User's Guide

TPS51217 Buck Controller Evaluation Module User's Guide

ABSTRACT

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.

Table of Contents

Trademarks

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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 2-1. 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

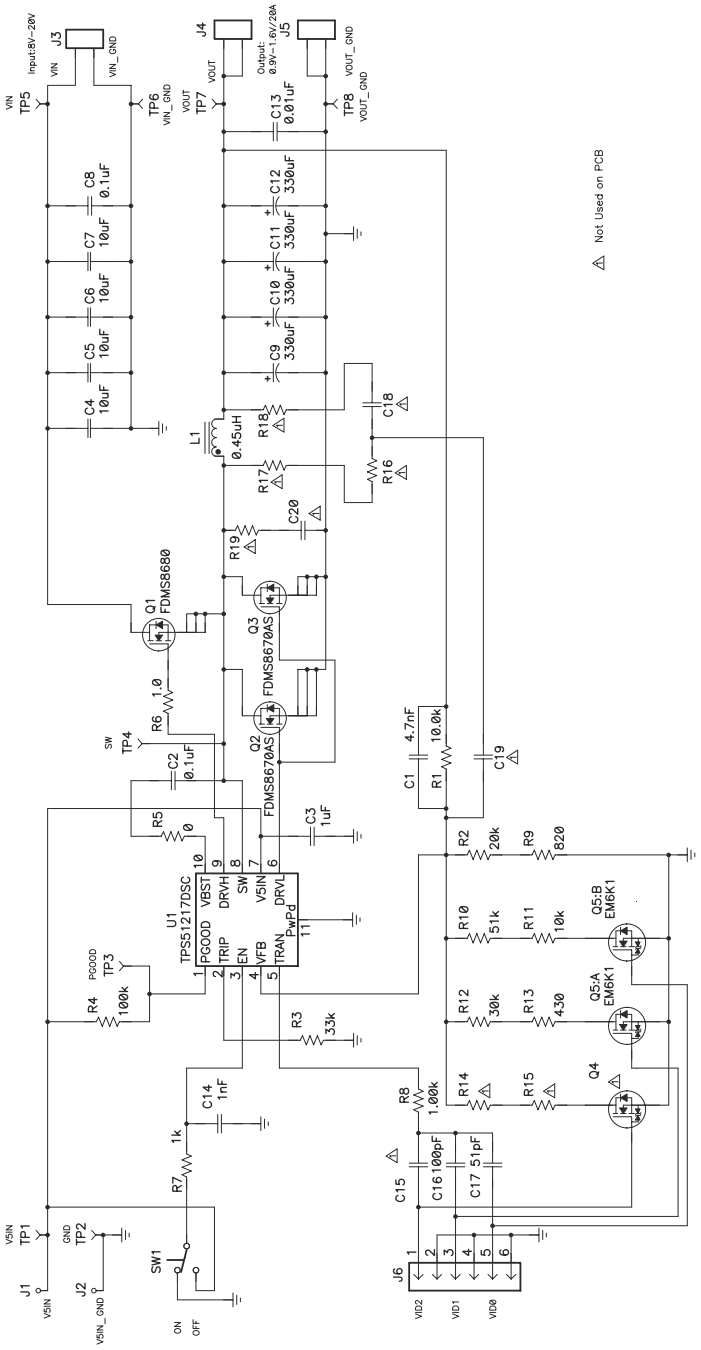

Figure 3-1. TPS51217EVM-533 Schematic

4 Test Setup

4.1 Test Equipment

Connect the test equipment and the 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 A_{DC}. Connect VIN to J3 as shown in Figure 4-2. The input voltage source V5IN should be variable DC source between 0 V and 5.5 V capable of supplying 1 A_{DC}. Connect V5IN to J1 and J2 as shown in Figure 4-2.

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 between 0 V and 7 V should be used to measure V5IN at TP1 (V5IN) and TP2 (V5IN_GND). A voltmeter between 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 4-2 is used for VIN input current measurements. A current meter between 0 A and 1 A (A2) as shown in Figure 4-2 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 the following:

- 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 4-1. Using a leaded ground connection can induce additional noise due to the large ground loop.

