User's Guide

TPS564201 Buck Converter Evaluation Module User's Guide

ABSTRACT

This user's guide contains information for the TPS564201 as well as support documentation for the TPS564201EVM-801 evaluation module. Included are the performance specifications, schematic, and the bill of materials of the TPS564201EVM-801.

Table of Contents

Trademarks

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1 Introduction

The TPS564201 is a single, adaptive on-time, D-CAP2™ mode, synchronous buck converter requiring a very low external component count. The D-CAP2 control circuit is optimized for low-ESR output capacitors such as POSCAP, SP-CAP, or ceramic types and features fast transient response with no external compensation. The switching frequency is internally set at a nominal 560 kHz and enters plus skip mode in light load conditions. The high-side and low-side switching MOSFETs are incorporated inside the TPS564201 package along with the gate-drive circuitry. The low drain-to-source on resistance of the MOSFETs allows the TPS564201 to achieve high efficiencies and helps keep the junction temperature low at high output currents. The TPS564201 dc/dc synchronous converter is designed to provide up to a 4-A output from an input voltage source of 4.5 V to 17 V. The output voltage range is from 0.759 V to 7 V. Rated input voltage and output current ranges for the evaluation module are given in Table 1-1.

The TPS564201EVM-801 evaluation module (EVM) is a single, synchronous buck converter providing 1.05 V at 4 A from 4.5-V to 17-V input. This user's guide describes the TPS564201EVM-801 performance.

Table 1-1. Input Voltage and Output Current Summary

EVM	Input Voltage (V_{IN}) Range	Output Current (I_{OUT}) Range
TPS564201EVM-801	4.5 V to 17 V	0 A to 4 A

2 Performance Specification Summary

A summary of the TPS564201EVM-801 performance specifications is provided in Table 2-1. Specifications are given for an input voltage of 12 V and an output voltage of 1.05 V, unless otherwise noted. The ambient temperature is 25°C for all measurement, unless otherwise noted.

Table 2-1. TPS564201EVM-801 Performance Specifications Summary

Specifications		Test Conditions	MIN	TYP	MAX	Unit
V_{IN}	Input voltage		4.5	12	17	V
CH1	Output voltage			1.05		V
	Operating frequency	V_{IN} = 12 V, I_{OUT} = 4 A		560		kHz
	Output current range		0		4	A
	Overcurrent limit	V_{IN} = 12 V, L_{OUT} = 2.2 µH		6		A
	Output ripple voltage	V_{IN} = 12 V, I_{OUT} = 4 A		20		mV_{PP}

3 Modifications

These evaluation modules are designed to provide access to the features of the TPS564201. Some modifications can be made to this module.

3.1 Output Voltage Setpoint

To change the output voltage of the EVMs, it is necessary to change the value of resistor R1. Changing the value of R1 can change the output voltage above 0.759 V. The value of R1 for a specific output voltage can be calculated using Equation 1.

$$R1 = \frac{R2 \times (V_{OUT} - 0.759\ V)}{0.759\ V} \quad (1)$$

Table 3-1 lists the R5 values for some common output voltages. Note that the values given in Table 3-1 are standard values and not the exact value calculated using Table 3-1.

Table 3-1. TPS564201EVM-801 Output Voltages

Output Voltage (V)	R1 (kΩ)	R2 (kΩ)	L1 (µH)			C5 + C6 +C7 (µF)
			MIN	TYP	MAX	
1.0	3.09	10.0	1.5	2.2	4.7	20 - 68
1.05	3.74	10.0	1.5	2.2	4.7	20 - 68
1.2	5.76	10.0	1.5	2.2	4.7	20 - 68
1.5	9.53	10.0	1.5	2.2	4.7	20 - 68
1.8	13.7	10.0	1.5	2.2	4.7	20 - 68
2.5	22.6	10.0	2.2	2.2	4.7	20 - 68
3.3	33.2	10.0	2.2	2.2	4.7	20 - 68
5.0	54.9	10.0	3.3	3.3	4.7	20 - 68
6.5	75.0	10.0	3.3	3.3	4.7	20 - 68

4 Test Setup and Results

This section describes how to properly connect, set up, and use the TPS564201EVM-801. The section also includes test results typical for the evaluation modules and efficiency, output load regulation, output line regulation, load transient response, output voltage ripple, input voltage ripple, start-up, and switching frequency.

