EVM User's Guide: TPS564252BEVM TPS564255BEVM TPS564257BEVM

TPS56425xB Step-Down Converter Evaluation Module

Description

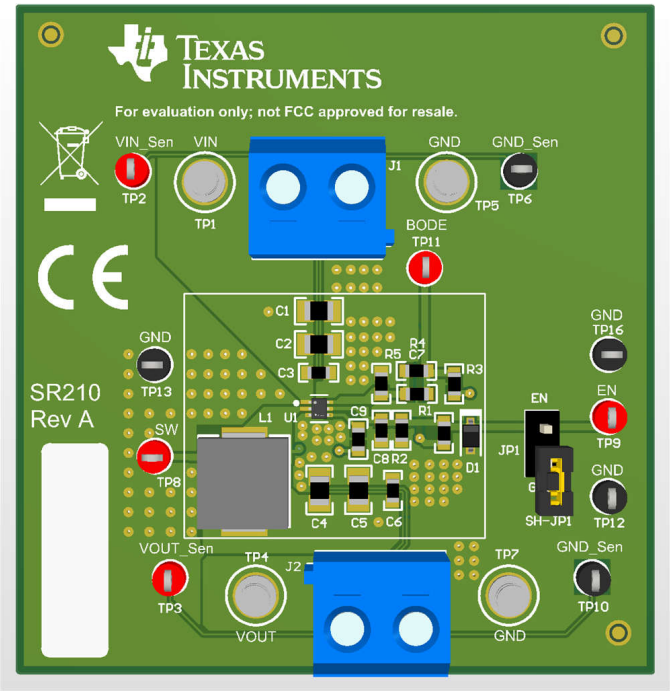
TPS56425xB evaluation module (EVM) is a simple, easy-to-use, fully assembled and tested evaluation module for the TPS56425xB 4A synchronous buck converter. The EVM operates from 3V to 17V input to deliver 1.05V output, with AC signal injection terminals for feedback loop measurements.

Features

- 3V to 17V input voltage range
- 0.6V to 10V output voltage range
- Up to 4A output current
- Eco-mode, FCCM mode, Out-of-Audio™ (OOA) mode
- Fast transient response

Applications

- WLAN/Wi-Fi access point, switch, router
- Pro-audio, surveillance, drone
- TV, STB and DVR, smart speaker
- Solid state drive (SSD)
- Electricity meter



TPS56425xBEVM Board (Top Side)

1 Evaluation Module Overview

1.1 Introduction

In light-load conditions, the TPS564252B operates in Eco-mode to enable higher efficiency by varying the switching frequency, the TPS564257B operates in FCCM to maintain constant switching frequency, and the TPS564255B operates in OOA mode to avoid audio noise. The main difference is at light loading, but the other behaviors are similar. This user's guide mainly introduces the TPS564252B and includes some TPS564257B and TPS564255B features that are different from the TPS564252B.

The TPS56425xB is a single, adaptive on-time, D-CAP3™ control mode, synchronous buck converter that requires a very low external component count. The D-CAP3 control mode 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 600kHz. The high-side and low-side switching MOSFETs are incorporated inside the TPS56425xB package along with the gate-drive circuitry. The low drain-to-source on resistance of the MOSFETs and fast switching slew rate allow the TPS56425xB to achieve high efficiency and help keep the junction temperature low at high output currents. Power sequencing is possible by correctly configuring the enable and power-good indicator. The TPS56425xB DC/DC synchronous converter is designed to support up to a 4A continuous current from an input voltage source of 3V to 17V. The output voltage range is from 0.6V to 10V. Table 1-1 gives the rated input voltage and output current ranges for the evaluation module.

Table 1-1. Input Voltage and Output Current Summary

EVM	INPUT VOLTAGE (V_{IN}) RANGE	OUTPUT CURRENT (I_{OUT}) RANGE
TPS564252BEVM	V_{IN} = 3V to 17V	0A to 4A
TPS564257BEVM		
TPS564255BEVM		

The TPS564252BEVM evaluation module (EVM) is a single, synchronous buck converter providing 1.05V at 4A from 3V to 17V input. This user’s guide describes the TPS564252BEVM performance.

This user's guide introduces the TPS564252BEVM, TPS564255BEVM, and TPS564257BEVM. These three devices differ in the light load behavior. The TPS564252B operates in Eco-mode, the TPS564255B operates in OOA mode, and the TPS564257B operates in FCCM mode. This user's guide contains information for the TPS564252B, TPS564255B, and TPS564257B as well as support documentation for the TPS564252BEVM, TPS564255BEVM, and TPS564257BEVM evaluation modules. This document also includes the performance specifications, board layout, schematic, and the list of materials of the TPS564252BEVM, TPS564255BEVM, and TPS564257BEVM.

1.2 Kit Contents

- One TPS56425xBEVM board
- EVM disclaimer Read Me

1.3 Specification

This EVM operates from 3V to 17V input, 12V nominal, and provides a 1.05V output at 4A. The EVM also includes AC signal injection terminals for feedback loop measurements. Specification, application information, and schematic are shown in Section 4.1 and Section 5.1.

1.4 Device Information

Synchronous buck converter TPS56425xB is used in the EVM to achieve the high-efficiency power delivery and voltage conversion. The TPS564252B operates in Eco-mode, which maintains high efficiency during light loading. The TPS564257B operates in FCCM mode, which keeps the same frequency and lower output ripple during all load conditions. The TPS564255B operates in OOA mode, which prevents audio noise generation.

Table 1-2. Device Information

PART NUMBER	MODE	PACKAGE
TPS564252B	ECO	DRL (SOT-563, 6)
TPS564255B	OOA	
TPS564257B	FCCM	

2 Performance Specification Summary

Table 2-1 provides a summary of the TPS564252BEVM performance specifications. Specifications are given for an input voltage of V_{IN} = 12V and an output voltage of 1.05V, unless otherwise noted. The ambient temperature is 25°C for all measurement, unless otherwise noted.

Table 2-1. Performance Specifications Summary

SPECIFICATIONS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Input voltage range		3	12	17	V
Output voltage set point			1.05		V
Operating frequency	V_{IN} = 12V, I_O = 2A		600		kHz
Output current range		0		4	A
Over current limit	V_{IN} = 12V, L_O = 1.5µH		5.6		A
Output ripple voltage	V_{IN} = 12V, I_O = 4A		11		mV_{PP}

3 Output Voltage Setpoint

The output voltage of the EVM can be selected by changing the value of resistor R_4 (R_{UPPER}) and R_5 (R_{LOWER}). Use Equation 1 to calculate the value of R_4 for a specific output voltage. The output voltage is set with a resistor divider from the output node to the FB pin. TI recommends using 1% tolerance or better divider resistors. Start with a 10kΩ or 30kΩ for R4 (R_{FBB}) and use Equation 1 to calculate R5 (R_{FBT}). To improve efficiency at light loads, consider using larger value resistors. If the values are too high, the regulator is more susceptible to noise and voltage errors from the FB input current are noticeable.

$$V_{OUT} = 0.6 \times \left(1 + \frac{R_4}{R_5}\right) \quad (1)$$

4 Hardware

4.1 Test Setup and Results

This section describes how to properly connect, set up, and use the TPS564252BEVM. The section also includes test results typical for the evaluation modules and the following:

- Efficiency
- Output load regulation
- Output line regulation
- Load transient response
- Start-up
- Shutdown
- Output voltage ripple

4.1.1 Input, Output Connections

The TPS564252BEVM is provided with input, output connectors, and test points as shown in Table 4-1. Figure 4-1 shows connectors and jumpers placement on TPS564252BEVM board.