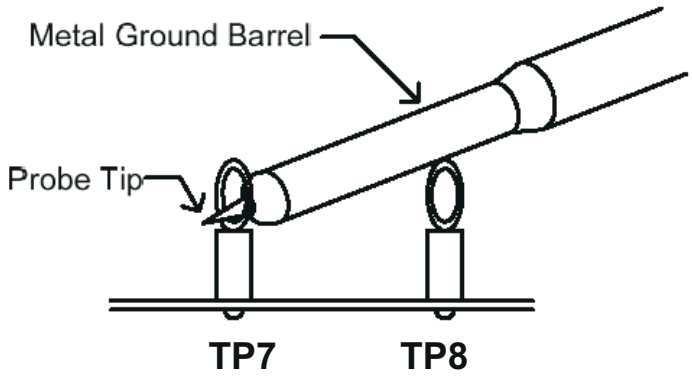

Figure 4-1. Tip and Barrel Measurement for Output Voltage Ripple

4.1.6 Fan

Some of the components in this EVM cam 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 1× AWG #14 per input connection, with the total length of wire less than four feet (2-feet input, 2-feet return). For J4 and J5 to LOAD, the minimum recommended wire size is 2× AWG #14, with the total length of wire less than four feet (2-feet output, 2-feet return).

4.2 Recommended Test Setup

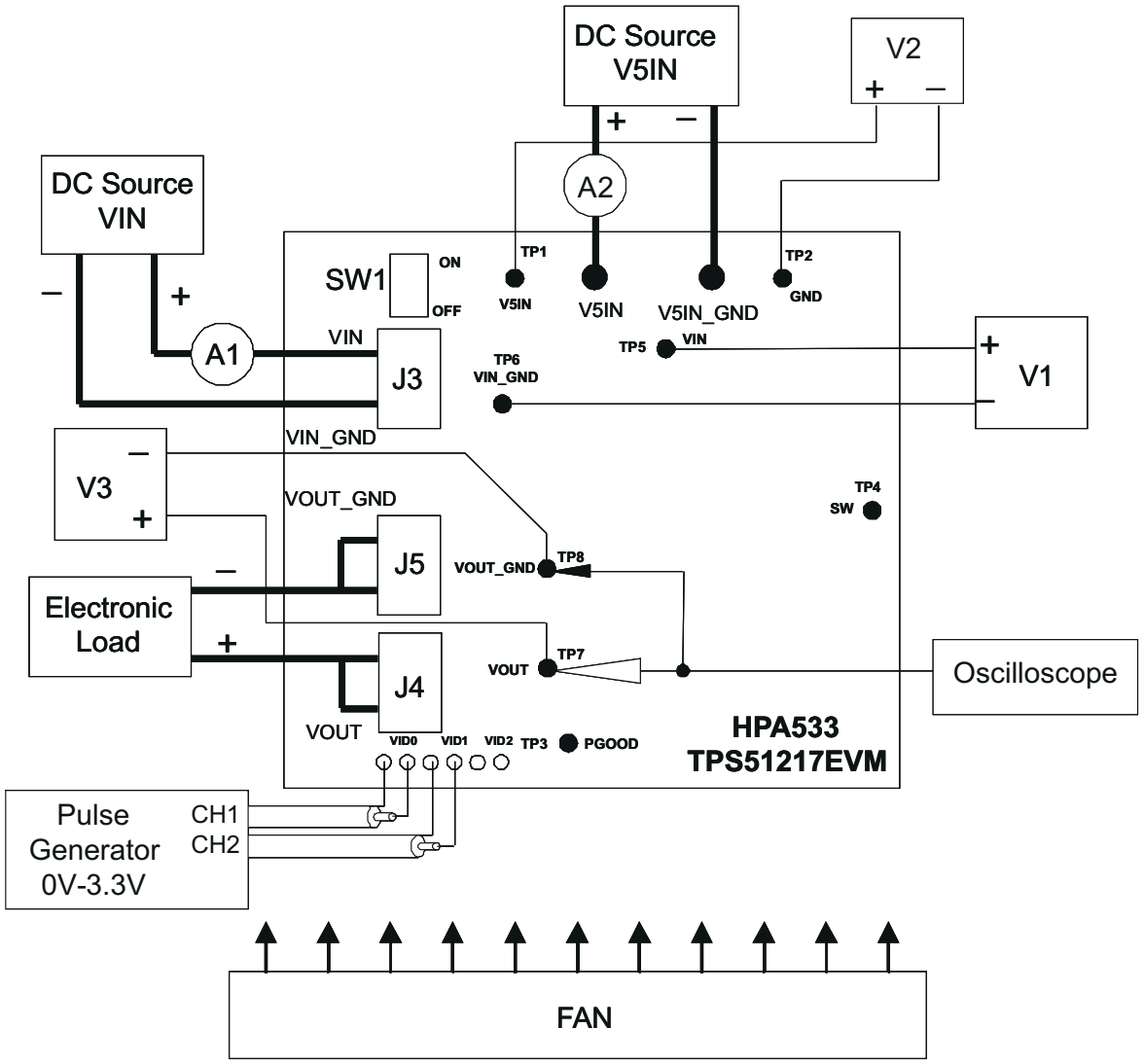

Figure 4-2. Recommended Test Setup

Figure 4-2 shows the recommended test setup 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 to 1 A maximum. Make sure VIN and V5IN are initially set to 0 V and connected as shown in Figure 4-2.
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 250-Hz, 3.3-V_{P-P} pulse and CH2 outputs 125-Hz, 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 the load to J4 (VOUT) and J5 (VOUT_GND) and set load to constant resistance mode to sink 0 A_{DC} 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 4-2 and turn it on, making sure air is flowing across the EVM.

4.3 List of Test Points

Table 4-1. 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 A_{DC}.
2. Ensure that the SW1 switch on the EVM is at the 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 the load from between 0 A_{DC} to 20 A_{DC}. 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 Section 5.1.
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 6-14.
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 6-15.
6. Stop the pulse generator.
7. Follow steps 11 to 13 of Section 5.1.

5.3 Equipment Shutdown

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

6 Performance and Typical Characteristic Curves

Figure 6-1 through Figure 6-15 present typical performance curves for the TPS51217EVM-533.

