TPS54160EVM-535 User's Guide

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1 Introduction

The TPS54160EVM-535 evaluation module (EVM) helps designers evaluate the operation and performance of the TPS54160 DC/DC converter as a high-brightness light emitting diode (LED) driver. The converter is a wide input voltage (3.5–60V), 2.5MHz, non-synchronous, externally compensated, step down converter capable of 1.5A of output current.

1.1 Background

The TPS54160EVM-535 provides a high-brightness LED driver based on the TPS54160. The converter is designed to operate from a nominal 24 VDC ±25% input voltage source. This input voltage range is typical for input supplies derived from rectified 24VAC sources. The converter provides an output current of 700mA with an output voltage sufficient to drive the four on board LEDs.

2 Schematic Diagram and Bill of Materials

2.1 Schematic Diagram

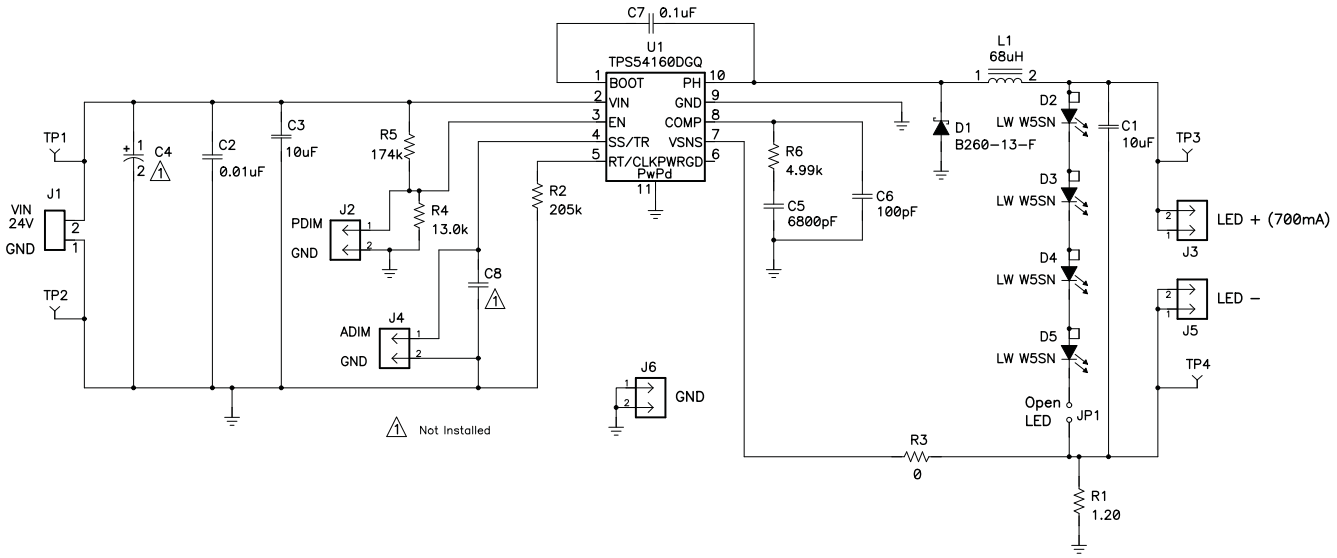

Figure 1. TPS54160EVM-535 Schematic Diagram

2.2 Bill of Materials

Table 1. Bill of Materials

Count	RefDes	Value	Description	Size	Part Number	MFR
2	C1, C3	10 µF	Capacitor, Ceramic, 50V, X5R, 20%	1210	Std	Std
1	C2	0.01 µF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std
1	C5	6800pF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std
1	C6	100pF	Capacitor, Ceramic, 50V, NPO, 5%	0603	Std	Std
1	C7	0.1 µF	Capacitor, Ceramic, 25V, X5R, 10%	0603	Std	Std
1	D1	B260-13-F	Diode, Schottky, 60V, 2A	SMB	B260-13-F	Vishay
4	D2, D3, D4, D5	"LW W5SN-JYKZ-5K8L-Z (see **Note 5 & 6**)"	Diode, Platinum Dragon LED White, 700-mA	0.244 × 0.441 inch	"LW W5SN-JYKZ-5K8L-Z (see **Note 5 & 6**)"	Osram
1	L1	68 µH	Inductor, SMT, 1.32A, 213 mΩ	0.402 × 0.394 inch	MSS1038-683ML	Coilcraft
1	R1	1.20	Resistor, Chip, 1W, 1%	2512	Std	Std
1	R2	205k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R4	13.0k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R5	174k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R6	4.99k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	U1	TPS54160DGQ	IC, DC-DC Converter	MSOP-10	TPS54160DGQ	TI