4.1 Input/Output Connections

The TPS564201EVM-801 is provided with input/output connectors and test points as shown in Table 4-1. A power supply capable of supplying 4 A must be connected to J1 through a pair of 20-AWG wires. The load must be connected to J2 through a pair of 20-AWG wires. The maximum load current capability is 4 A. Wire lengths must be minimized to reduce losses in the wires. Test point TP1 provides a place to monitor the V_{IN} input voltages with TP2 providing a convenient ground reference. TP7 is used to monitor the output voltage with TP8 as the ground reference.

Table 4-1. Connection and Test Points

REFERENCE DESIGNATOR	FUNCTION
J1	V_{IN} (see Table 1-1 for V_{IN} range)
J2	V_{OUT}, 1.05 V at 4-A maximum
JP1	EN control. Shunt EN to GND to disable, shunt EN to V_{IN} to enable.
TP1	V_{IN} positive monitor point
TP2	GND monitor test point
TP3	EN test point
TP4	Switch node test point
TP5	Test point for loop response measurements
TP6	V_{OUT} positive monitor point
TP7	GND monitor test point
TP8	GND monitor test point

4.2 Start-Up Procedure

1. Ensure that the jumper at JP1 (Enable control) pins 1 and 2 are covered to shunt EN to GND, disabling the output.
2. Apply appropriate input voltage to VIN (J1-2) and GND (J1-1).
3. Move the jumper at JP1 (Enable control) from pins 1 and 2 (EN and GND), to pins 2 and 3 (EN and V_{IN}) enabling the output.

4.3 Efficiency

Figure 4-1 shows the efficiency for the TPS564201EVM-801 at an ambient temperature of 25°C.

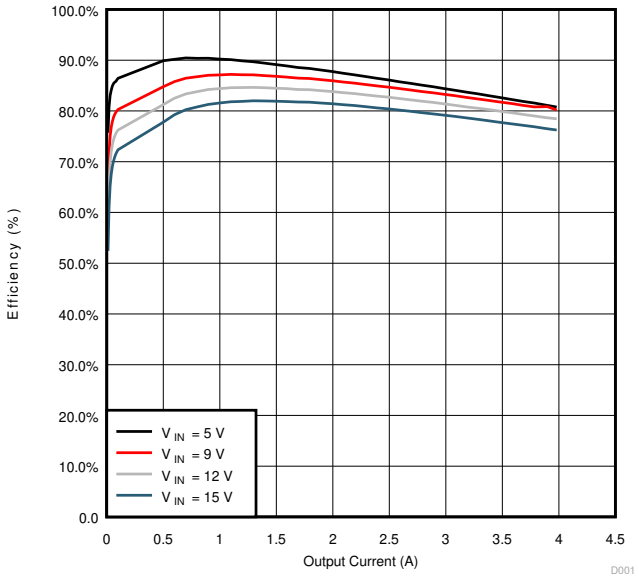

Figure 4-1. Efficiency

Figure 4-2 shows the efficiency at light loads for the TPS564201EVM-801 at an ambient temperature of 25°C.

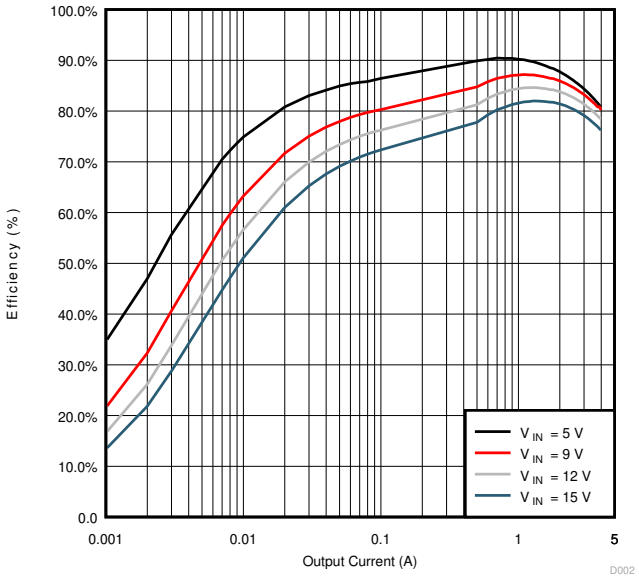

Figure 4-2. Light Load Efficiency

4.4 Load Regulation

The load regulation for the TPS564201EVM-801 is shown in Figure 4-3.