6.1 Efficiency

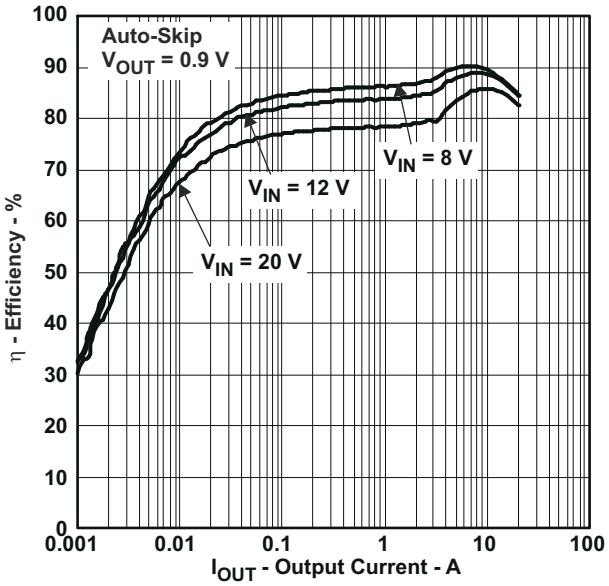

Figure 6-1. Efficiency at 0.9-V Output

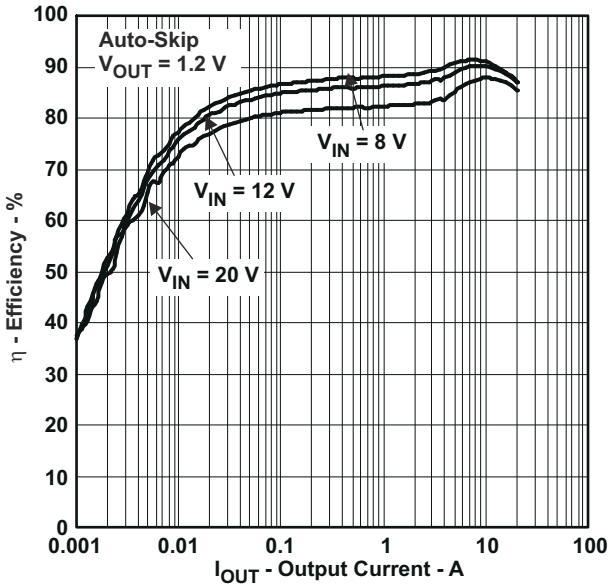

Figure 6-2. Efficiency at 1.2-V Output

6.2 Load Regulation

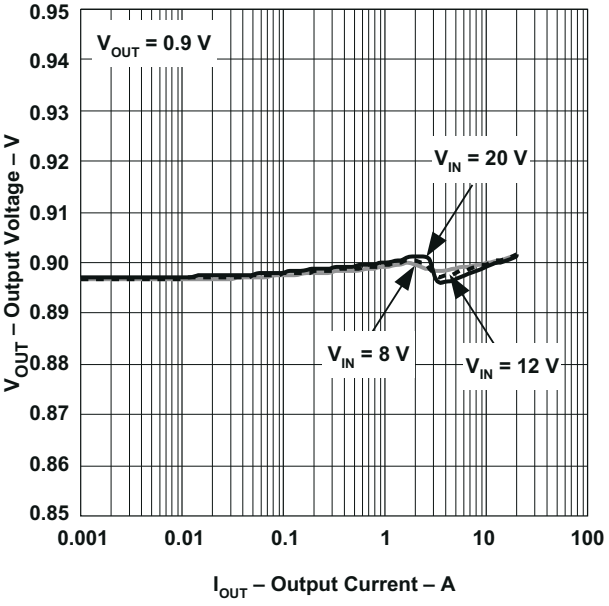

Figure 6-3. Load Regulation at 0.9-V Output

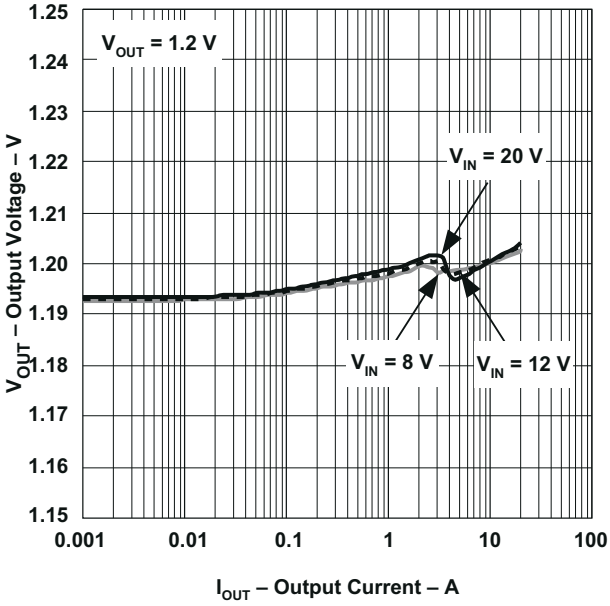

Figure 6-4. Load Regulation at 1.2-V Output

6.3 Line Regulation

