User's Guide

TPS565242 and TPS565247 Step-Down Converter Evaluation Module User's Guide

ABSTRACT

This user's guide introduces the TPS565242EVM and TPS556247EVM. These two devices differ in their light load behavior. The TPS565242 operates in Eco mode and the TPS565247 operates in FCCM mode. This user's guide contains information for the TPS565242 and TPS565247 as well as support documentation for the TPS565242EVM and TPS565247EVM evaluation module. This document also includes the performance specifications, board layout, schematic, and the list of materials of the TPS565242EVM and TPS565247EVM.

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Trademarks

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1 Introduction

In light-load conditions, the TPS565242 operates in Eco mode to enable higher efficiency by varying its switching frequency. The TPS565247 operates in FCCM to maintain constant switching frequency. The main difference is at light loading, but the other behaviors are similar. This user's guide mainly introduces the TPS565242 and includes some features about the TPS565247 that are different from the TPS565242.

The TPS56524x 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 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 600 kHz. The high-side and low-side switching MOSFETs are incorporated inside the TPS56524x package along with the gate-drive circuitry. The low drain-to-source on resistance of the MOSFETs and fast switching slew rate allow the TPS56524x to achieve high efficiencies and help keep the junction temperature low at high output currents. The TPS56524x DC/DC synchronous converter is designed to provide up to a 5-A output from an input voltage source of 3 V to 16 V. The output voltage range is from 0.6 V to 7 V. Rated input voltage and output current ranges for the evaluation module are given in Table 1-1.

The TPS565242EVM evaluation module (EVM) is a single, synchronous buck converter providing 1.05 V at 5 A from 3-V to 17-V input. This user's guide describes the TPS565242EVM performance.

Table 1-1. Input Voltage and Output Current Summary

EVM	Input Voltage Range	Output Current Range
TPS565242EVM	V_{IN} = 3 V to 16 V	0 A to 5 A
TPS565247EVM	V_{IN} = 3 V to 16 V	0 A to 5 A

2 Performance Specification Summary

A summary of the TPS565242EVM performance specifications is provided in Table 2-1. Specifications are given for an input voltage of V_{IN} = 12 V and an output voltage of 1.05 V, unless otherwise noted. The ambient temperature is 25°C for all measurements, unless otherwise noted.

Table 2-1. Performance Specifications Summary

SPECIFICATIONS	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Input voltage range		3	12	16	V
Output voltage set point			1.05		V
Operating frequency	V_{IN} = 12 V, I_O = 5 A		600		kHz
Output current range		0		5	A
Overcurrent limit	V_{IN} = 12 V, L_O = 1 µH		6.9		A
Output ripple voltage	V_{IN} = 12 V, I_O = 5 A		14		mV_{PP}

3 Modifications

These evaluation modules are designed to provide access to the features of the TPS565242. 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 R_4 (R_{UPPER}) and R_5 (R_{LOWER}). Changing the value of R_4 and R_5 can change the output voltage. The value of R_4 for a specific output voltage can be calculated using Equation 1.

$$R_4 = \frac{R_5 \times (V_{out} - 0.6V)}{0.6V} \tag{1}$$

4 Test Setup and Results

This section describes how to properly connect, set up, and use the TPS565242EVM. The section also includes test results typical for the evaluation modules and the following:

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

4.1 Input/Output Connections

The TPS565242EVM is provided with input/output connectors and test points as shown in Table 4-1. Figure 4-1 shows connectors and jumpers placement on the TPS565242EVM board. A power supply capable of supplying 5 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 5 A. 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.

