

# TPS563200 Step-Down Converter Evaluation Module User's Guide



## ABSTRACT

This user's guide contains information for the TPS563200 as well as support documentation for the TPS563200EVM-652 evaluation module. Included are the performance specifications, schematic, and the bill of materials of the TPS563200EVM-652.

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## 1 Introduction

The TPS563200 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 650 kHz and enters Advanced Eco-mode in light load conditions. The high-side and low-side switching MOSFETs are incorporated inside the TPS563200 package along with the gate-drive circuitry. The low drain-to-source on resistance of the MOSFETs allows the TPS563200 to achieve high efficiencies and helps keep the junction temperature low at high output currents. The TPS563200 dc/dc synchronous converter is designed to provide up to a 3-A output from an input voltage source of 4.5 V to 17 V. The output voltage range is from 0.8 V to 6.5 V. Rated input voltage and output current ranges for the evaluation module are given in [Table 1-1](#).

The TPS563200EVM-652 evaluation module (EVM) is a single, synchronous buck converter providing 1.05 V at 3 A from 4.5-V to 17-V input. This user's guide describes the TPS563200EVM-652 performance.

**Table 1-1. Input Voltage and Output Current Summary**

| EVM              | Input Voltage Range                       | Output Current Range |
|------------------|---|----------------------|
| TPS563200EVM-652 | $V_{IN} = 4.5 \text{ V to } 17 \text{ V}$ | 0 A to 3 A           |

## 2 Performance Specification Summary

A summary of the TPS563200EVM-652 performance specifications is provided in [Table 2-1](#). Specifications are given for an input voltage of  $V_{IN} = 12\text{ V}$  and an output voltage of  $1.05\text{ V}$ , unless otherwise noted. The ambient temperature is  $25^{\circ}\text{C}$  for all measurement, unless otherwise noted.

**Table 2-1. TPS563200EVM-652 Performance Specifications Summary**

| Specifications                   |                       | Test Conditions                                      | Min | Typ  | Max | Unit             |
|----------------------------------|-----------------------|--|-----|------|-----|------------------|
| Input voltage range ( $V_{IN}$ ) |                       |  | 4.5 | 12   | 17  | V                |
| CH1                              | Output voltage        |  |     | 1.05 |     | V                |
|                                  | Operating frequency   | $V_{IN} = 12\text{ V}, I_O = 3\text{ A}$             |     | 650  |     | kHz              |
|                                  | Output current range  |  | 0   |      | 3   | A                |
|                                  | Over current limit    | $V_{IN} = 12\text{ V}, L_O = 1.5\text{ }\mu\text{H}$ |     |      |     | A                |
|                                  | Output ripple voltage | $V_{IN} = 12\text{ V}, I_O = 3\text{ A}$             |     | 20   |     | mV <sub>PP</sub> |

### 3 Modifications

These evaluation modules are designed to provide access to the features of the TPS563200. 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 0.765 V. The value of R1 for a specific output voltage can be calculated using [Equation 1](#).

$$R1 = \frac{R2 \times (V_{OUT} - 0.765 \text{ V})}{0.765 \text{ V}} \quad (1)$$

[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. 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        | 3.3 | 4.7 | 20 - 68              |
| 3.3                   | 33.2       | 10.0       | 2.2        | 3.3 | 4.7 | 20 - 68              |
| 5.0                   | 54.9       | 10.0       | 3.3        | 4.7 | 4.7 | 20 - 68              |
| 6.5                   | 75.0       | 10.0       | 3.3        | 4.7 | 4.7 | 20 - 68              |

## 4 Test Setup and Results

This section describes how to properly connect, set up, and use the TPS563200EVM-652. 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 TPS563200EVM-652 is provided with input/output connectors and test points as shown in [Table 4-1](#). A power supply capable of supplying 3 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 3 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 <a href="#">Table 1-1</a> for $V_{IN}$ range)             |
| J2                   | $V_{OUT}$ , 1.05 V at 3-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  |

### 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  $V_{IN}$  voltage to VI (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 TPS563200EVM-652 at an ambient temperature of 25°C.

