

# 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.

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## 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   | $V_{IN} = 12\text{ V}$ , $I_{OUT} = 4\text{ A}$             |     | 560  |     | kHz              |
|                | Output current range  |   | 0   |      | 4   | A                |
|                | Overcurrent limit     | $V_{IN} = 12\text{ V}$ , $L_{OUT} = 2.2\text{ }\mu\text{H}$ |     | 6    |     | A                |
|                | Output ripple voltage | $V_{IN} = 12\text{ V}$ , $I_{OUT} = 4\text{ A}$             |     | 20   |     | mV <sub>PP</sub> |

### 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](#).

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

[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<br>(V) | R1<br>(kΩ) | R2<br>(kΩ) | L1<br>(μH) |     |     | C5 + C6 +C7<br>(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  $V_{IN}$  (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.

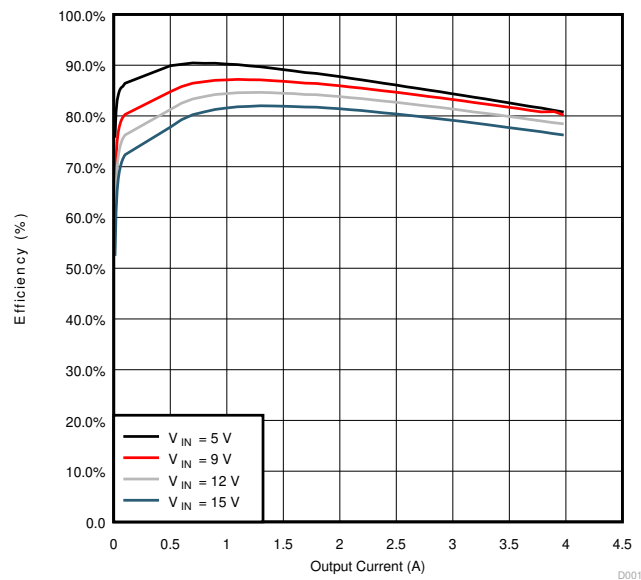
**Figure 4-1. Efficiency**

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

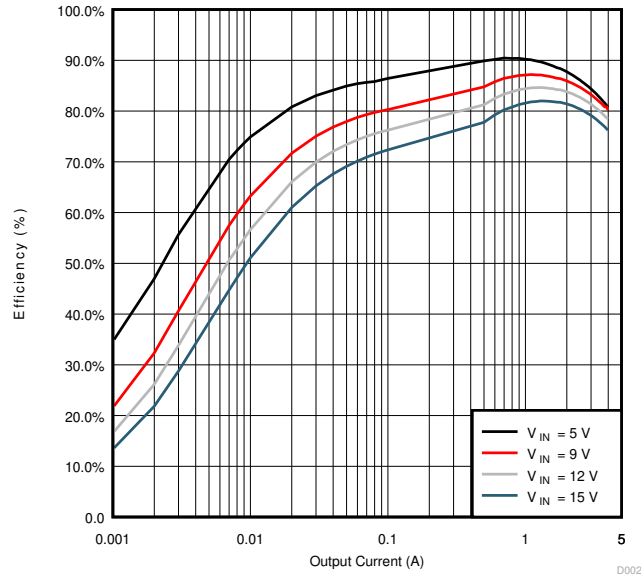


Figure 4-2. Light Load Efficiency

#### 4.4 Load Regulation

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

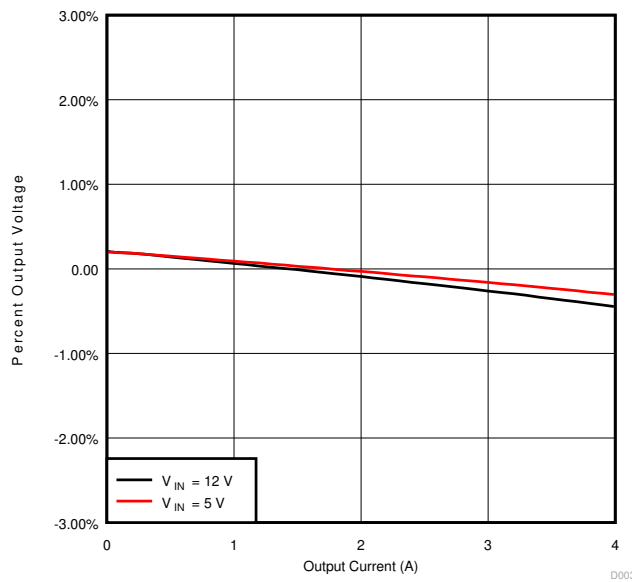


Figure 4-3. Load Regulation

### 4.5 Line Regulation

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

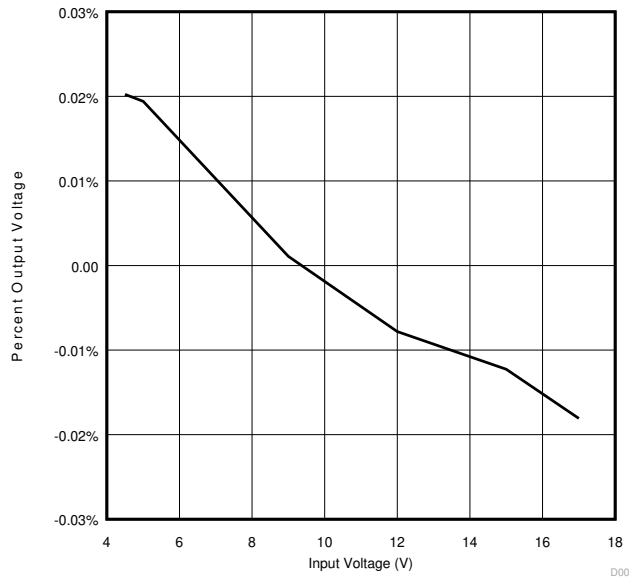


Figure 4-4. Line Regulation

### 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.

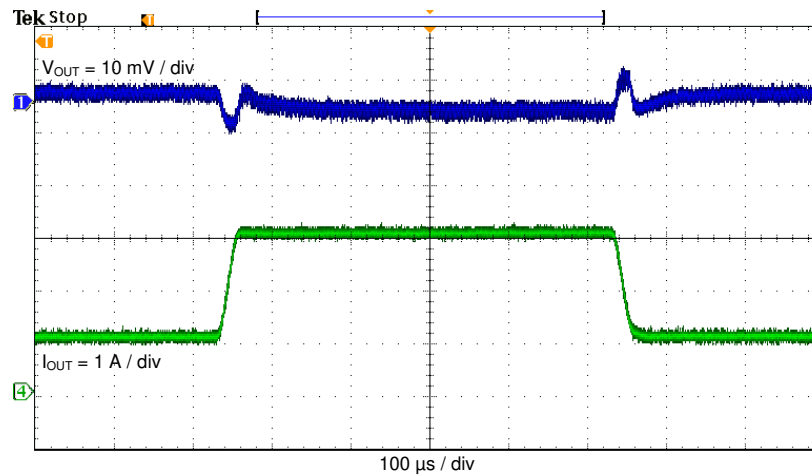
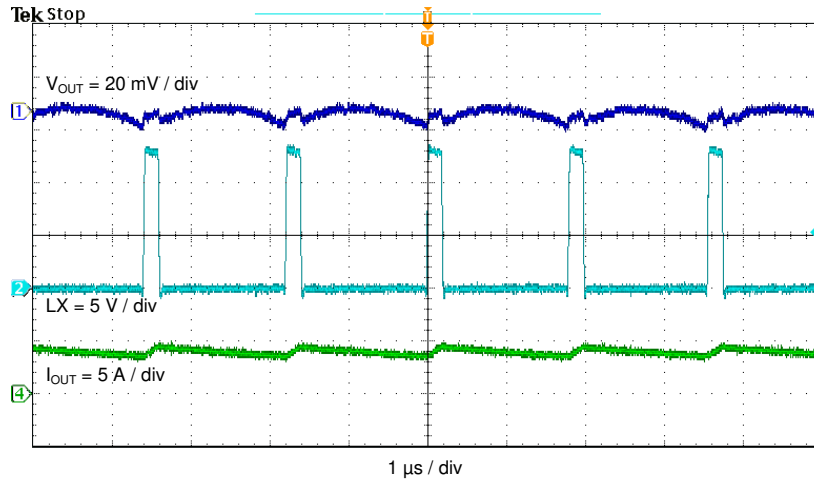


