User's Guide

SLUU420–MAY 2010

Using the TPS51217EVM-533, High-Performance, Single-Synchronous Step-Down Controller for Notebook Power Supply

The TPS51217EVM-533 evaluation module (EVM) uses the TPS51217, a small-size single buck controller with adaptive on-time D-CAP™ providing dynamically selectable 0.9-V to 1.2-V output at up to 20 A from input voltages ranging from 8 V to 20 V.

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1 Description

The TPS51217EVM is designed to use a regulated voltage between 8 V and 20 V to produce dynamically selectable 0.9 V to 1.2 V output at up to 20 A of load current. The TPS51217EVM is designed to demonstrate the TPS51217 in a typical low-voltage application while providing a number of test points to evaluate the performance of the TPS51217.

1.1 Typical Applications

- Notebook Computers
- I/O Supplies
- System Power Supplies

1.2 Features

- Dynamically selectable output voltage from 0.9 V to 1.2 V by 0.1-V step
- 20-A DC steady state current
- Supports pre-bias output voltage start-up
- 340-kHz switching frequency
- SW1 for enable function
- Convenient test points for probing critical waveforms

2 Electrical Performance Specifications

Table 1. TPS51217EVM Electrical Performance Specifications

SPECIFICATION		TEST CONDITIONS	MIN	TYP	MAX	UNITS
INPUT						
V_{IN}	Input voltage range		8	12	20	V
I_{MAX}	Maximum input current	V_{IN}=8 V, I_{OUT}= 20 A		3		A
	No load input current	V_{IN}=8 V, I_{OUT}= 0 A		0.01		mA
V_{V5IN}	Voltage range		4.5	5.0	5.5	V
I_{MAX}	Maximum input current	V_{V5IN}=5 V, V_{IN}=12 V, I_{OUT}= 20 A		15		mA
	No load input current	V_{V5IN}=5 V, V_{IN}=12 V, I_{OUT}= 0 A		0.4		mA
OUTPUT						
V_{OUT}	Output voltage	V_{IN}=12 V, (VID1,VID0)=(0,0), I_{OUT}= 10 A		0.9		V
		V_{IN}=12 V, (VID1,VID0)=(0,1), I_{OUT}= 10 A		1.0		
		V_{IN}=12 V, (VID1,VID0)=(1,0), I_{OUT}= 10 A		1.1		
		V_{IN}=12 V, (VID1,VID0)=(0,0), I_{OUT}= 10 A		1.2		
I_{OUT}	Output current	Output load current		20		A
	Line Regulation	8 V ≤ V_{IN} ≤ 20 V, V_{OUT}=0.9 V, I_{OUT}= 20 A		0.3%		
	Load Regulation	V_{IN} = 12 V, V_{OUT}=0.9 V, 1 mA ≤ I_{OUT} ≤ 20 A		0.4%		
$V_{RIPPLEL}$		V_{IN} = 12 V, V_{OUT}=0.9 V, I_{OUT}= 20 A		29		mV_{P-P}
I_{OC}	Output overcurrent			28		
SYSTEM						
f_{SW}	Switching frequency	V_{IN} = 8 V, V_{OUT}=0.9 V, I_{OUT}= 10 A		340		kHz
	Peak efficiency	V_{IN} = 12 V, V_{OUT}=0.9		88.8%		
	Full load efficiency	V_{IN} = 12 V, V_{OUT}=0.9 V, I_{OUT}= 20 A		84.4%		
T_A	Operating ambient temperature			25		°C