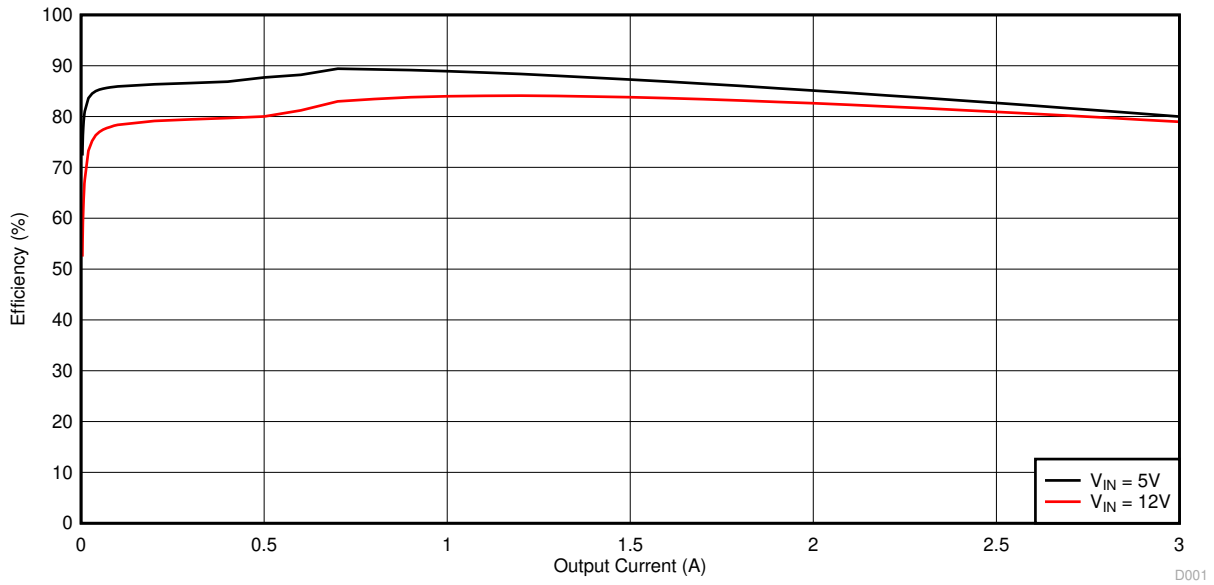


Figure 4-1. TPS563200EVM-652 Efficiency

Figure 4-2 shows the efficiency at light loads for the TPS563200EVM-652 at an ambient temperature of 25°C.

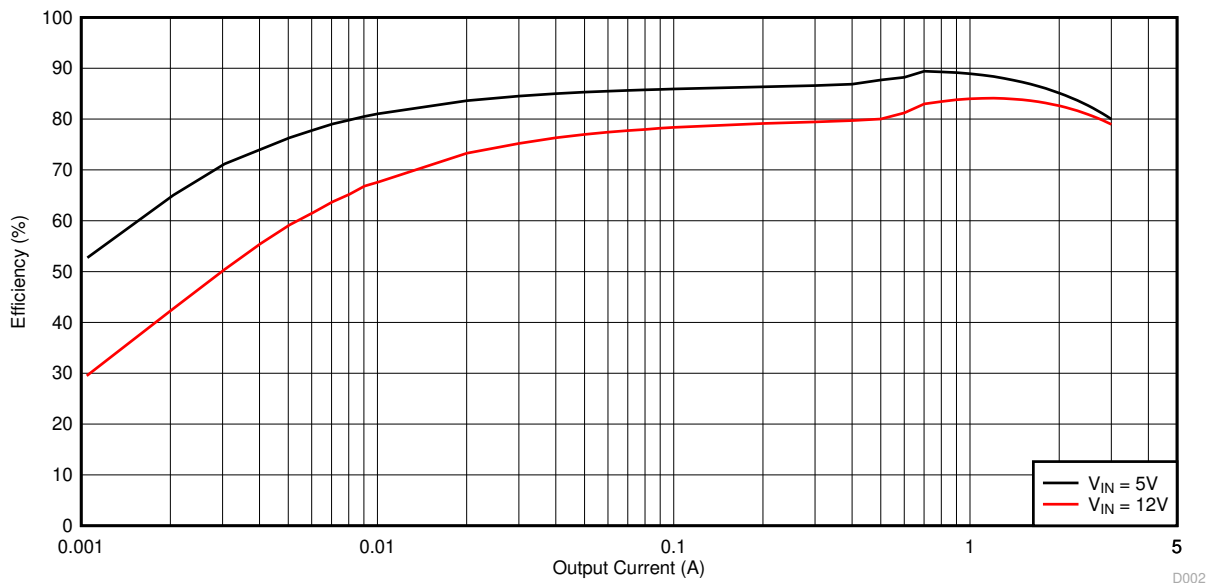


Figure 4-2. TPS563200EVM-652 Light Load Efficiency

### 4.4 Load Regulation

The load regulation for the TPS563200EVM-652 is shown in Figure 4-3 and Figure 4-4.