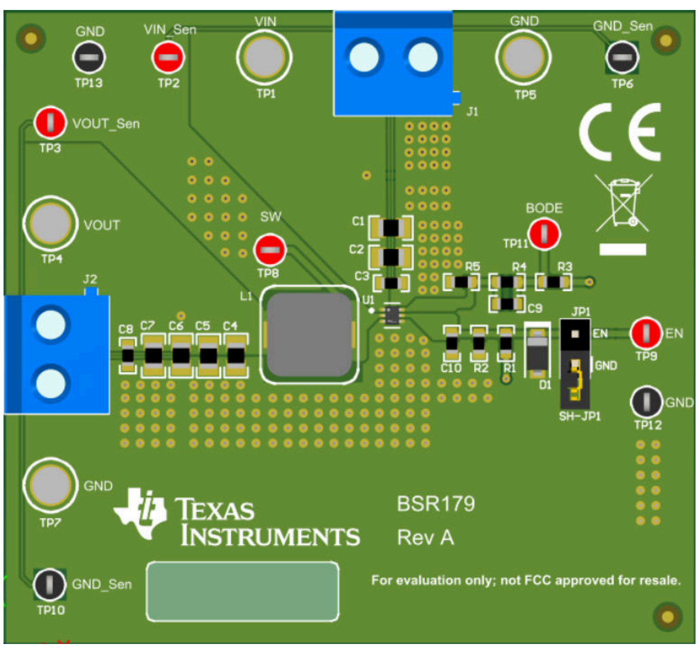

Figure 4-1. TPS565242EVM Connectors and Jumpers Placement

Table 4-1. Connection and Test Points

Reference Designator	Function
J1	V_{IN} (see Table 1-1 for V_{IN} range)
J2	V_{OUT}, 1.05 V at 5-A 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	GND monitor point
TP8	Switch node test point
TP9	EN test point
TP11	Test point for loop response measurements

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) pins 1 and 2 (EN and GND) to enable the output.

4.3 Efficiency

Figure 4-2 shows the efficiency for the TPS565242EVM at an ambient temperature of 25°C.

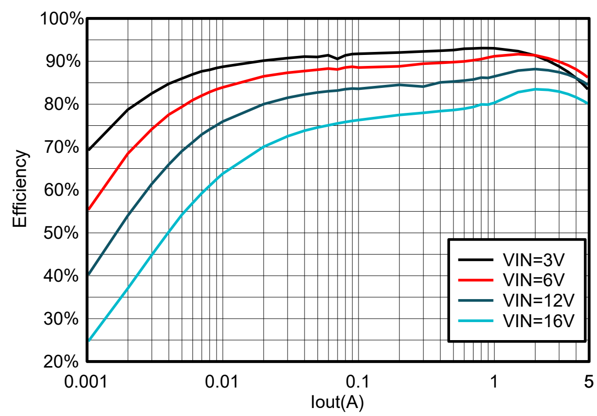

Figure 4-2. TPS565242EVM Efficiency

4.4 Load Regulation

Figure 4-3 shows the load regulation for the TPS565242EVM.

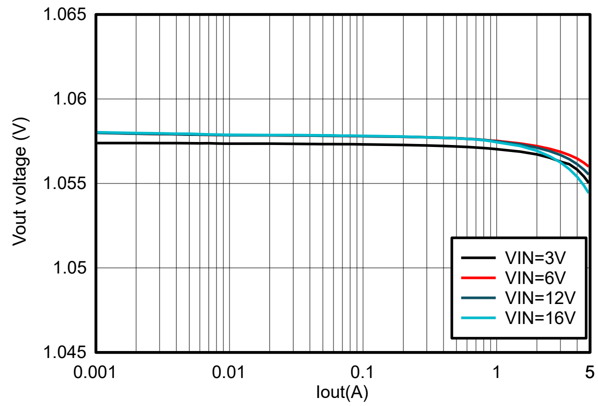

Figure 4-3. TPS565242EVM Load Regulation

4.5 Line Regulation

Figure 4-4 shows the line regulation for the TPS565242EVM.

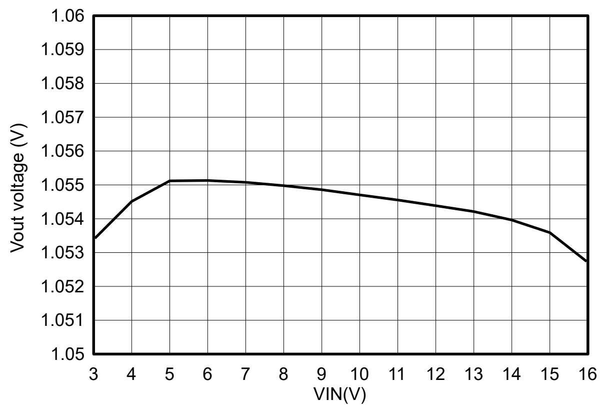

Figure 4-4. TPS565242EVM Line Regulation

4.6 Load Transient Response

Figure 4-5 shows the TPS565242EVM response to load transient. The current steps slew rates is 2.5 A/µs.