Figure 4-5. Load Transient Response, 1 A to 3 A

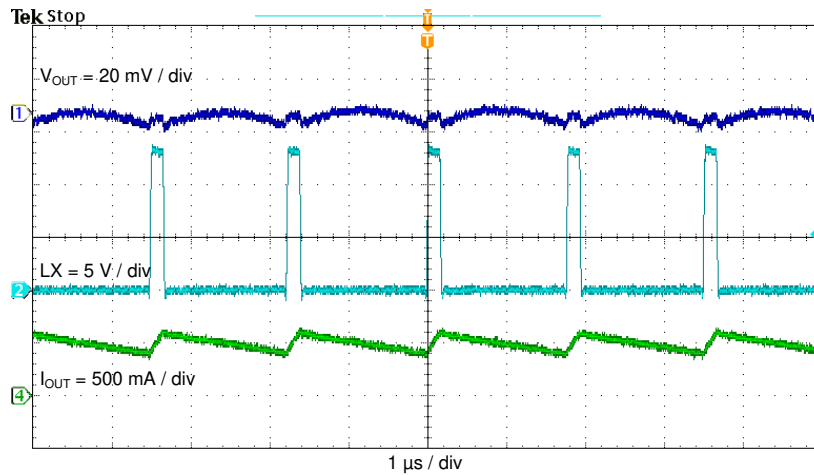


## 4.7 Output Voltage Ripple

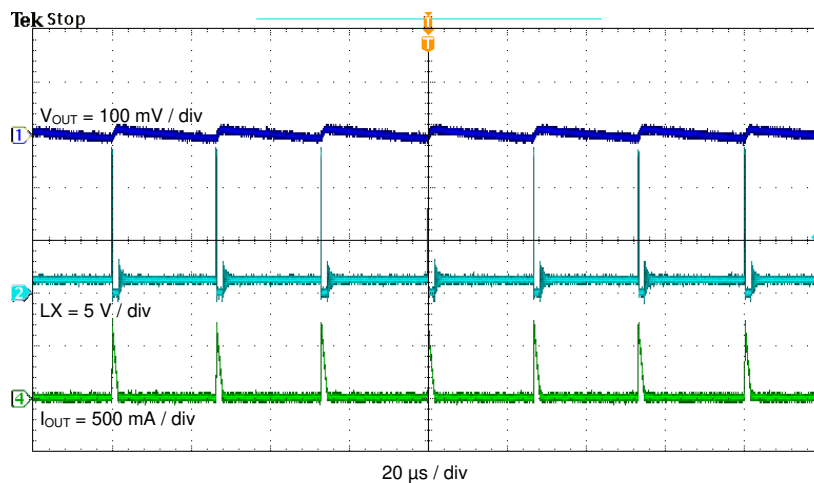
The TPS564201EVM-801 output voltage ripple is shown in [Figure 4-6](#), [Figure 4-7](#), and [Figure 4-8](#). The output currents are as indicated.



