User's Guide

TPS56C231 Step-Down Converter Evaluation Module User's Guide

ABSTRACT

This user's guide contains information for the TPS56C231 as well as support documentation for the TPS56C231EVM evaluation module. This document also includes the performance specifications, board layout, schematic, and the list of materials of the TPS56C231EVM.

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1 Introduction

The TPS56C231 is a single, D-CAP3™ mode, synchronous buck converter requiring a very low external component count. The TPS56C231 is a high-efficiency, cost effective, low quiescent current synchronous buck converter with integrated FETs. A mode pin is used to select output current limit, switching frequency, and forced continuous conduction mode (FCCM) and discontinuous conduction mode (DCM) operation. The device uses D-CAP3 control mode to provide a fast transient response, good line, load regulation, no requirement for external compensation, and supports low ESR output capacitors. Additionally, the TPS56C231 provides adjustable soft start, undervoltage lockout inputs and a power good output. Rated input voltage and output current ranges for the evaluation module are given in Table 1-1.

The TPS56C231EVM evaluation module (EVM) is a single, synchronous buck converter providing 1.2 V at 12 A from 4.5-V to 17-V input. This user's guide describes the TPS56C231EVM performance.

Table 1-1. Input Voltage and Output Current Summary

EVM	Input Voltage (V_{IN}) Range	Output Current (I_{OUT}) Range
TPS56C231EVM	4.5 V to 17 V	0 A to 12 A

2 Performance Specification Summary

A summary of the TPS56C231EVM performance specifications is provided in Table 2-1. Specifications are given for an input voltage of 12 V and an output voltage of 1.2 V, unless otherwise noted. The ambient temperature is 25°C for all measurement, unless otherwise noted.

Table 2-1. TPS56C231EVM Performance Specifications Summary

Specifications		Test Conditions	MIN	TYP	MAX	Unit
V_{IN}	Input voltage		4.5	12	17	V
CH1	Output voltage			1.2		V
	Operating frequency	V_{IN} = 12 V, I_{OUT} = 6 A		800		kHz
	Output current range		0		12	A
	Overcurrent limit	V_{IN} = 12 V, L_{OUT} = 0.68 µH		17		A
	Output ripple voltage	V_{IN} = 12 V, I_{OUT} = 12 A		10		mV_{PP}

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3 Modifications

This evaluation module is designed to provide access to the features of the TPS56C231. Some modifications can be made to this module.

3.1 Output Voltage Setpoint

To change the output voltage of the EVM, it is necessary to change the value of resistor R7 (R_{UPPER}) and R9 (R_{LOWER}). The value of R7 and R9 for a specific output voltage can be calculated using Equation 1 and refer to Table 3-1 for some recommendation values. See the *TPS56C231x 3.8-V to 17-V Input , 12-A Synchronous Step-Down Converter* data sheet. See Table 3-1 to set the switching frequency.

$$V_{OUT} = 0.6 \times (1 + \frac{R_{UPPER}}{R_{LOWER}}) \quad (1)$$

Table 3-1. Recommended Component Values

V_{OUT} (V)	R_{LOWER} (kΩ)	R_{UPPER} (kΩ)	f_{SW} (kHz)	L_{OUT} (µH)	$C_{OUT(min)}$ (µF)	$C_{OUT(max)}$ (µF)	C_{FF} (PF)
0.6	10	0	400	0.68	300	500	—
			800	0.47	100	500	—
			1200	0.33	88	500	—
1.2	10	10	400	1.2	100	500	—
			800	0.68	88	500	—
			1200	0.47	88	500	—
3.3	10	45.3	400	2.4	88	500	100-220
			800	1.5	88	500	100-220
			1200	1.2	88	500	100-220
5.0	10	82.5	400	3.3	88	500	100-220
			800	2.4	88	500	100-220
			1200	1.5	88	700	100-220

3.2 Adjustable UVLO

The undervoltage lockout (UVLO) can be adjusted externally using R1 ($R_{EN(TOP)}$) and R2 ($R_{EN(BOT)}$). See the *TPS56C231x 3.8-V to 17-V Input , 12-A Synchronous Step-Down Converter* data sheet for detailed instructions for setting the external UVLO.

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4 Test Setup and Results

This section describes how to properly connect, set up, and use the TPS56C231EVM. The section also includes test results typical for the evaluation modules, includes power on, power off, and voltage ripple.