3 Board Layout

3.1 Layout

The following figures show the layout for each layer of the TPS54160EVM-535. The top and bottom layers of the board are 2-oz. copper. The top layer is predominantly used to route the high current traces of the input and output voltages. Some noise sensitive traces, such as the feedback trace, have been routed on the bottom layer so that they are shielded by the large ground plane on the bottom layer. Board layout is critical for all high frequency switch mode power supplies. The nodes with high switching frequencies and currents are kept as short as possible to minimize trace inductance. Careful attention has been given to the routing of high frequency current loops and a single point grounding scheme is used. Refer to the datasheet for specific layout guidelines.

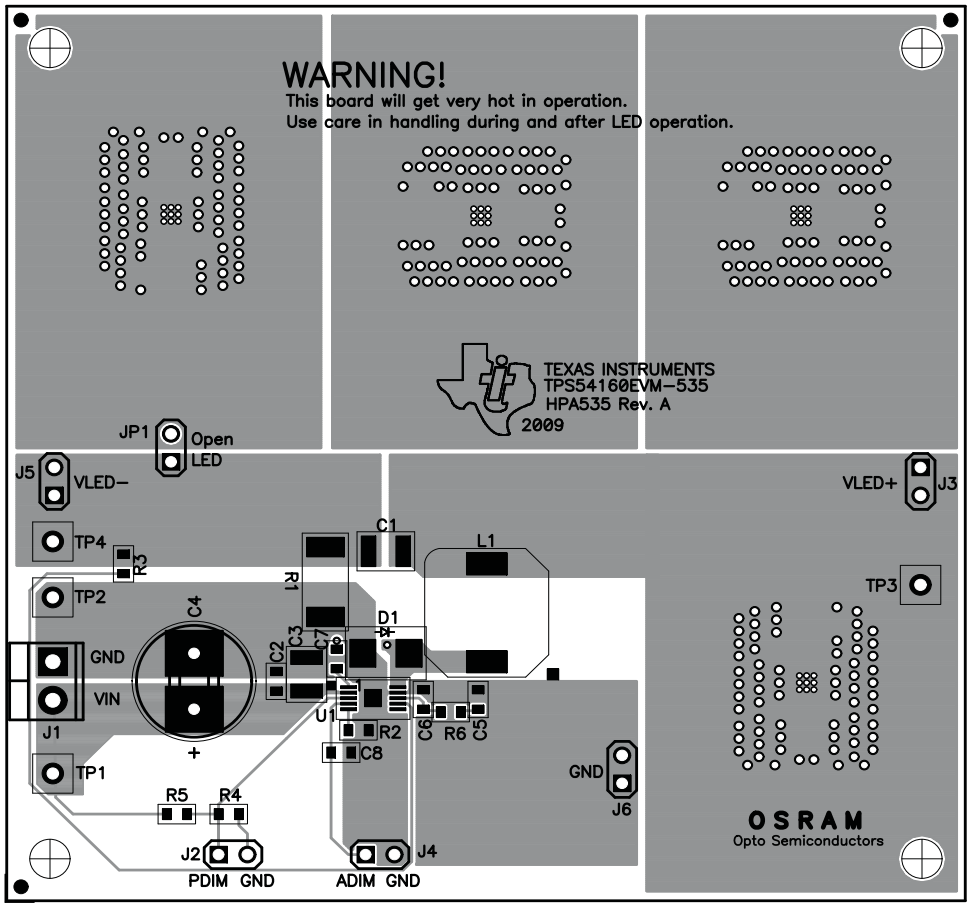

Figure 2. Top Assembly Layer

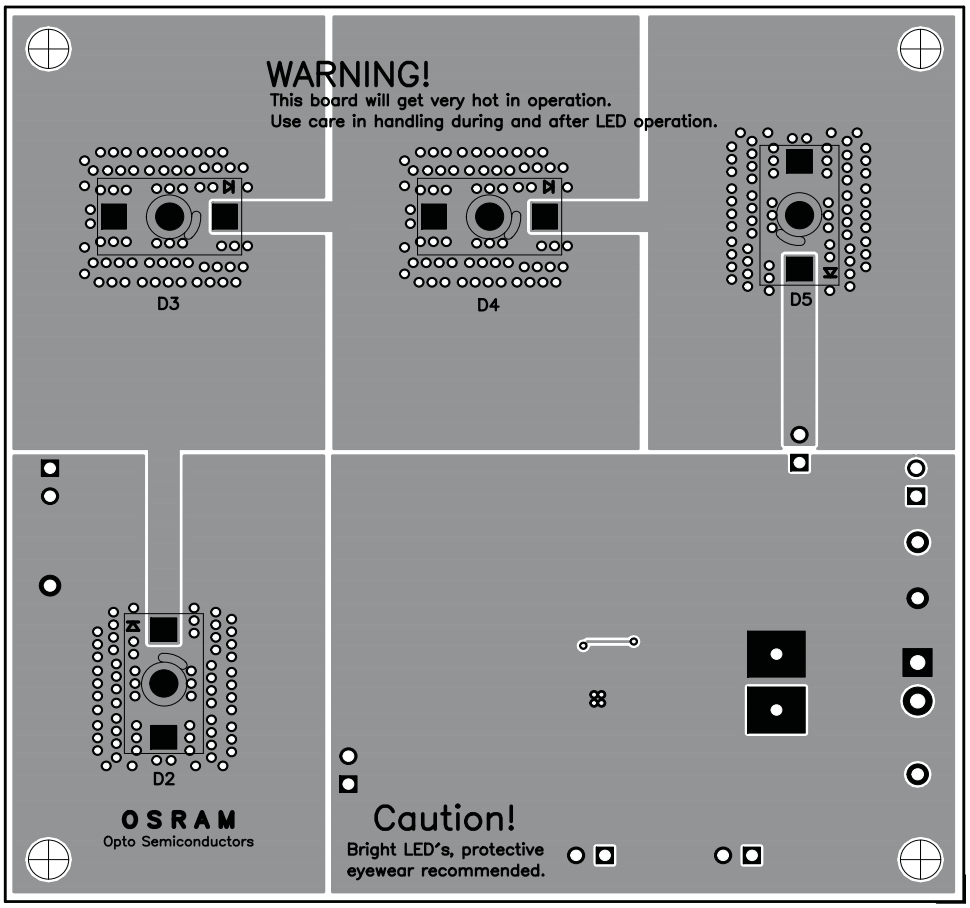

Figure 3. Bottom Assembly Layer

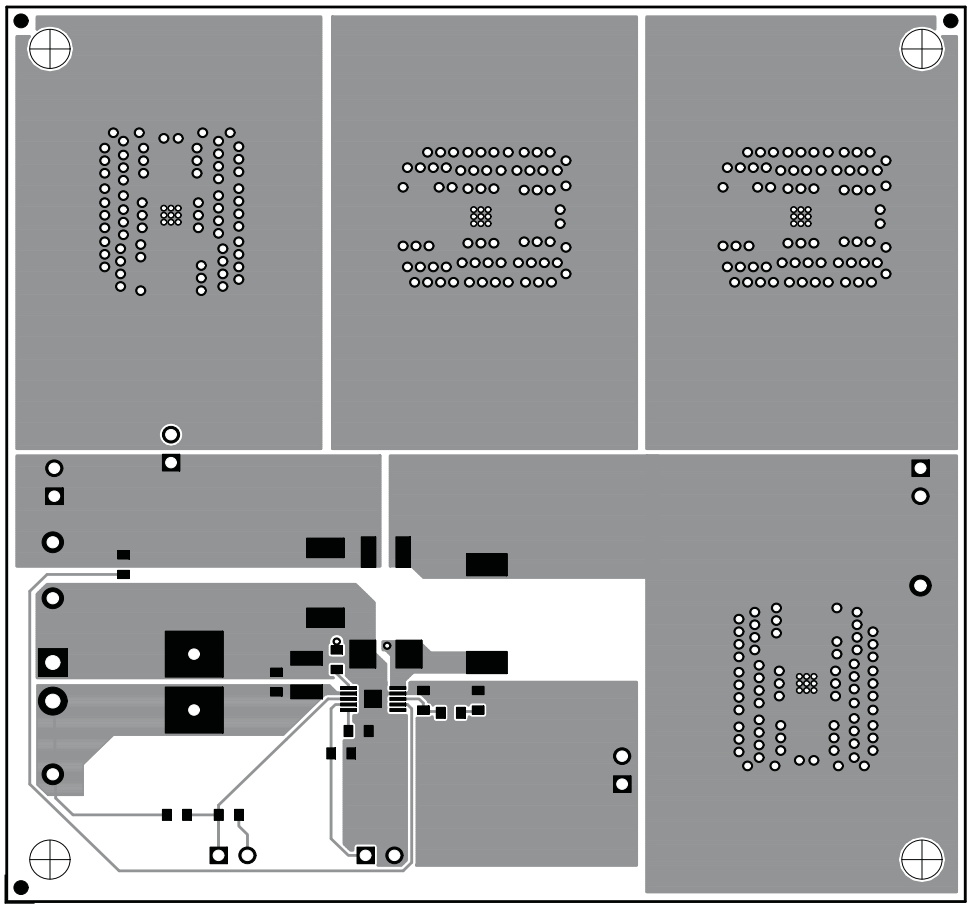

Figure 4. Top Layer Routing

4 Connector Description

This chapter describes the jumpers and connectors on the EVM as well as how to properly connect, setup and use the TPS54160EVM-535.

4.1 Input/Output Connector Descriptions

4.1.1 J1 – GND, VIN

This header is the return and positive input voltage supply to the converter. The leads to the input supply should be twisted and kept as short as possible to minimize EMI transmission. Additional bulk capacitance should be added between J1 and J2 if the supply leads are greater than six inches. An additional 47µF or greater capacitor improves the transient response of the TPS54160 and helps to reduce ringing on the input when long supply wires are used.