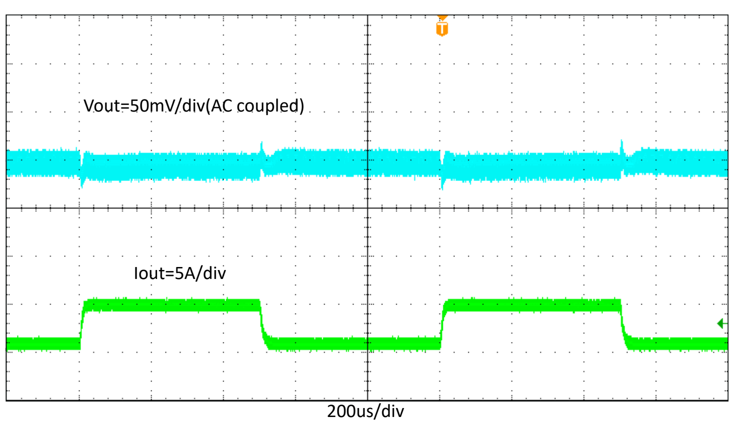

Figure 4-5. TPS565242EVM Load Transient Response, 10% to 90% (0.5 A–4.5 A) Load Step

4.7 Output Voltage Ripple

Figure 4-6, Figure 4-7, and Figure 4-8 shows the TPS565242EVM output voltage ripple. The output currents are as indicated.