3 Schematic

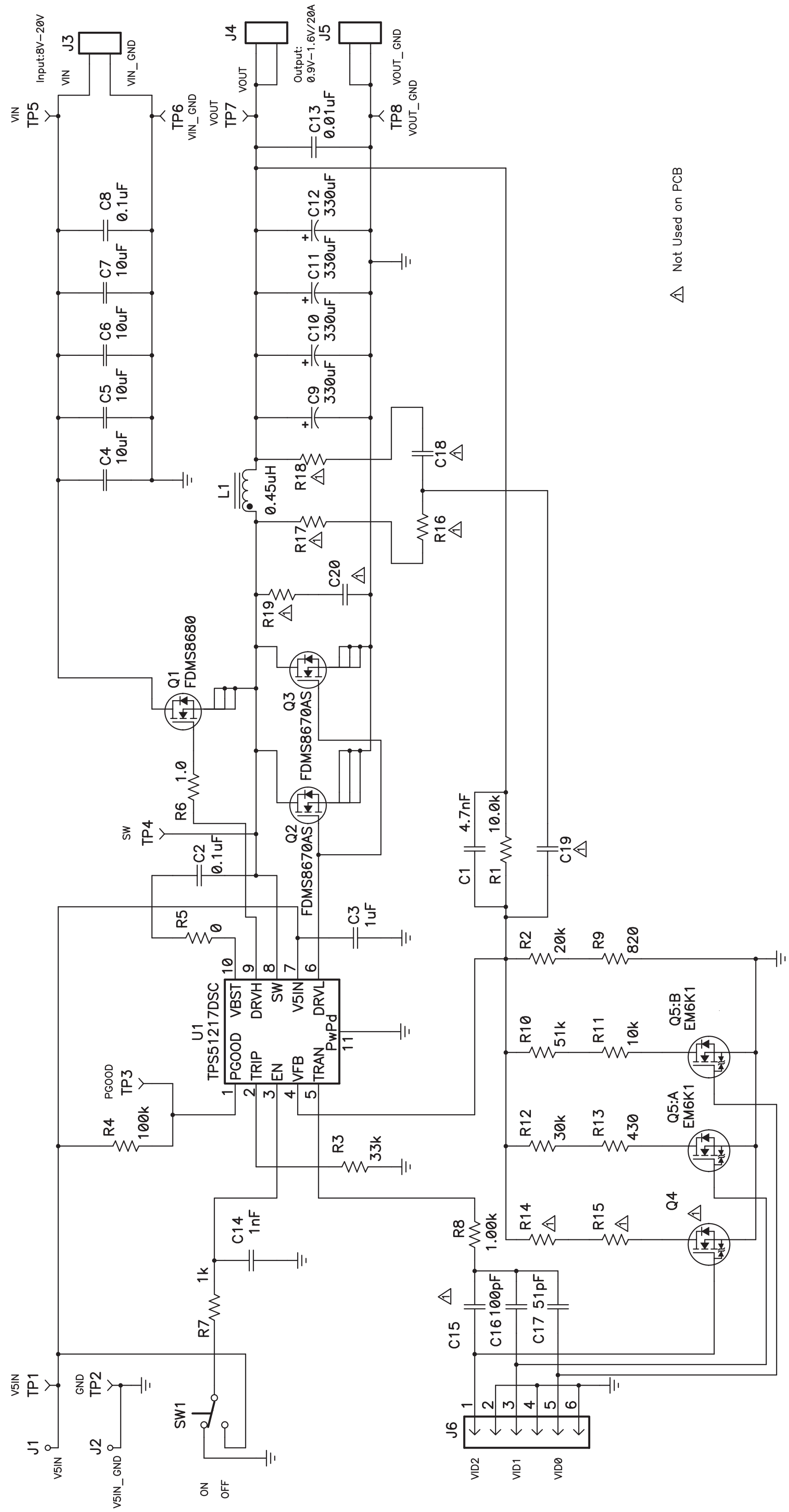

Figure 1. TPS51217EVM-533 Schematic

4 Test Setup

4.1 Test Equipment

Connect test equipment and TPS51125AEVM board as shown in Section 4.2.

4.1.1 Voltage Source

The input voltage source VIN should be a variable DC source between 0 V and 20 V capable of supplying 10 Adc. Connect VIN to J3 as shown in Figure 3. The input voltage source V5IN should be variable DC source between 0 V and 5.5 V capable of supplying 1 Adc. Connect V5IN to J1 and J2 as shown in Figure 3.

4.1.2 Multimeters

A voltmeter between 0 V and 21 V should be used to measure VIN at TP5 (VIN) and TP6 (VIN_GND). A voltmeter betwen 0 V and 7 V should be used to measure V5IN at TP1 (V5IN) and TP2 (V5IN_GND). A voltmeter betwen 0 V and 5 V should be used to measure VOUT at TP7(VOUT) and TP8 (VOUT_GND). A current meter between 0 A and 10 A (A1) as shown in Figure 3 is used for VIN input current measurements. A current meter between 0 A and 1 A (A2) as shown in Figure 3 is used for V5IN input current measurements.

4.1.3 Pulse Generator

A dual-channel pulse generator capable of 250 Hz, 3.3 V_{P-P} pulse output should be used.

4.1.4 Output Load

The output load should be an electronic constant resistance mode load capable of between 0 Adc and 30 Adc at 0.9 V to 1.2 V.

4.1.5 Oscilloscope

A digital or analog oscilloscope can be used to measure the output ripple. The oscilloscope should be set for 1 MΩ impedance, 20 MHz bandwidth, AC coupling, 2 µs/division horizontal resolution, 50 mV/division vertical resolution. Test points TP7 and TP8 can be used to measure the output ripple voltage by placing the oscilloscope probe tip through TP7 and holding the ground barrel TP8 as shown in Figure 2. Using a leaded ground connection may induce additional noise due to the large ground loop.

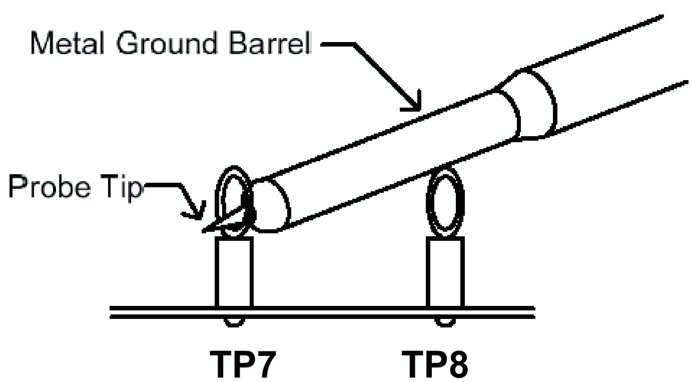

Figure 2. Tip and Barrel Measurement for Output Voltage Ripple

4.1.6 Fan

Some of the components in this EVM may approach temperatures of 60°C during operation. A small fan capable of between 200 LFM and 400 LFM is recommended to reduce component temperatures while the EVM is operating. The EVM should not be probed while the fan is not running.

4.1.7 Recommended Wire Gauge

For VIN to J3 (between 8 V and 20 V input) the recommended wire size is 1x AWG #14 per input connection, with the total length of wire less than 4 feet (2 feet input, 2 feet return). For J4 and J5 to LOAD the minimum recommended wire size is 2x AWG #14, with the total length of wire less than 4 feet (2 feet output, 2 feet return).