4.1 Input and Output Connections

The TPS56C231EVM is provided with input and output connectors and test points as shown in Table 4-1. A power supply capable of supplying 6 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 12 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 TP4 providing a convenient ground reference. TP7 is used to monitor the output voltage with TP10 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}, 1.2 V at 12-A maximum
J3	En Control. Short pin1 and pin2 to make EN low. Short pin2 and pin3 to make EN high.
J4	V_{IN} positive monitor point
J5	GND monitor test point
J6	GND monitor test point
J7	PGOOD monitor test point
J8	VREG5 monitor test point
J9	MODE monitor test point
J10	Soft Start test point
J11	Switch node test point
J12	Loop test point
J13	GND monitor test point
J14	V_{OUT} positive monitor point
J15	GND monitor test point
J16	GND monitor test point
TP2	V_{IN} positive monitor point
TP4	GND monitor test point
TP7	V_{OUT} positive monitor point
TP10	GND monitor test point

4.2 Start-Up Procedure

1. Ensure that the J3 (Enable control) pins 1 and 2 are shorted to shunt EN to GND, disabling the output.
2. Apply appropriate input voltage to VIN (J1-2) or TP2 and GND (J1-1) or TP4. Note that the board cannot support hot plug-in. Connect the input lines between J1 and external power source first before turning on the power source.
3. Disconnect J3 (Enable control) pins 1 and 2 (EN and L). Ensure that pins 2 and 3 (EN and H) are shorted, then the output can be enabled.
4. Apply the loading to VOUT (J2-1) or TP7 and GND (J2-2) or TP10.

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4.3 Start-Up

The TPS56C231EVM start-up waveform relative to EN is shown in Figure 4-1.

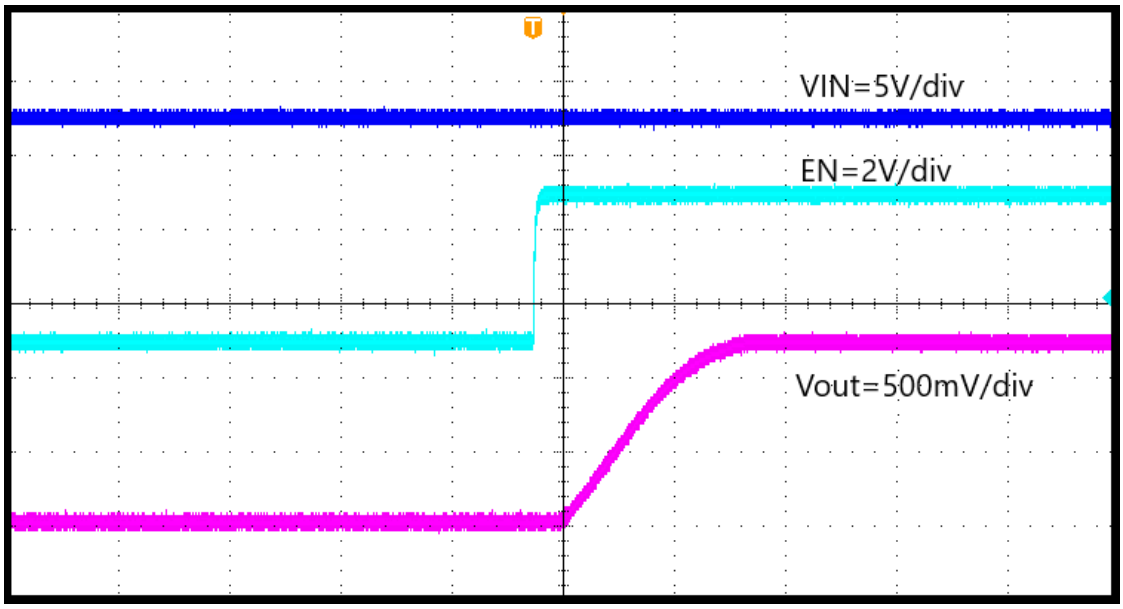

Figure 4-1. Start-Up Relative to EN, I_{OUT} = 6 A (4 ms/div)

4.4 Shutdown

The TPS56C231EVM shutdown waveform relative to EN is shown in Figure 4-2.

