User's Guide

TPS51396AEVM Evaluation Module

ABSTRACT

This user's guide contains information for the TPS51396AEVM evaluation module as well as the TPS51396A DC/DC converter. Also included are the performance specifications, board layout, schematic, and the list of materials for the TPS51396AEVM.

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1 Trademarks

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2 Introduction

TPS51396A DC/DC converter is a synchronous buck converter designed to provide up to a 8-A output. The input (VIN) is rated for 4.5 V to 24 V. The TPS51396A uses a proprietary DCAP3 Control mode. Rated input voltage and output current range for the evaluation module are given in Table 2-1. The high-side and low-side MOSFETs are incorporated inside the TPS51396A package along with the gate-drive circuitry. An external divider allows for an adjustable output voltage. Additionally, the TPS51396A provides 1.3ms internal soft start or external soft start, under voltage lockout inputs and power good output.

Table 2-1. Input voltage and output current range summary

EVM	INPUT VOLTAGE RANGE	OUTPUT CURRENT RANGE
TPS51396AEVM	4.5 V to 24 V	0 A to 8 A

3 Performance Specification Summary

A summary of the TPS51396AEVM performance specifications is provided in Table 3-1. Specifications are given for an input voltage of VIN = 12 V and an output voltage of 1.0 V, unless otherwise specified. The TPS51396AEVM is designed and tested for VIN = 4.5 V to 24 V. The ambient temperature is 25°C for all measurements, unless otherwise noted.

Table 3-1. Summary of performance

SPECIFICATION	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Input voltage		4.5	12	24	V
Output voltage setpoint			1.0		V
FB voltage	TJ = 25°C	594	600	606	mV
Output current range		0		8	A
Soft start time	External soft start time		2.6		ms
Operating frequency			600k		Hz
Mode	Light load operating mode		ECO		
Over current	Valley current set point		9.8		A

TPS51396A supports six different kinds of mode by selecting divider resister on mode pin. Please refer Table 3-2.

In this TPS51396AEVM board, mode can be selected to 600kHz/ECO and 600kHz/OOA by Mode Jumper. If you want to select other mode, please replace mode divider resister according to below table.

Table 3-2. Mode Table

R_Top(kΩ)	R_Bottom (kΩ)	LIGHT LOAD OPERATION	FREQUENCY (kHz)
330	5.1	Eco	600
330	15	Eco	800
330	27	Eco	1000
200	27	OOA	600
150	33	OOA	800
160	51	OOA	1000

4 Schematic and List of Materials

This section presents the TPS51396AEVM schematic and List of Materials.