4.2 Recommended Test Setup

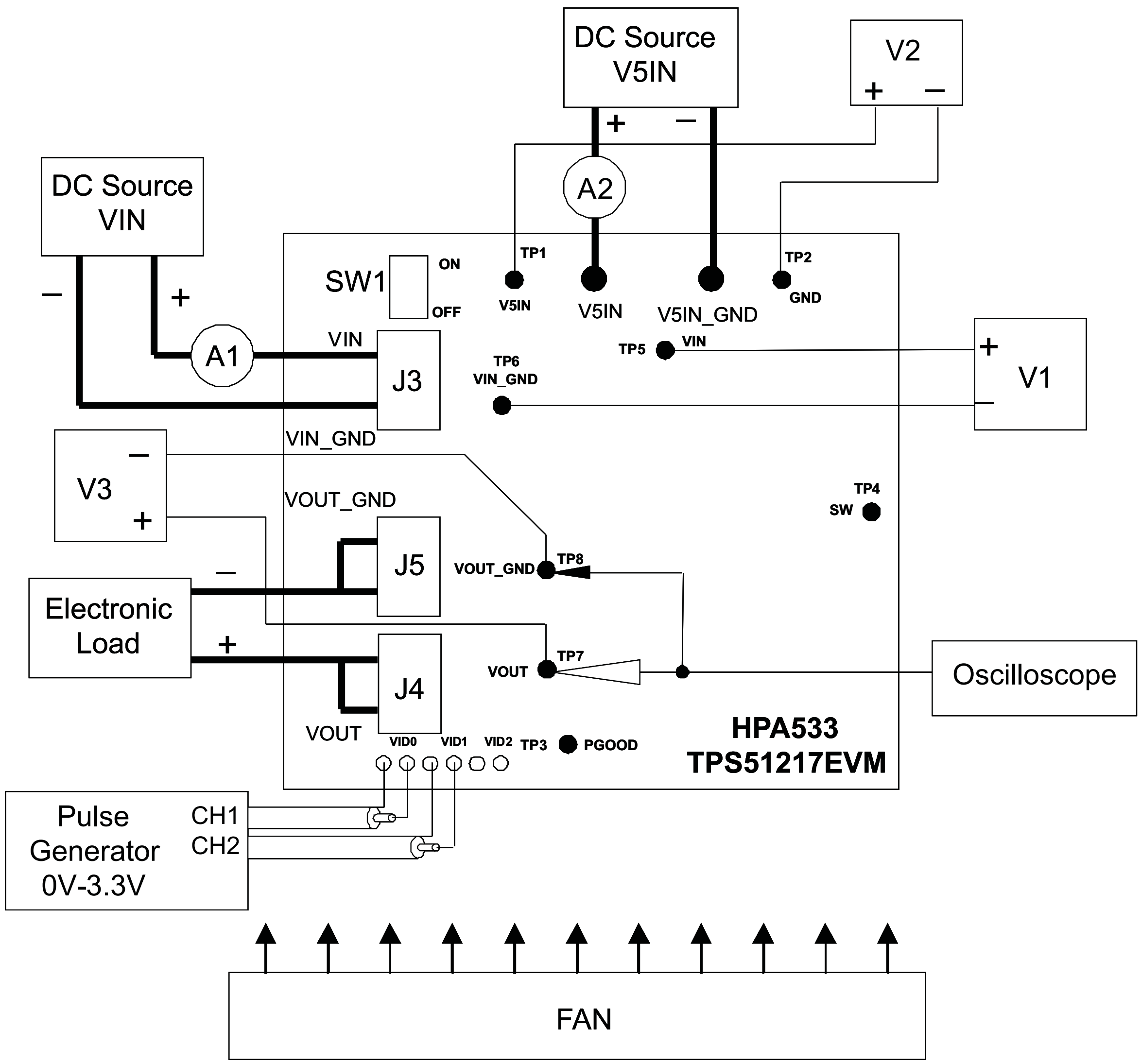

Figure 3. Recommended Test Set Up

Figure 3 shows the recommended test set up to evaluate the TPS51217EVM. Working at an ESD workstation, make sure that any wrist straps, bootstraps or mats are connected referencing the user to earth ground before power is applied to the EVM.

4.2.1 Input Connections

1. Prior to connecting the DC input source VIN and V5IN, it is advisable to limit the source current from VIN to 10 A and from V5IN to1A maximum. Make sure VIN and V5IN are initially set to 0 V and connected as shown in Figure 3.
2. Connect a voltmeter V1 at TP5 (VIN) and TP6 (VIN_GND) to measure the input voltage.
3. Connect a current meter A1 to measure the input current.
4. Connect a voltmeter V2 at TP1 (V5IN) and TP2 (V5IN_GND) to measure the 5-V input voltage.
5. Connect a pulse generator to input 2-bit VID signal for dynamic VOUT control. Make sure CH1 outputs 250Hz, 3.3-V_{P-P} pulse and CH2 outputs 125Hz, 3.3-V_{P-P} pulse synchronized with CH1. It is advisable to set transition time of the leading and trailing edge between 100 ns and 500 ns.

4.2.2 Output Connections

1. Connect load to J4 (VOUT) and J5 (VOUT_GND) and set load to constant resistance mode to sink 0 Adc before VIN is applied.
2. Connect a voltmeter V3 at TP7 (VOUT) and TP8 (VOUT_GND) to measure the output voltage.

4.2.3 Other Connections

Place a fan as shown in Figure 3 and turn on, making sure air is flowing across the EVM.

4.3 List of Test Points

Table 2. Test Point Functions

TEST POINTS	NAME	DESCRIPTION
TP1	V5IN	5-V supply
TP2	V5IN_GND	GND for 5-V supply
TP3	PGOOD	Power good
TP4	SW	Switch node
TP5	VIN	VIN supply
TP6	VIN_GND	GND for VIN supply
TP7	VOUT	VOUT
TP8	VOUT_GND	GND for VOUT

5 Test Procedure

5.1 Line/Load Regulation and Efficiency Measurement Procedure

1. Ensure that the load is set to constant resistance mode and to sink 0 Adc.
2. Ensure that the SW1 switch on the EVM is at OFF position before VIN and V5IN are applied.
3. Increase VIN from 0 V to 8 V, using V1 to measure input voltage.
4. Increase V5IN from 0 V to 5, using V2 to measure input voltage.
5. Turn the SW1 switch to the ON position to enable the controller.
6. Input 0 V or 3.3 V (DC) to VID0 and VID1 to select V_{OUT} among 0.9 V, 1.0 V, 1.1 V and 1.2 V.
7. Vary load from between 0 Adc to 20 Adc, V_{OUT} should remain in load regulation.
8. Vary VIN from between 8 V and 20 V, V_{OUT} should remain in line regulation.
9. Decrease the load to 0 A.
10. Input 0 V to VID0 and VID1.
11. Turn the SW1 switch to the OFF position to disable the controller.
12. Decrease V5IN to 0 V.
13. Decrease VIN to 0 V.

5.2 Dynamic Output Voltage Transition Measurement Procedure

1. Follow steps 1 to 5 of *Line/Load Regulation and Efficiency Measurement Procedure*.
2. Ensure pulse configuration is Return-to-Zero (RZ) with 50% duty ratio.
3. Run the pulse generator. V_{OUT} steps down from 1.2 V to 0.9 V as shown in Figure 17.
4. Stop the pulse generator. Change the configuration as inverted.
5. Run the pulse generator again. V_{OUT} steps up from 0.9 V to 1.2 V as shown in Figure 18.
6. Stop the pulse generator.
7. Follow steps 11 to 13 of *Line/Load Regulation and Efficiency Measurement Procedure.*

5.3 Equipment Shutdown

1. Shut down load.
2. Shut down pulse generator.
3. Shut down V5IN.
4. Shut down VIN.
5. Shut down FAN.

6 Performance and Typical Characteristic Curves

Figure 4 through Figure 18 present typical performance curves for TPS51217EVM-533.