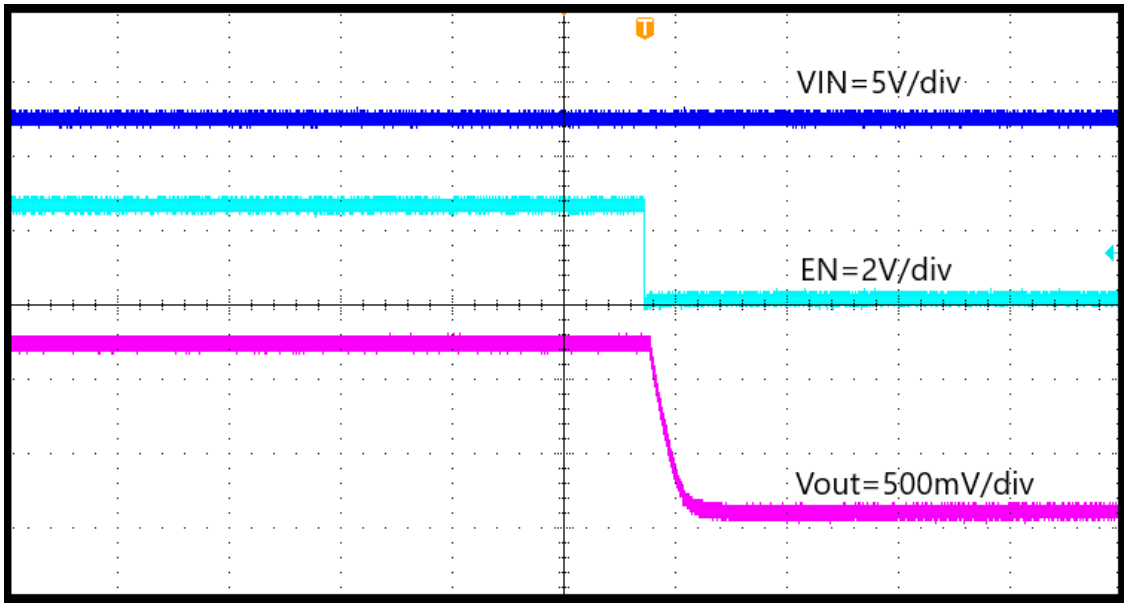

Figure 4-2. Shutdown Relative to EN, I_{OUT} = 6 A (200 µs/div)

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4.5 Output Voltage Ripple

The TPS56C231EVM output voltage ripple is shown in Figure 4-3 and Figure 4-4. The output currents are as indicated.

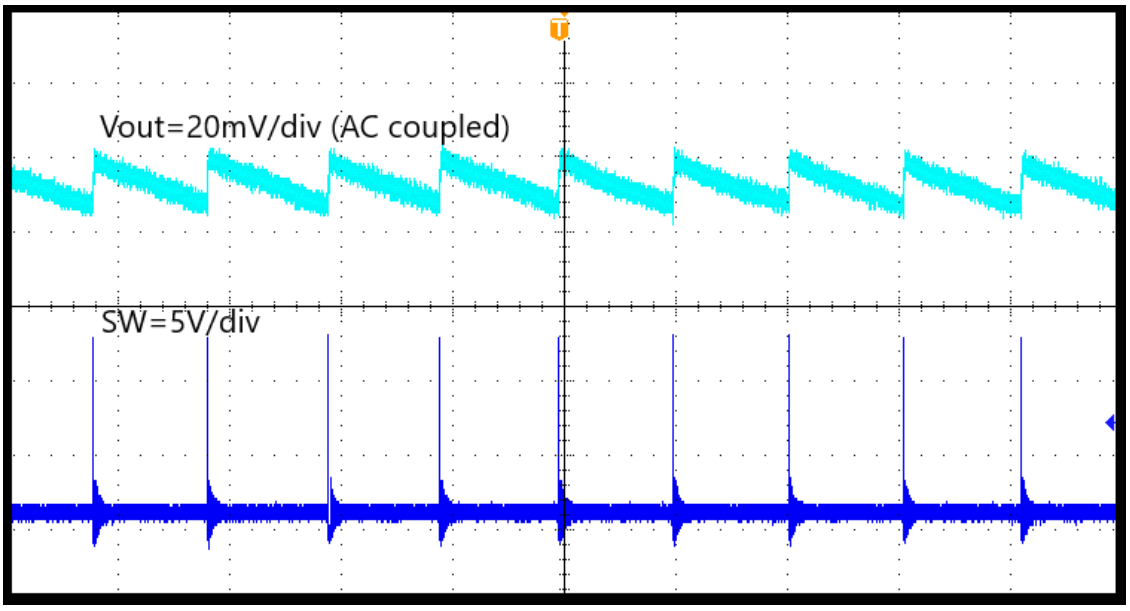

Figure 4-3. TPS56C231 Output Voltage Ripple, I_{OUT} = 0.01 A (80 µs/div)