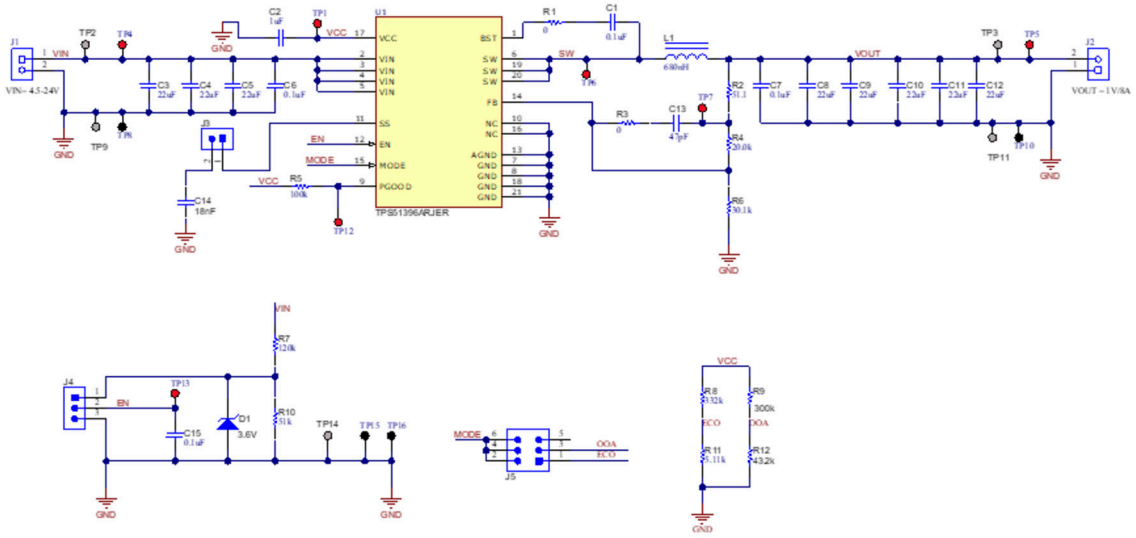

Figure 4-1. Schematic

Table 4-1. TPS51396AEVM List of Materials

DES	QTY	DESCRIPTION	PART NUMBER	MAN
C2	1	Capacitor, ceramic, 1 µF, 25 V, ±10%, X5R, 0603	C1608X5R1E105K080AC	TDK
C3, C4, C5	3	Capacitor, ceramic, 22 µF, 35 V, ±20%, X5R, 1206	C3216X5R1V226M160AC	TDK
C1, C6, C7, C15	4	Capacitor, ceramic, 0.1 µF, 50 V, ±10%, X7R, 0603	C1608X7R1H104K080AA	TDK
C14	1	Capacitor, ceramic, 0.018 µF, 16 V, ±10%, X7R, 0603	GRM188R71C183KA01D	MuRata
C8, C9, C10, C11, C12	5	Capacitor, ceramic, 22 µF, 10 V, +±20%, X7S, 1206	C3216X7S1A226M160AC	TDK
C13	1	Capacitor, ceramic, 47 pF, 50 V, +±5%, C0G/NP0, 0603	06035A470JAT2A	AVX
D1	1	Diode, Zener, 3.6 V, 500 mW, SOD-123	MMSZ4685T1G	ON Semiconductor
J1, J2	2	Terminal block, 5.08 mm, 2x1, brass, TH	ED120/2DS	On-Shore Technology
J3	1	Header, 100 mil, 2x1, tin, TH	PEC02SAAN	Sullins Connector Solutions
J4	1	Header, 100 mil, 3x1, tin, TH	PEC03SAAN	Sullins Connector Solutions
J5	1	Header, 100 mil, 3x2, tin, TH	PEC03DAAN	Sullins Connector Solutions
L1	1	Inductor, shielded drum core, Superflux, 680 nH, 17 A, 0.0035 Ω, SMD	744311068	Wurth Elektronik
R7	1	Resistor, 120 kΩ, 5%, 0.1 W, AEC-Q200 grade 0, 0603	CRCW0603120KJNEA	Vishay-Dale
R10	1	Resistor, 51 kΩ, 5%, 0.1 W, AEC-Q200 grade 0, 0603	CRCW060351K0JNEA	Vishay-Dale
R11	1	Resistor, 5.11 kΩ, 1%, 0.1 W, AEC-Q200 grade 0, 0603	CRCW06035K11FKEA	Vishay-Dale
R8	1	Resistor, 332 kΩ, 1%, 0.1 W, AEC-Q200 grade 0, 0603	CRCW0603332KFKEA	Vishay-Dale
R5	1	Resistor, 100 kΩ, 1%, 0.1 W, AEC-Q200 grade 0, 0603	CRCW0603100KFKEA	Vishay-Dale
R1, R3	2	Resistor, 0 Ω, 5%, 0.1 W, AEC-Q200 grade 0, 0603	CRCW06030000Z0EA	Vishay-Dale
R2	1	Resistor, 51.1 Ω, 1%, 0.1 W, AEC-Q200 grade 0, 0603	CRCW060351R1FKEA	Vishay-Dale
R6	1	Resistor, 30.1 kΩ, 1%, 0.1 W, AEC-Q200 grade 0, 0603	CRCW060330K1FKEA	Vishay-Dale
R4	1	Resistor, 20.0 kΩ, 1%, 0.1 W, AEC-Q200 grade 0, 0603	CRCW060320K0FKEA	Vishay-Dale
R12	1	Resistor, 27.4 kΩ, 1%, 0.1 W, AEC-Q200 grade 0, 0603	CRCW060327K4FKEA	Vishay-Dale
R9	1	Resistor, 200 kΩ, 1%, 0.1 W, AEC-Q200 grade 0, 0603	CRCW0603200KFKEA	Vishay-Dale
SH-J1, SH-J2, SH-J3	3	Shunt, 100 mil, gold plated, black	SNT-100-BK-G	Samtec
TP1, TP4, TP5, TP6, TP7, TP12, TP13	7	Test point, miniature, red, TH	5000	Keystone
TP8, TP10, TP15, TP16	4	Test point, miniature, black, TH	5000	Keystone
TP2, TP3, TP9, TP11, TP14	5	Terminal, turret, TH, Triple	1598-2	Keystone
U1	1	4.5-V to 24-V input, 8-A synchronous step-down voltage regulator, RJE0020A (VQFN-HR-20)	TPS51396ARJER	Texas Instruments

5 Board Layout

This section provides a description of the TPS51396AEVM board layout and layer illustrations. The board layout for the TPS51396AEVM is shown in below figures. The top-side layer of the EVM is laid out in a manner typical of a user application. The top and bottom layers are 2-oz copper, and internal layers are 1-oz copper.

The top layer contains the main power traces for VIN, VOUT, and SW. Also on the top layer are connections for the remaining pins of the TPS51396A and the majority of the signal traces. There is a large area filled with ground. The internal layer-1 and layer-2 are ground plane. The bottom layer is another ground plane with some additional signal. The top-side ground traces are connected to the bottom and internal ground planes with multiple vias placed around the board.

The input decoupling capacitors and bootstrap capacitor are all located as close to the IC as possible. Additionally, the voltage set point resistor divider components are kept close to the IC. The voltage divider network ties to the output voltage at the point of regulation. For the TPS51396A, an additional input bulk capacitor may be required, depending on the EVM connection to the input supply. Critical analog circuits such as the voltage set point divider, EN resistor, SS capacitor, MODE resistor, and AGND pin are terminated to quiet analog ground island.