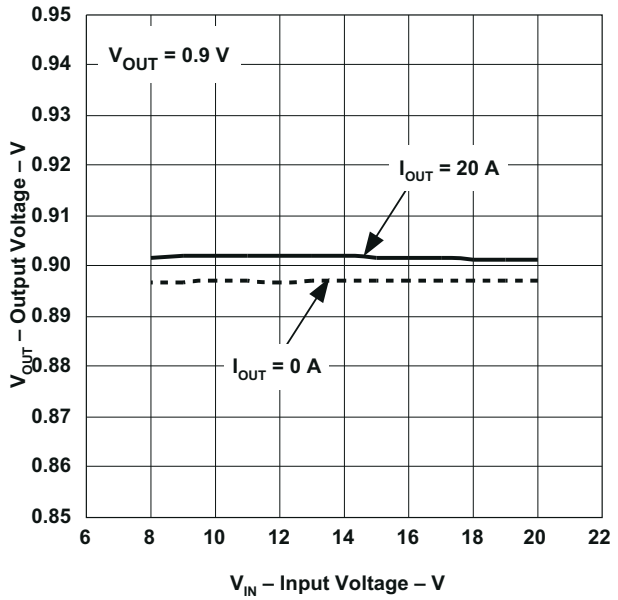

Figure 6-5. Line Regulation at 0.9-V Output

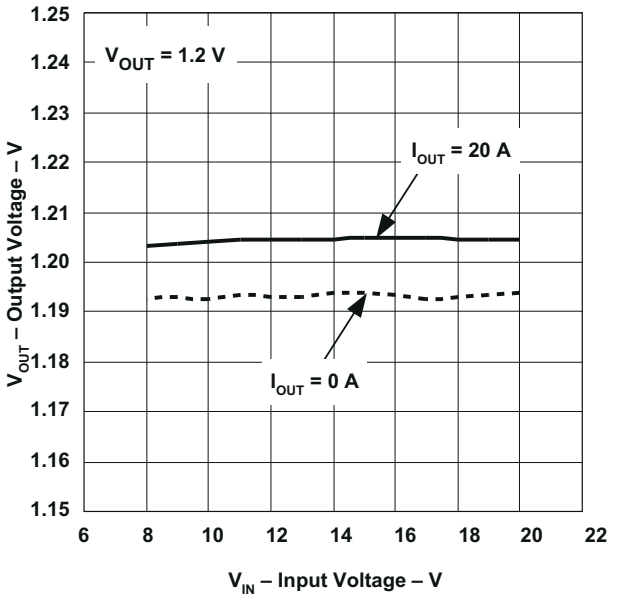

Figure 6-6. Line Regulation at 1.2-V Output

6.4 Transient Response

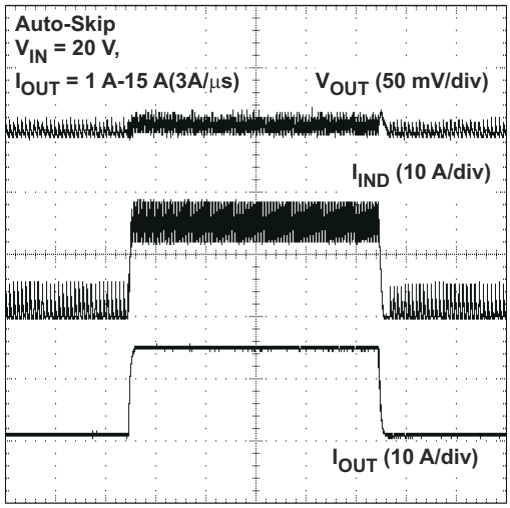

Figure 6-7. Load Transient 0.9-V Output

6.5 Output Ripple

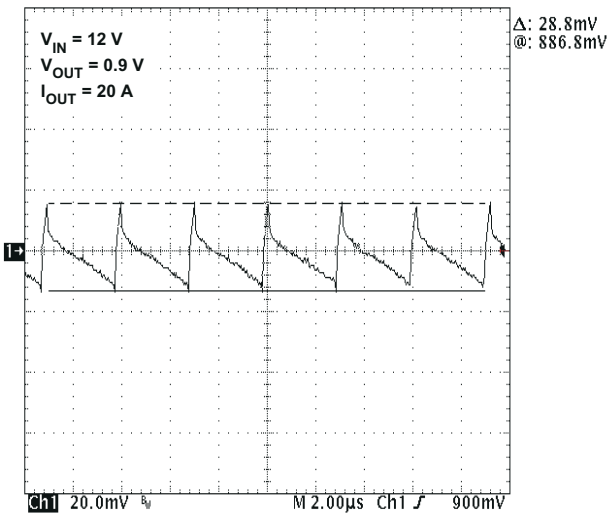

Figure 6-8. Output Ripple at 0.9-V Output