6.1 Efficiency

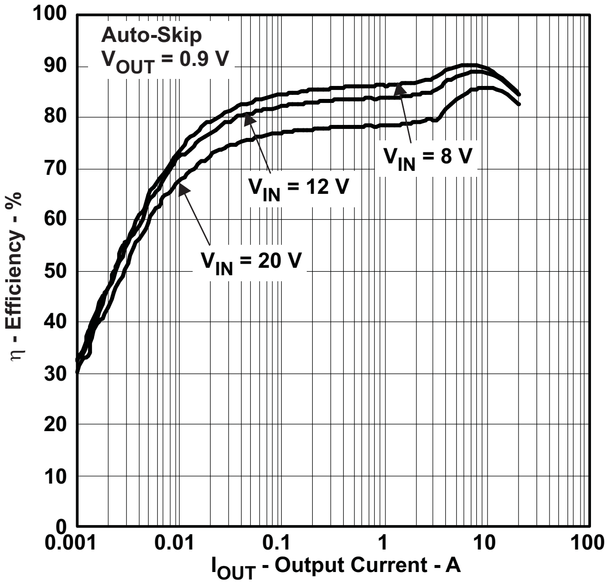

Figure 4. Efficiency at 0.9-V Output

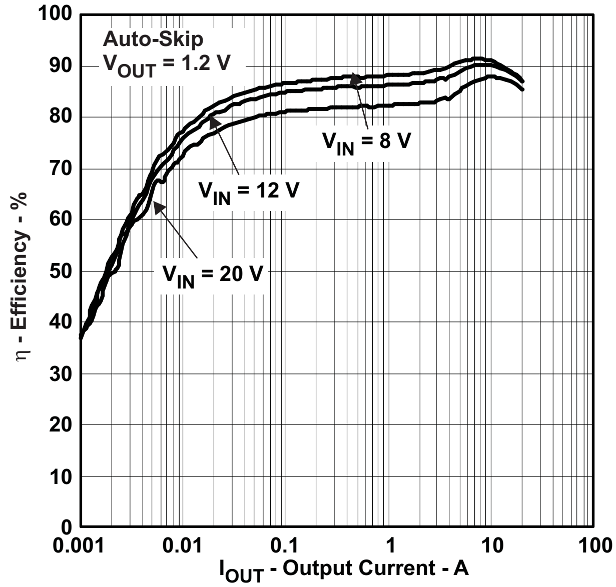

Figure 5. Efficiency at 1.2-V Output

6.2 Load Regulation

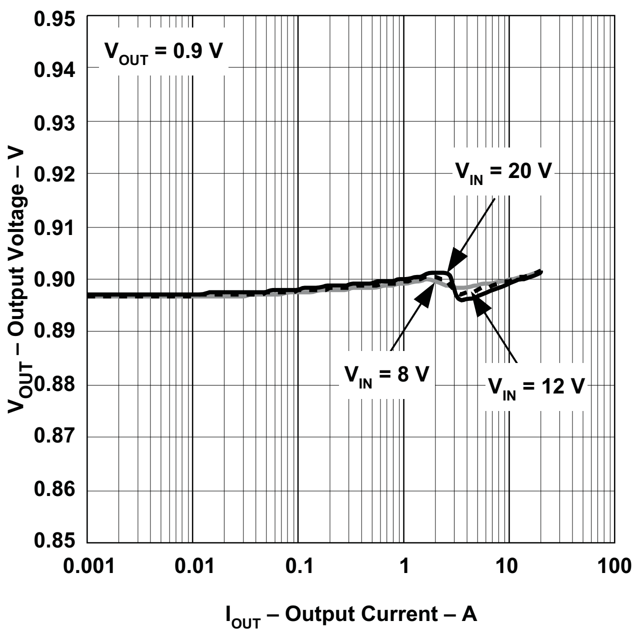

Figure 6. Load Regulation at 0.9-V Output

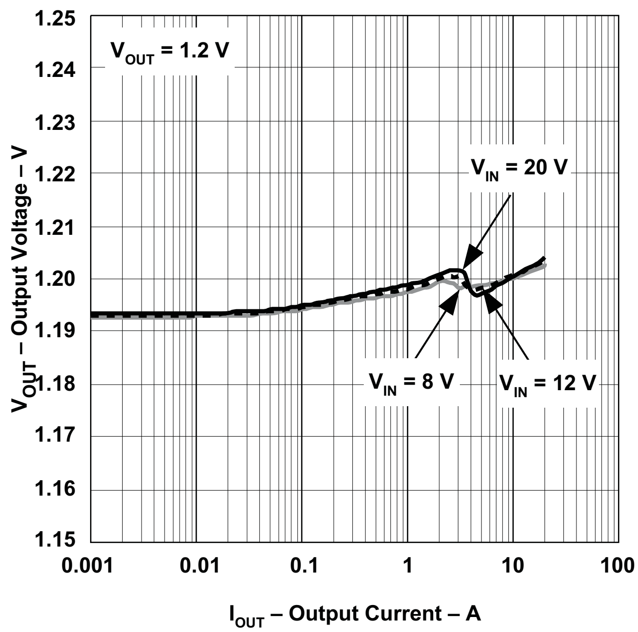

Figure 7. Load Regulation at 1.2-V Output

6.3 Line Regulation

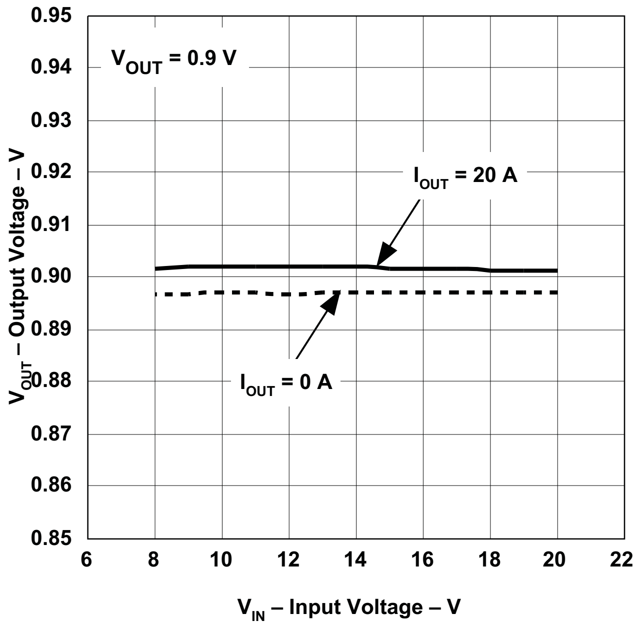

Figure 8. Line Regulation at 0.9-V Output

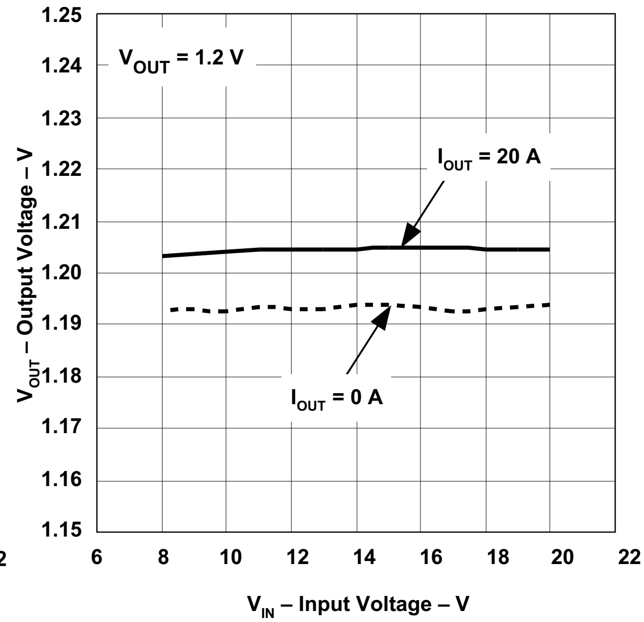

Figure 9. Line Regulation at 1.2-V Output

