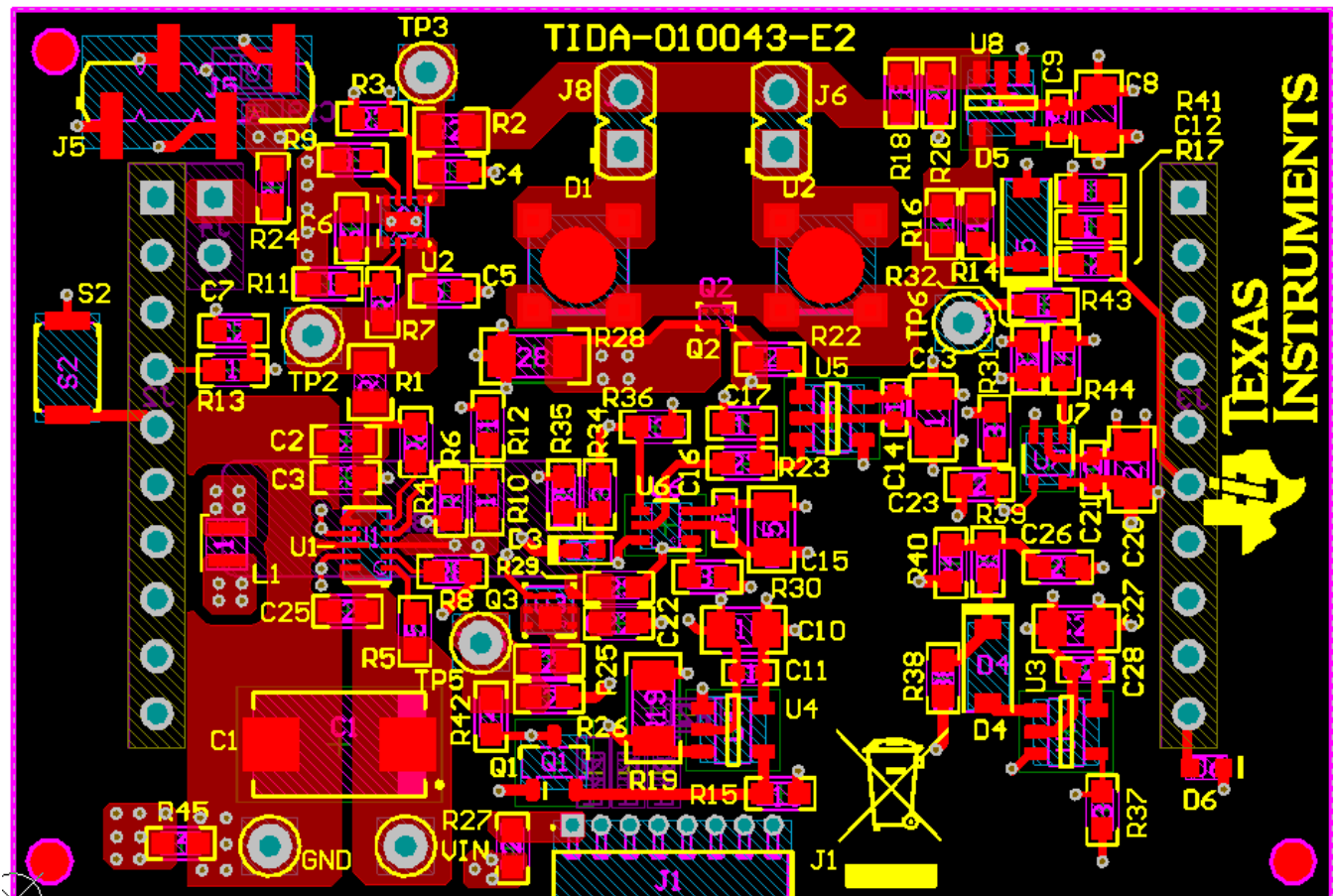


図 31. Bottom Layer of the TIDA-010043 Board