4.1.2 J2 – PDIM, GND

This header is for dimming using pulse width modulation. PDIM is connected to the EN pin of the TPS54160. Applying a PWM will adjust the average output current proportional to the duty cycle. GND is connected to the common ground plane.

4.1.3 J3 – LED+

When using external LEDs, connect anode to LED+.

4.1.4 J4 – ADIM, GND

This header is for analog dimming. ADIM is connected to the SS/TR pin on the TPS54160. The voltage applied to this pin is used as reference if below the TPS54610 internal voltage reference of 800mV. GND is connected to the common ground plane. Figure 10 shows the LED current vs. ADIM voltage.

4.1.5 J5 – LED–

When using external LEDs, connect cathode to LED–.

4.1.6 J6 – GND

This header is connected to the common ground plane.

4.1.7 JP1 – OPEN LED

Connect shorting jumper on JP1 to use the on-board LEDs. The user may monitor the LED current by connecting an ammeter between the two pins. Open JP1 to use external LEDs.

5 Performance Specifications

5.1 Converter Specifications

Table 2 provides a summary of the converters specifications. The converter is designed and tested for VIN = 24V±25%. Operation at other input voltages is possible but some performance specifications will vary compared to those shown. The ambient temperature is 25°C for all measurements, unless otherwise noted.