6.4 Transient Response

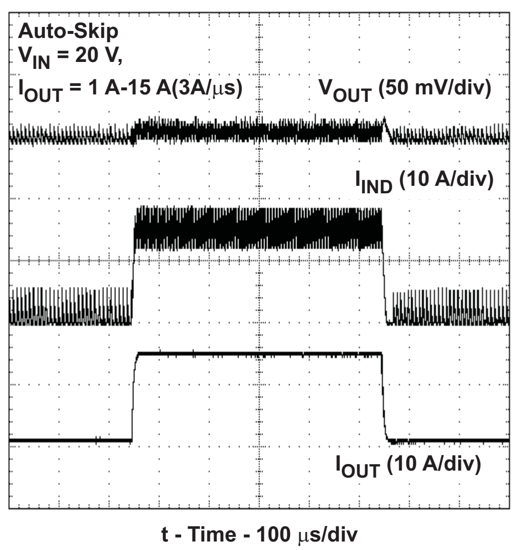

Figure 10. Load Transient 0.9-V Output

6.5 Output Ripple

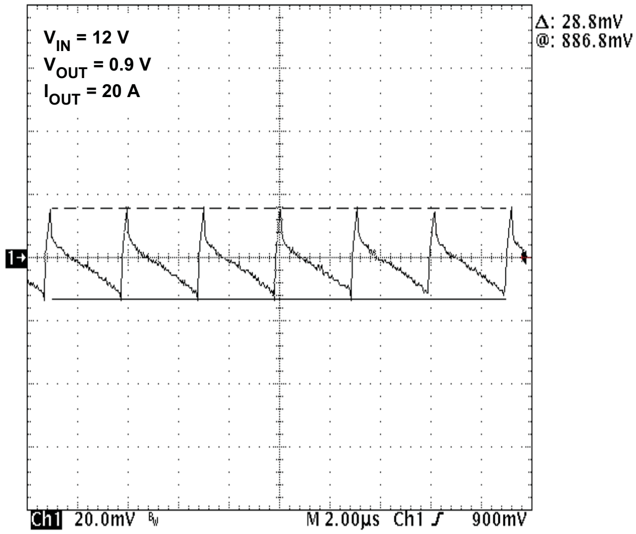

Figure 11. Output Ripple at 0.9-V Output

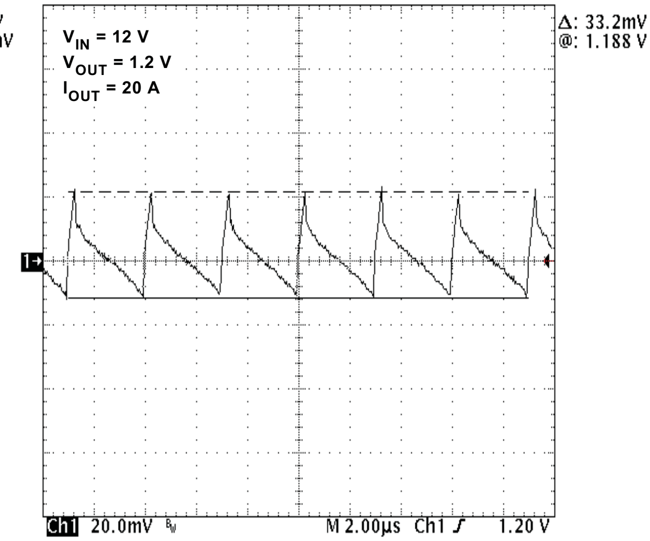

Figure 12. Output Ripple at 1.2-V Output

6.6 Switch-Node Voltage

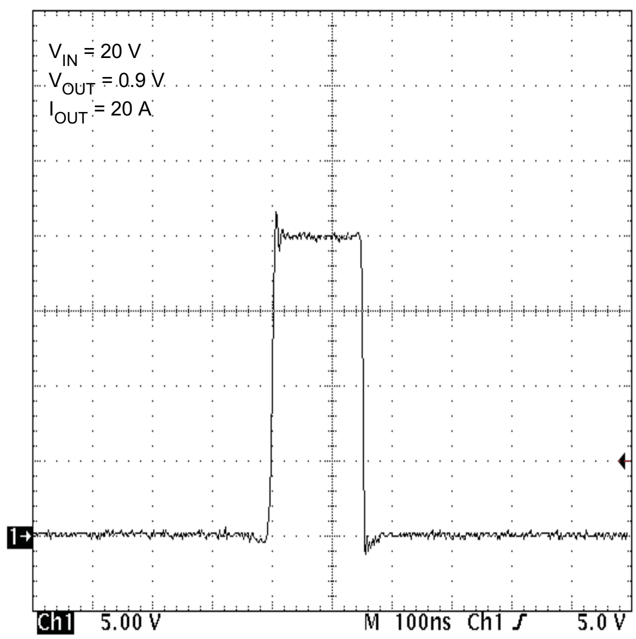

Figure 13. Switching Node Waveform

6.7 Start and Stop

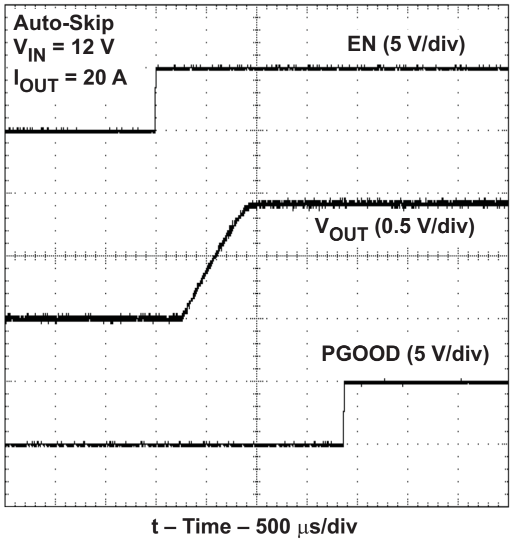

Figure 14. Enable Turn-On Waveform at 0.9-V Output

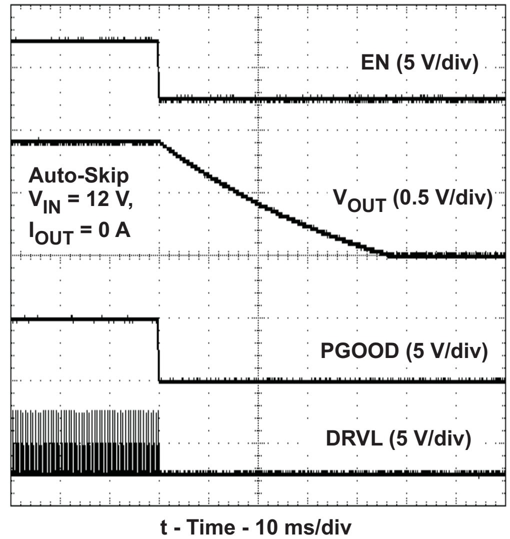