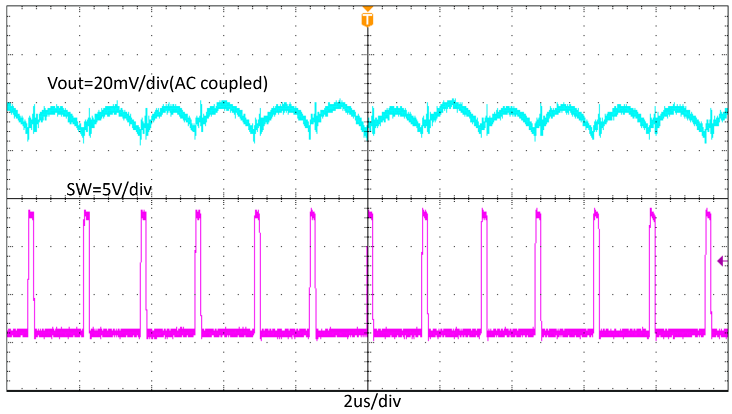

Figure 4-6. TPS565242EVM Output Voltage Ripple, I_{OUT} = 5 A

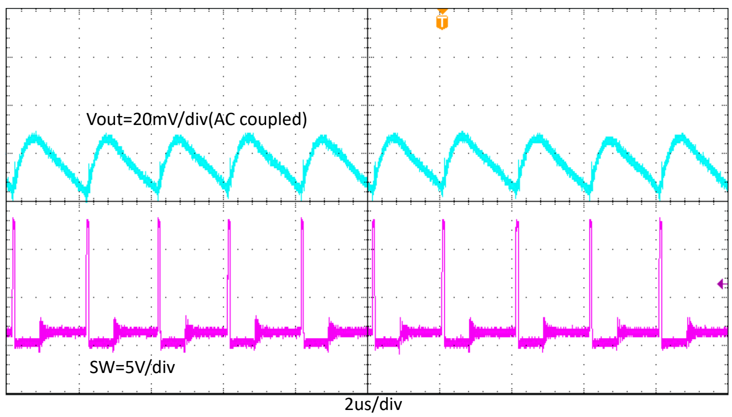

Figure 4-7. TPS565242EVM Output Voltage Ripple, I_{OUT} = 300 mA

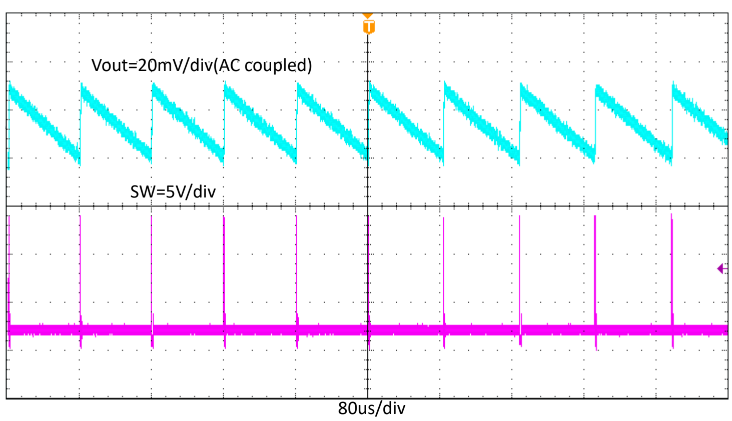

Figure 4-8. TPS565242EVM Output Voltage Ripple, I_{OUT} = 10 mA

4.8 Start-Up

Figure 4-9 shows the TPS565242EVM start-up waveform relative to V_{IN}. Load = 5 A

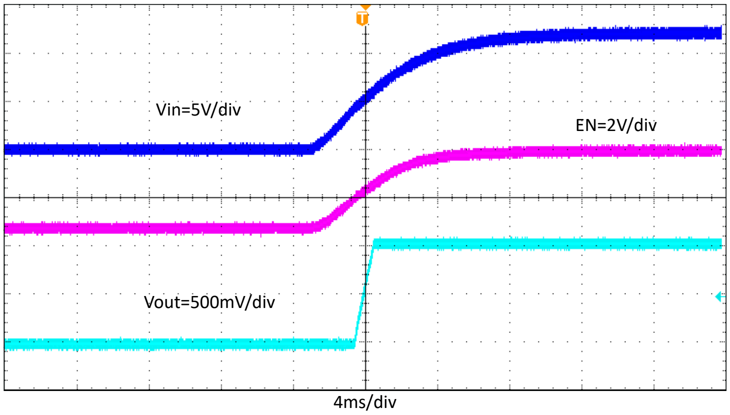

Figure 4-9. TPS565242EVM Start-Up Relative to V_{IN}

Figure 4-10 shows the TPS565242EVM start-up waveform relative to enable (EN). Load = 5 A

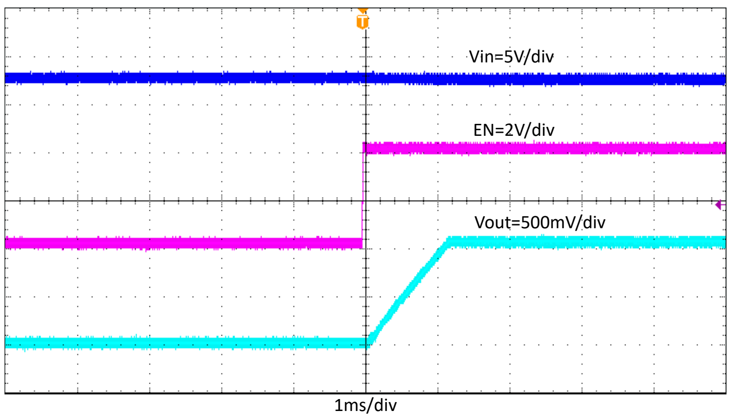

Figure 4-10. TPS565242EVM Start-Up Relative to EN

4.9 Shutdown

Figure 4-11 shows the TPS565242EVM shutdown waveform relative to V_{IN}. Load = 5 A