Table 2. Converter Specifications

Specification	Test Conditions	Min	Typ	Max	Unit
VIN input voltage range		18	24	30	V
Output current			675		mA
Output voltage			14.8		V
Loop bandwidth			50		kHz
Phase margin			100		°
Operating Frequency			570		kHz
Maximum Efficiency	Vin = 24 V, Iout = 700 mA		90%		
Converter enable voltage $V_{turn\ on}$	Vin rising, Iout = 700 mA		17.8		V
Converter disable voltage $V_{turn\ off}$	Vin falling, Iout = 700 mA		17.3		V
Output current rise time			0.4		ms

5.2 Modifications to the Converter

This converter is meant to show an application of the TPS54160 as an LED driver with the specification above. For applications with a different input voltage range or different numbers of LEDs, refer to the application note, *How to use the TPS54160 as a High-Brightness LED Driver* (SLVA374).

5.3 PWM Dimming

The brightness of the LEDs can be adjusted by applying a PWM signal to the PDIM pin. The average LED current is proportional to the PWM signal duty cycle. When PDIM is greater than $V_{turn\ on}$ × R4/(R4+R5) the TPS54160 drives current through the LEDs. When less than $V_{turn\ off}$ × R4/(R4+R5), the TPS54160 turns off and stops driving current through the LEDs. Where V_{turn} on is the converter enable voltage and $V_{turn\ off}$ is converter disable voltage as displayed Table 2.

5.4 Analog Dimming

ADIM is connected to the SS/TR pin on the TPS54160. The voltage applied to this pin is used as reference if below the TPS54610 internal voltage reference of 800mV. See Figure 10.

