Using the TPS53317AEVM-726

User's Guide

Literature Number: SLUUBD2
November 2015

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User's Guide
SLUUBD2–November 2015

TPS53317AEVM-726 D-CAP+™ Mode Synchronous Step-Down Integrated FETs Converter

1 Introduction

The TPS53317AEVM-726 evaluation module (EVM) is a synchronous buck regulator featuring TPS53317A. The TPS53317A is a fully integrated synchronous buck regulator employing D-CAP+™ technology.

2 Description

The TPS53317AEVM-726 is designed to use a 1.2-V voltage rail to produce a regulated 0.6-V output at up to 6-A load current. The TPS53317AEVM-726 is designed to demonstrate the TPS53317A in a typical low voltage application while providing a number of test points to evaluate the performance of the TPS53317A.

2.1 Typical Applications

- VTT terminators
- Low-voltage applications for 0.9-V to 6-V step-down rails

2.2 Features

The TPS53317AEVM-726 features:

- Integrated droop support
- External tracking support
- Selectable switching frequency settings (600 kHz and 1 MHz)
- Selectable light-load operation modes (auto-skip and forced CCM)
- Selectable valley overcurrent limit
- PGOOD function
- Convenient test points for probing critical waveforms

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3 Electrical Performance Specifications

Table 1 contains the TPS53317AEVM-726 electrical performance specifications.

Table 1. TPS53317AEVM-726 Electrical Performance Specifications[(1)]

Parameter	Test Conditions	MIN	TYP	MAX	Units
Input Characteristics					
Voltage range	V_{IN}	1.1	1.2	1.3	V
Maximum input current	V_{IN} = 1.2 V, I_{OUT} = 6 A		3.8		A
No load input current	V_{IN} = 1.2 V, I_{OUT} = 0 A under PWM mode, f_{SW} = 600 kHz		25		mA
Output Characteristics					
Output voltage			0.6		V
Output voltage regulation	Setpoint accuracy (V_{IN} = 1.2 V, I_{OUT} = 0 A, non-droop)	-2%		2%	
	Line regulation (V_{IN} = 1.1 V – 1.3 V, I_{OUT} = 6 A, non-droop, f_{SW} = 600 kHz)			0.1%	
	Load regulation, (V_{IN} = 1.2 V, I_{OUT} = 0 A – 6 A, non-droop, f_{SW} = 600 kHz)			0.5%	
Output voltage ripple	V_{IN} = 1.2 V, I_{OUT} = 6 A		10		mVpp
Output load current		0		6	A
Over current limit valley			7.6/5.4		
Systems Characteristics					
Switching frequency			600/1000		kHz
Peak efficiency	V_{IN} = 1.2 V, I_{OUT} = 1.6 A under PWM mode, f_{SW} = 600 kHz		86.9%		
Full load efficiency	V_{IN} = 1.2 V, I_{OUT} = 6 A under PWM mode, f_{SW} = 600 kHz		78.9%		
Operating temperature			25		ºC

(1) Jumpers set to default locations, See Section 6 of this user's guide

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4 Schematic

Figure 1 illustrates the EVM schematic.