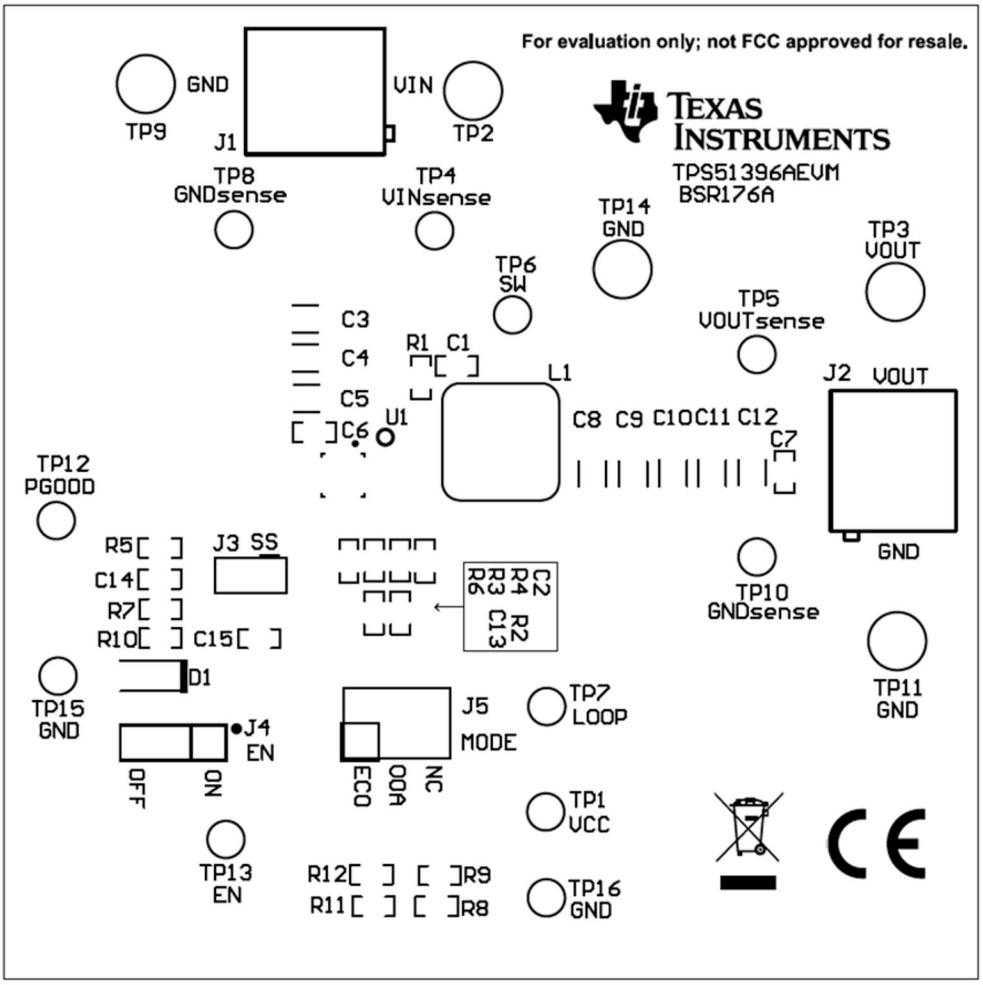

Figure 5-1. Component Placements

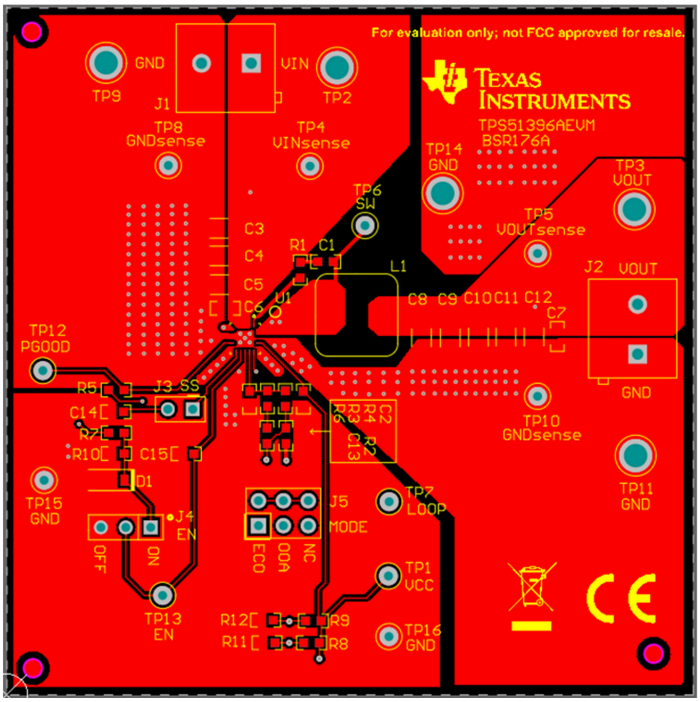

Figure 5-2. Top Layer

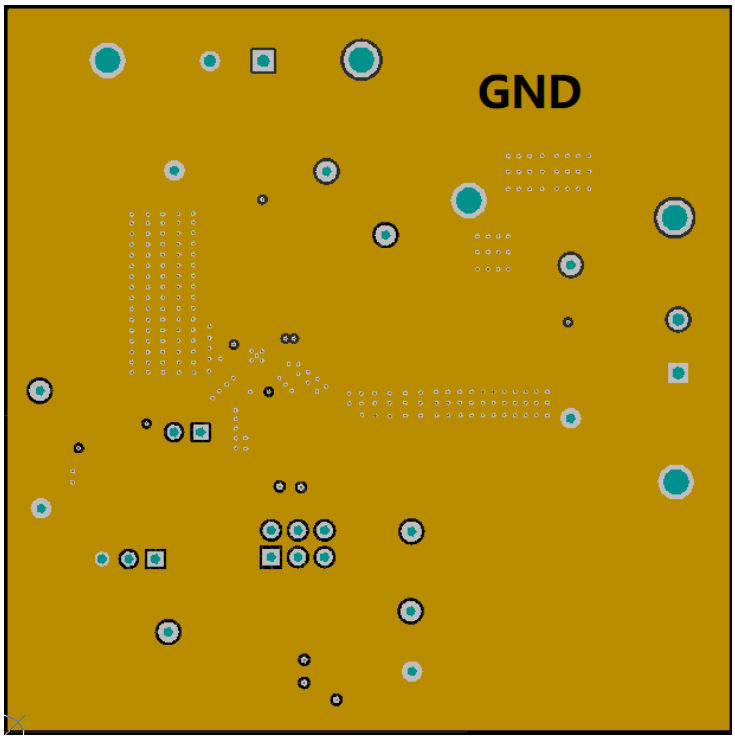

Figure 5-3. Internal Layer1

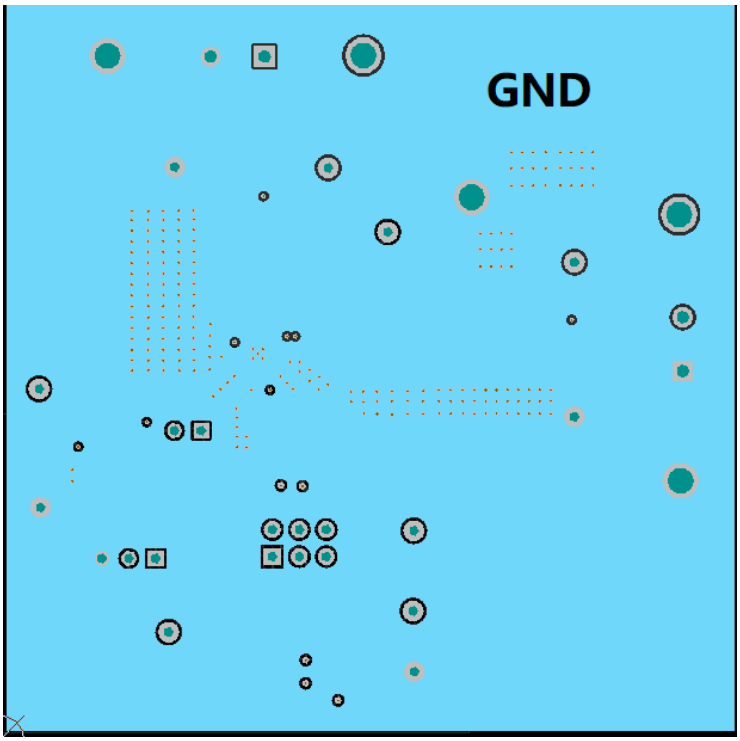

Figure 5-4. Internal Layer2

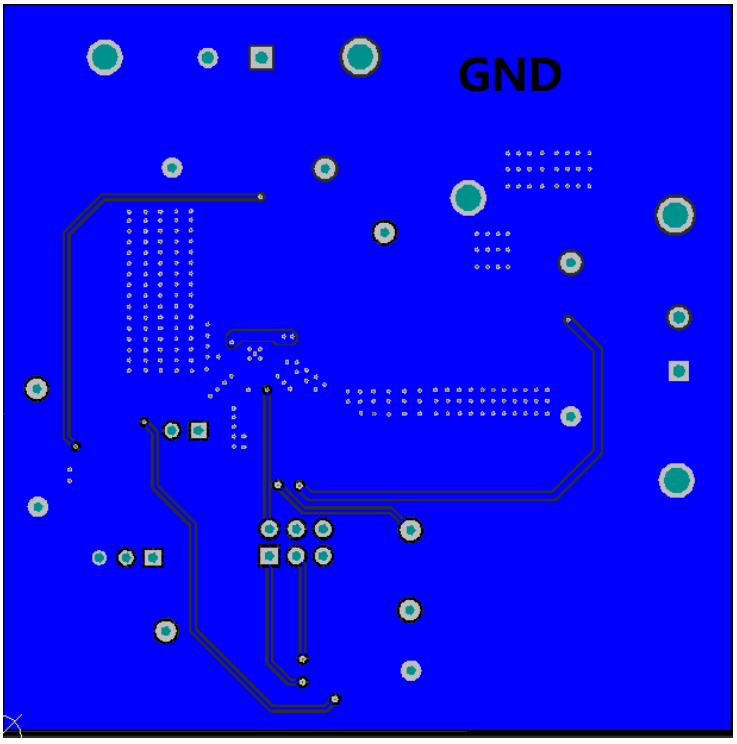

Figure 5-5. Bottom Layer

Figure 5-6 and Figure 5-7 are high revolution images of the EVM board.

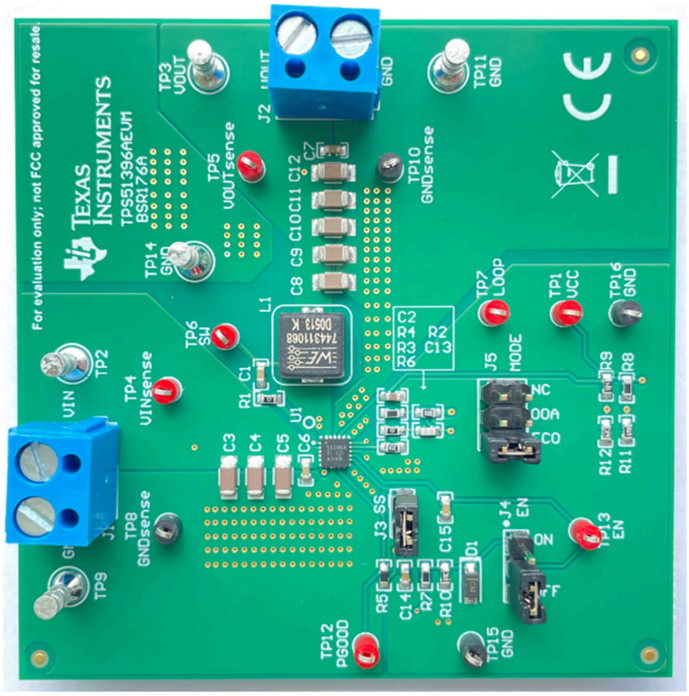

Figure 5-6. EVM Front View

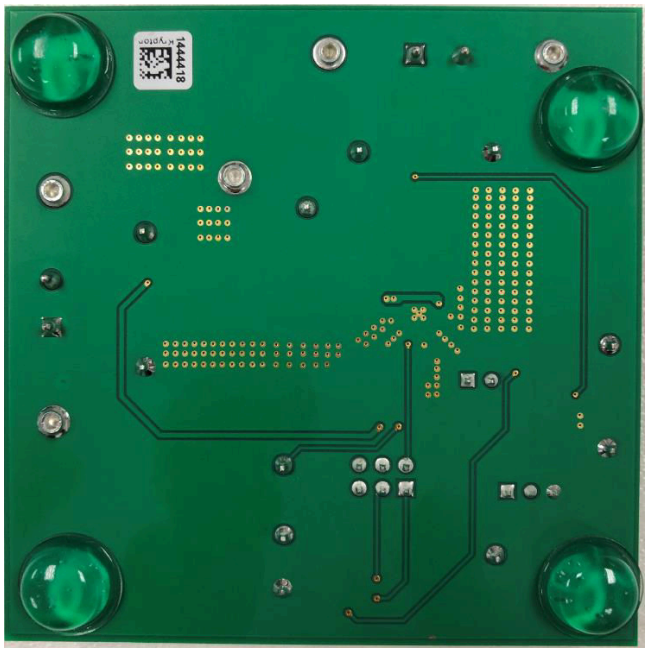

Figure 5-7. EVM Back View

6 Bench Test Setup conditions

This section describes how to properly connect, set up, and use the TPS51396AEVM evaluation module.

6.1 Headers Description and Jumper Placement.

The TPS51396AEVM header description is as Figure 6-1. A power supply capable of supplying greater than 4 A must be connected to J1 through a pair of 20-AWG wires or better. The load must be connected to J2 through a pair of 20-AWG wires or better. The maximum load current capability is 8 A. Wire lengths must be minimized to reduce losses in the wires. Test point TP2 provides a place to monitor the VIN input voltages with TP9 providing a convenient ground reference. TP3 is used to monitor the output voltage with TP11 as the ground reference.