6 Test Results

This chapter provides typical performance waveforms for the TPS54160EVM-535

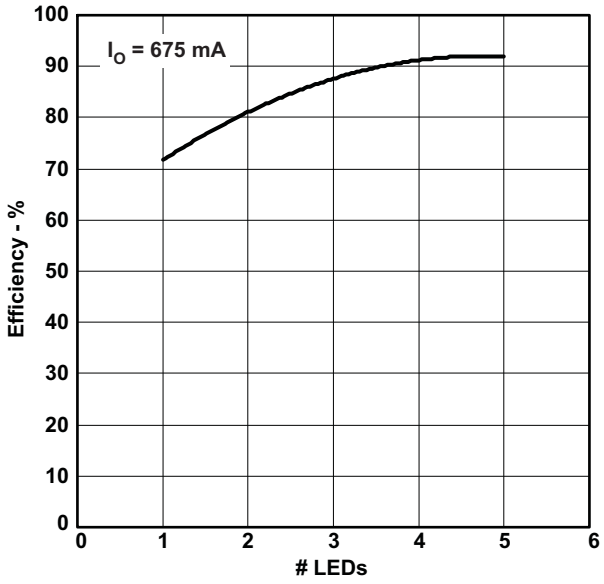

Figure 5. Efficiency, Vin=24V

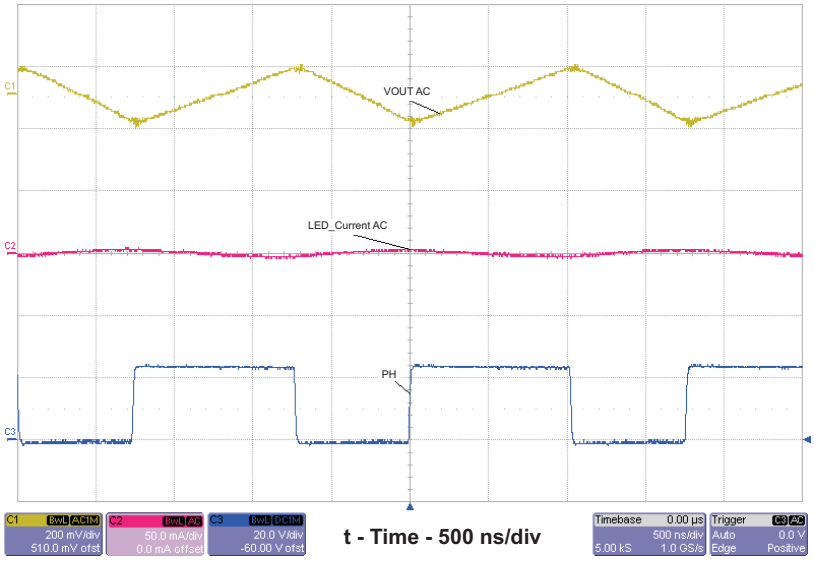

Figure 6. Output Ripple, Vin=24.0V, Iout=675mA, AC Coupled