A power supply capable of supplying 4A must be connected to J1 through a pair of 20AWG wires. The load must be connected to J2 through a pair of 20AWG wires. The maximum load current capability is 4A. Wire lengths must be minimized to reduce losses in the wires. Test point TP2 provides a place to monitor the V_{IN} input voltages with TP6 providing a convenient ground reference. TP3 is used to monitor the output voltage with TP10 as the ground reference.

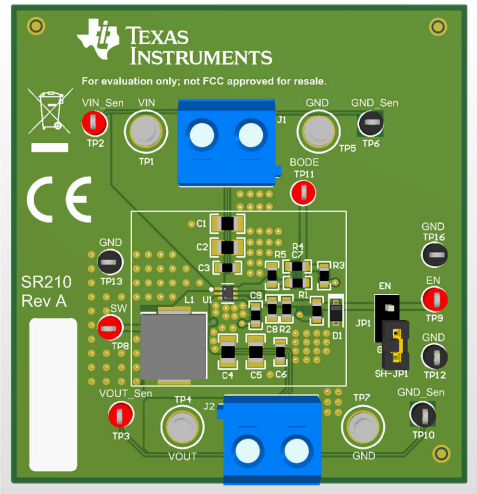


Figure 4-1. TPS564252BEVM Connectors and Jumpers Placement

Table 4-1. Connection and Test Points

REFERENCE DESIGNATOR	FUNCTION
J1	V_{IN} (see Table 1-1 for V_{IN} range)
J2	V_{OUT}, 1.05V at 4A maximum
JP1	EN control. Shunt EN to GND to disable
TP1	V_{IN} positive power point
TP2	V_{IN} positive monitor point
TP3	V_{OUT} positive monitor point
TP4	V_{OUT} positive power point
TP5, TP7	GND power point
TP6, TP10, TP12, TP13, TP16	GND monitor point
TP8	Switch node test point
TP9	EN test point
TP11	Test point for loop response measurements

4.1.2 Start-Up Procedure

1. Verify 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 J1 (Enable control) pin 2 and 1 (EN and GND) to enable the output.

4.1.3 Efficiency

Figure 4-2 shows the efficiency for the TPS564252BEVM at an ambient temperature of 25°C. Figure 4-3 shows the efficiency for the TPS564257BEVM at an ambient temperature of 25°C. Figure 4-4 shows the efficiency for the TPS564255BEVM at an ambient temperature of 25°C.

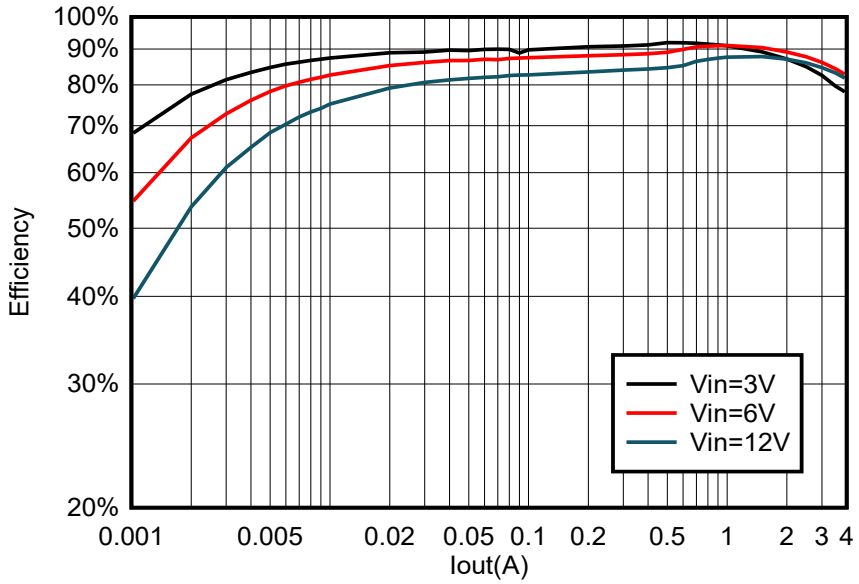


Figure 4-2. TPS564252BEVM Efficiency

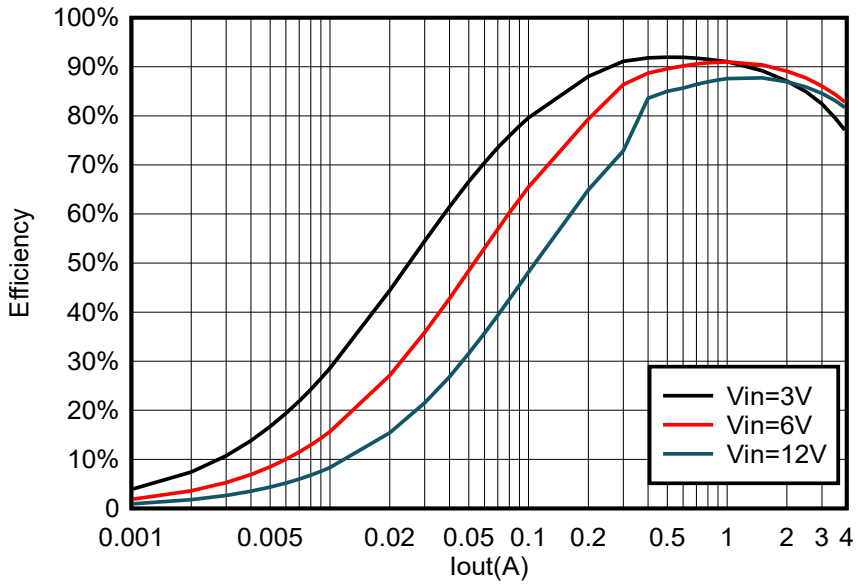


Figure 4-3. TPS564257BEVM Efficiency

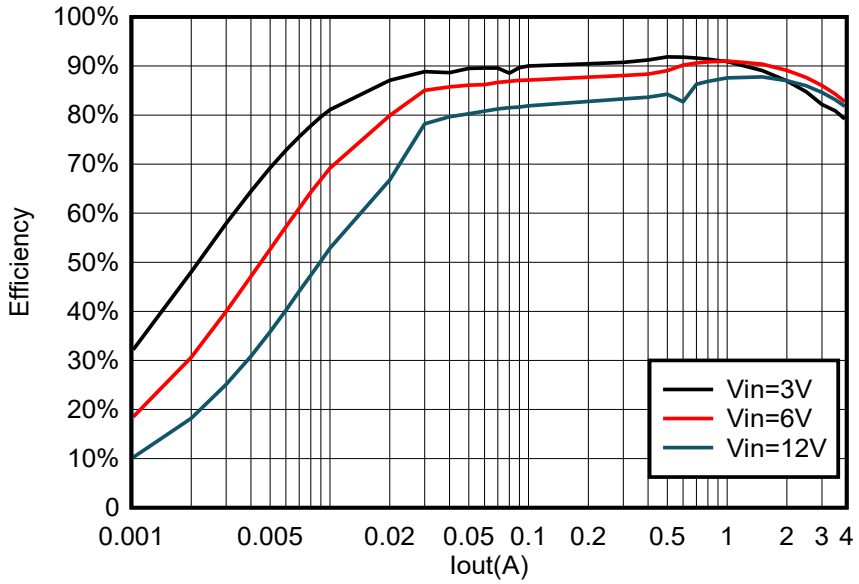


Figure 4-4. TPS564255BEVM Efficiency

4.1.4 Load Regulation

Figure 4-5 shows load regulation for the TPS564252BEVM. Figure 4-6 shows load regulation for the TPS564257BEVM. Figure 4-7 shows load regulation for the TPS564255BEVM.