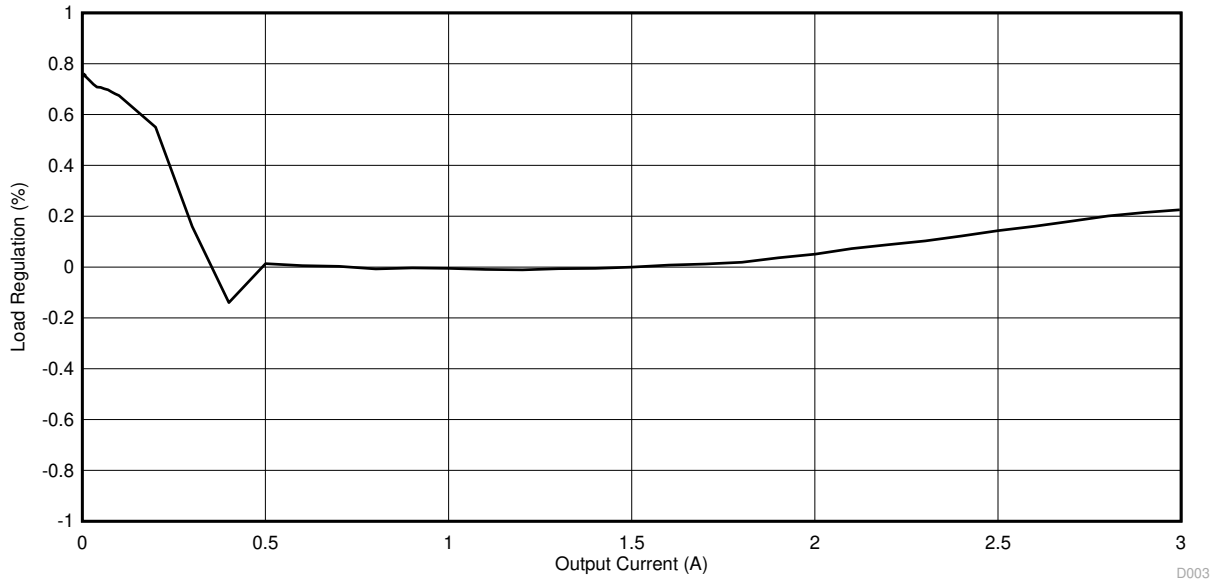


Figure 4-3. TPS563200EVM-652 Load Regulation, 5 V Input

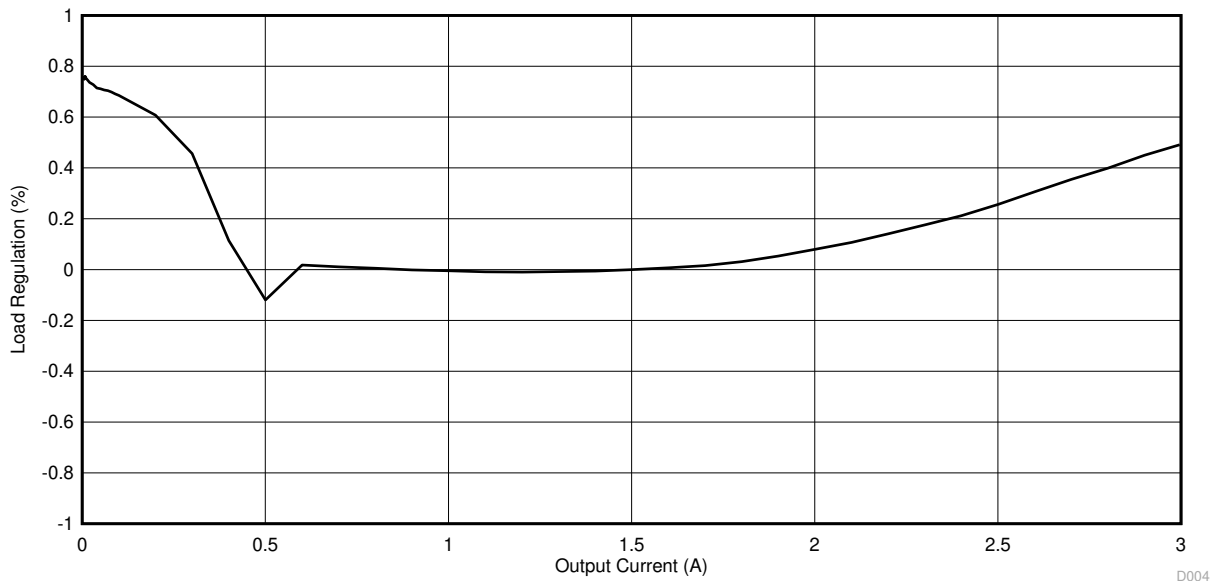


Figure 4-4. TPS563200EVM-652 Load Regulation, 12 V Input



### 4.5 Line Regulation

The line regulation for the TPS563200EVM-652 is shown in [Figure 4-5](#).

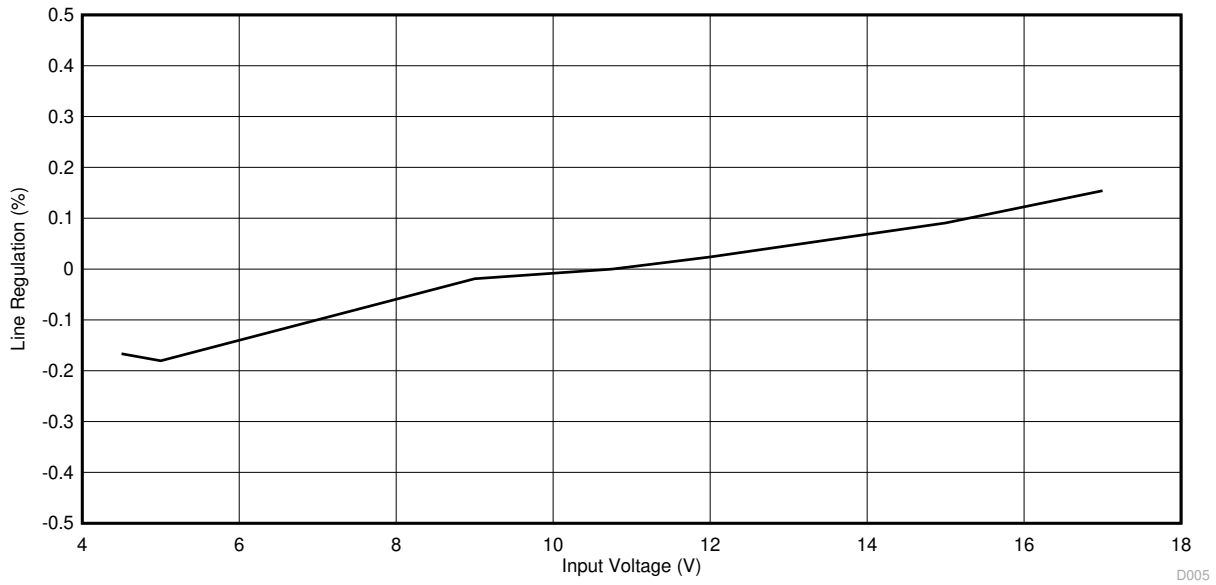


Figure 4-5. TPS563200EVM-652 Line Regulation

### 4.6 Load Transient Response

The TPS563200EVM-652 response to load transient is shown in [Figure 4-6](#). The current steps and slew rates are indicated in the figures. Total peak-to-peak voltage variation is as shown.