**Figure 4-6. Output Voltage Ripple,  $I_{OUT} = 4 \text{ A}$**



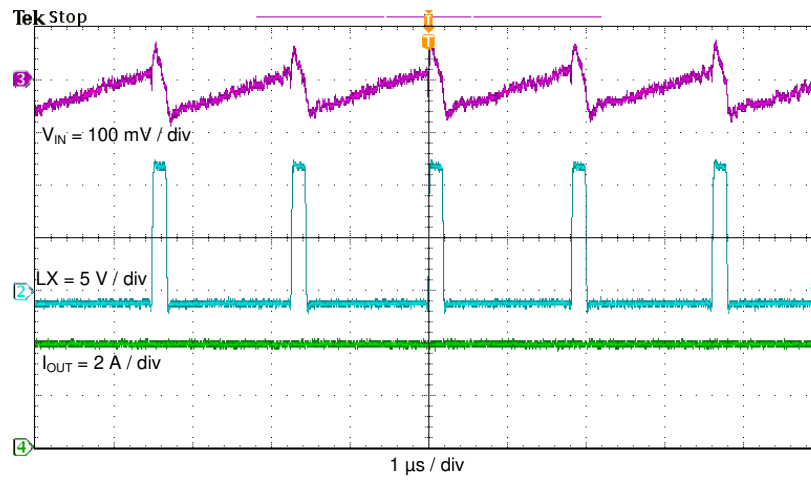
**Figure 4-7. Output Voltage Ripple,  $I_{OUT} = 2 \text{ A}$**