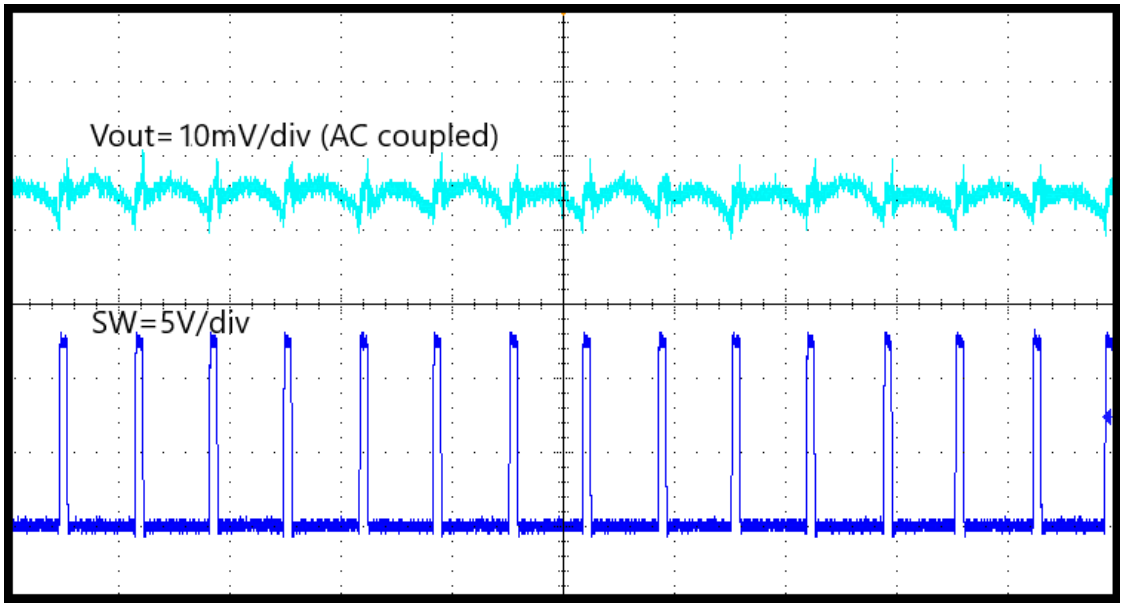

Figure 4-4. TPS56C231 Output Voltage Ripple, I_{OUT} = 12 A (2 µs/div)

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5 Board Layout

This section provides a description of the TPS56C231EVM, board layout, and layer illustrations.

5.1 Layout

The board layout for the TPS56C231EVM is shown in Figure 5-1 to Figure 5-5. The TPS56C231EVM is with four layers. The top layer contains the main power traces for VIN, VOUT, SW, and GND. Also, on the top layer are connections for the pins of the TPS56C231 and a large area filled with ground. Most of the signal traces are also located on the top side. The input decoupling capacitors are located as close to the VIN pins and PGND pins of the IC as possible. The internal layer-1 is dedicated ground plane. The internal layer-2 contains an additional large ground copper area as well as an additional VIN and VOUT copper fill. The bottom layer is a ground plane along with 4 traces for VIN, VOUT, EN, and BOOT connection.