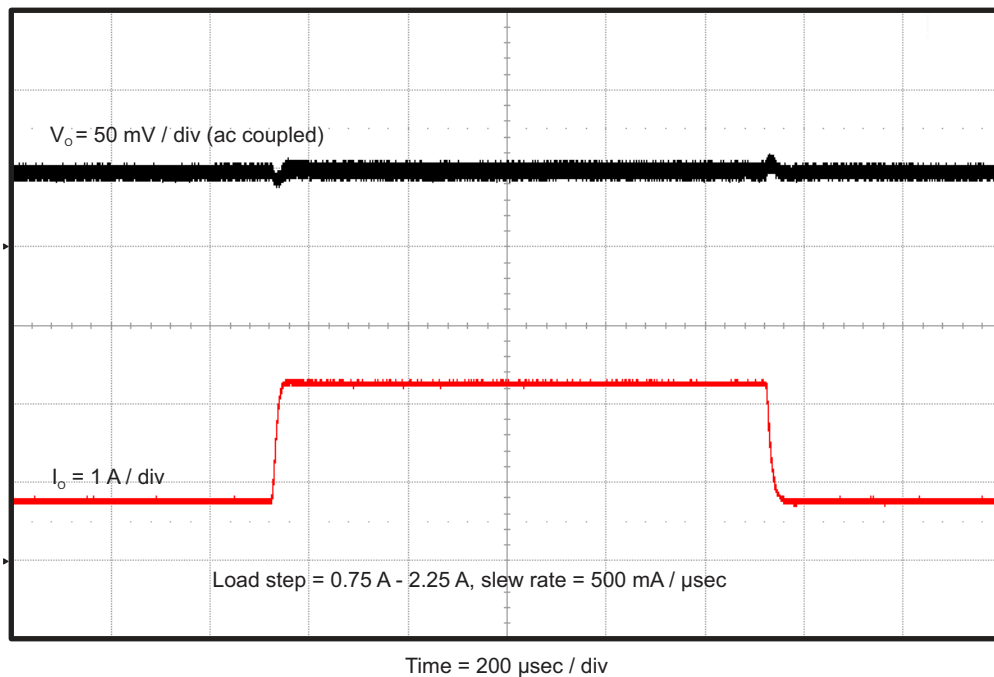
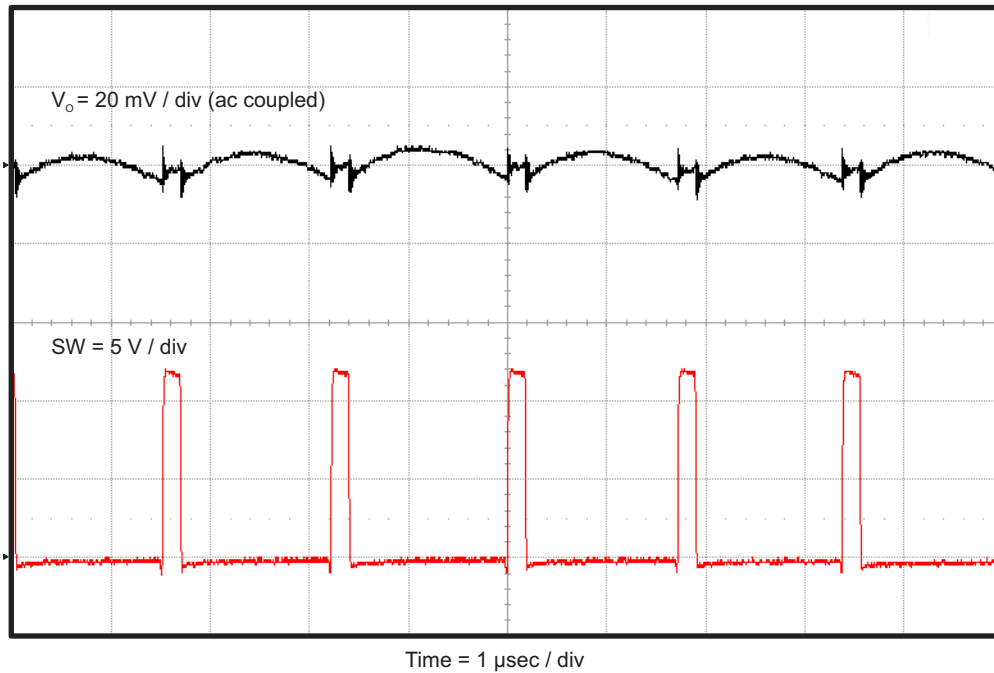