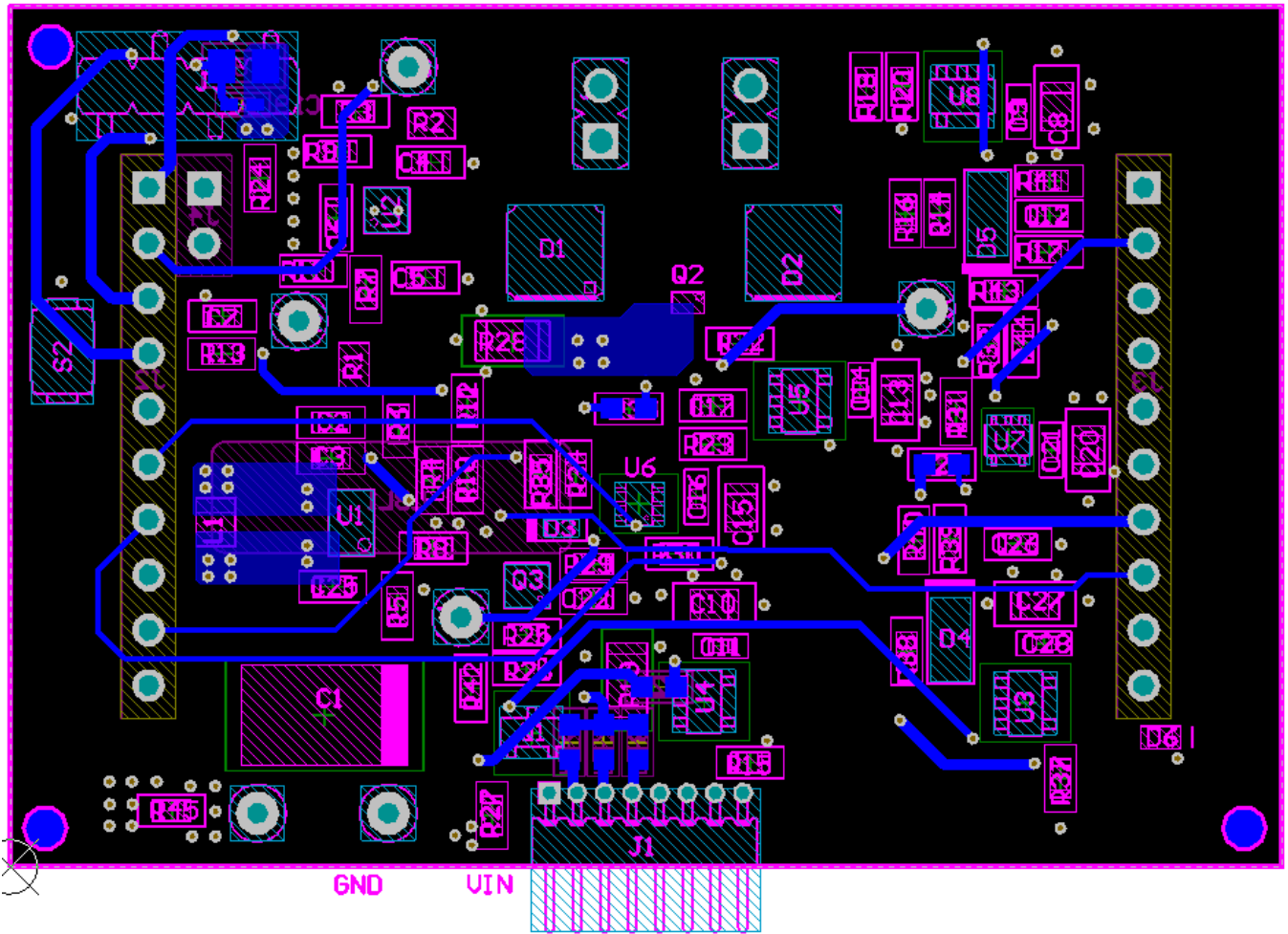


図 32. Power Layer of the TIDA-010043 Board

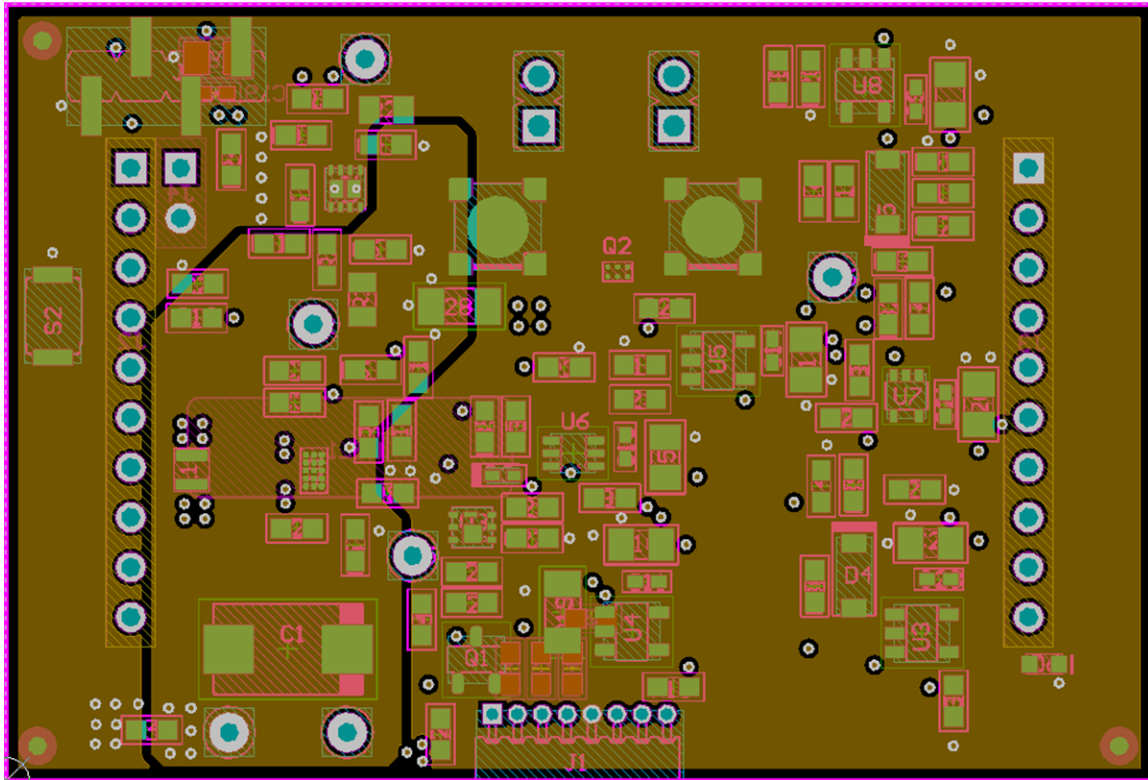