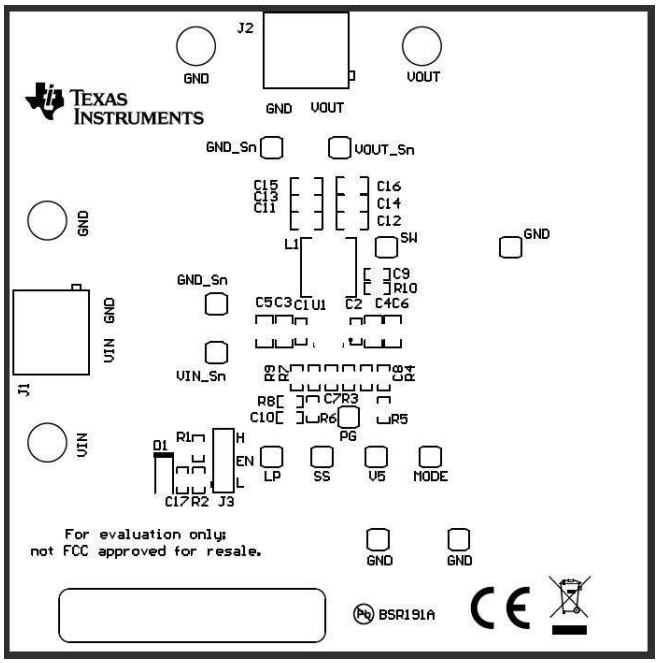

Figure 5-1. Top Assembly

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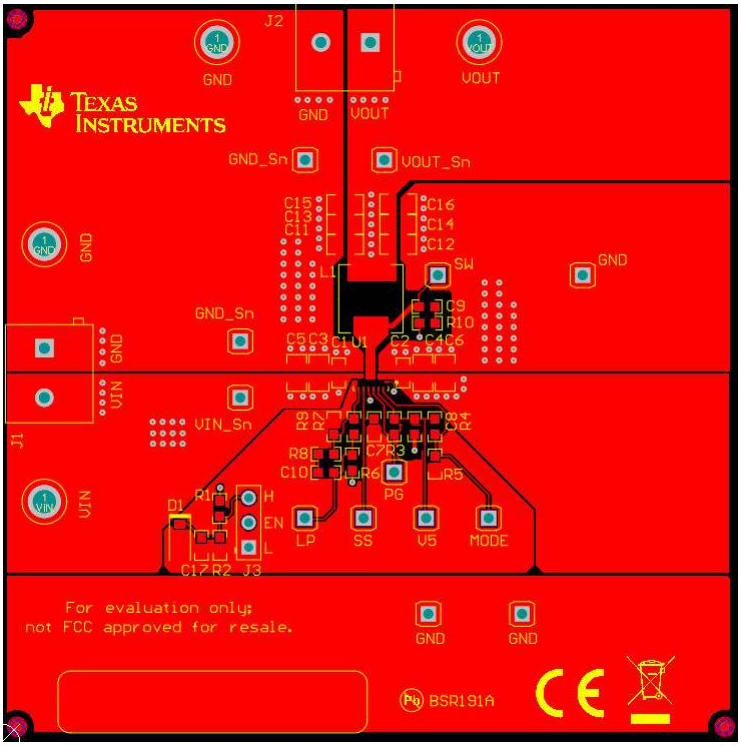