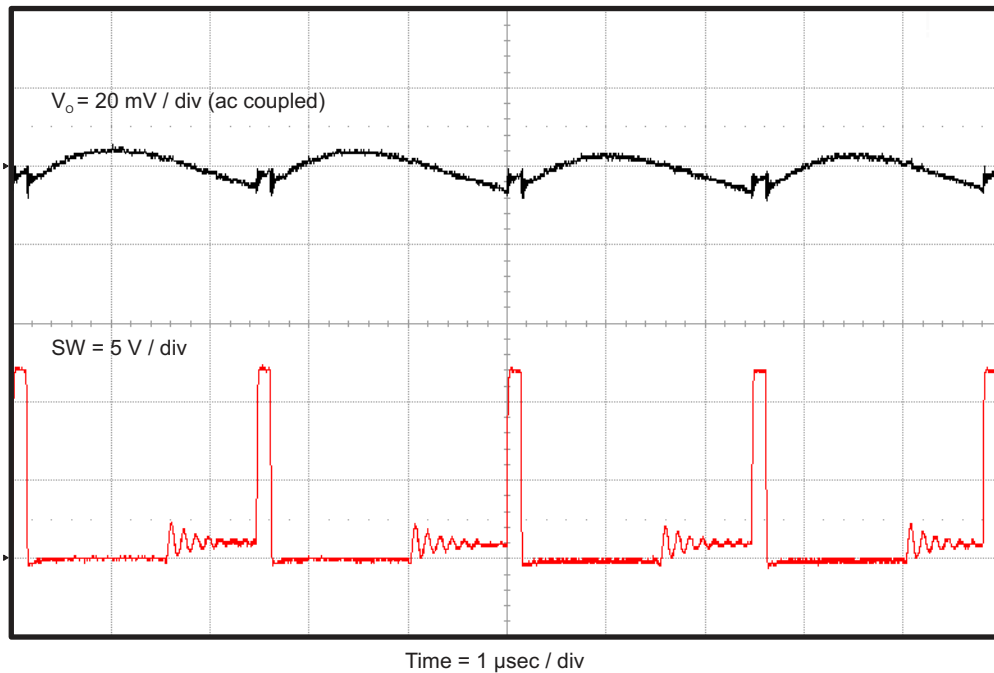
Figure 4-6. TPS563200EVM-652 Load Transient Response, 25% to 75% Load Step

### 4.7 Output Voltage Ripple

The TPS563200EVM-652 output voltage ripple is shown in [Figure 4-7](#), [Figure 4-8](#), and [Figure 4-9](#). The output currents are as indicated.



**Figure 4-7. TPS563200EVM-652 Output Voltage Ripple,  $I_{OUT} = 3 \text{ A}$**



**Figure 4-8. TPS563200EVM-652 Output Voltage Ripple,  $I_{OUT} = 300 \text{ mA}$**

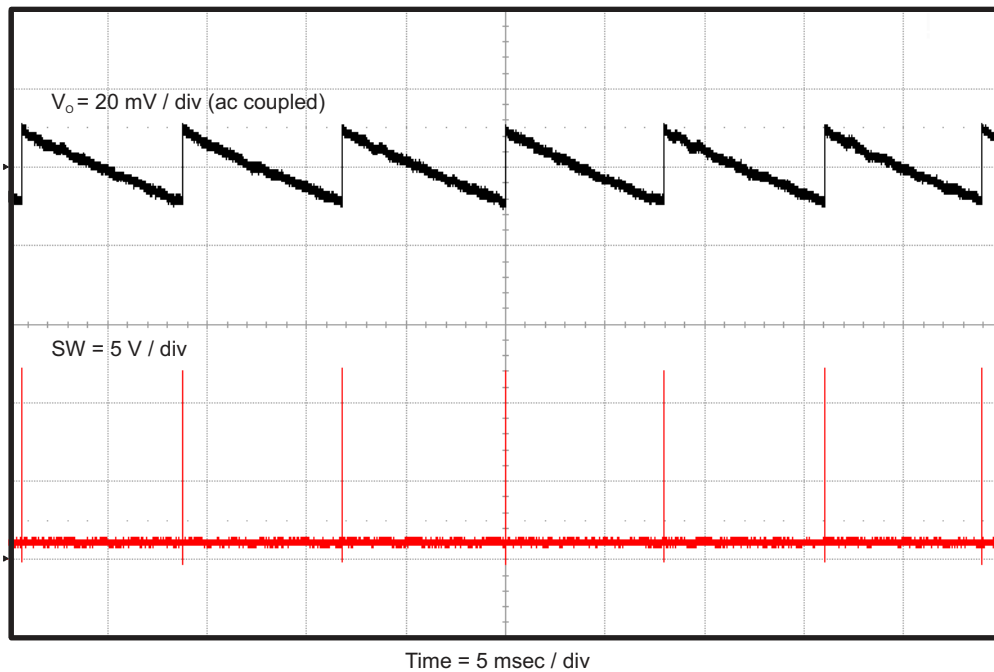


Figure 4-9. TPS563200EVM-652 Output Voltage Ripple,  $I_{OUT} = 0 \text{ mA}$

#### 4.8 Input Voltage Ripple

The TPS563200EVM-652 input voltage ripple is shown in [Figure 4-10](#). The output current is as indicated.