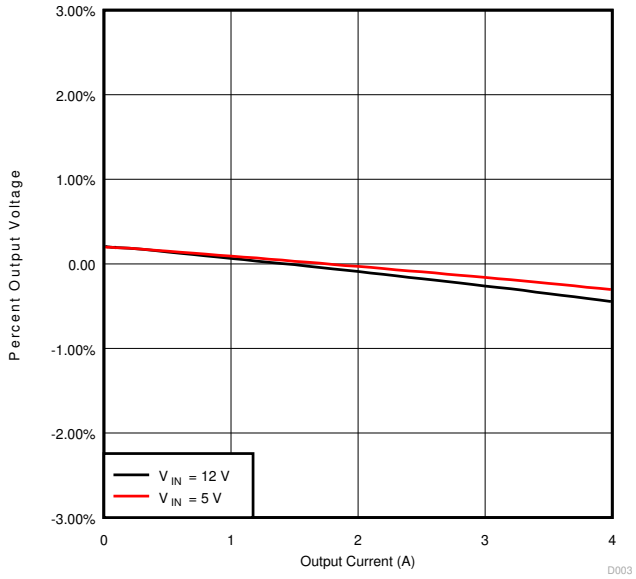

Figure 4-3. Load Regulation

4.5 Line Regulation

The line regulation for the TPS564201EVM-801 is shown in Figure 4-4.

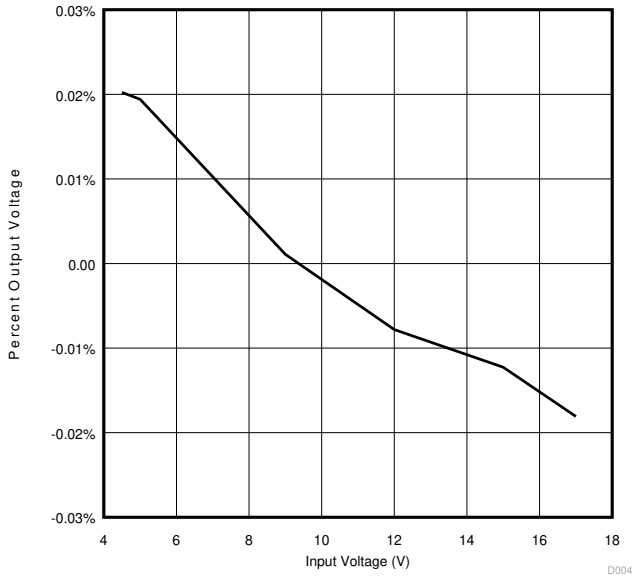

Figure 4-4. Line Regulation

4.6 Load Transient Response

The TPS564201EVM-801 response to load transient is shown in Figure 4-5. The current steps and slew rates are indicated in the figures. Total peak-to-peak voltage variation is as shown.

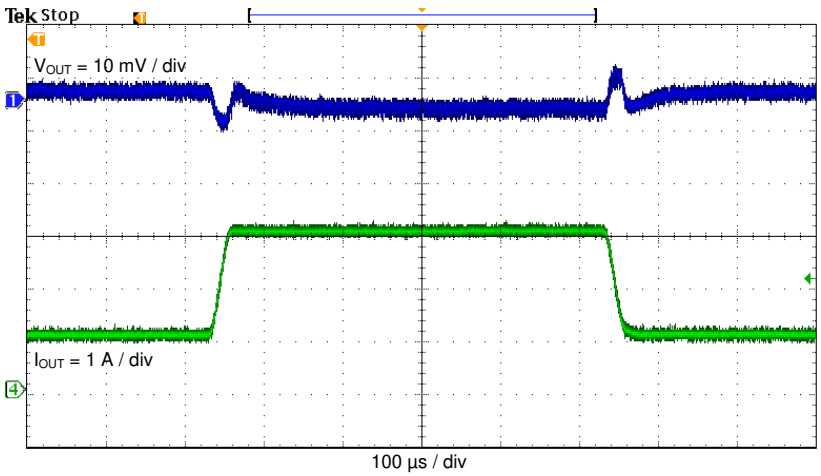

Figure 4-5. Load Transient Response, 1 A to 3 A

4.7 Output Voltage Ripple

The TPS564201EVM-801 output voltage ripple is shown in Figure 4-6, Figure 4-7, and Figure 4-8. The output currents are as indicated.