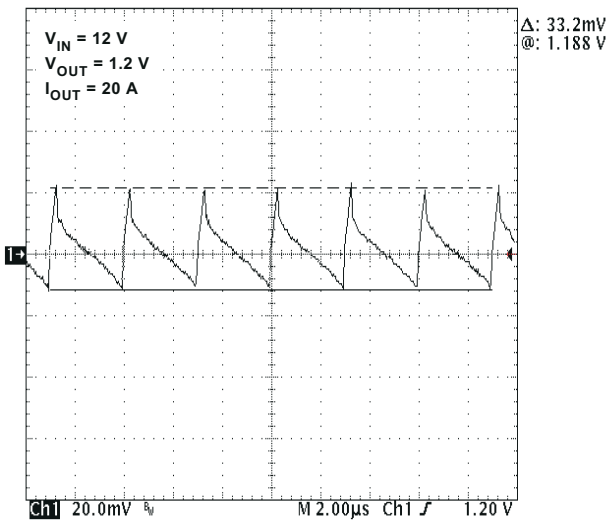

Figure 6-9. Output Ripple at 1.2-V Output

6.6 Switch-Node Voltage

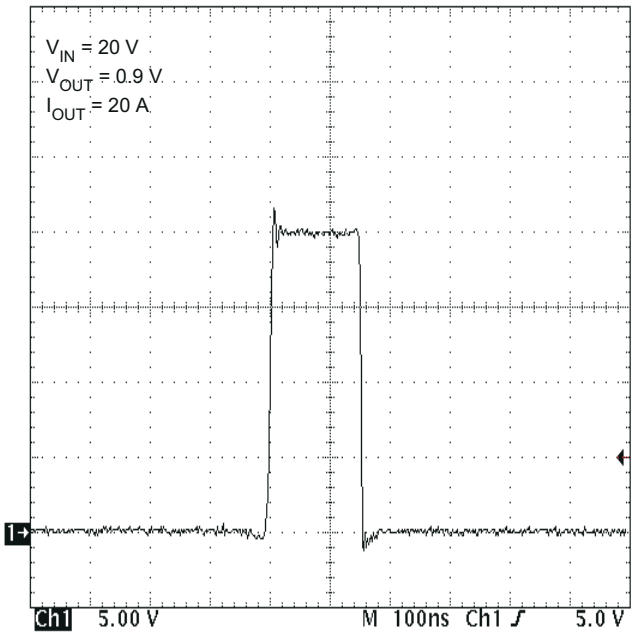

Figure 6-10. Switching Node Waveform

6.7 Start and Stop

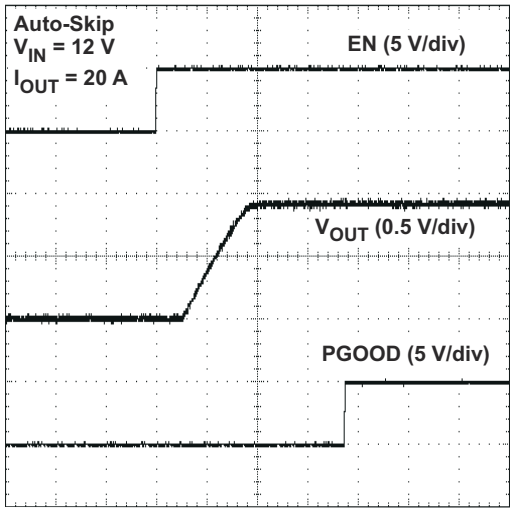

Figure 6-11. Enable Turn-On Waveform at 0.9-V Output

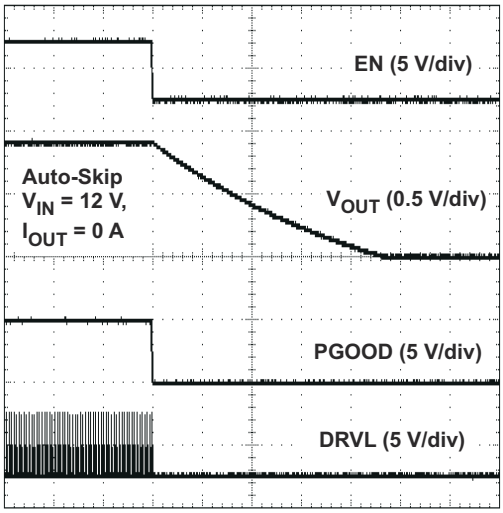

Figure 6-12. Enable Turn-Off Waveform at 0.9-V Output