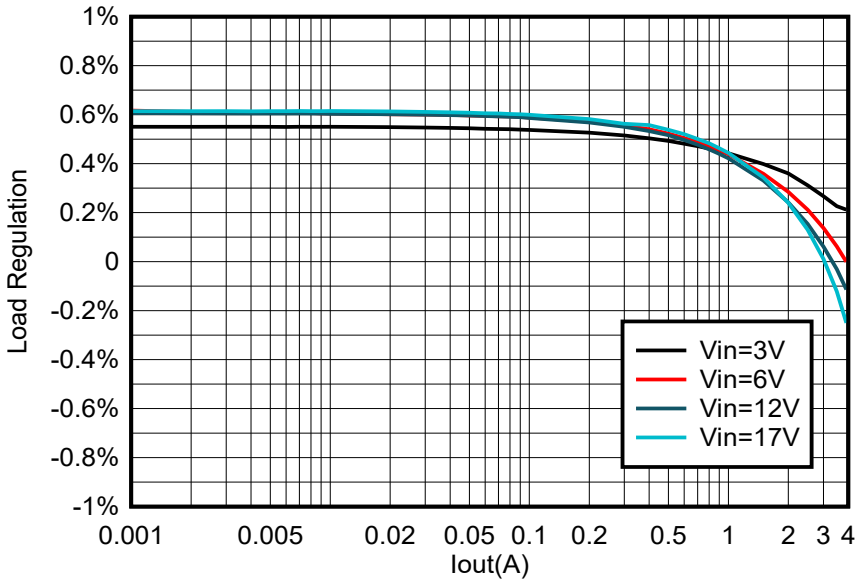


Figure 4-5. TPS564252BEVM Load Regulation

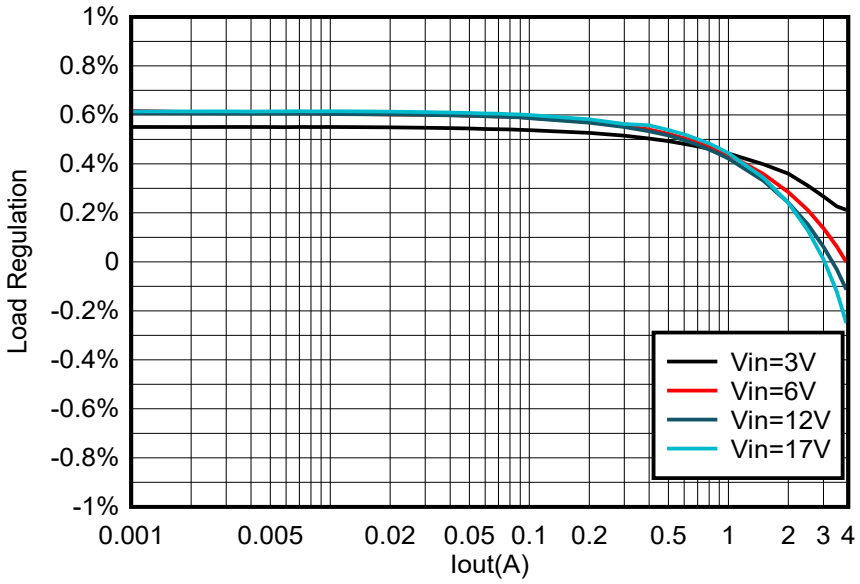


Figure 4-6. TPS564257BEVM Load Regulation

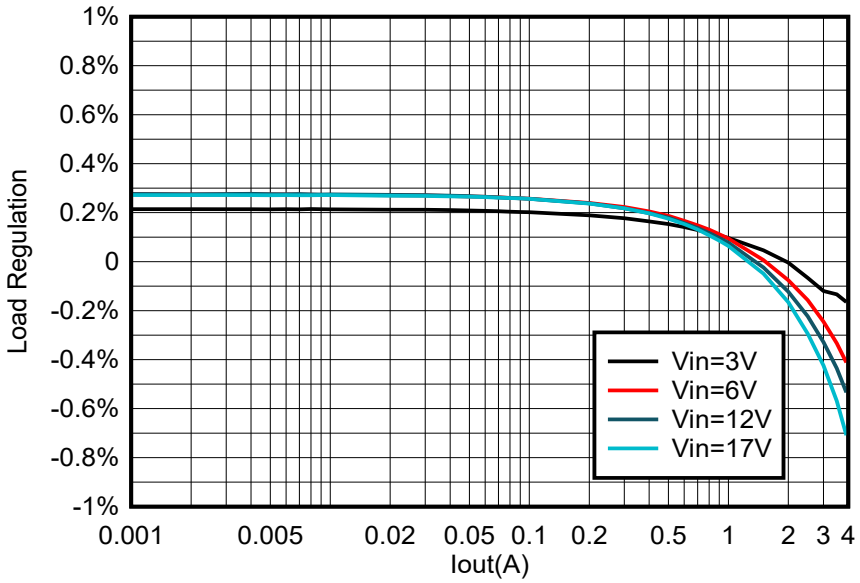


Figure 4-7. TPS564255BEVM Load Regulation

4.1.5 Line Regulation

Figure 4-8 shows line regulation for the TPS564252BEVM. Figure 4-9 shows line regulation for the TPS564257BEVM. Figure 4-10 shows line regulation for the TPS564255BEVM.