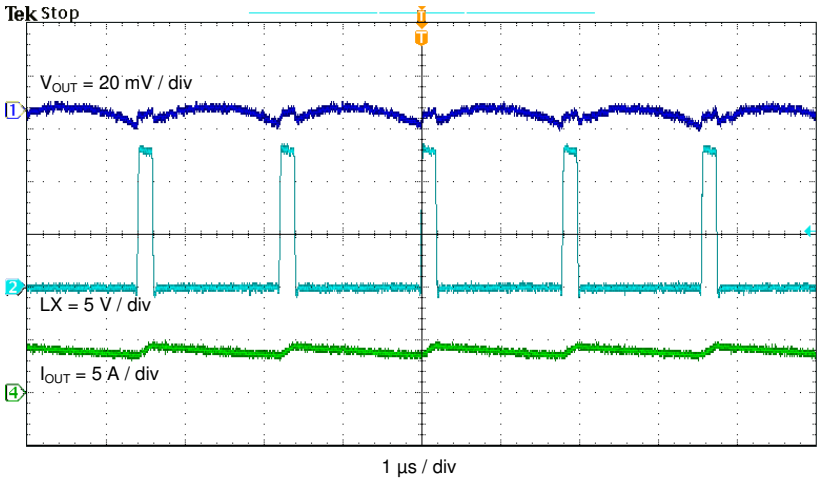

Figure 4-6. Output Voltage Ripple, I_{OUT} = 4 A

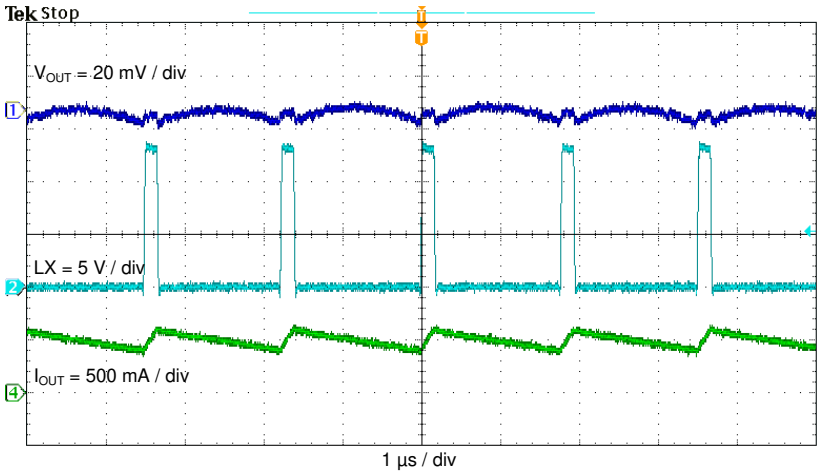

Figure 4-7. Output Voltage Ripple, I_{OUT} = 2 A

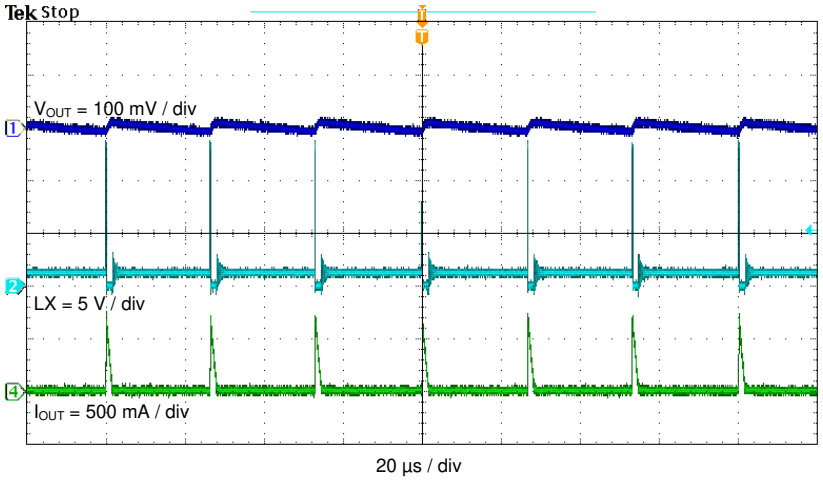

Figure 4-8. TPS564201 Output Voltage Ripple, no Load

4.8 Input Voltage Ripple

The TPS564201EVM-801 input voltage ripple is shown in Figure 4-9. The output current is as indicated.