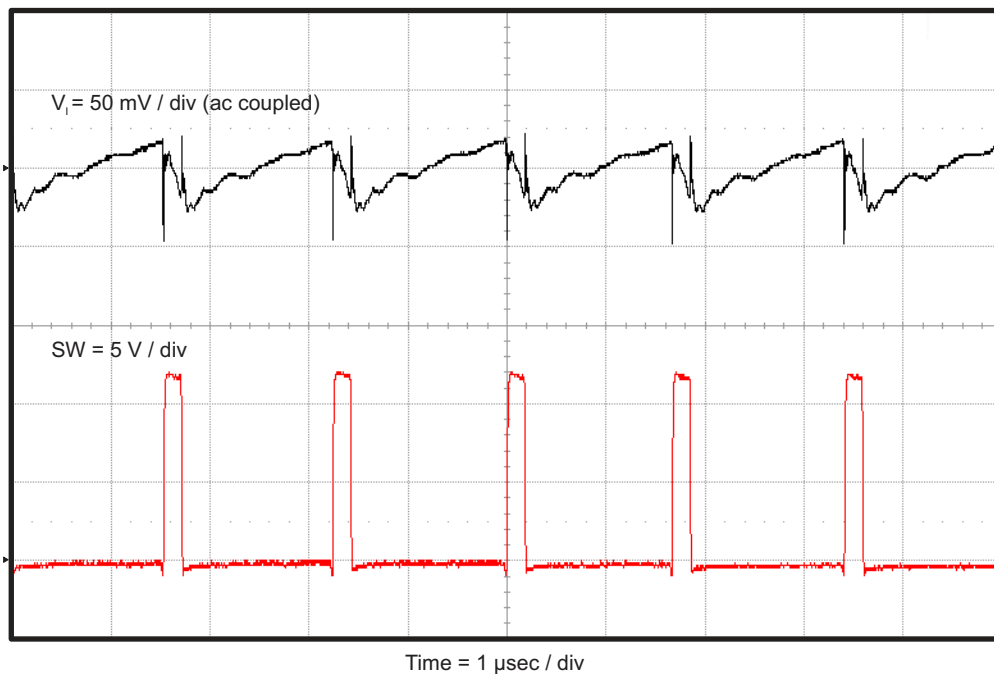


Figure 4-10. TPS563200EVM-652 Input Voltage Ripple,  $I_{OUT} = 3 \text{ A}$

### 4.9 Start-Up

The TPS563200EVM-652 start-up waveform relative to  $V_{IN}$  is shown in Figure 4-11. Load = 1  $\Omega$  resistive.

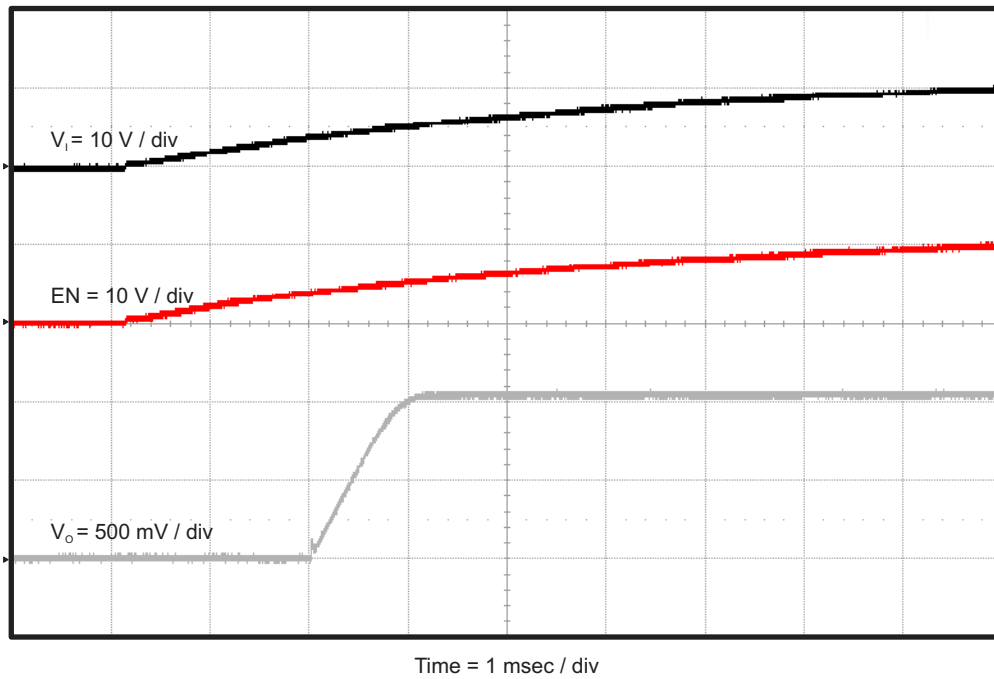


Figure 4-11. TPS563200EVM-652 Start-Up Relative to  $V_{IN}$

The TPS563200EVM-652 start-up waveform relative to enable (EN) is shown in Figure 4-12. Load = 1  $\Omega$  resistive.