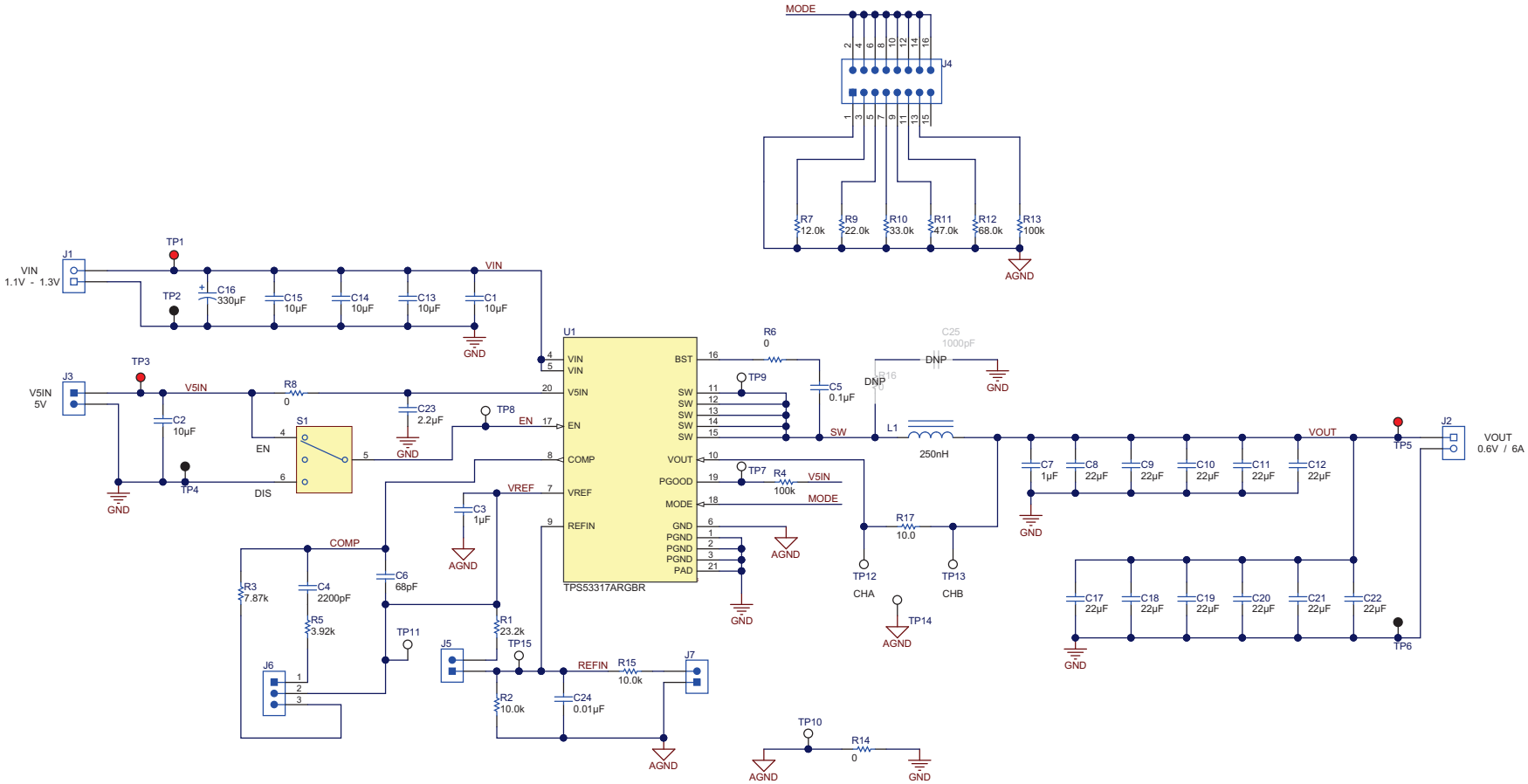

Figure 1. TPS53317AEVM-726 Schematic

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5 Test Setup

5.1 Test Equipment

Voltage Source:

- **VIN:** The input voltage source VIN should be a 0-V to 6-V variable DC source capable of supplying 8 A_{DC}. Connect VIN to J1 as shown in Figure 3.
- **V5IN:** The V5IN voltage source should be a 5-V DC source capable of supplying 1 A_{DC}. Connect V5IN to J3 as shown in Figure 3.

Multimeters:

- **V1:** VIN at TP1 (VIN) and TP2 (PGND), 0-V to 6-V voltmeter
- **V2:** V5IN at TP3 (V5IN) and TP4 (PGND)
- **V3:** VOUT at TP5 (VOUT) and TP6 (PGND)
- **A1:** VIN input current, 0 A_{DC} to 8 A_{DC} Ammeter

Output Load: The output load should be an electronic constant resistance mode load capable of 0 A_{DC} to 10 A_{DC}

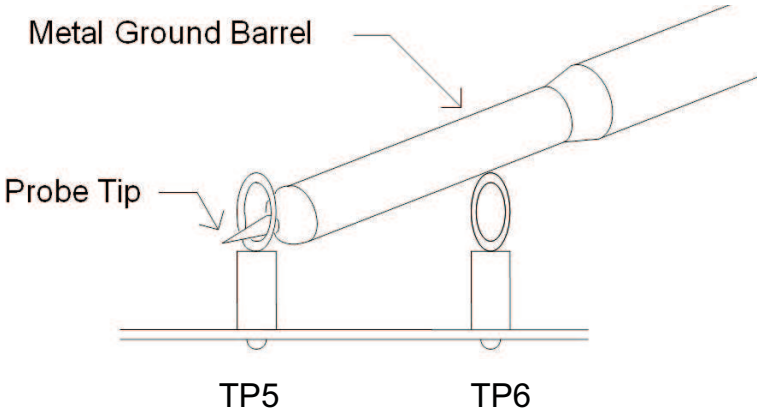

Figure 2. Tip and Barrel Measurement for VOUT Ripple

Fan: Some of the components in this EVM may approach temperatures of 55ºC during operation. A small fan capable of 200 LFM to 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.

Recommended Wire Gauge:

- ***VIN to J1 (1.2-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).
- ***J2 to LOAD:*** The minimum recommended wire size is 1x AWG #14, with the total length of wire less than 4 feet (2-feet output, 2-feet return)
- ***V5IN to J3 (5-V input):*** The recommended wire size is 1x AWG #16 per input connection, with the total length of wire less than 4 feet (2-feet input, 2-feet return).