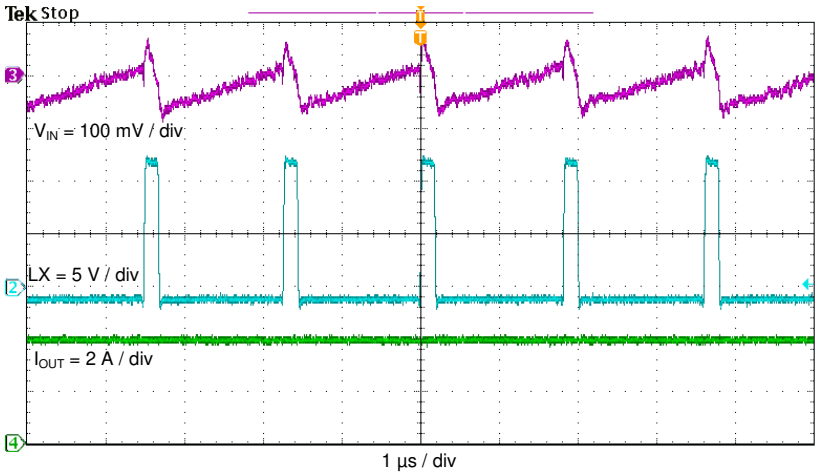

Figure 4-9. Input Voltage Ripple

4.9 Start-Up

The TPS564201EVM-801 start-up waveform relative to V_{IN} is shown in Figure 4-10. Load = 1 Ω resistive.

The TPS564201EVM-801 start-up waveform relative to enable (EN) is shown in Figure 4-11. Load = 1 Ω resistive.

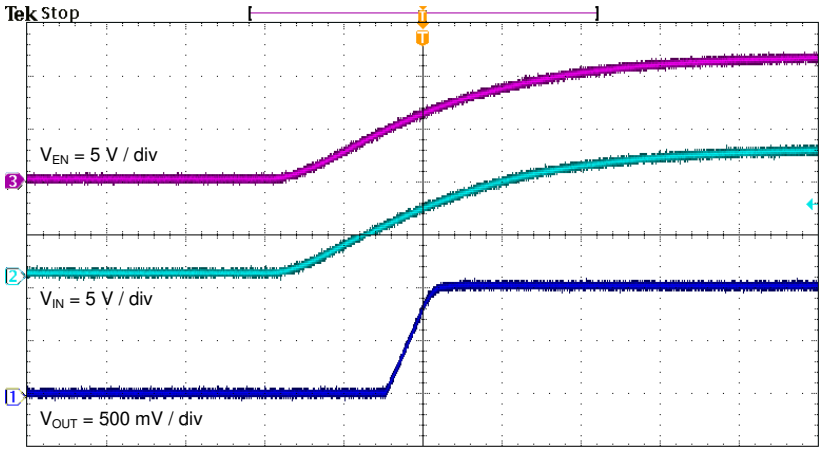

Figure 4-10. Start-Up Relative to V_{IN}

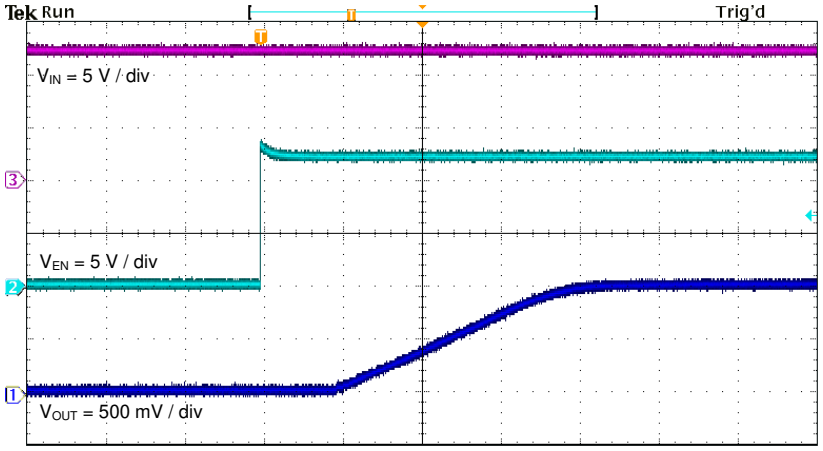

Figure 4-11. Start-Up Relative to EN

4.10 Shut-Down

The TPS564201EVM-801 shut-down waveform relative to V_{IN} is shown in Figure 4-12. Load = 1 Ω resistive.