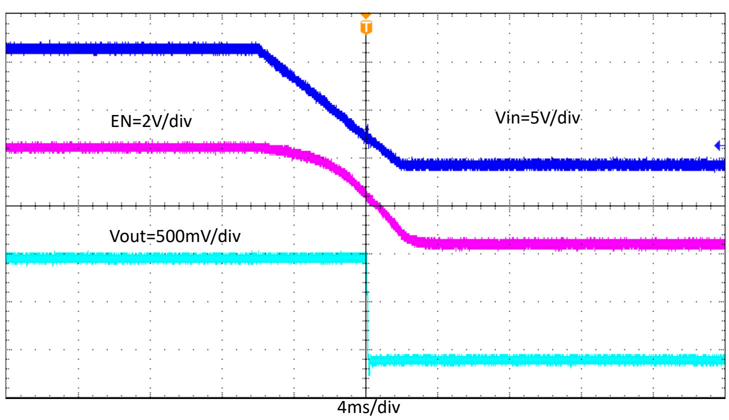

Figure 4-11. TPS565242EVM Shutdown Relative to V_{IN}

Figure 4-12 shows the TPS565242EVM shutdown waveform relative to EN. Load = 5 A

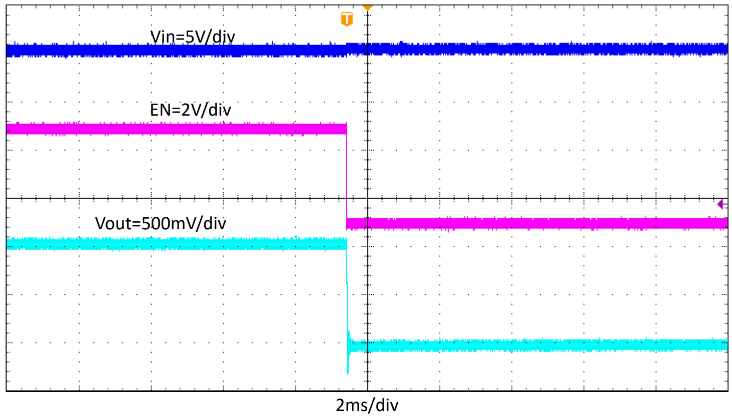

Figure 4-12. TPS565242EVM Shutdown Relative to EN

5 Board Layout

This section provides a description of the TPS56524xEVM, board layout, and layer illustrations.

5.1 Layout

Figure 5-1, Figure 5-2, and Figure 5-3 shows the board layout for the TPS565242EVM. 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 TPS565242 and a large area filled with ground. Most of the signal traces are also located on the top side. The input decoupling capacitors 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 2-oz copper thickness.

Figure 5-4 and Figure 5-5 are the TPS565242EVM board top view and bottom view, respectively.