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5.2 Recommended Test Setup

Figure 3 is the recommended test set up to evaluate the TPS53317AEVM-726. 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.

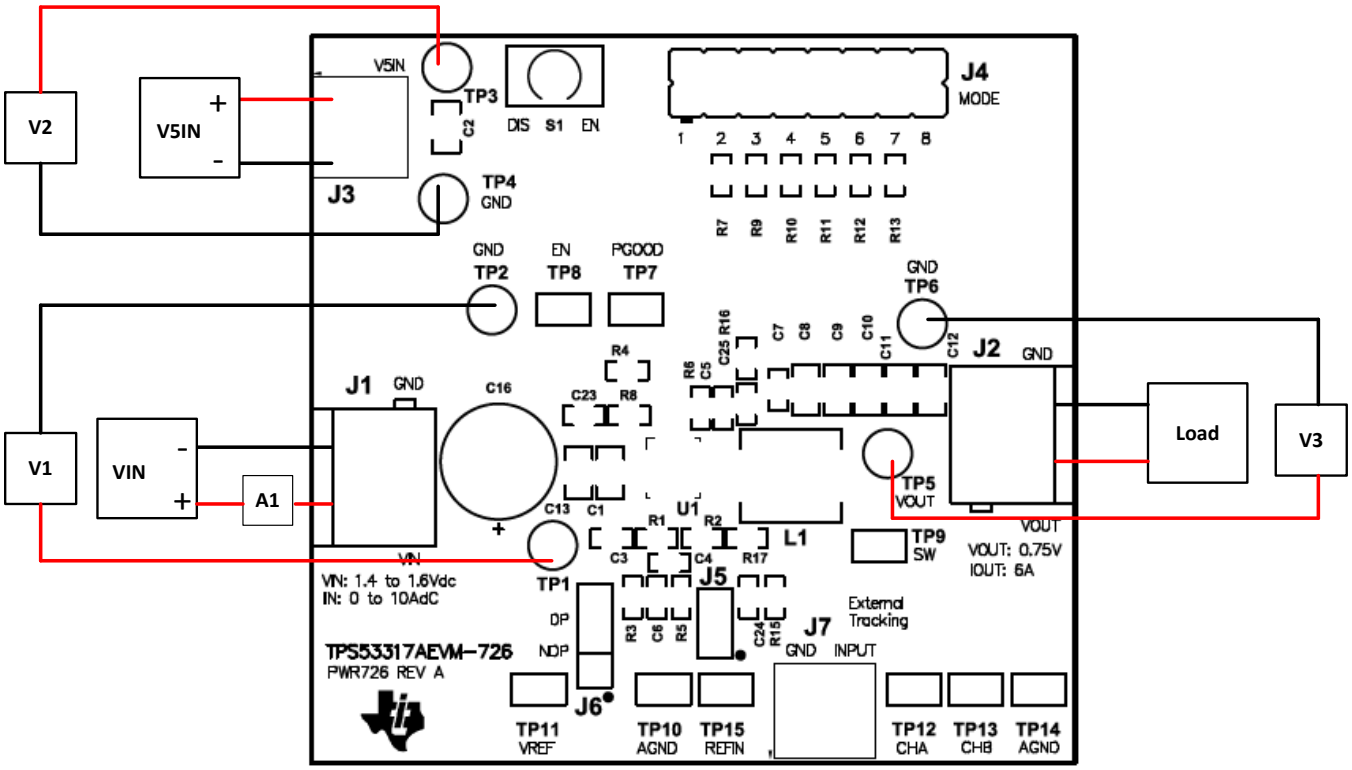

Figure 3. TPS53317AEVM-726 Recommended Test Set Up

Input Connections:

1. Prior to connecting the DC input source VIN, it is advisable to limit the source current from VIN to 8 A maximum. Make sure VIN is initially set to 0 V and connected to J1 as shown in Figure 3.
2. Connect a current meter A1 between VIN and J1 to measure the input current.
3. Connect a voltmeter V1 at TP1 (VIN) and TP2 (PGND) to measure the input voltage.
4. Prior to connecting the 5-V DC source V5IN, it is advisable to limit the source current from V5IN to 1 A maximum. Make sure V5IN is initially set to 0 V and connected to J3 as shown in Figure 3.
5. Connect a voltmeter V2 at TP3 (V5IN) and TP4 (PGND) to measure the V5IN voltage.

Output Connections:

1. Connect Load to J2 and set Load to constant resistance mode to sink 0 A_{DC} before VIN is applied.
2. Connect a voltmeter V3 at TP5 (VOUT) and TP6 (PGND) to measure the output voltage.

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

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6 Configurations

All Jumper selections should be made prior to applying power to the EVM. User can configure this EVM per following configurations.