The TPS564201EVM-801 shut-down waveform relative to EN is shown in Figure 4-13. Load = 1 Ω resistive.

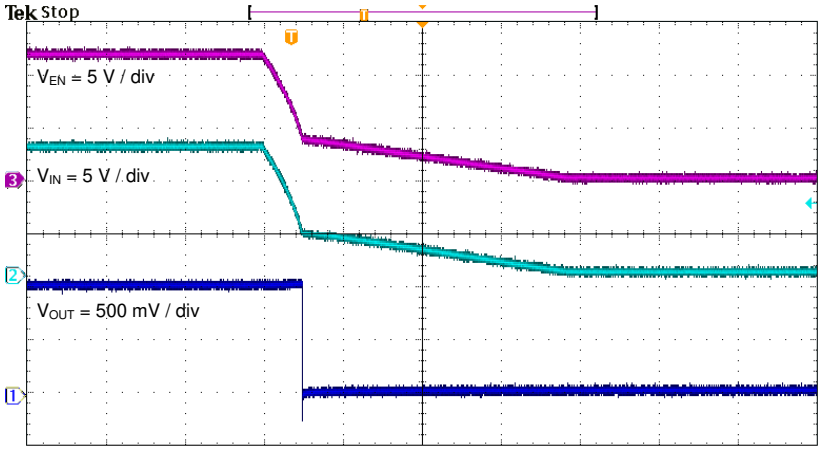

Figure 4-12. Shut-Down Relative to V_{IN}

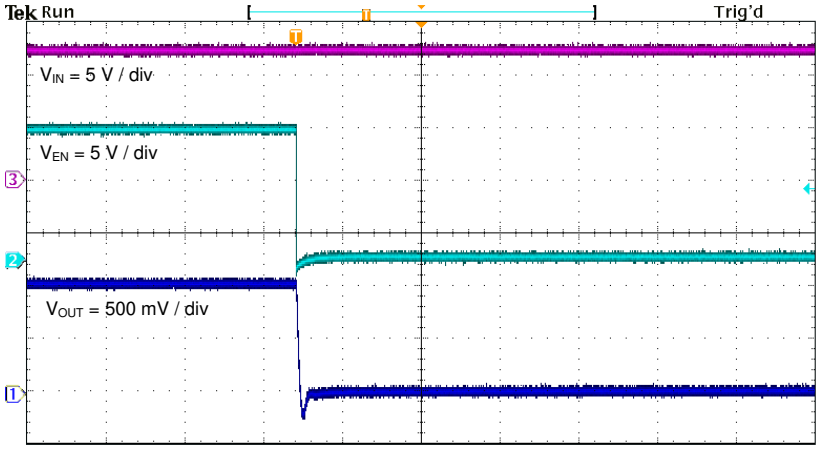

Figure 4-13. Shut-Down Relative to EN

5 Board Layout

This section provides a description of the TPS564201EVM-801, board layout, and layer illustrations.

5.1 Layout

The board layout for the TPS564201EVM-801 is shown in Figure 5-1, Figure 5-2 and Figure 5-3. The top layer contains the main power traces for VIN, VOUT, and ground. Also on the top layer are connections for the pins of the TPS564201 and a large area filled with ground. Most of the signal traces are also located on the top side. The input decoupling capacitors, C1, C2, and C3 are located as close to the IC as possible. The input and output connectors, test points, and all of the components are located on the top side. The bottom layer is a ground plane along with the switching node copper fill, signal ground copper fill and the feed back trace from the point of regulation to the top of the resistor divider network.