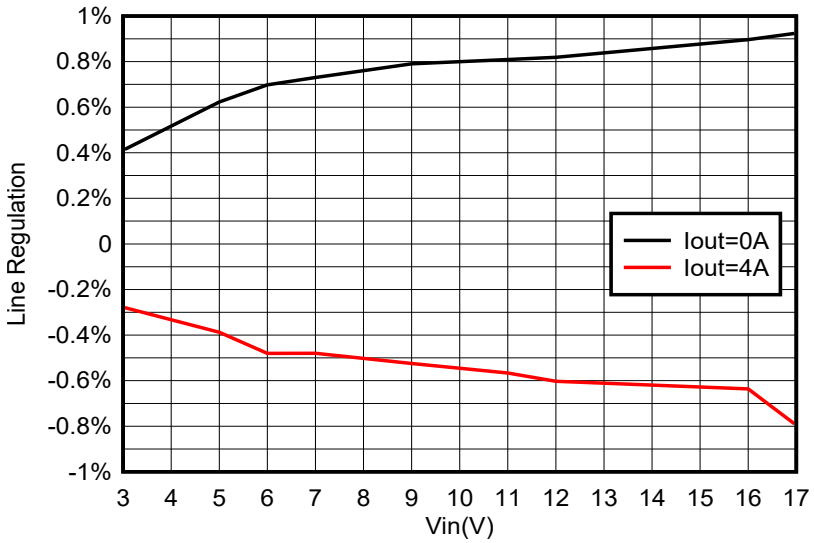


Figure 4-8. TPS564252BEVM Line Regulation

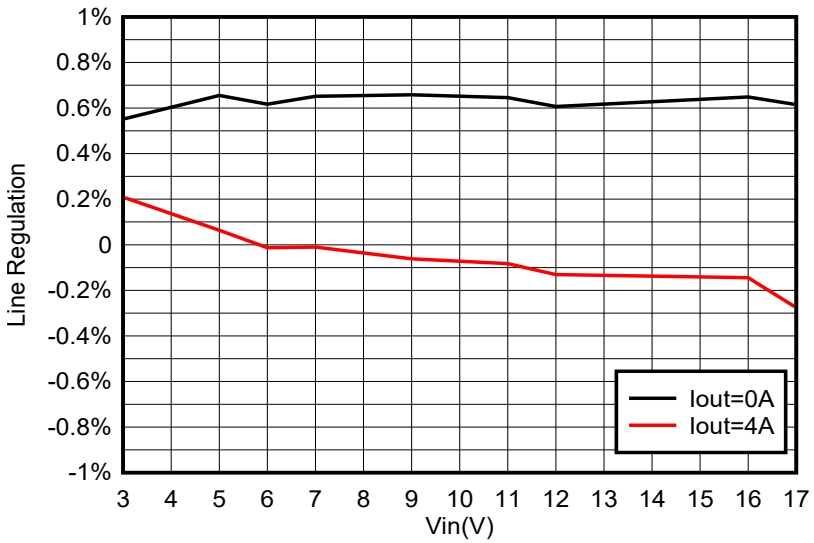


Figure 4-9. TPS564257BEVM Line Regulation

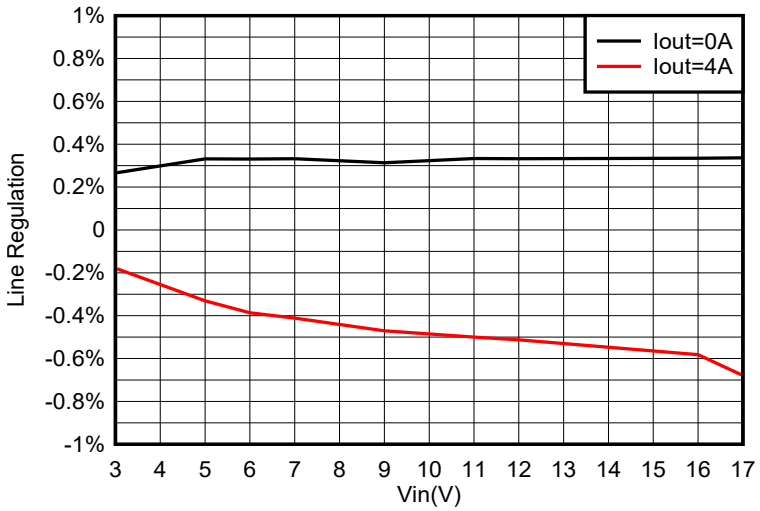


Figure 4-10. TPS564255BEVM Line Regulation

4.1.6 Load Transient Response

Figure 4-11 shows the response to load transient for TPS564252BEVM. Figure 4-12 shows the response to load transient for the TPS564257BEVM. Figure 4-13 shows the response to load transient for the TPS564255BEVM. The current steps slew rate is set as 2.5A/µs.

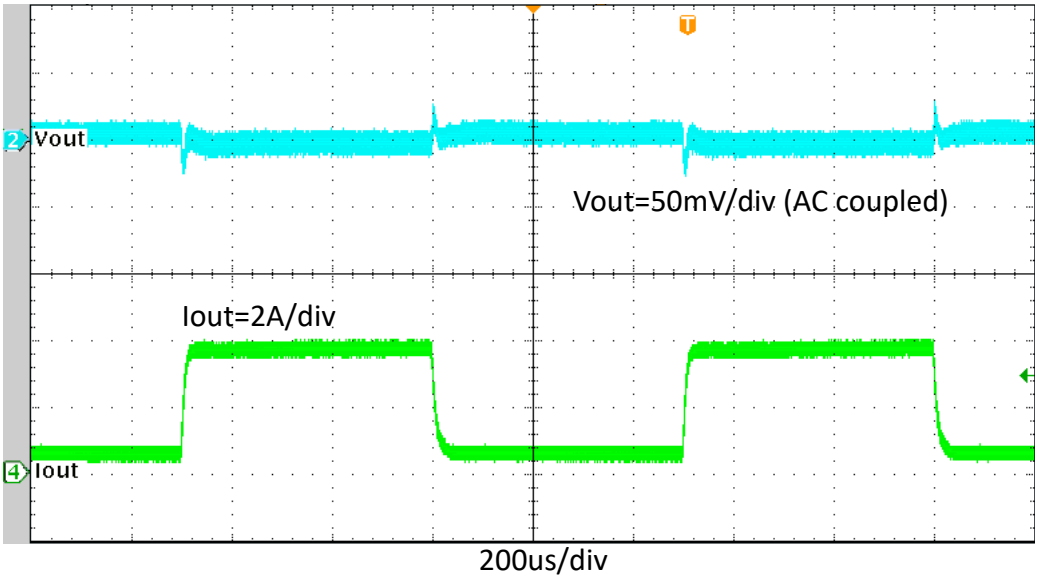


Figure 4-11. TPS564252BEVM Load Transient Response, 10% to 90% (0.4A to 3.6A) Load Step

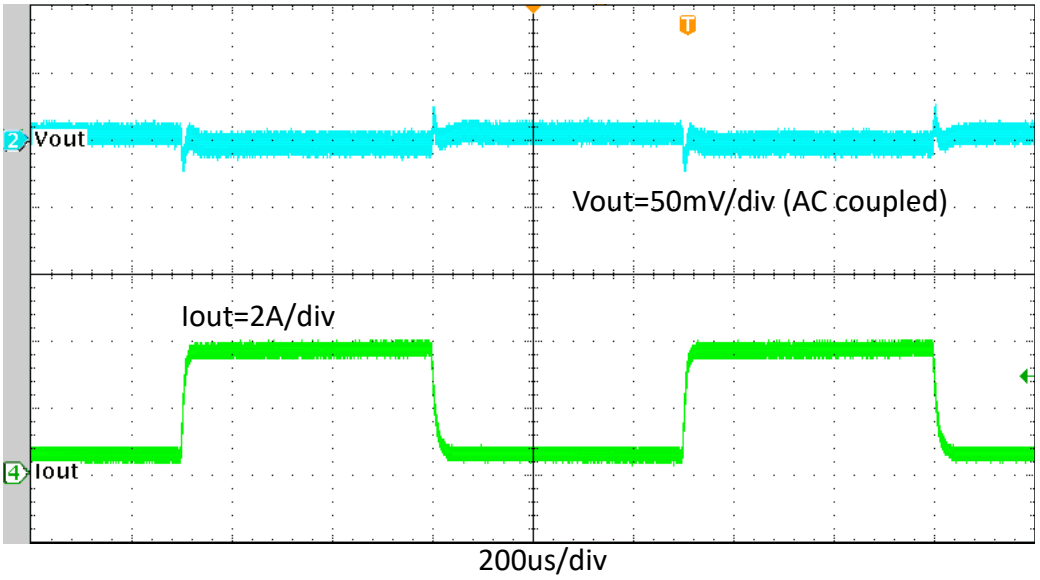


Figure 4-12. TPS564257BEVM Load Transient Response, 10% to 90% (0.3A to 3.6A) Load Step