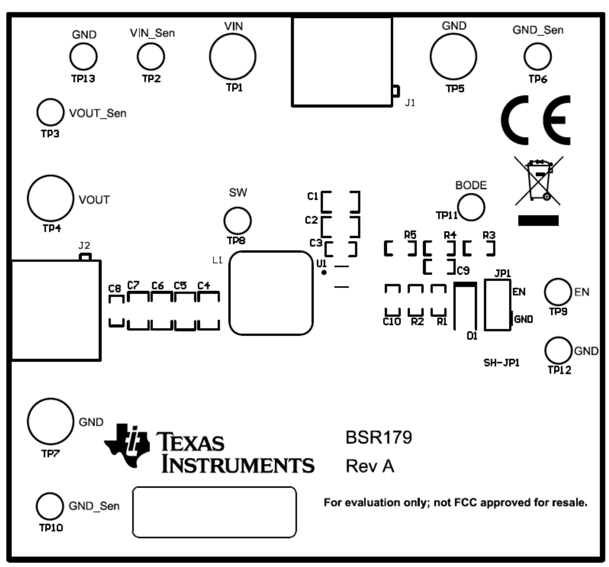

Figure 5-1. TPS565242EVM Top Assembly

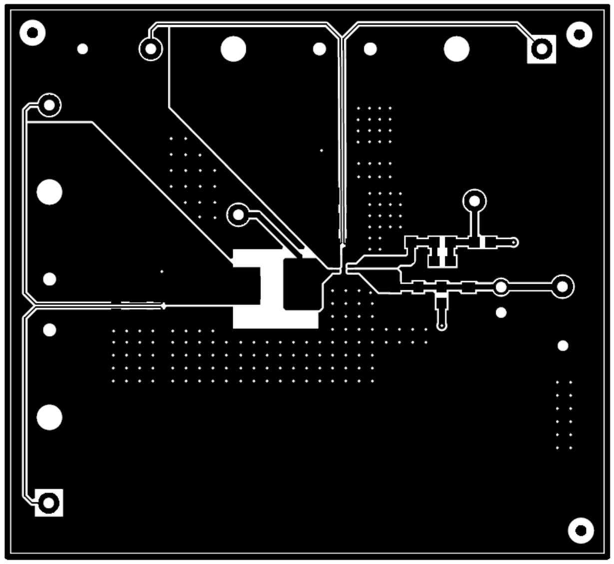

Figure 5-2. TPS565242EVM Top Layer

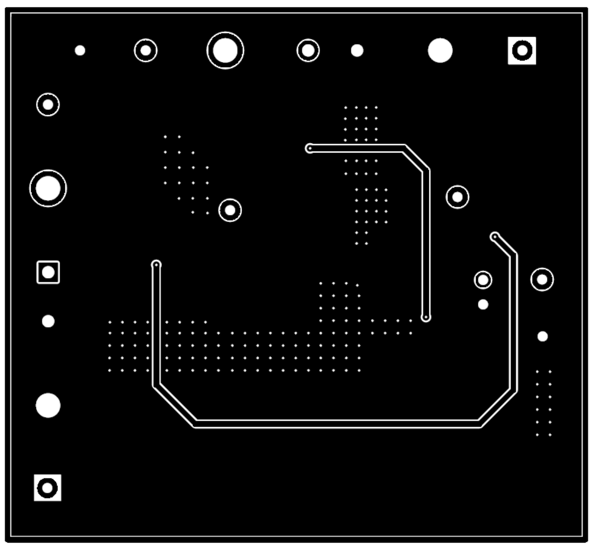

Figure 5-3. TPS565242EVM Bottom Layer

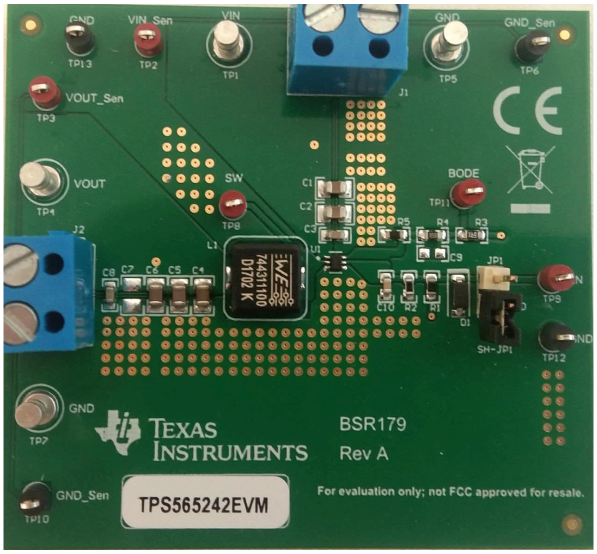

Figure 5-4. TPS565242EVM Board (Top View)

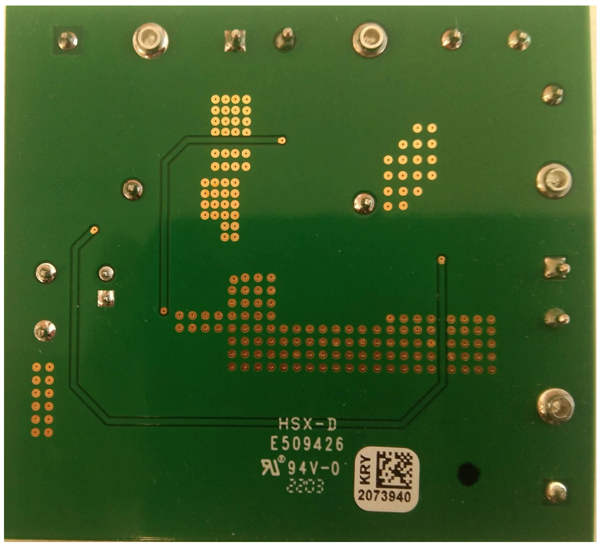

Figure 5-5. TPS565242EVM Board (Bottom View)

6 Schematic and List of Materials

6.1 Schematic

Figure 6-1 is the schematic for the TPS565242EVM.