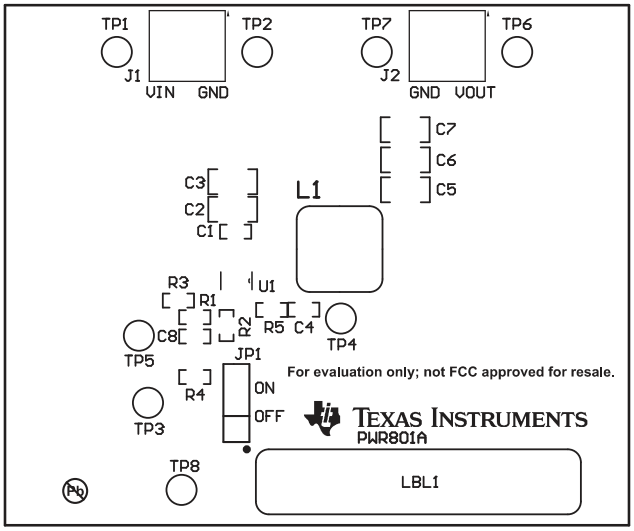

Figure 5-1. Top Assembly

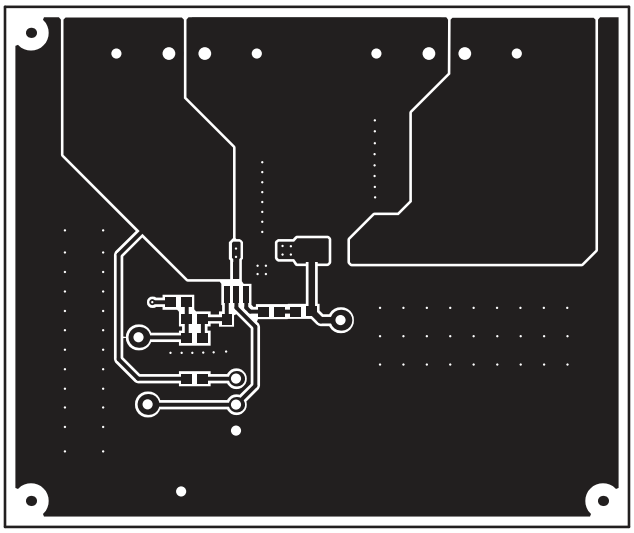

Figure 5-2. Top Layer

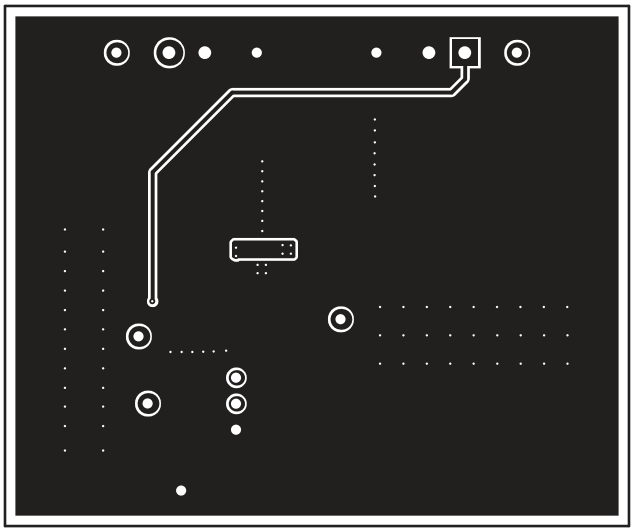

Figure 5-3. Bottom Layer

6 Schematic, Bill of Materials, and Reference

6.1 Schematic

Figure 6-1 is the schematic for the TPS564201EVM-801.