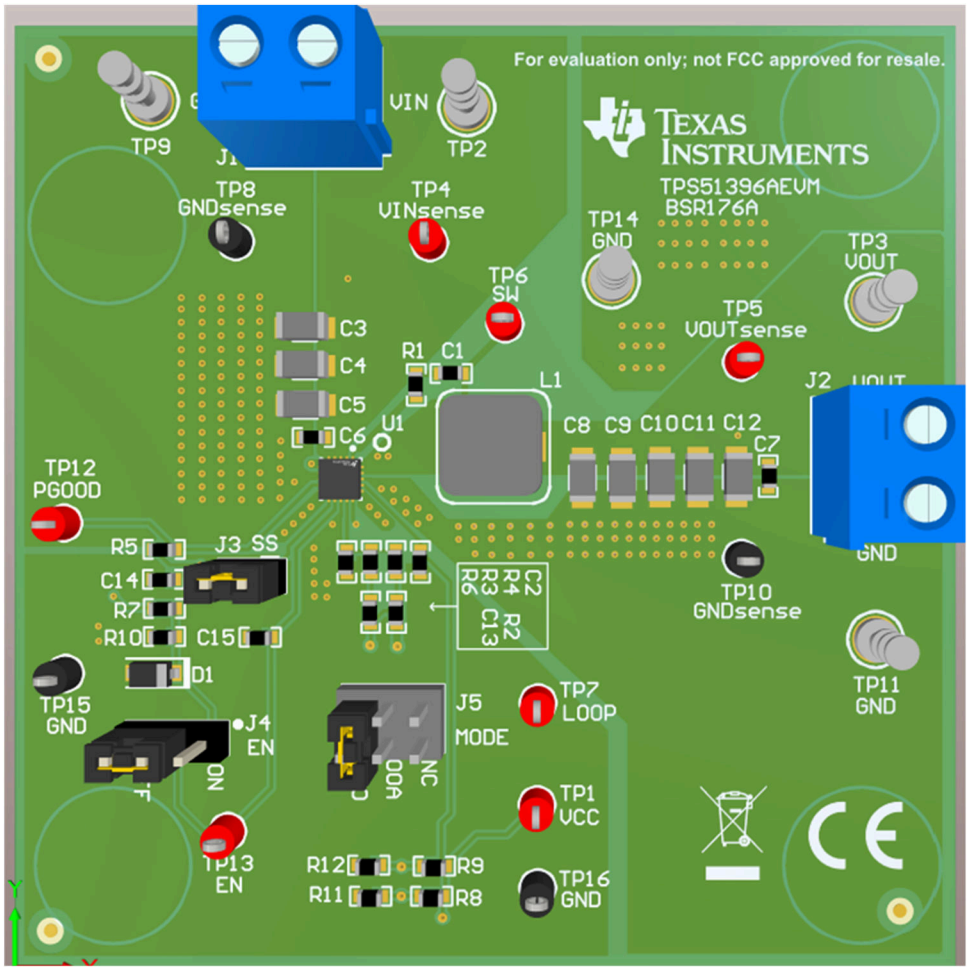

Figure 6-1. Headers Description and Jumper Placement

Connector and test point description is as Table 6-1.

Table 6-1. Input and Output Connection

#	FUNCTION	DESCRIPTION
J1	VIN connector	VIN power
J2	VOUT connector	VOUT power
J3	Internal/external Soft Start selection	When short J3, IC uses external SS by charging the cap C6. When float J3, IC uses internal SS.
J4	Enable control	Middle pin is Buck Enable PIN. When this PIN is floating, the IC is disable. When the jumper short EN on, IC is enable. When the jumper short EN off, IC is disable.
J5	Mode selection	This EVM provides three kinds of mode. When short OOA, IC works with out of audio mode, frequency is 600kHz. When short ECO, IC works with pulse skip mode, frequency is 600kHz.
TP1	VCC test point	Test VCC
TP2	VIN test point	Test VIN
TP8/9/10/11/14/15/16	GND connector	Ground
TP4	VIN connector	VIN power
TP12	PGOOD test point	Test PGOOD
TP6	SW test point	Test SW
TP5	VOUT test point	Test VOUT
TP3	VOUT connector	VOUT loading
TP7	Loop test point	Test loop
TP13	Enable test point	Test Enable signal

6.2 Power-Up Procedure

POWER-UP with external Enable Buck signal.

1, Select Mode function.

2, Apply 4.5 V~24 V to J1.

3, Apply 1.4 V~3.3 V to J4 middle pin(enable pin).

4, Apply loading to J2 output connector.

POWER-UP with V_{IN} control Enable Buck signal.

1, Select Mode function.

2, Connect J4 middle pin and left pin together with Jumper cap.

3, Apply 4.5 V~24 V to J1.

4, Apply loading to the J2 output connectors.

7 Test Waveform

7.1 Power Up

Figure 7-1 and Figure 7-2 show the start-up waveforms with 0-A and 8-A loading for the TPS51396AEVM board. The applied input voltage is 12 V. Once the EN is high, Vout ramps up.