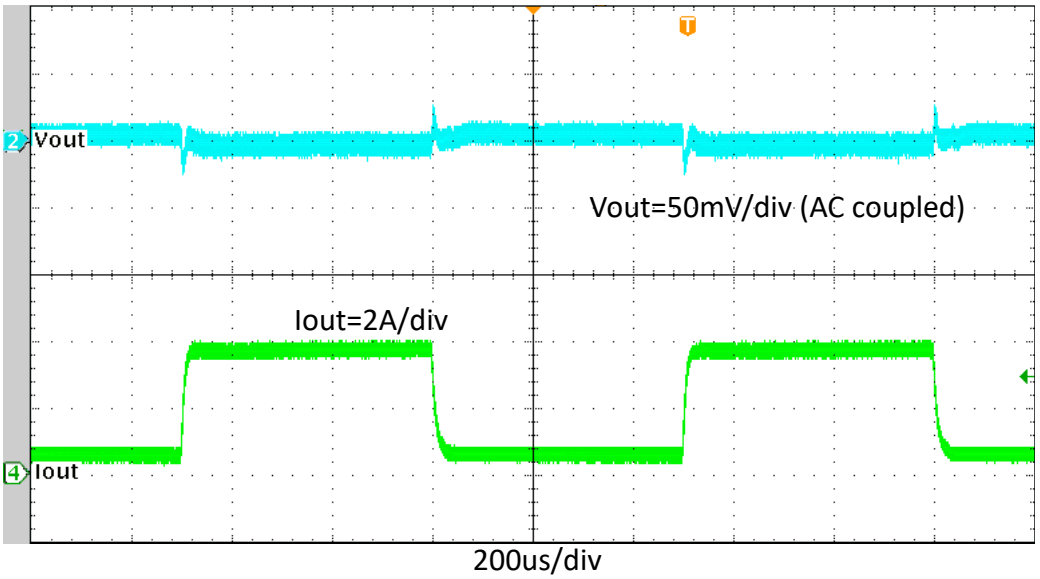


Figure 4-13. TPS564255BEVM Load Transient Response, 10% to 90% (0.3A to 3.6A) Load Step

4.1.7 Start-Up

Figure 4-14 shows the TPS564252BEVM start-up waveform relative to V_{IN}. The load is 4A.

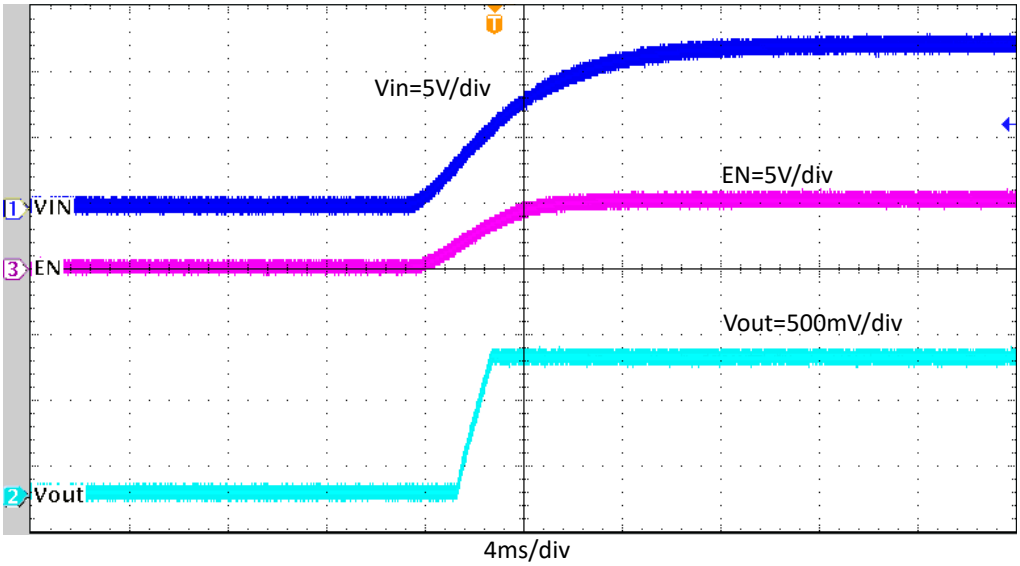


Figure 4-14. TPS564252BEVM Start-Up Relative to V_{IN}

Figure 4-15 shows the TPS564252BEVM start-up waveform relative to enable (EN). The load is 4A.

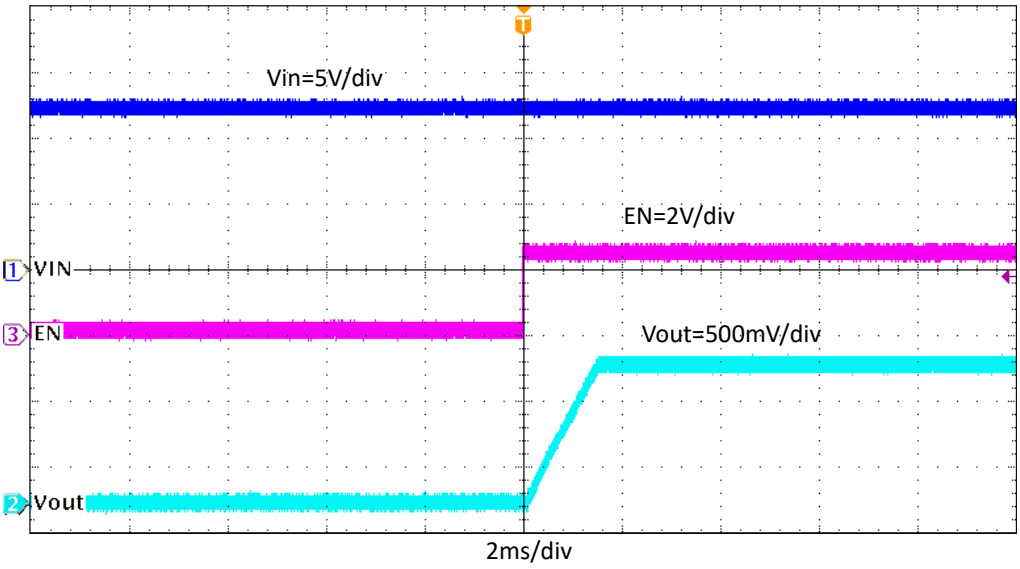


Figure 4-15. TPS564252BEVM Start-Up Relative to EN

4.1.8 Shutdown

Figure 4-16 shows the TPS564252BEVM shut-up waveform relative to V_{IN}. The load is 4A.

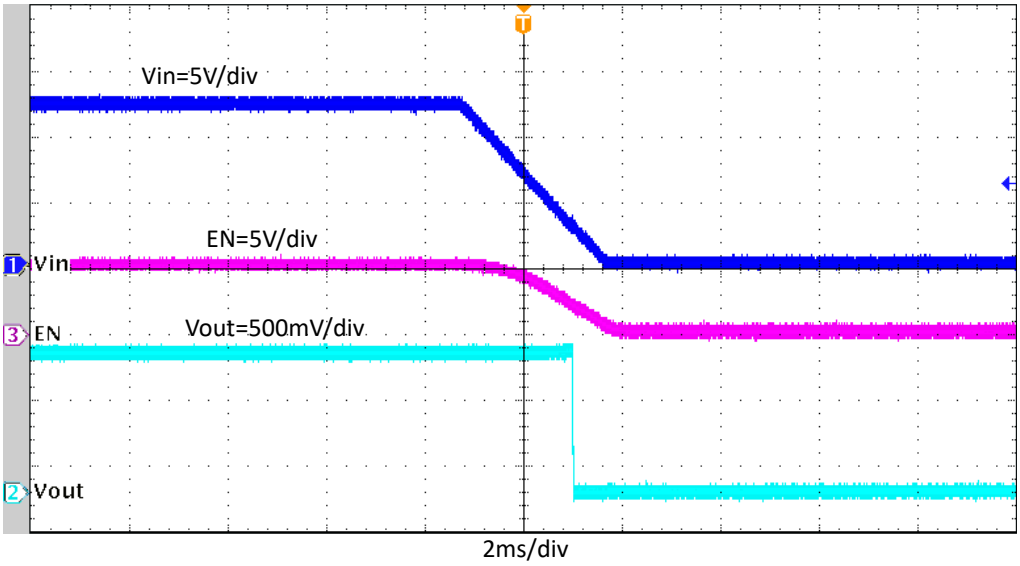


Figure 4-16. TPS564252BEVM Shutdown Relative to V_{IN}

Figure 4-17 shows the TPS564252BEVM shut-up waveform relative to enable (EN). The load is 4A.