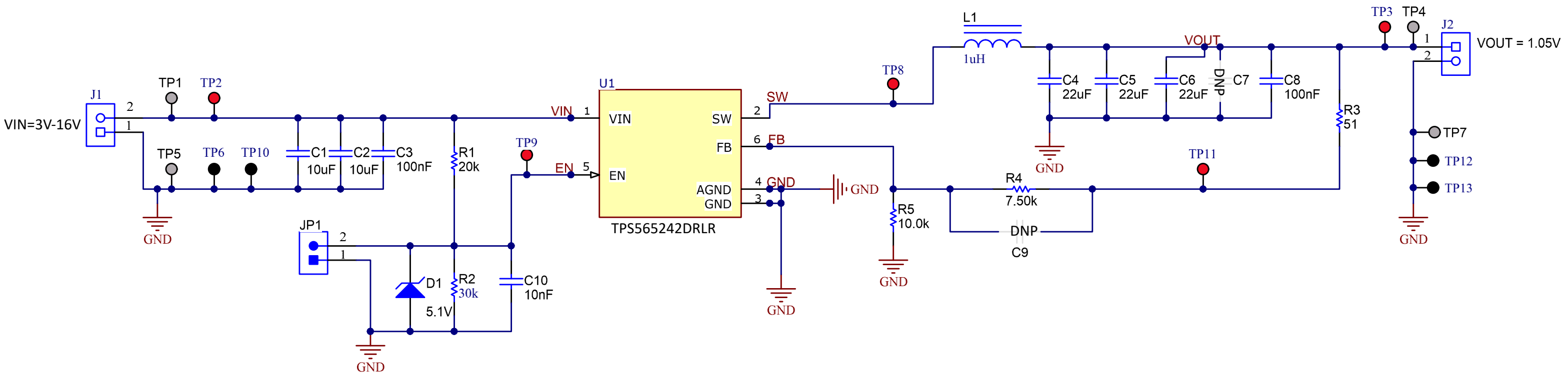

Figure 6-1. TPS565242EVM Schematic Diagram

6.2 List of Materials

Table 6-1. List of Materials

Des	QTY	Description	Part Number	Manufacturer
!PCB1	1	Printed Circuit Board	BSR179	Any
C1, C2	2	Capacitor, ceramic, 10 µF, 25 V, ±20%, X5R, 0805	GRM21BR61E106MA73L	MuRata
C3, C8	2	Capacitor, ceramic, 0.1 µF, 25 V, ±10%, X7R, 0603	C0603C104J3RACAUTO	KEMET
C4, C5, C6	3	Capacitor, ceramic, 22 µF, 10 V, ±20%, X5R, 0805	GRM21BR61A226ME44L	MuRata
C10	1	Capacitor, ceramic, 0.01 uF, 50 V, +/- 10%, X7R, 0603	C1608X7R1H103K080AA	TDK
J1, J2	2	Terminal block, 5.08 mm, 2 ×1, Brass, TH	ED120/2DS	On-Shore Technology
JP1	1	Header, 100 mil, 2 × 1, tin, TH	PEC02SAAN	Sullins Connector Solutions
L1	1	Inductor, Shielded Drum Core, WE-Superflux200, 1 uH, 15 A, 0.0046 ohm, SMD	744311100	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, 20 kΩ, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06030000Z0EA	Vishay-Dale
R2	1	Resistor, 30 kΩ, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060320K0JNEA	Vishay-Dale
R3	1	Resistor, 51 Ω, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060351R0JNEA	Vishay-Dale
R4	1	Resistor, 7.5 kΩ, 1%, 0.1 W, 0603	RC0603FR-073K09L	Yageo
R5	1	Resistor, 10.0 kΩ, 1%, 0.1 W, 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	4	Test Point, miniature, black, TH	5001	Keystone
U1	1	3-V to 16-V Input, 5-A Synchronous Buck Converter, DRL0006A (SOT-563)	TPS565242DRLR	Texas Instruments
D1	1	Diode, Zener, 5.1 V, 500 mW, SOD-123	MMSZ5231B-7-F	Diodes Inc.

7 Reference

Texas Instruments, *TPS56524x 3-V to 16-V Input Voltage, 5-A Synchronous Buck Converter in a SOT-5X3 Package*

8 Revision History

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

Changes from Revision * (February 2022) to Revision A (March 2022) **Page**

- Updated Table 6-1 11