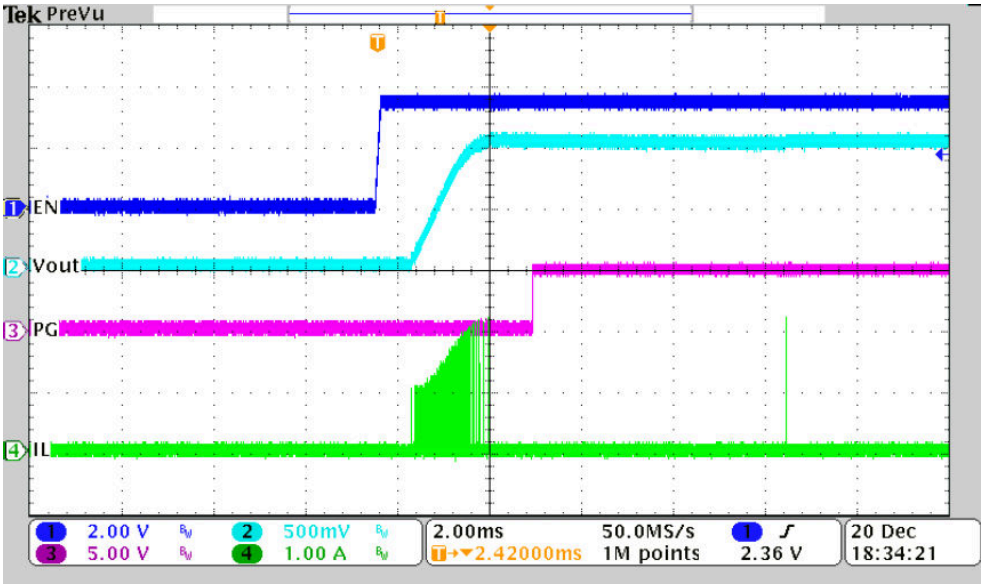

Figure 7-1. Power Up with 0 A

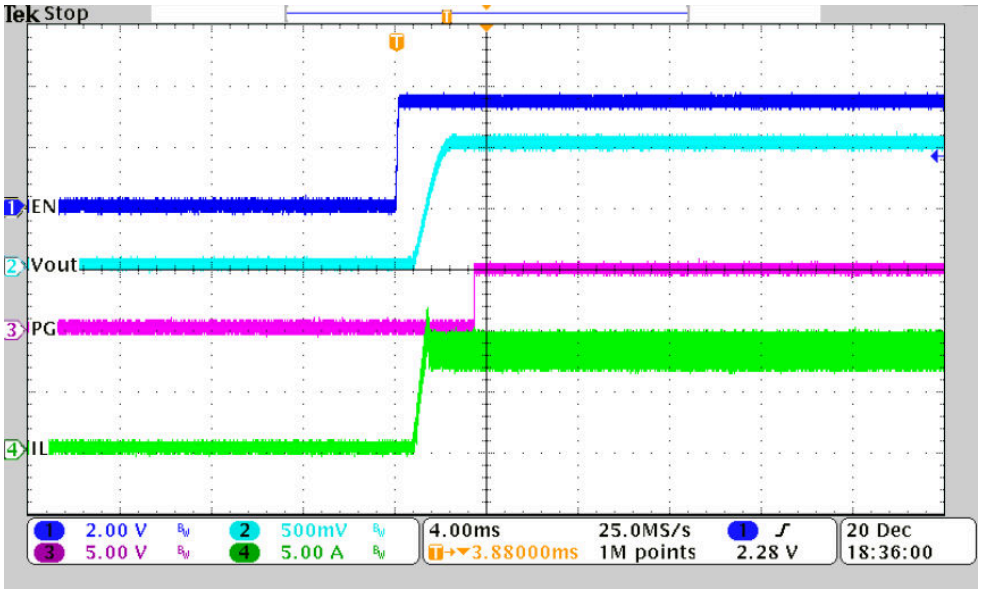

Figure 7-2. Power Up with 8 A

7.2 Power Down

Figure 7-3 and Figure 7-4 show the power down waveforms for the TPS51396AEVM board. The applied input voltage is 12 V. Once the EN is down, Vout ramps down.

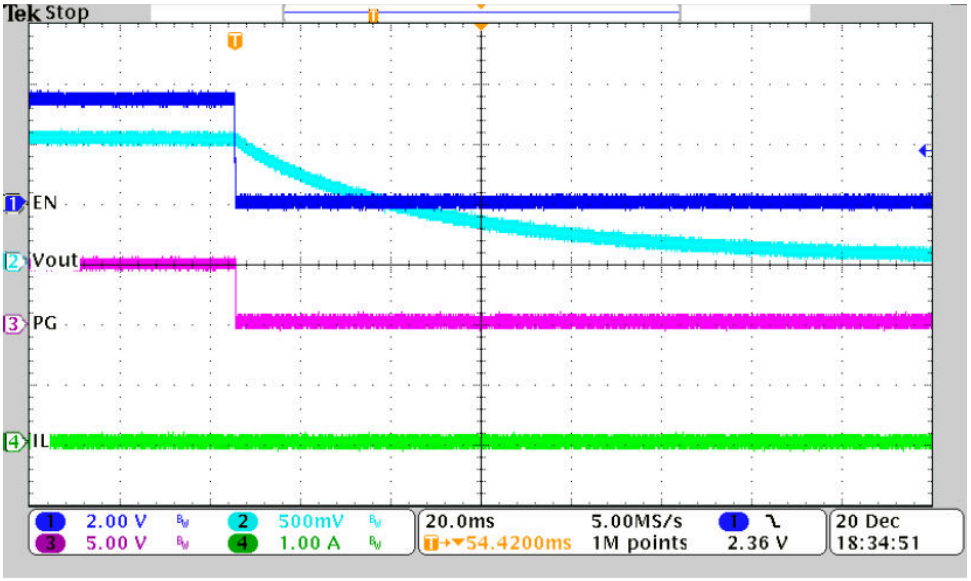

Figure 7-3. Power Down with 0 A

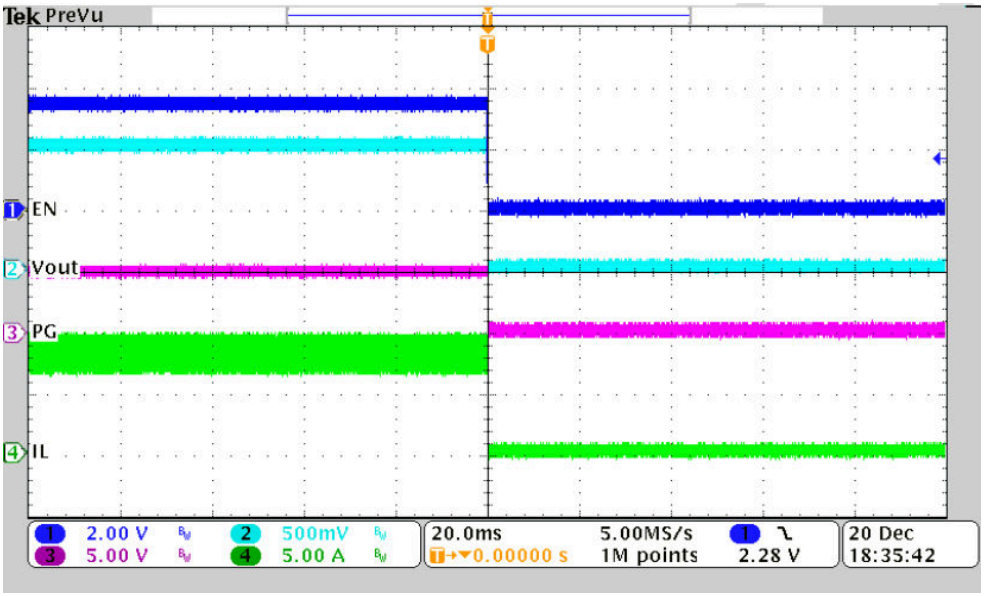

Figure 7-4. Power Down with 8 A

7.3 Output Voltage Ripple

Figure 7-5 and Figure 7-6 show the output voltage ripple with 0 A and 8 A for the TPS51396AEVM board. The input voltage is 12 V.