Figure 15. Enable Turn-Off Waveform at 0.9-V Output

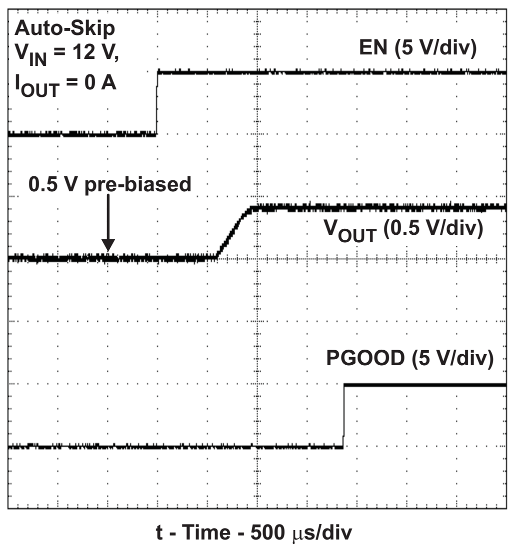

Figure 16. Pre-Bias Turn-On Waveform at 0.9-V Output

6.8 Dymamic Output Voltage Transitions

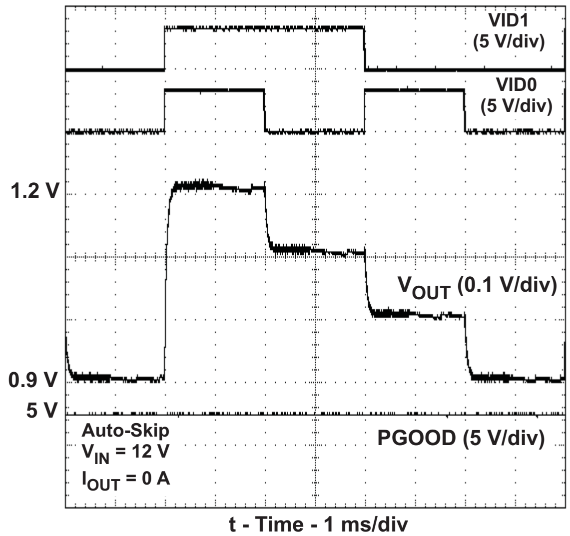

Figure 17. Output Voltage Step-Down

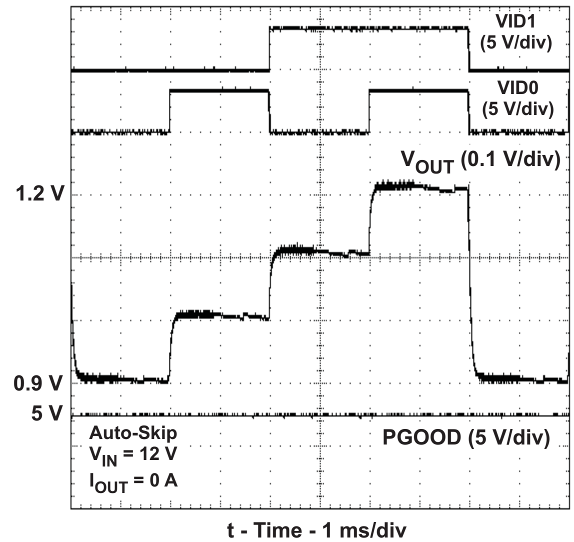

Figure 18. Output Voltage Step-Up

7 EVM Assembly Drawing and PCB Layouts

Figure 19 through Figure 24 show the design of the TPS51217EVM-533 printed circuit board. The EVM has been designed using four layers, of 2-oz. copper circuit board.