Figure 5-2. Top Layer

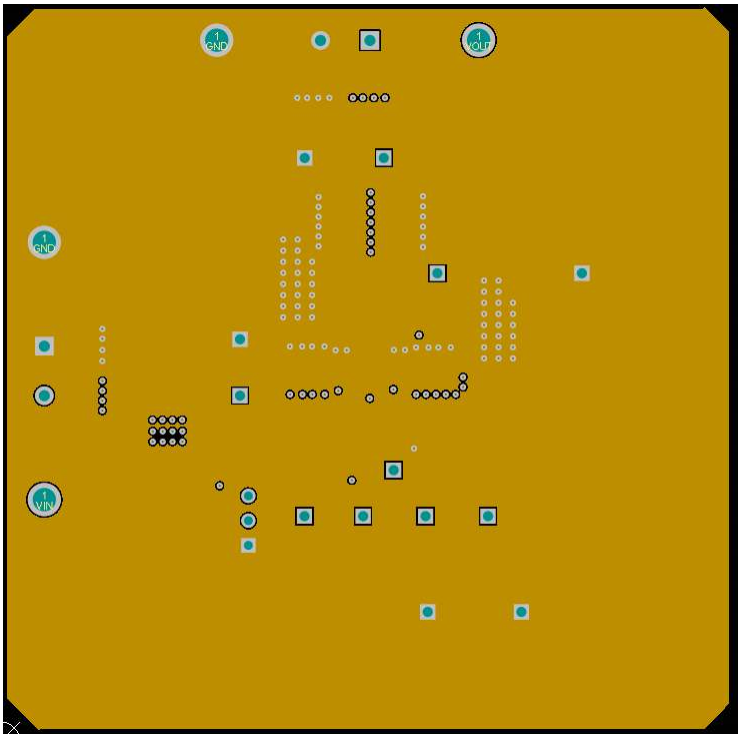

Figure 5-3. Inner1 Layer

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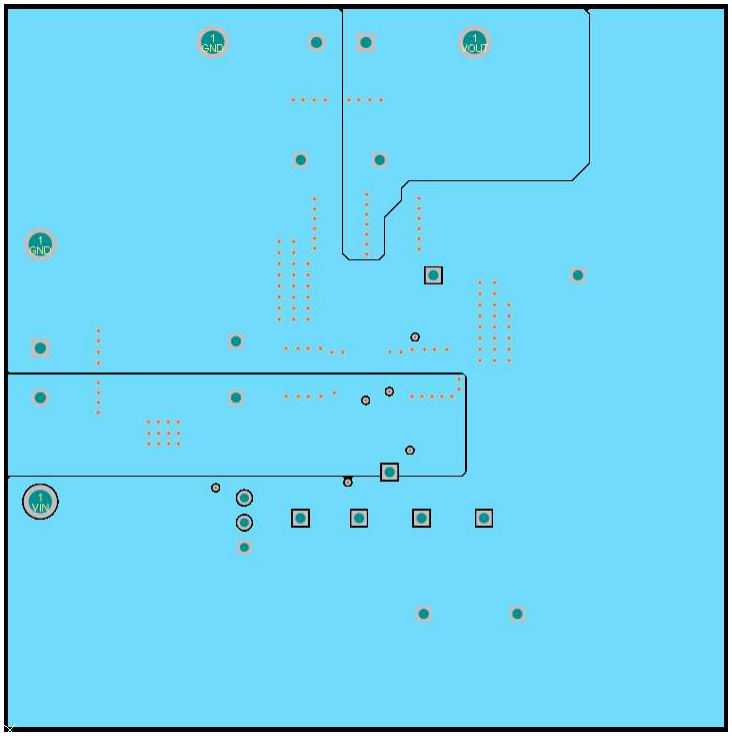

Figure 5-4. Inner2 Layer

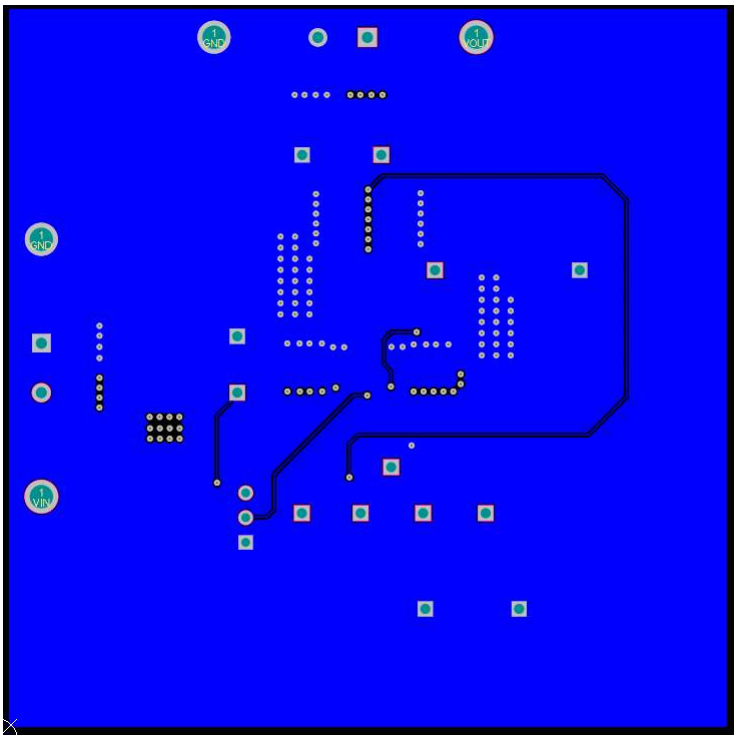

Figure 5-5. Bottom Layer

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6 Board Profile, Schematic, and List of Materials

6.1 Board Profile

Figure 6-1 is the top view for the TPS56C231EVM.