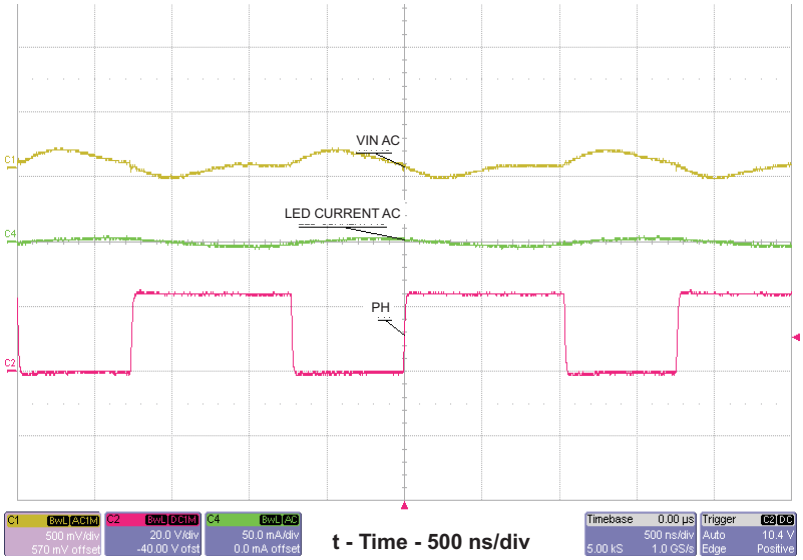

Figure 7. Input Voltage Ripple, Vin=24.0V, Iout=675mA, AC Coupled

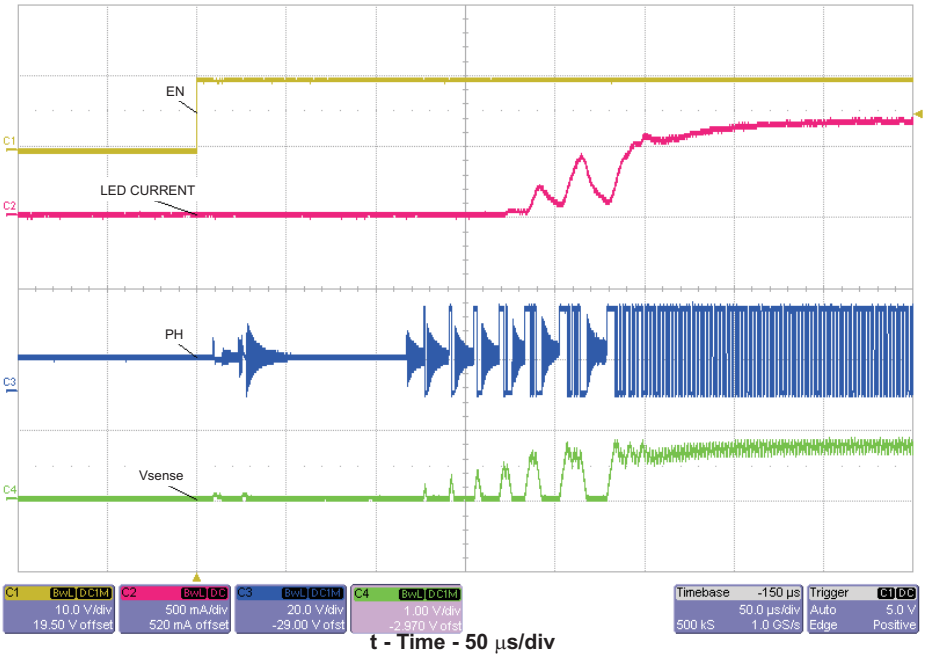

Figure 8. Start-up relative to EN, Vin=24V, Iout=675mA