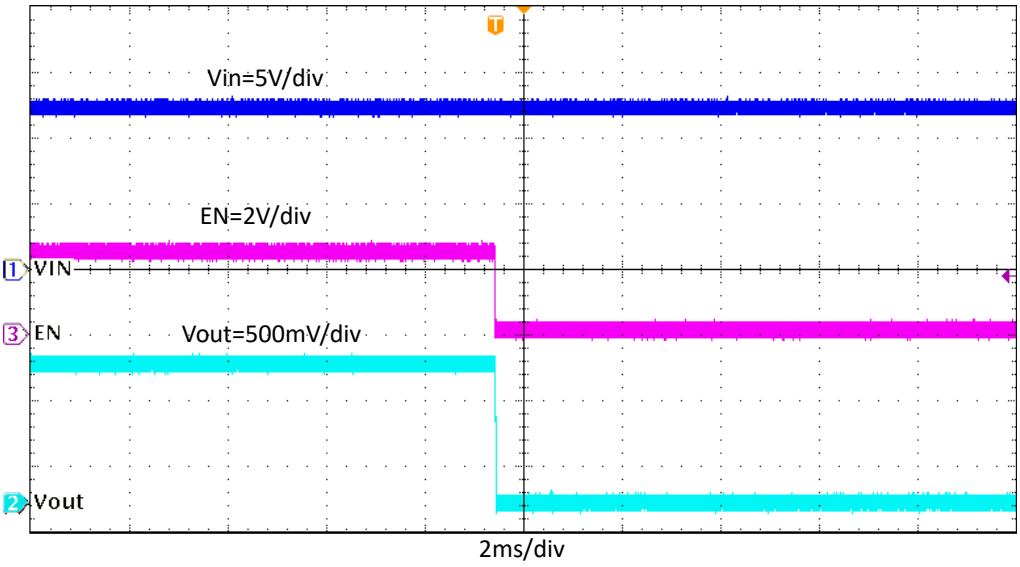


Figure 4-17. TPS564252BEVM Shutdown Relative to EN

4.1.9 Output Voltage Ripple

Figure 4-18 and Figure 4-19 show the TPS564252BEVM output voltage ripple. Figure 4-20 shows the TPS564257BEVM output voltage ripple. Figure 4-21 shows the TPS564255BEVM output voltage ripple. The output currents are as indicated.