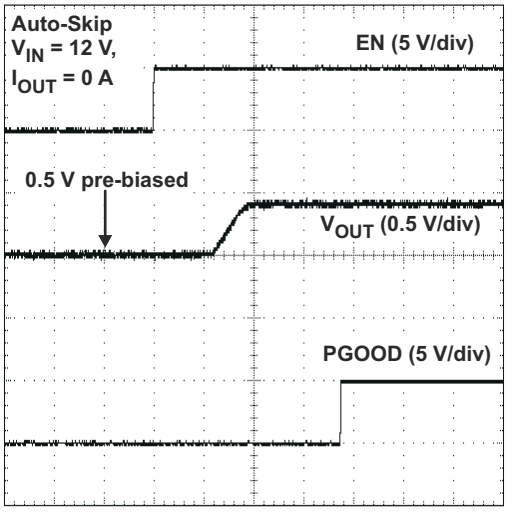

Figure 6-13. Pre-Bias Turn-On Waveform at 0.9-V Output

6.8 Dymamic Output Voltage Transitions

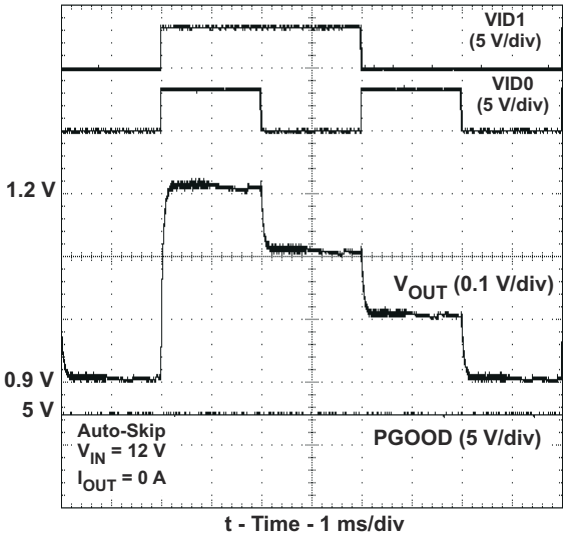

Figure 6-14. Output Voltage Step-Down

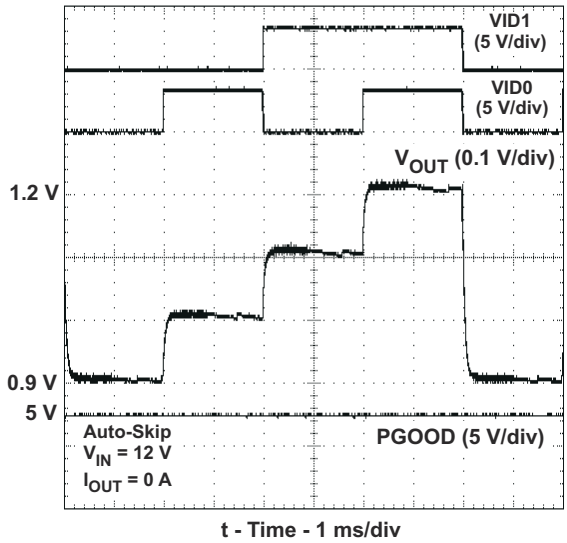

Figure 6-15. Output Voltage Step-Up

7 EVM Assembly Drawing and PCB Layouts