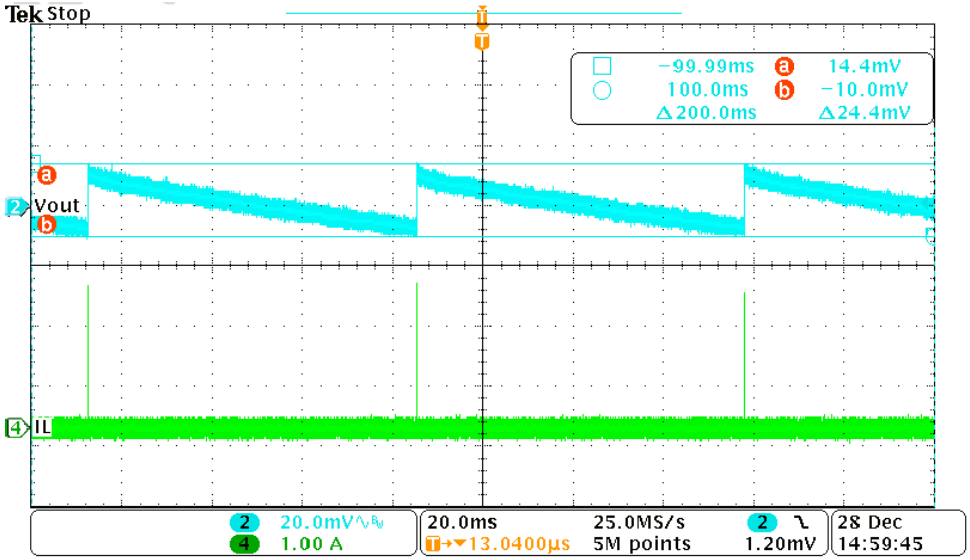

Figure 7-5. Output Ripple with 0 A Loading at ECO Mode

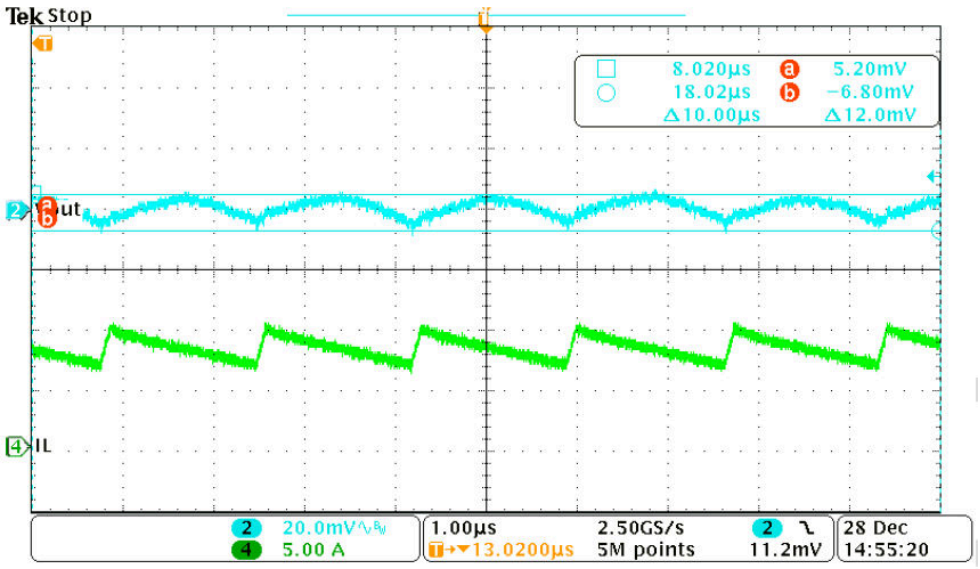

Figure 7-6. Output Ripple with 8 A Loading at ECO Mode

Figure 7-7 shows the output voltage ripple with 0-A loading at OOA mode. Input voltage is 12 V.

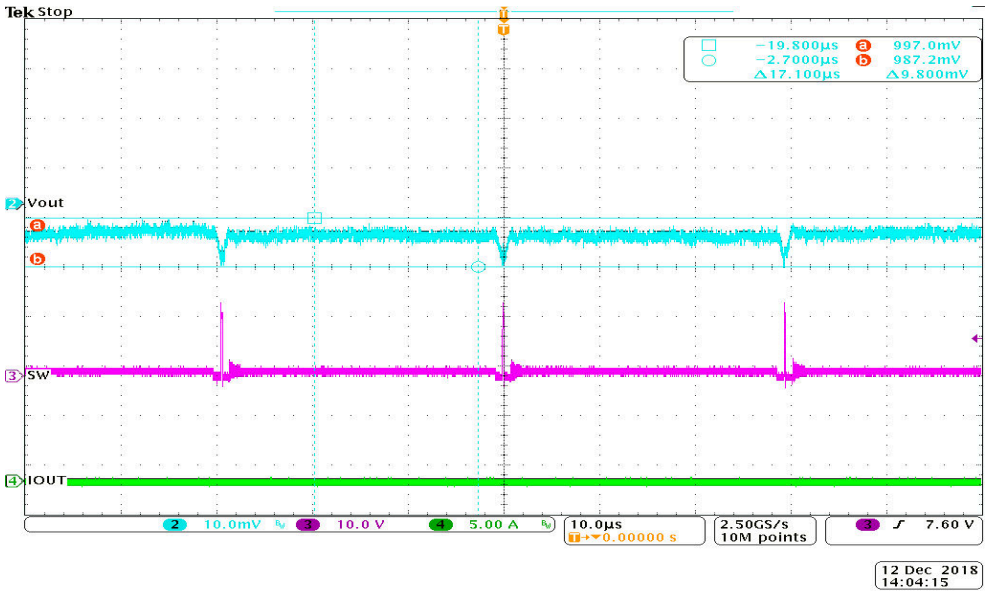

Figure 7-7. Output Ripple with 0 A at OOA Mode

7.4 Load Transient

Below figures show TPS51396A response to load transient at 12-V input and 1.0-V output. In Figure 7-8, the current step is from 0.8 A to 7.2 A and the current step slew rate is 2.5 A/µs. In Figure 7-9, the current load is from 2 A to 6 A.