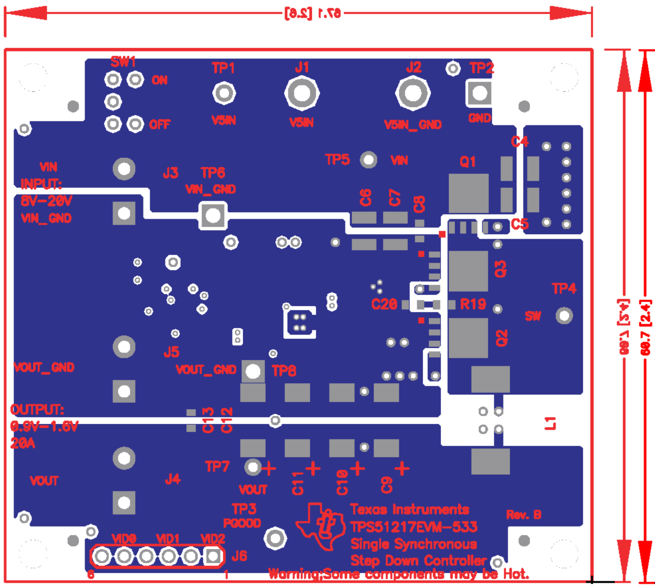

Figure 19. Top Layer Assembly Drawing (Top View)

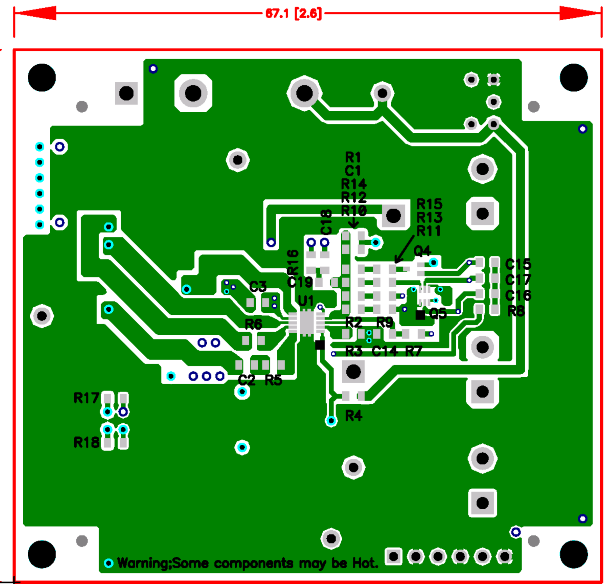

Figure 20. Bottom Assembly Drawing (Bottom View)

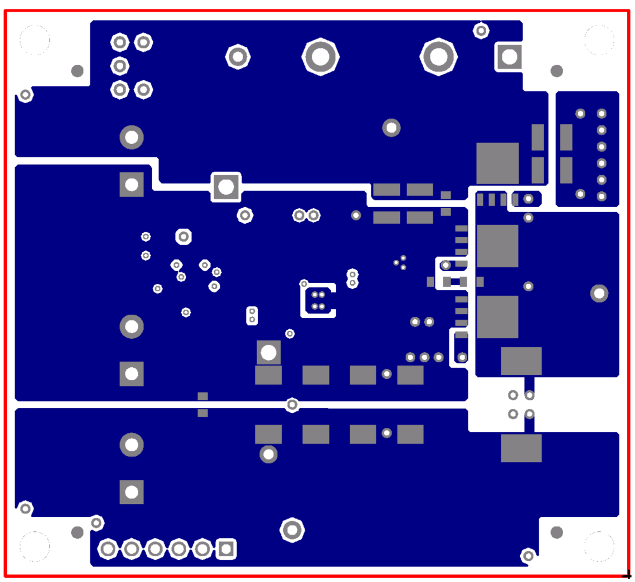

Figure 21. Top Copper (Top View)

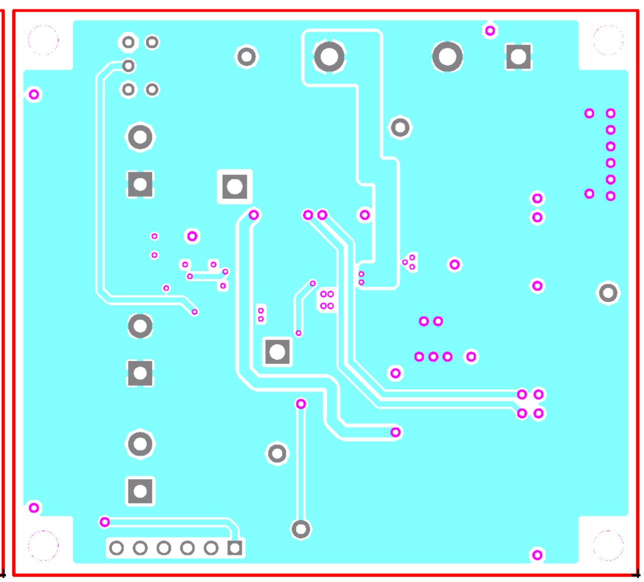

Figure 22. Internal Layer 1 (Top View)

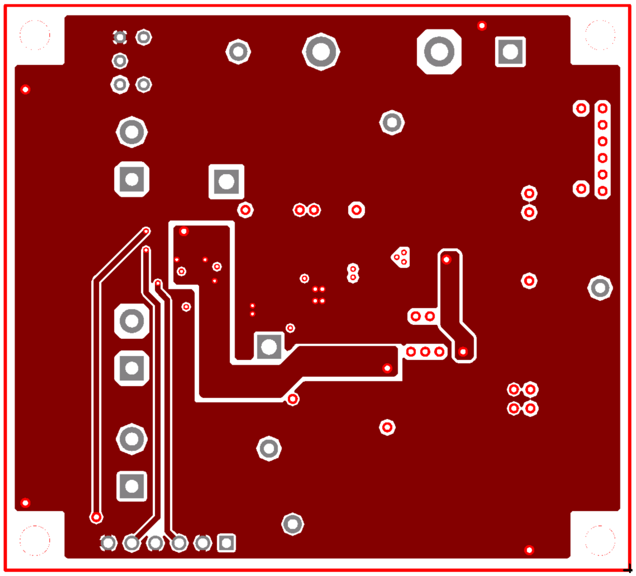

Figure 23. Internal Layer 2 (Top View)