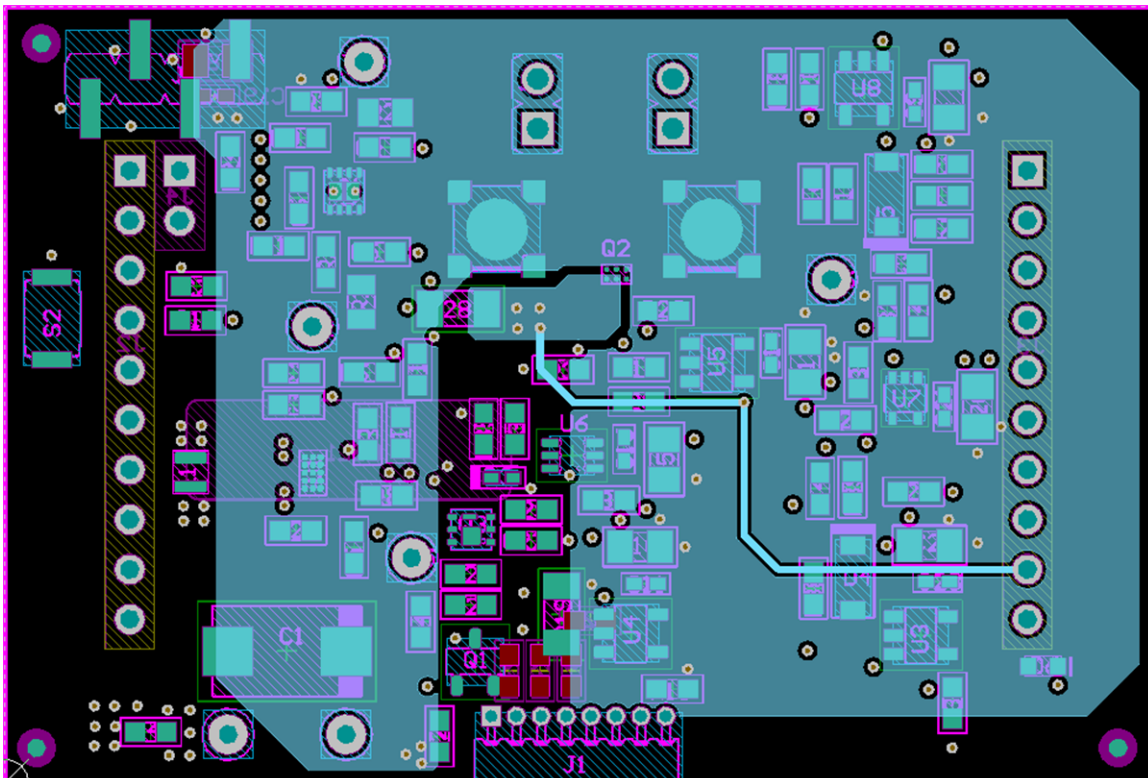
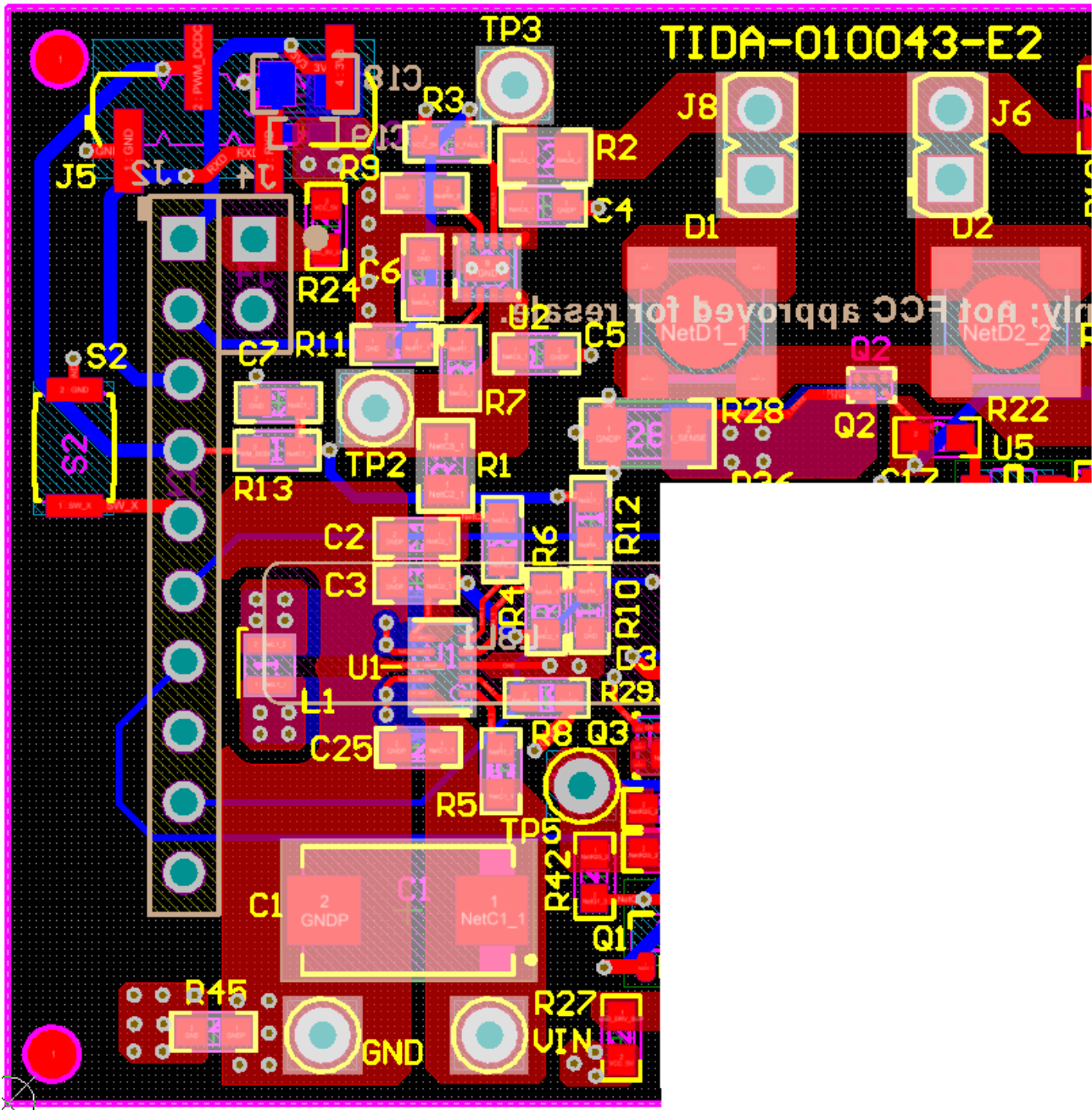