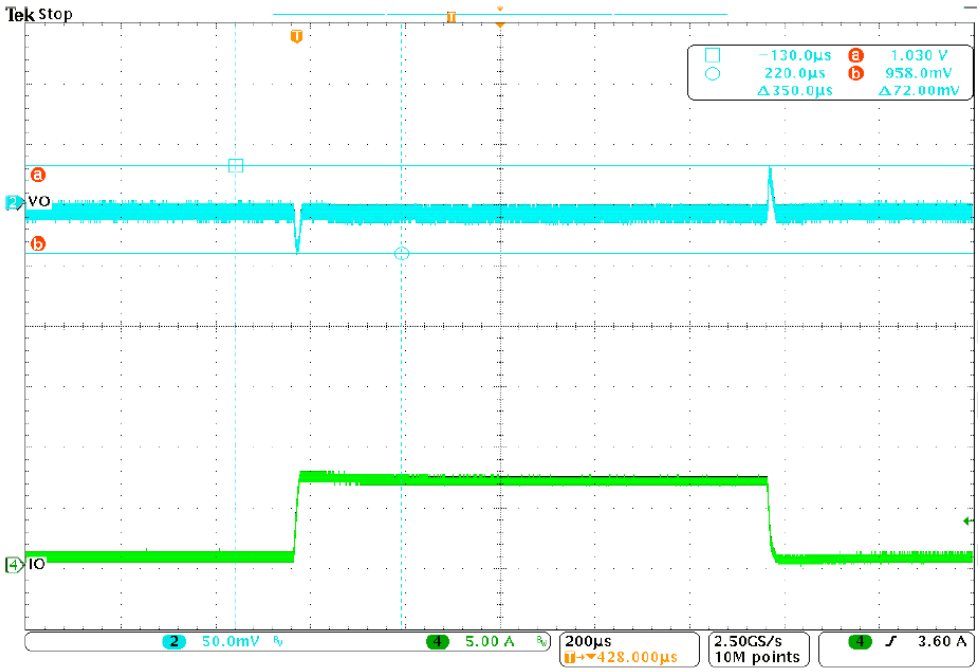

Figure 7-8. Load Transient from 0.8 A to 7.2 A

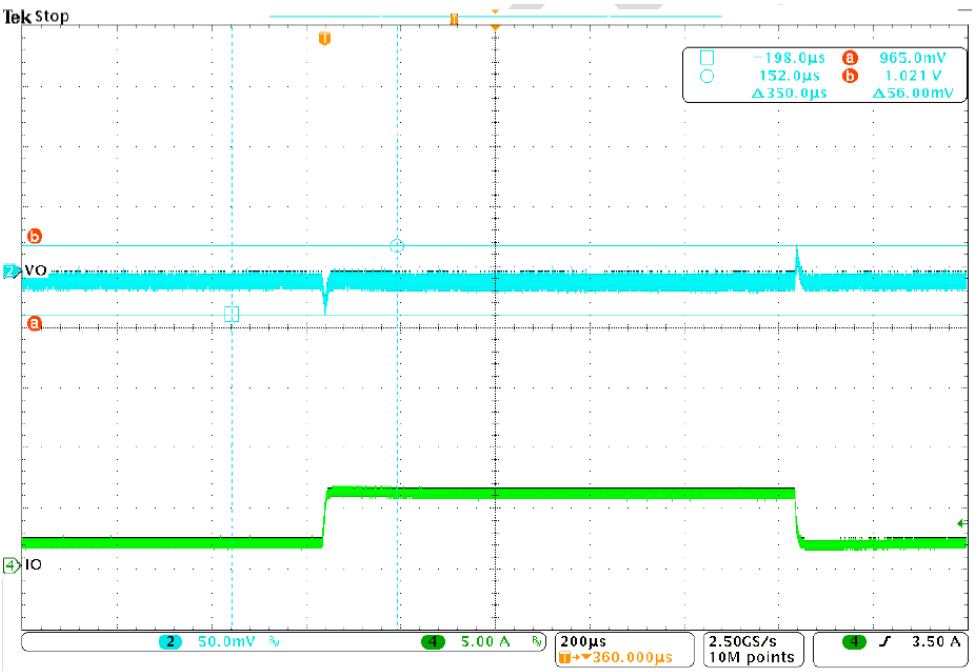

Figure 7-9. Load Transient from 2 A to 6 A

7.5 Thermal

The thermal image in Figure 7-10 shows the EVM with 12-V input, 1.0-V output and full loading of 8 A at room temperature.

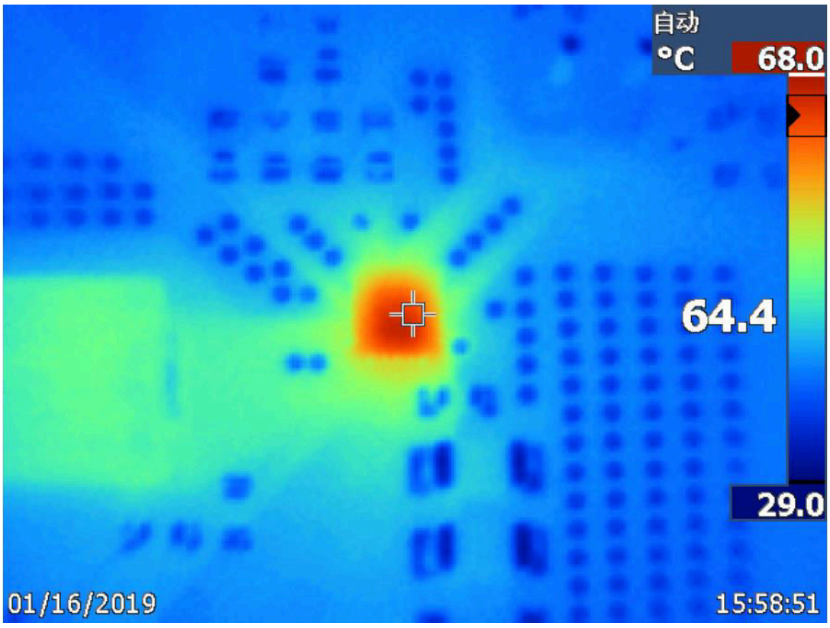

Figure 7-10. Thermal

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