Figure 7-1 through Figure 7-6 show the design of the TPS51217EVM-533 printed circuit board. The EVM has been designed using four layers, of 2-oz. copper circuit board.

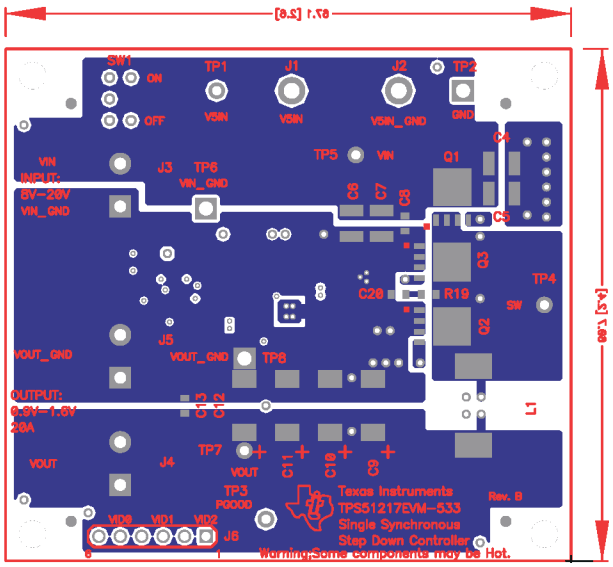

Figure 7-1. Top Layer Assembly Drawing (Top View)

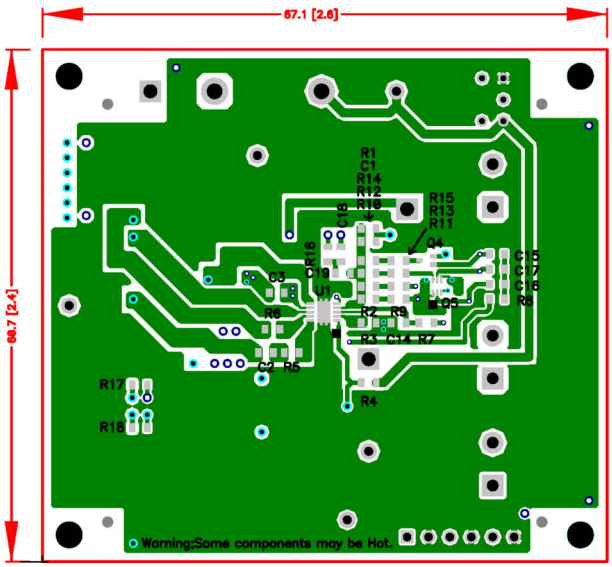

Figure 7-2. Bottom Assembly Drawing (Bottom View)

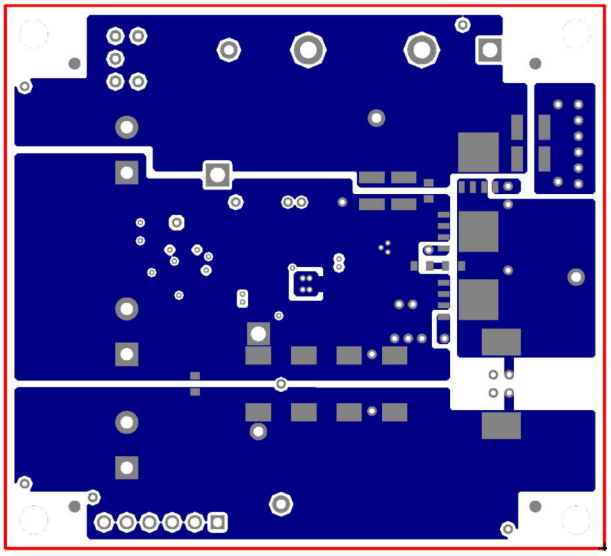

Figure 7-3. Top Copper (Top View)