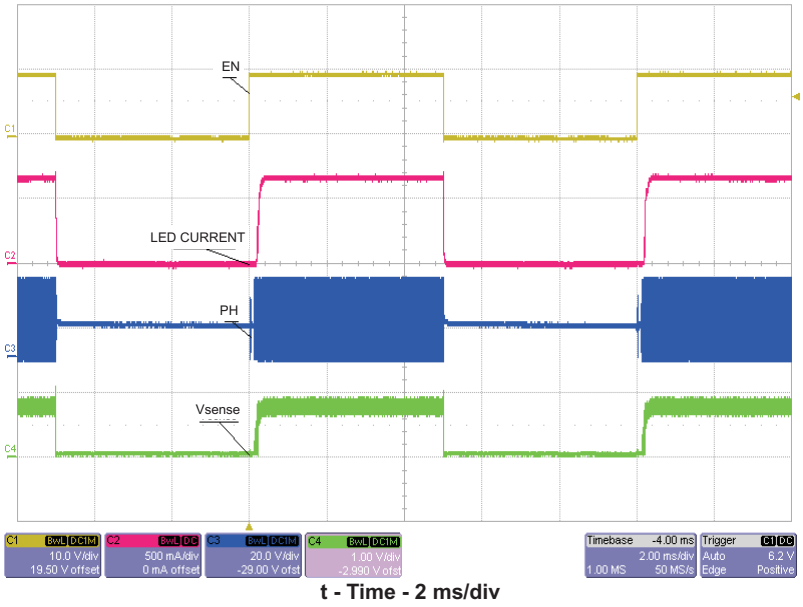

Figure 9. PWM Dimming, Vin=24V, Iout=675mA

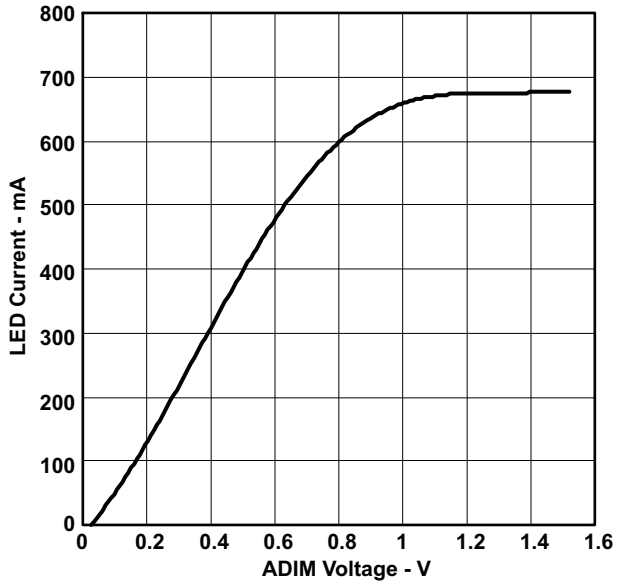

Figure 10. Analog Dimming, LED Current vs. ADIM Voltage

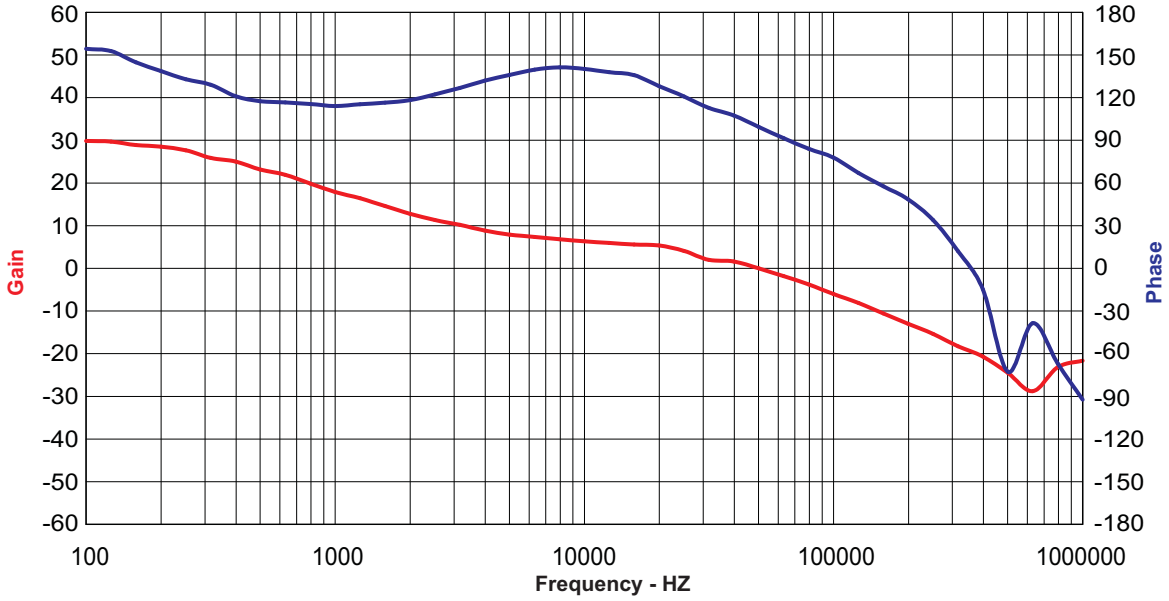