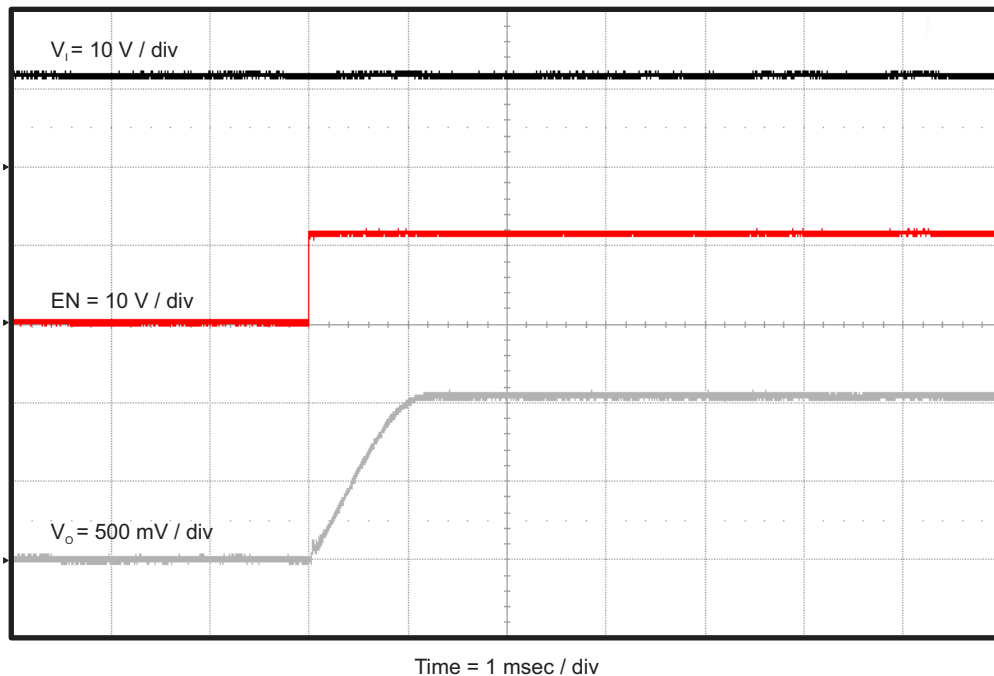
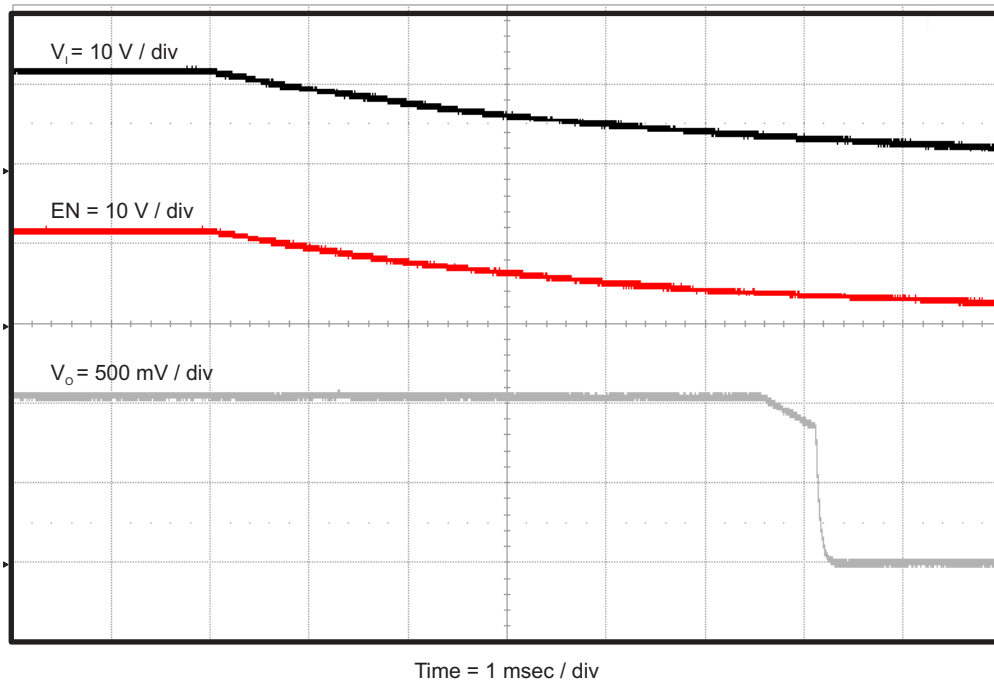


Figure 4-12. TPS563200EVM-652 Start-Up Relative to EN

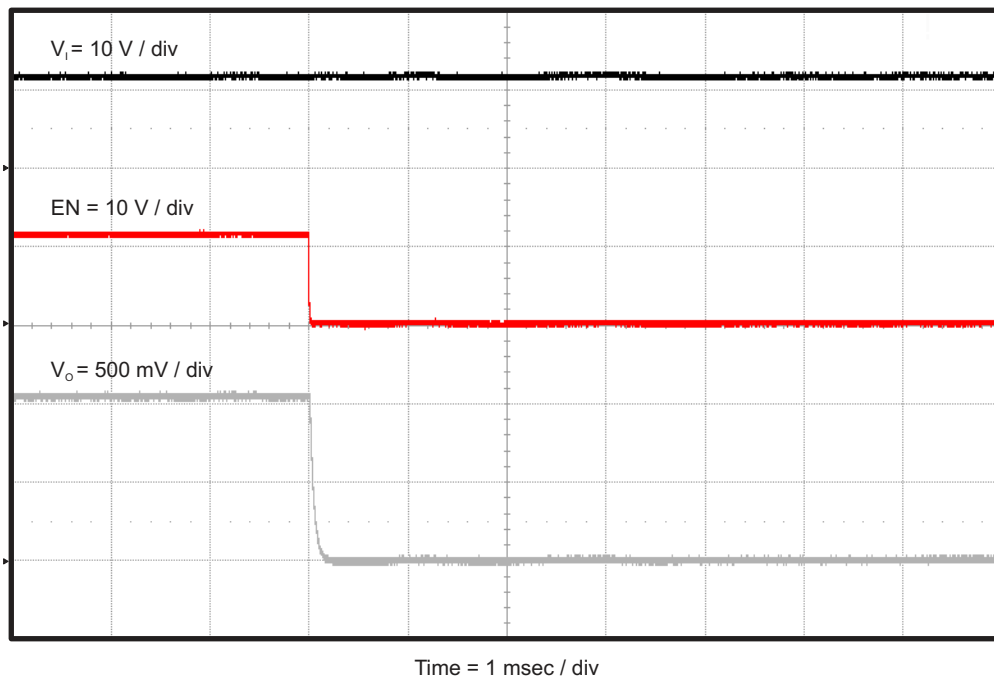
## 4.10 Shut-Down

The TPS563200EVM-652 shut-down waveform relative to  $V_{IN}$  is shown in [Figure 4-13](#). Load = 1  $\Omega$  resistive.