図 33. Ground Layer of the TIDA-010043 Board



5.3.2 Highlighting the LED Driving Path

図 34. Highlighting the LED Driving Path



5.3.3 Layout Prints

To download the layer plots, see the design files at [TIDA-010043](http://www.ti.com/Design-Files/TIDA-010043).

5.4 Altium Project

To download the Altium Designer® project files, see the design files at [TIDA-010043](http://www.ti.com/Design-Files/TIDA-010043).

5.5 Gerber Files

To download the Gerber files, see the design files at [TIDA-010043](#).

5.6 Assembly Drawings

To download the assembly drawings, see the design files at [TIDA-010043](#).

6 Software Files

To download the software files, see the design files at [TIDA-010043](#).

7 Related Documentation

1. Texas Instruments, [Miniaturized pulse oximeter reference design](#)

7.1 商標

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8 About the Author

SANJAY PITHADIA is a systems designer at Texas Instruments, where he is responsible for developing subsystem design solutions for the Medical Healthcare and Fitness sector. Sanjay has been with TI since 2008 and has been involved in designing reference designs related to energy, smart grid, industrial motor drives, and medical imaging. Sanjay brings to this role his experience in analog design, mixed signal design, industrial interfaces, and power supplies. Sanjay earned his bachelor of technology in electronics engineering at VJTI, Mumbai.

SANJAY DIXIT is System Architect in the Industrial Systems-Medical Healthcare and Fitness Sector at Texas Instruments, responsible for specifying reference designs.

9 Acknowledgement

The authors would like to thank **KIRAN RAJMOHAN** for helping on MSP430 based code for testing the TIDA-010043.

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