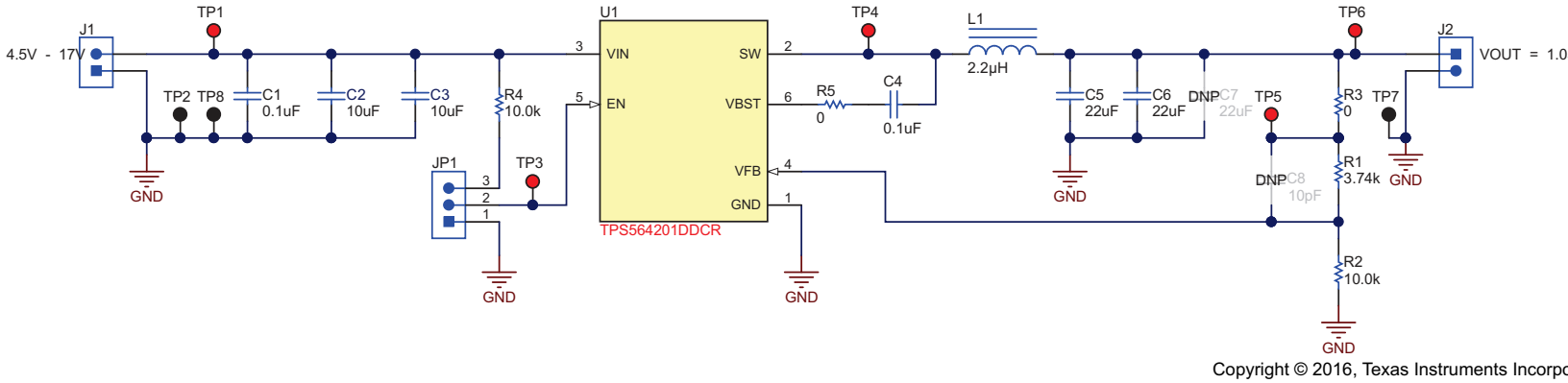

Figure 6-1. TPS564201EVM-801 Schematic Diagram

6.2 Bill of Materials

Table 6-1. Bill of Materials

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number	Alternate Manufacturer
!PCB1	1		Printed Circuit Board		PWR801	Any	-	-
C1, C4	2	0.1uF	CAP, CERM, 0.1uF, 25V, +/-10%, X5R, 0603	0603	GRM188R61E104KA01D	Murata		
C2, C3	2	10uF	CAP, CERM, 10uF, 25V, +/-10%, X5R, 1206	1206	GRM31CR61E106KA12L	Murata		
C5, C6	2	22uF	CAP, CERM, 22uF, 10V, +/-10%, X7R, 1206	1206	GRM31CR71A226KE15L	Murata		
J1, J2	2		Terminal Block, 6A, 3.5mm Pitch, 2-Pos, TH	7.0x8.2x6.5mm	ED555/2DS	On-Shore Technology		
JP1	1		Header, 100mil, 3x1, Tin, TH	Header, 3 PIN, 100mil, Tin	PEC03SAAN	Sullins Connector Solutions		
L1	1	2.2uH	Inductor, Shielded Drum Core, Superflux, 2.2 µH, 9 A, 0.0115 ohm, SMD	WE-HC4	744311220	Wurth Elektronik		
LBL1	1		Thermal Transfer Printable Labels, 1.250" W x 0.250" H - 10,000 per roll	PCB Label 1.25"H x 0.250"W	THT-13-457-10	Brady		
R1	1	3.74k	RES, 3.74k ohm, 1%, 0.1W, 0603	0603	CRCW06033K74FKEA	Vishay-Dale		
R2, R4	2	10.0k	RES, 10.0k ohm, 1%, 0.1W, 0603	0603	CRCW060310K0FKEA	Vishay-Dale		
R3, R5	2	0	RES, 0 ohm, 5%, 0.1W, 0603	0603	ERJ-3GEY0R00V	Panasonic		
SH-JP1	1	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M	SNT-100-BK-G	Samtec
TP1, TP3, TP4, TP5, TP6	5	Red	Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone		
TP2, TP7, TP8	3	Black	Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone		
U1	1		4.5V to 17 V Input, 4-A Synchronous Step-Down Voltage Regulator, DDC0006A	DDC0006A	TPS564201DDCR	Texas Instruments	TPS564201DDCT	Texas Instruments
C7	0	22uF	CAP, CERM, 22uF, 10V, +/-10%, X7R, 1206	1206	GRM31CR71A226KE15L	Murata		
C8	0	10pF	CAP, CERM, 10 pF, 100 V, +/- 5%, C0G/NP0, 0603	0603	GRM1885C2A100JA01D	Murata		
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A		
	Notes:	Unless otherwise noted in the Alternate PartNumber and/or Alternate Manufacturer columns, all parts may be substituted with equivalents.						

6.3 Reference

1. *TPS564201 4.5 V to 17 V Input, 4-A Synchronous Step-Down Voltage Regulator in SOT-23* data sheet (SLVSDJ7)

7 Revision History

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

Changes from Revision * (May 2016) to Revision A (June 2021)	Page
• Updated user's guide title	2
• Updated the numbering format for tables, figures, and cross-references throughout the document.	2

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