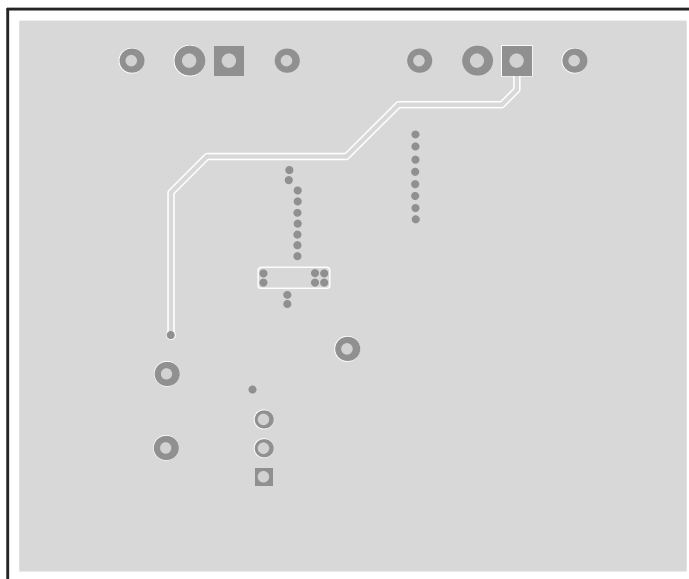
**Figure 4-13. TPS563200EVM-652 Shut-Down Relative to  $V_{IN}$**

The TPS563200EVM-652 shut-down waveform relative to EN is shown in [Figure 4-14](#). Load = 1  $\Omega$  resistive.



**Figure 4-14. TPS563200EVM-652 Shut-Down Relative to EN**



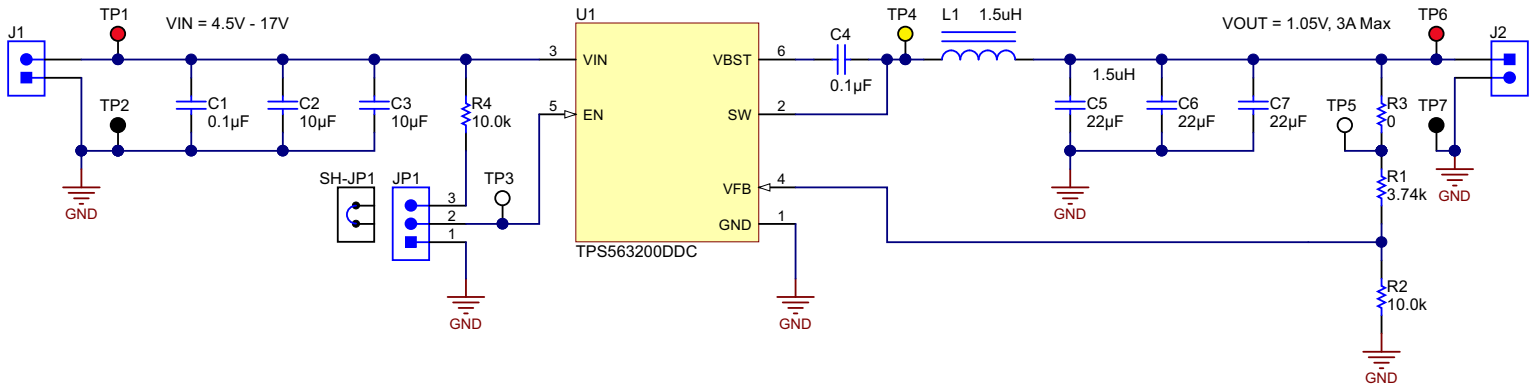


**Figure 5-3. Bottom Layer**

## 6 Schematic, Bill of Materials, and Reference

### 6.1 Schematic

Figure 6-1 is the schematic for the TPS563200EVM-652.



**Figure 6-1. TPS563200EVM-652 Schematic Diagram**



## 6.2 Bill of Materials

**Table 6-1. Bill of Materials**

| Designator | Quantity | Value  | Description   | Package Reference          | Part Number        | Manufacturer                |
|------------|----------|--------|---|----------------------------|--------------------|-----------------------------|
| !PCB1      | 1        |        | Printed Circuit Board   |                            | PWR652             | 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, 1210   | 1210                       | GRM32DR61E106KA12L | MuRata                      |
| C5, C6, C7 | 3        | 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        | 1.5uH  | Inductor, Shielded Drum Core, Superflux, 1.5uH, 11A, 0.0078 ohm, SMD                          | WE-HC4                     | 744311150          | Würth Elektronik eiSos      |
| 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         | 1        | 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                          |
| TP1, TP6   | 2        | Red    | Test Point, Miniature, Red, TH  | Red Miniature Testpoint    | 5000               | Keystone                    |
| TP2, TP7   | 2        | Black  | Test Point, Miniature, Black, TH  | Black Miniature Testpoint  | 5001               | Keystone                    |
| TP3, TP5   | 2        | White  | Test Point, Miniature, White, TH  | White Miniature Testpoint  | 5002               | Keystone                    |
| TP4        | 1        | Yellow | Test Point, Miniature, Yellow, TH   | Yellow Miniature Testpoint | 5004               | Keystone                    |
| U1         | 1        |        | TPS563200 4.5V to 17 V Input, 3-A Synchronous Step-Down Voltage Regulator in SOT-23, DDC0006A | DDC0006A                   | TPS563200DDC       | Texas Instruments           |

### 6.3 Reference

1. *TPS56320x 4.5 V to 17 V Input, 3-A Synchronous Step-Down Voltage Regulator in SOT-23 data sheet (SLVSCB0)*

### 7 Revision History

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

| <b>Changes from Revision * (August 2014) to Revision A (July 2021)</b>                                 | <b>Page</b> |
|--|-------------|
| • Updated the numbering format for tables, figures, and cross-references throughout the document. .... | 3           |
| • Updated user's guide title.....  | 3           |

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