**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  $\Omega$  resistive.

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

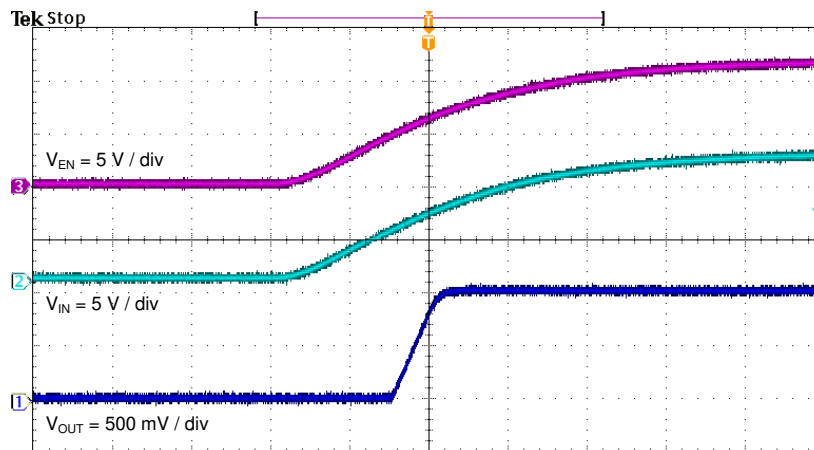


Figure 4-10. Start-Up Relative to  $V_{IN}$

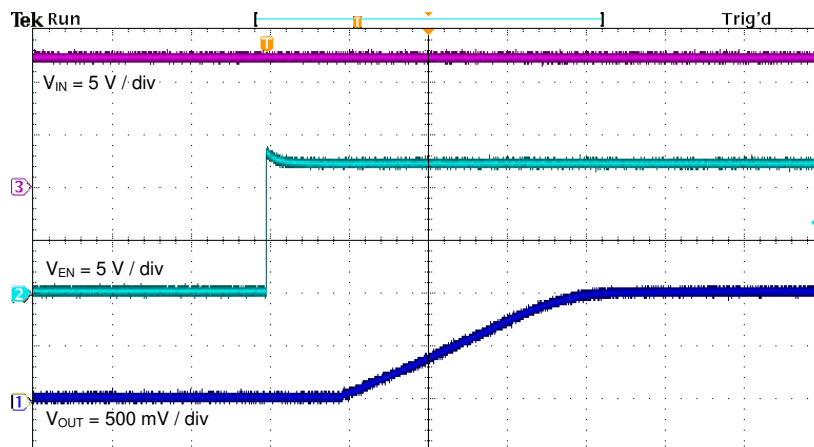


Figure 4-11. Start-Up Relative to EN

## 4.10 Shut-Down

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

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

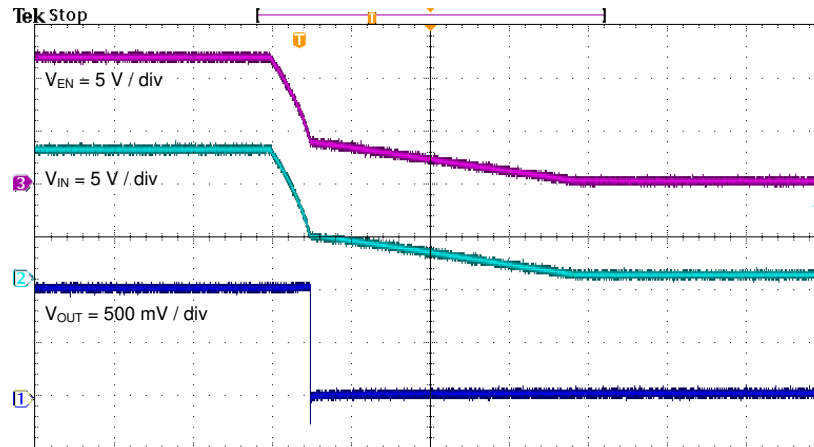


Figure 4-12. Shut-Down Relative to  $V_{IN}$

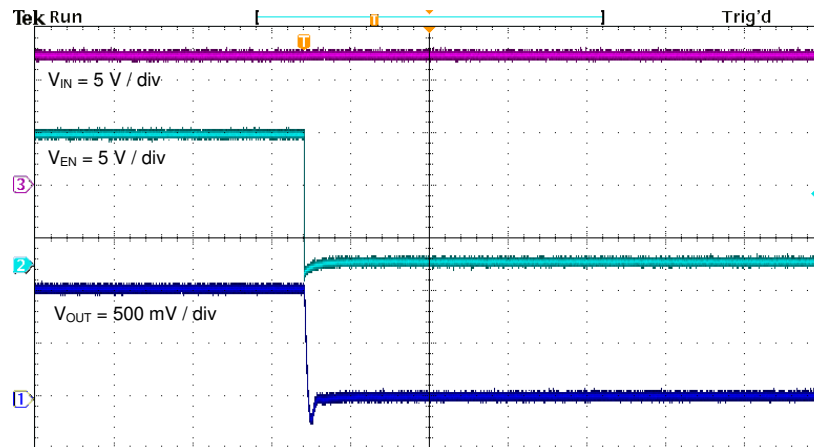


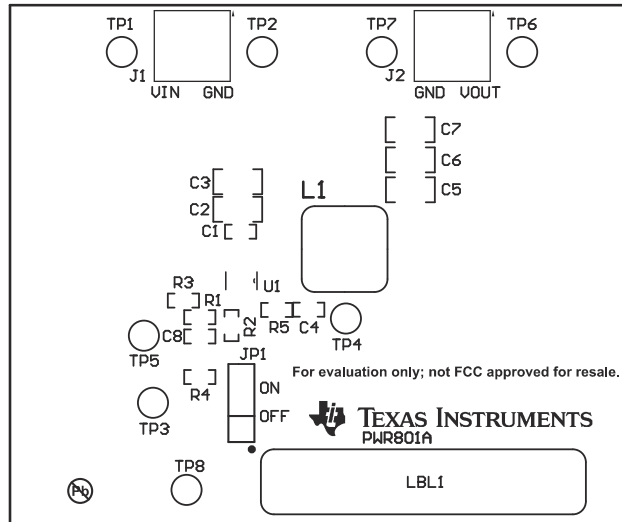
Figure 4-13. Shut-Down Relative to EN

## 5 Board Layout

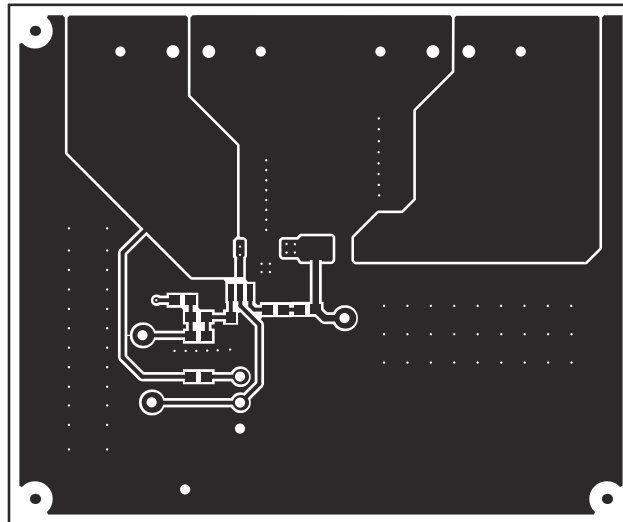
This section provides a description of the TPS564201EVM-801, board layout, and layer illustrations.