Figure 6-1. Top View of TPS56C231EVM

Figure 6-2 is the bottom view for the TPS56C231EVM.

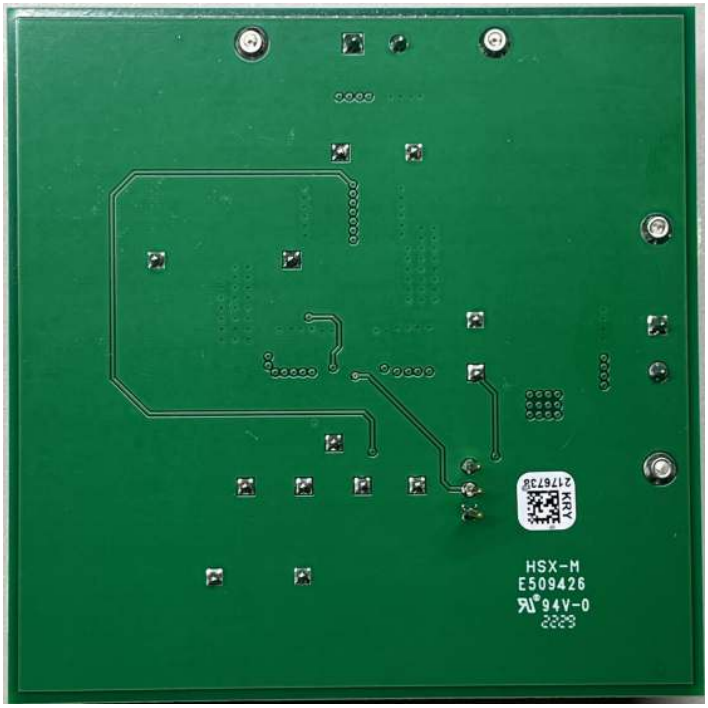

Figure 6-2. Bottom View of TPS56C231EVM

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6.2 Schematic

Figure 6-3 is the schematic for the TPS56C231EVM.

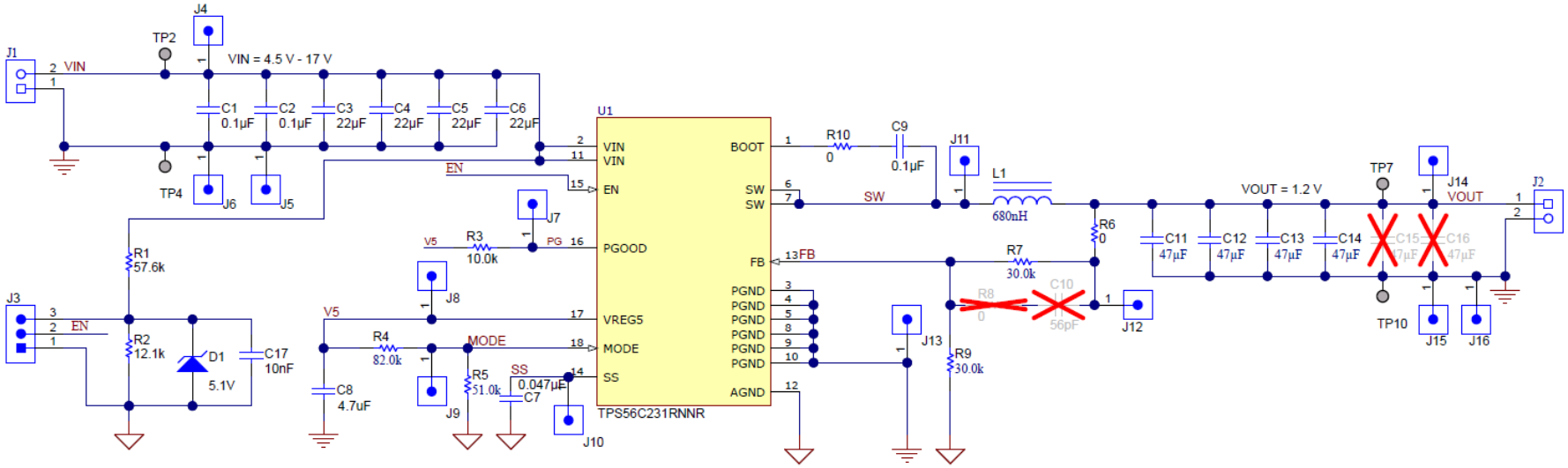

Figure 6-3. TPS56C231EVM Schematic Diagram

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6.3 List of Materials

Table 6-1 displays the TPS56C231EVM list of materials.