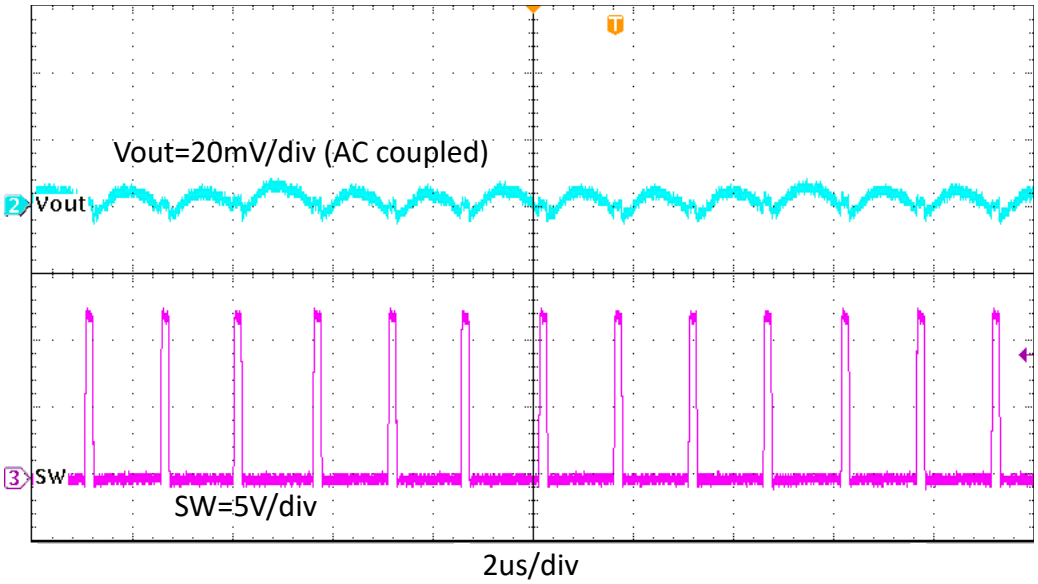


Figure 4-18. TPS564252BEVM Output Voltage Ripple, I_{OUT} = 4A

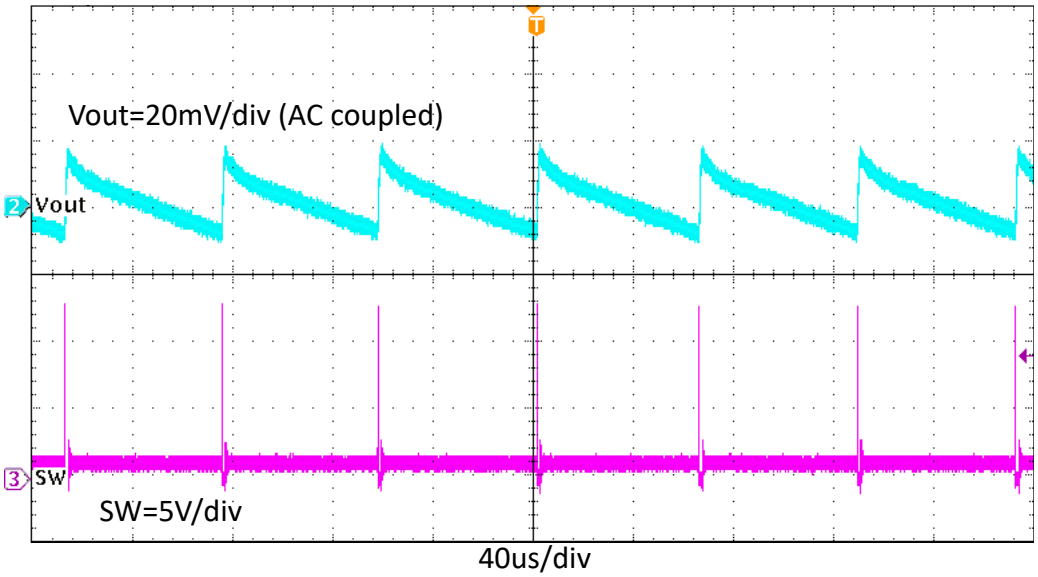


Figure 4-19. TPS564252BEVM Output Voltage Ripple, I_{OUT} = 0.01A

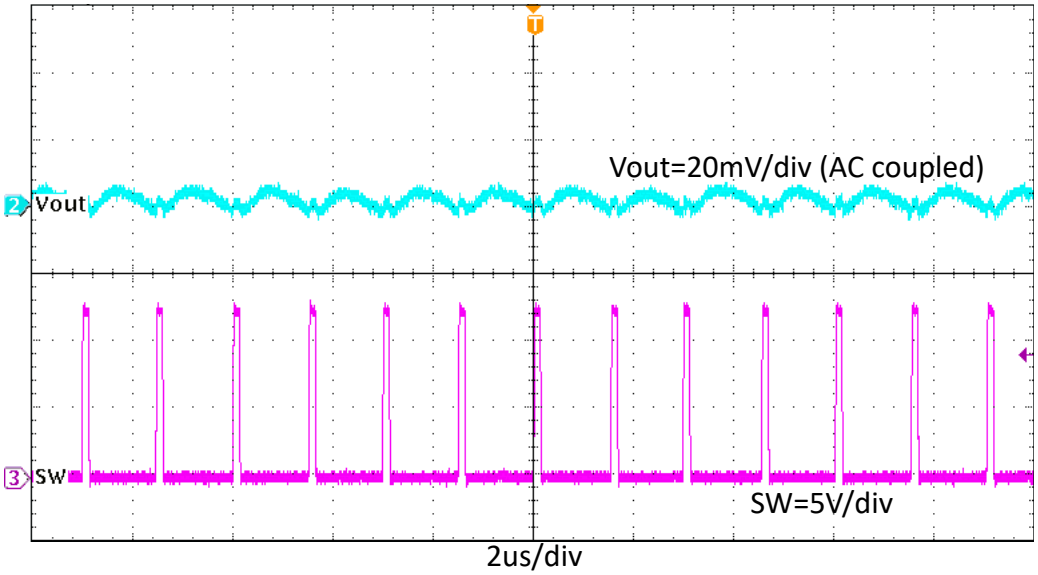


Figure 4-20. TPS564257BEVM Output Voltage Ripple, I_{OUT} = 0.01A

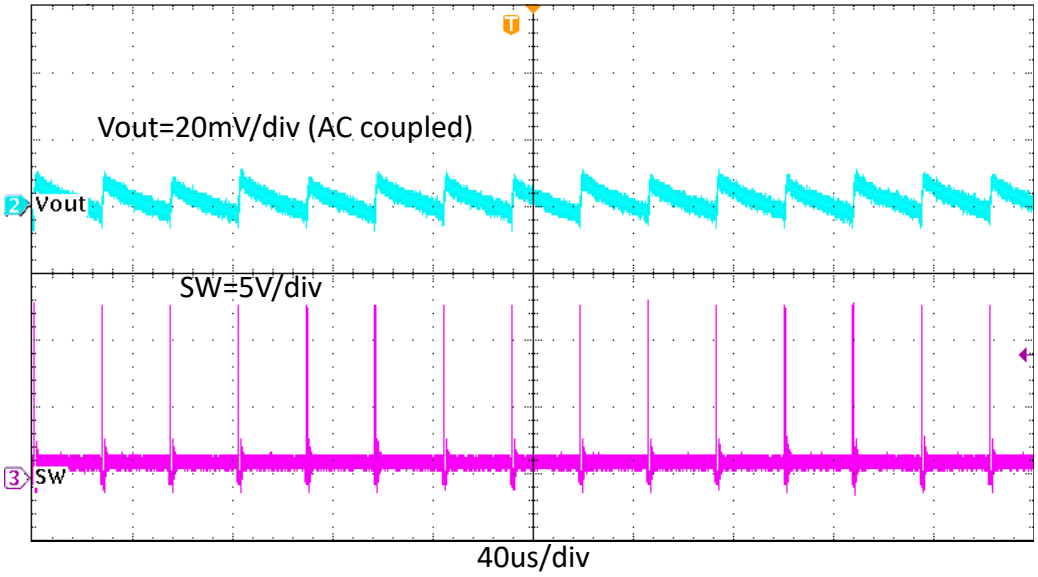


Figure 4-21. TPS564255BEVM Output Voltage Ripple, I_{OUT} = 0.01A

5 Hardware Design Files

5.1 Schematic

Figure 5-1 is the schematic for the TPS564252BEVM.

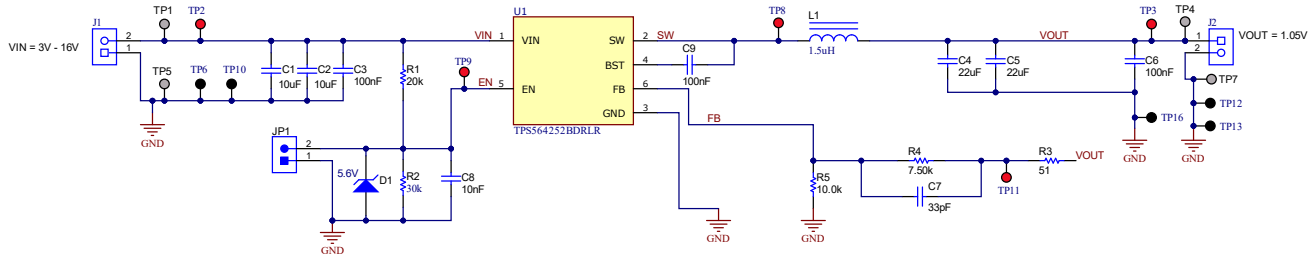


Figure 5-1. TPS564252BEVM Schematic Diagram

5.2 PCB Layout

This section provides a description of the TPS56425xBEVM, board layout, and layer illustrations.

Figure 5-2, Figure 5-3, and Figure 5-4 show the board layout for the TPS564252BEVM. The top layer contains the main power traces for VIN, VOUT, and ground. Connections for the pins of the TPS564252B and a large area filled with ground are also on the top layer. 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 signal ground copper fill and the feedback trace from the point of regulation to the top of the resistor divider network. Both the top layer and bottom layer use 2oz copper thickness.

Figure 5-5 and Figure 5-6 are the TPS564252BEVM board top view and bottom view, respectively.