### 5.1 Layout

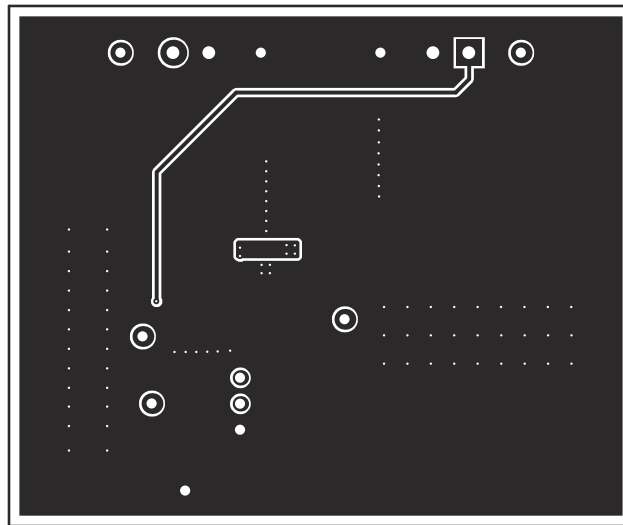
The board layout for the TPS564201EVM-801 is shown in [Figure 5-1](#), [Figure 5-2](#) and [Figure 5-3](#). The top layer contains the main power traces for VIN, VOUT, and ground. Also on the top layer are connections for the pins of the TPS564201 and a large area filled with ground. Most of the signal 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**

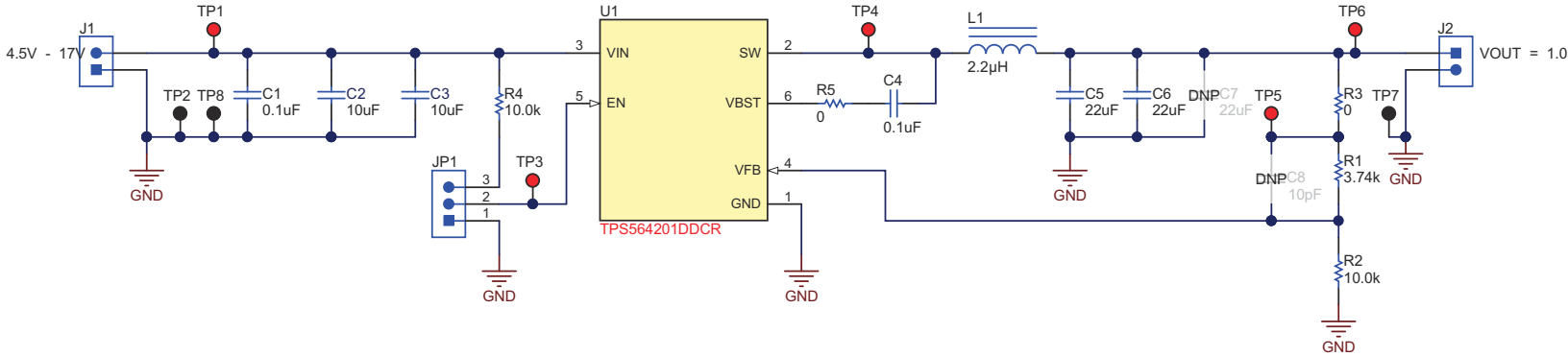


**Figure 5-3. Bottom Layer**

## 6 Schematic, Bill of Materials, and Reference

### 6.1 Schematic

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



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**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 uH, 9 A, 0.0115 ohm, SMD     | WE-HC4                     | 744311220          | Würth 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%, COG/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.

| <b>Changes from Revision * (May 2016) to Revision A (June 2021)</b>                                    | <b>Page</b>       |
|--|-------------------|
| • Updated user's guide title.....  | <a href="#">2</a> |
| • Updated the numbering format for tables, figures, and cross-references throughout the document. .... | <a href="#">2</a> |

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