Table 6-1. List of Materials

Designator	Qty	Description	Part Number[1]	Manufacturer
PCB1	1	Printed Circuit Board	BSR191	Any
C1, C2, C9	3	Capacitor, ceramic, 0.1 µF, 25 V, ±10%, X7R, 0603	GRM188R71E104KA01D	MuRata
C3, C4, C5, C6	4	Capacitor, ceramic, 22 µF, 35 V, ±20%, X5R, 0805	C2012X5R1V226M125AC	TDK
C7	1	Capacitor, ceramic, 0.047 µF, 50 V, ±10%, X7R, 0603	GRM188R71H473KA61D	MuRata
C8	1	Capacitor, ceramic, 4.7 µF, 10 V, ±10%, X5R, 0805	C0603C475K8PACTU	Kemet
C11, C12, C13, C14	4	Capacitor, ceramic, 47 µF, 10 V, ±20%, X5R, 0805	GRM21BR61A476ME15L	MuRata
C17	1	Capacitor, ceramic, 0.01 µF, 50 V, ±20%, X7R, 0603	C1608X7R1H103K080AA	TDK
D1	1	Diode, Zener, 5.1 V, 500 mW, SOD-123	MMSZ5231B-7-F	Diodes Inc.
J1, J2	2	Terminal Block, 5.08 mm, 2 × 1, Brass, TH	ED120/2DS	On-Shore Technology
J3	1	Header, 100mil, 3 × 1, Gold, TH	HTSW-103-09-G-S	Samtec
J4, J5, J6, J7, J8, J9, J10, J11, J12, J13, J14, J15, J16	13	Header, 2.54 mm, 1 × 1, Gold, TH	61300111121	Wurth Elektronik
L1	1	Inductor, Shielded Drum Core, Powdered Iron, 680 nH, 15.5 A, 0.005 Ω, SMD	IHLP2525CZERR68M01	Vishay-Dale
LBL1	1	Thermal Transfer Printable Labels, 1.250" W × 0.250" H - 10,000 per roll	THT-13-457-10	Brady
R1	1	Resistor, 57.6 k, 1%, 0.1 W, 0603	CRCW060357K6FKEA	Vishay-Dale
R2	1	Resistor, 12.1 k, 1%, 0.1 W, 0603	CRCW060312K1FKEA	Vishay-Dale
R3	1	Resistor, 10.0 k, 1%, 0.1 W, 0603	CRCW060310K0FKEA	Vishay-Dale
R4	1	Resistor, 82.0 k, 1%, 0.1 W, 0603	RC0603FR-0782KL	Yageo
R5	1	Resistor, 51.0 k, 1%, 0.1 W, 0603	RC0603FR-0751KL	Yageo
R6	1	Resistor, 0, 5%, 0.1 W, 0603	MCR03EZPJ000	Rohm
R7, R9	2	Resistor, 30 k, 1%, 0.1 W, 0603	RC0603FR-0730KL	Yageo
R10	1	Resistor, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06030000Z0EA	Vishay-Dale
TP2, TP4, TP7, TP10	4	Terminal, Turret, TH, Double	1502-2	Keystone
U1	1	3.8-V to 17-V Input, 12-A Synchronous Step-Down Voltage Regulator	TPS56C231RNNR	Texas Instruments
C15, C16	0	Capacitor, ceramic, 47 µF, 10 V, ±20%, X5R, 0805	GRM21BR61A476ME15L	MuRata
C10	0	Capacitor, ceramic, 56 pF, 50 V, ±5%, C0G/NP0, 0805	GRM1885C1H560JA01D	MuRata
R8	0	Resistor, 0, 5%, 0.1 W, 0603	MCR03EZPJ000	Rohm
FID1, FID2, FID3	0	Fiducial mark. There is nothing to buy or mount.	N/A	N/A

(1) Unless otherwise noted in the *Alternate Part Number* or *Alternate Manufacturer* columns, all parts may be substituted with equivalents.

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7 References

Texas Instruments, *TPS56C231 3.8 V to 17 V Input, 12-A Synchronous Step-Down Converter* data sheet

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