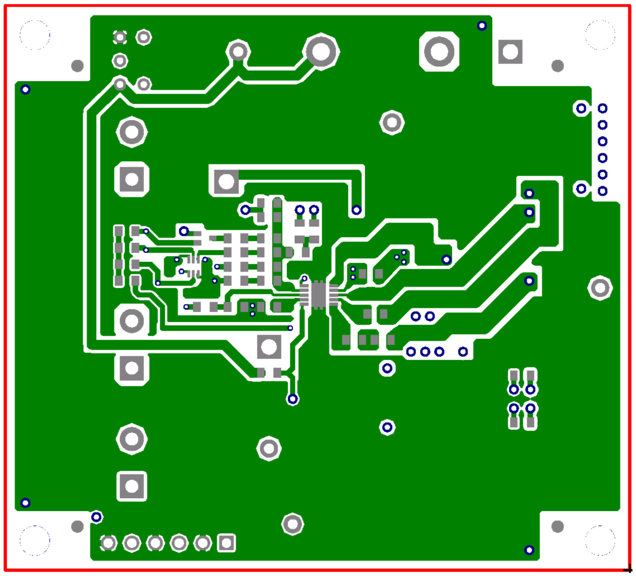

Figure 24. Bottom Copper (Top View)

8 List of Materials

List of materials for the TPS51217EVM.

Table 3. List of Materials

REFDES	QTY	DESCRIPTION	MFR	PART NUMBER
C1	1	Capacitor, ceramic, 4.7 nF, 50 V, X7R, 5%, 0603	STD	STD
C2, C8	2	Capacitor, ceramic, 0.1 µF, 50 V, X7R, 10%, 0603	STD	STD
C3	1	Capacitor, ceramic, 1 µF, 16 V, X7R, 10%, 0603	STD	STD
C4, C5, C6, C7	4	Capacitor, ceramic, 10 µF, 25 V, X7R, 10%, 1210	TDK	C3225X7R1E106K
C9, C10, C11, C12	4	Capacitor, aluminum, 330 µF, 2 V, 12 mΩ, 20%	Panasonic	EEFCX0D331XR
C13	1	Capacitor, ceramic, 0.01 µF, 50 V, X7R, 10%, 0603	STD	STD
C14	1	Capacitor, ceramic, 1 nF, 50 V, X7R, 10%, 0603	STD	STD
C16	1	Capacitor, ceramic, 100 pF, 50 V, CH, 5%, 0603	STD	STD
C17	1	Capacitor, ceramic, 51 pF, 50 V, CH, 5%, 0603	STD	STD
C15, C18, C19, C20	0	Not used		
L1	1	Inductor, power choke SMT, 17 A, 1.1 mΩ	Panasonic	ETQP4LR45XFC
Q1	1	MOSFET, N-channel, 30 V, 35 A, 7.0 mΩ	Fairchild	FDMS8680
Q2, Q3	2	MOSFET, N-channel, 30 V, 42 A, 3.0 mΩ	Fairchild	FDMS8670AS
Q5	1	MOSFET, dual, N-channel, 30 V, 100 mA	Rohm	EM6K1
Q4	0	Not used		
R1	1	Resistor, chip, 10.0 kΩ, 1/16W, 1%, 0603	STD	STD
R2	1	Resistor, chip, 20 kΩ, 1/16W, 1%, 0603	STD	STD
R3	1	Resistor, chip, 33 kΩ, 1/16W, 1%, 0603	STD	STD
R4	1	Resistor, chip, 100 kΩ, 1/16W, 1%, 0603	STD	STD
R5	1	Resistor, chip, 0 Ω 1/16W, 1%, 0603	STD	STD
R6	1	Resistor, chip, 1 Ω, 1/16W, 1%, 0603	STD	STD
R7, R8	2	Resistor, chip, 1 kΩ, 1/16W, 1%, 0603	STD	STD
R9	1	Resistor, chip, 820 Ω, 1/16W, 1%, 0603	STD	STD
R10	1	Resistor, chip, 51 kΩ, 1/16W, 1%, 0603	STD	STD
R11	1	Resistor, chip, 10 kΩ, 1/16W, 1%, 0603	STD	STD
R12	1	Resistor, chip, 30 kΩ, 1/16W, 1%, 0603	STD	STD
R13	1	Resistor, chip, 430 Ω, 1/16W, 1%, 0603	STD	STD
R14, R15, R16, R17, R18, R19	0	Not used		
U1	1	IC, single synchronous step-down controller	TI	TPS51217DSC

9 References

TPS51217 High-Performance, Single-Synchronous Step-Down Controller for Notebook Power Supply (SLUS947)

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Your Sole Responsibility and Risk. You acknowledge, represent and agree that

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard.
3. Since the EVM is not a completed product, it may not meet all applicable regulatory and safety compliance standards (such as UL, CSA, VDE, CE, RoHS and WEEE) which may normally be associated with similar items. You assume full responsibility to determine and/or assure compliance with any such standards and related certifications as may be applicable. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.

Certain Instructions. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, some circuit components may have case temperatures greater than 60°C as long as the input and output ranges are maintained at nominal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be indentified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch.

EVALUATION BOARD/KIT/MODULE (EVM) WARNINGS, RESTRICTIONS AND DISCLAIMER (continued)

Agreement to Defend, Indemnify and Hold Harmless. You agree to defend, indemnify and hold TI, its licensors and their representatives harmless from and against any and all claims, damages, losses, expenses, costs and liabilities (collectively, “Claims”) arising out of or in connection with any use of the EVM that is not in accordance with the terms of this agreement. This obligation shall apply whether Claims arise under the law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

S**afety-Critical or Life-Critical Applications**. If you intend to evaluate TI components for possible use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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