Figure 11. Loop response, VIN = 24V, Iout = 675mA

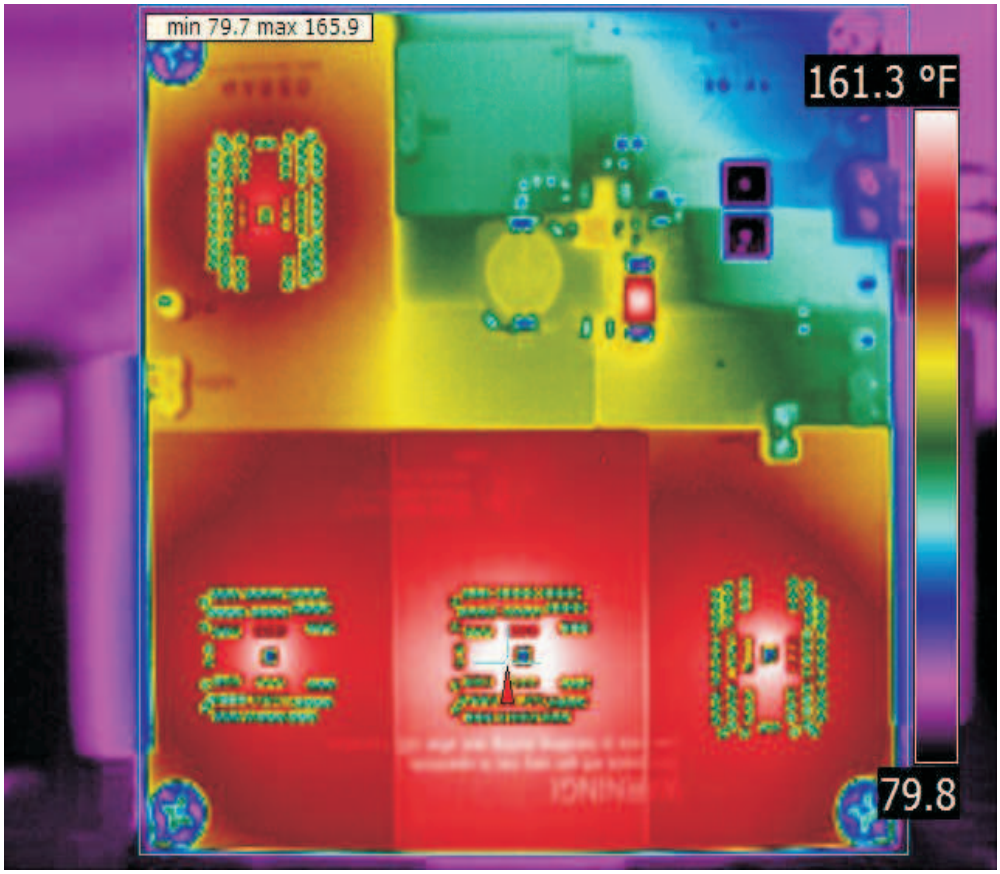

Figure 12. Thermal Performance, Top

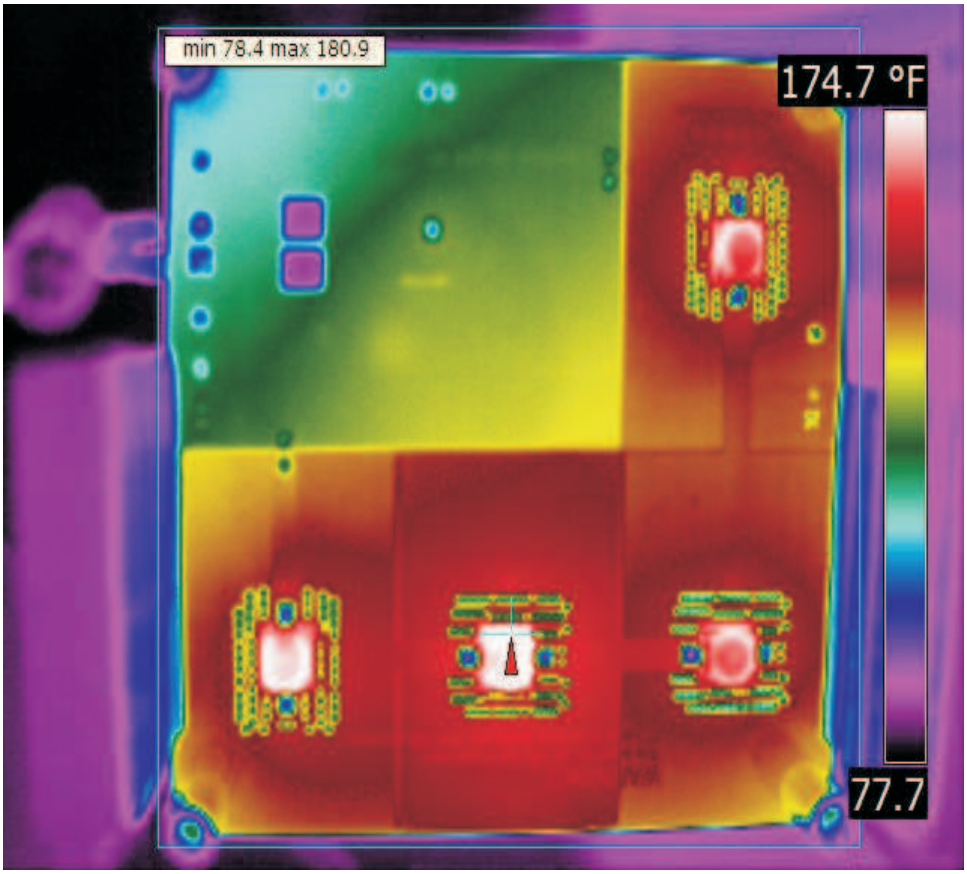

Figure 13. Thermal Performance, Bottom

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