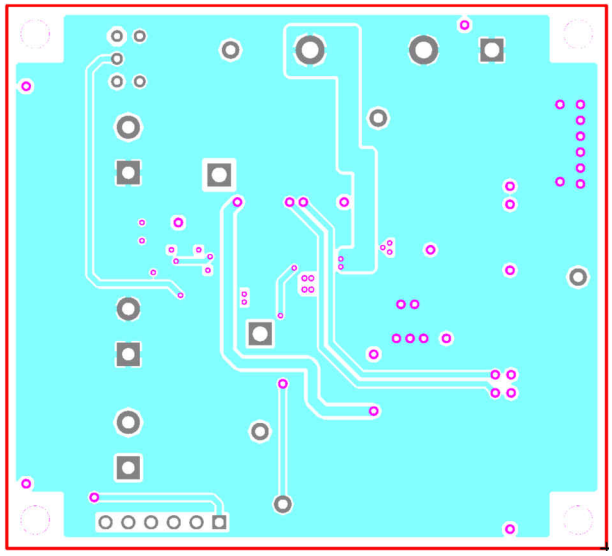

Figure 7-4. Internal Layer 1 (Top View)

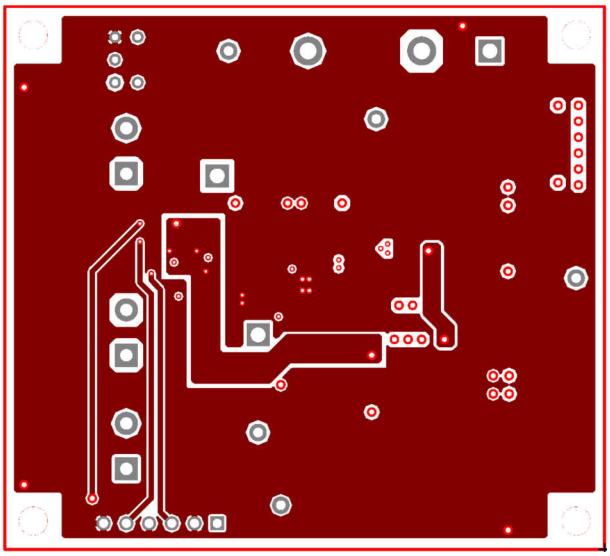

Figure 7-5. Internal Layer 2 (Top View)

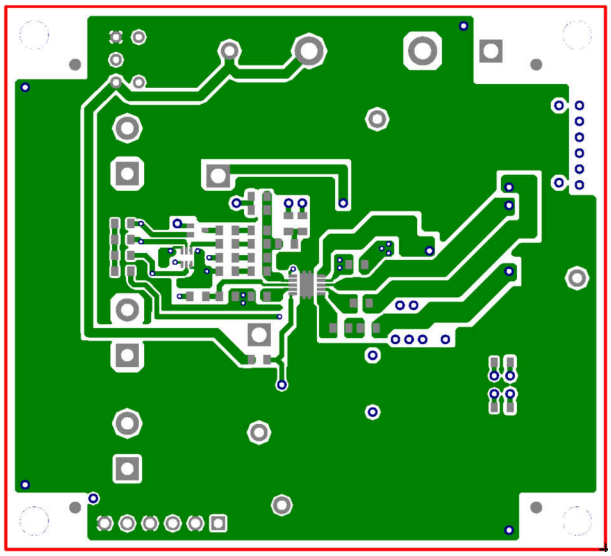

Figure 7-6. Bottom Copper (Top View)

8 List of Materials

List of materials for the TPS51217EVM.

Table 8-1. 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

Texas Instruments, *TPS51217 High-Performance, Single-Synchronous Step-Down Controller for Notebook Power Supply* data sheet

10 Revision History

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

Changes from Revision * (May 2010) to Revision A (February 2022) **Page**

- Updated the numbering format for tables, figures, and cross-references throughout the document. 2
- Updated the user's guide title..... 2

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