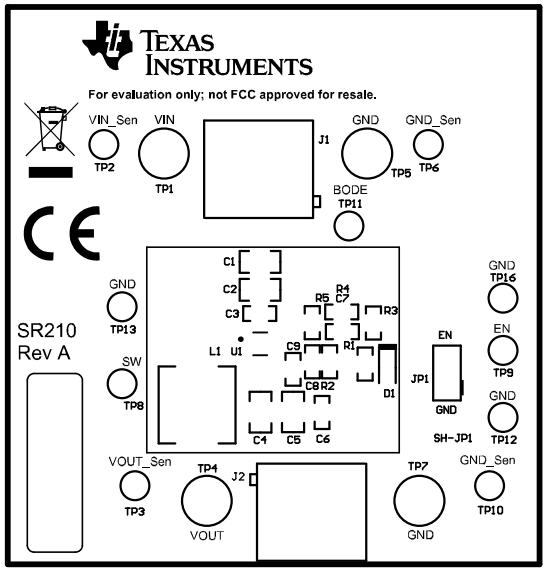


Figure 5-2. TPS564252BEVM Top Assembly

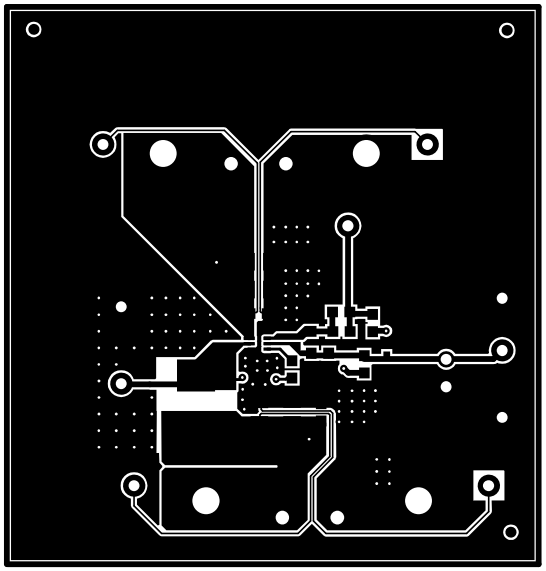


Figure 5-3. TPS564252BEVM Top Layer

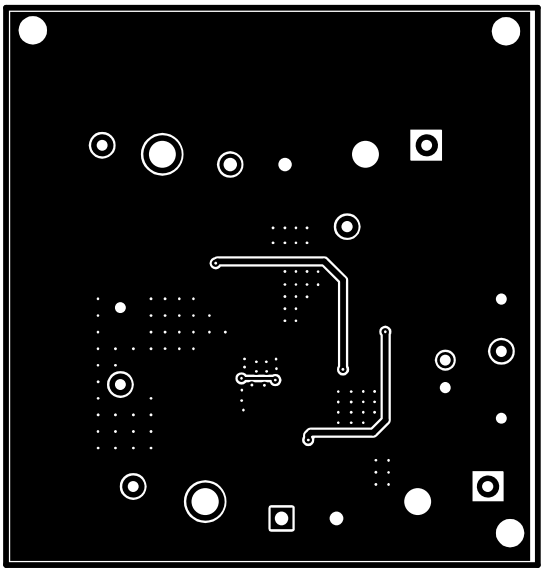


Figure 5-4. TPS564252BEVM Bottom Layer

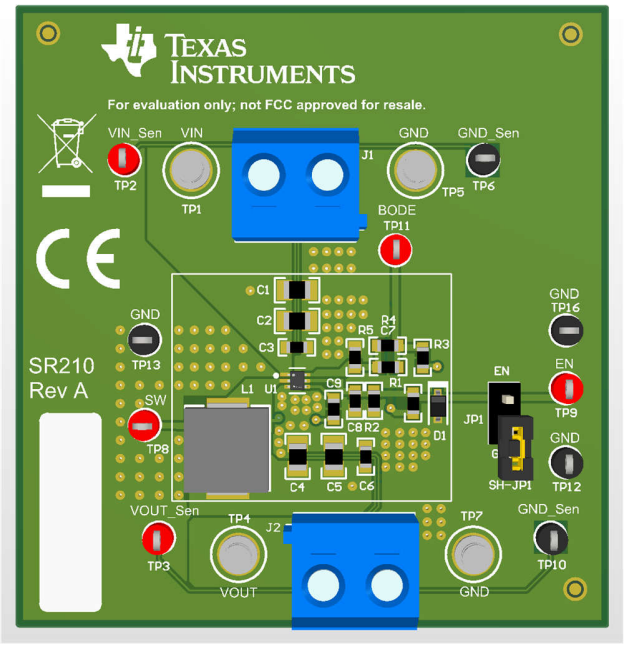


Figure 5-5. TPS564252BEVM Board (Top View)

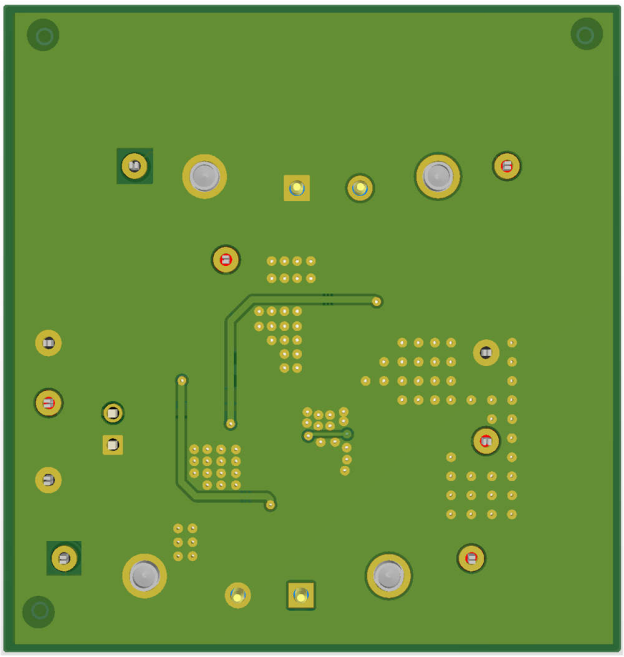


Figure 5-6. TPS564252BEVM Board (Bottom View)

5.3 Bill of Materials

Table 5-1 lists the bill of materials.

Table 5-1. Bill of Materials

DES	QTY	DESCRIPTION	PART NUMBER	MANUFACTURER
!PCB1	1	Printed Circuit Board	SR210	Any
C1, C2	2	Capacitor, ceramic, 10µF, 25V, ±20%, X5R, 0805	GRM21BR61E106MA73L	MuRata
C3, C6, C9	3	Capacitor, ceramic, 0.1uF, 25V, ± 10%, X7R, 0603	C1608X7R1E104K080AA	TDK
C4, C5	2	Capacitor, ceramic, 22µF, 10V, ±20%, X5R, 0805	GRM21BR61A226ME44L	MuRata
C7	1	Capacitor, ceramic, 33pF, 100V, ±5%, C0G/NP0, 0603	GRM1885C2A330JA01D	MuRata
C8	1	Capacitor, ceramic, 0.01µF, 50V, ±10%, X7R, 0603	C1608X7R1H103K080AA	TDK
J1, J2	2	Terminal block, 5.08mm, 2 × 1, Brass, TH	ED120/2DS	On-Shore Technology
JP1	1	Header, 100 mil, 2 × 1, Tin, TH	PEC02SAAN	Sullins Connector Solutions
L1	1	Shielded Inductor, 1.5uH, 8A, 0.0086Ω, SMD	74437349015	Wurth Elektronik
LBL1	1	Thermal transfer printable labels, 0.650" W × 0.200" H – 10,000 per roll	THT-14-423-10	Brady
R1	1	Resistor, 20kΩ, 5%, 0.1W, AEC-Q200 Grade 0, 0603	CRCW060320K0JNEA	Vishay-Dale
R2	1	Resistor, 30kΩ, 5%, 0.1W, AEC-Q200 Grade 0, 0603	CRCW060330K0JNEA	Vishay-Dale
R3	1	Resistor, 51Ω, 5%, 0.1W, AEC-Q200 Grade 0, 0603	CRCW060351R0JNEA	Vishay-Dale
R4	1	Resistor, 7.5kΩ, 1%, 0.1W, 0603	RC0603FR-077K5L	Yageo
R5	1	Resistor, 10.0kΩ, 1%, 0.1W, AEC-Q200 Grade 0, 0603	CRCW060310K0FKEA	Vishay-Dale
SH-JP1	1	Shunt, 100 mil, gold plated, black	SNT-100-BK-G	Samtec
TP1, TP4, TP5, TP7	4	Terminal, turret, TH, double	1502-2	Keystone
TP2, TP3, TP8, TP9, TP11	5	Test point, miniature, red, TH	5000	Keystone
TP6, TP10, TP12, TP13, TP16	5	Test point, miniature, black, TH	5001	Keystone
D1	1	Diode, Zener, 5.6V, 200 mW, SOD-323	MMSZ5232BS-7F	Diodes Inc.
U1	1	3V to 17V Input, 4A Synchronous Buck Converter, SOT-563	TPS564252BDRLR	Texas Instruments

6 Additional Information

6.1 Trademarks

Out-of-Audio™ and D-CAP3™ are trademarks of Texas Instruments.
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7 Reference

Texas Instruments, *TPS56425xB 3V to 17V Input, 4A Synchronous Buck Converter in SOT-563 Package* datasheet

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