6.1 Mode Selection

The MODE can be set by J4.

6.1.1 Default setting: MODE5

Table 2. MODE Selection

Jumper Setting	Mode	Mode Resistances (kΩ)	Light-Load Power-Saving Mode	Switching Frequency (kHz)	Overcurrent Limit (OCL) Valley (A)
1st (1-2 pin shorted)	1	0	Skip	600	7.6
2nd (3-4 pin shorted)	2	12		600	5.4
3rd (5-6 pin shorted)	3	22		1000	5.4
4th (7-8 pin shorted)	4	33		1000	7.6
5th (9-10 pin shorted)	5	47	PWM	600	7.6
6th (11-12 pin shorted)	6	68		600	5.4
7th (13-14 pin shorted)	7	100		1000	5.4
8th (15-16 pin shorted)	8	Open		1000	7.6

6.2 Droop/Non-Droop Configuration

The droop function can be configured by J6.

6.2.1 Default Setting: Non-Droop

Table 3. Droop Configuration

Jumper Setting	Droop Configuration
Top(1-2 pin shorted)	Droop
Bottom(2-3 pin shorted)	Non-droop

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6.3 External Tracking Selection

The external tracking can be configured by J5. If jumper J5 is shorted, the internal 2-V VREF voltage is used to set the target output voltage to be 0.6 V. If jumper J5 is open, the external reference between 0.9 V to 4.0 V can be applied to J7. The output voltage will be regulated to ½ of the external reference voltage. For example, applying 1.5 V to J7, the output voltage is 0.75 V.

6.3.1 Default setting: No External Tracking

Table 4. External Tracking Configuration

Jumper Setting	External Tracking Configuration
Short	No external tracking
Open	External tracking

6.4 Enable Selection

The controller can be enabled and disabled by S1.

6.4.1 Default setting: Switch to disable the controller

Table 5. Enable Selection

Switch Setting	Enable Selection
DIS	Disable the controller
EN	Enable the controller

7 Test Procedure

7.1 Line/Load Regulation and Efficiency Measurement Procedure

1. Set up EVM as described in Figure 3.
2. Ensure Load is set to constant resistance mode and to sink 0 A_{DC}.
3. Ensure all jumpers and switch configuration settings per Section 6.
4. Increase V5IN from 0 V to 5 V. Using V2 to measure V5IN voltage.
5. Increase VIN from 0 V to 1.2 V. Using V1 to measure VIN voltage.
6. Set switch S1 to EN to enable the controller.
7. Use V3 to measure VOUT voltage, A1 to measure VIN current.
8. Vary Load from 0 A_{DC} to 6 A_{DC}, VOUT should remain in load regulation.
9. Vary VIN from 1.1 V to 1.3 V, VOUT should remain in line regulation.
10. Set switch S1 to DIS to disable the controller.
11. Decrease Load to 0 A.
12. Decrease VIN to 0 V.
13. Decrease V5IN to 0 V.

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7.2 Control Loop Gain and Phase Measurement Procedure

TPS53317AEVM-726 contains a 10-Ω series resistor in the feedback loop for loop response analysis.

1. Set up EVM as described in Figure 3.
2. Connect isolation transformer to test points marked TP12 and TP13.
3. Connect input signal amplitude measurement probe (channel A) to TP12. Connect output signal amplitude measurement probe (channel B) to TP13.
4. Connect ground lead of channel A and channel B to TP14.
5. Inject around 40 mV or less signal through the isolation transformer.
6. Sweep the frequency from 100 Hz to 1 MHz with 10 Hz or lower post filter. The control loop gain and phase margin can be measured.
7. Disconnect isolation transformer from bode plot test points before making other measurements (signal injection into feedback may interfere with accuracy of other measurements).

7.3 List of Test Points

Table 6. The Functions of Each Test Points

Test Points	Name	Description
TP1	VIN	Input voltage
TP2	PGND	PGND for VIN
TP3	V5IN	5-V power supply for analog circuits and gate drive
TP4	PGND	PGND for V5IN
TP5	VOUT	Output voltage
TP6	PGND	PGND for VOUT
TP7	PGOOD	Power good
TP8	EN	Enable pin
TP9	SW	Switching node
TP10	AGND	Signal ground
TP11	VREF	Internal 2-V reference voltage output
TP12	CHA	Input A for loop injection
TP13	CHB	Input B for loop injection
TP14	AGND	Signal ground
TP15	REFIN	Target output voltage input

7.4 Equipment Shutdown

1. Shut down VIN
2. Shut down V5IN
3. Shut down Load
4. Shut down FAN

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8 Performance Data and Typical Characteristic Curves

Figure 4 through Figure 15 present typical performance curves for TPS53317AEVM-726.

8.1 Efficiency

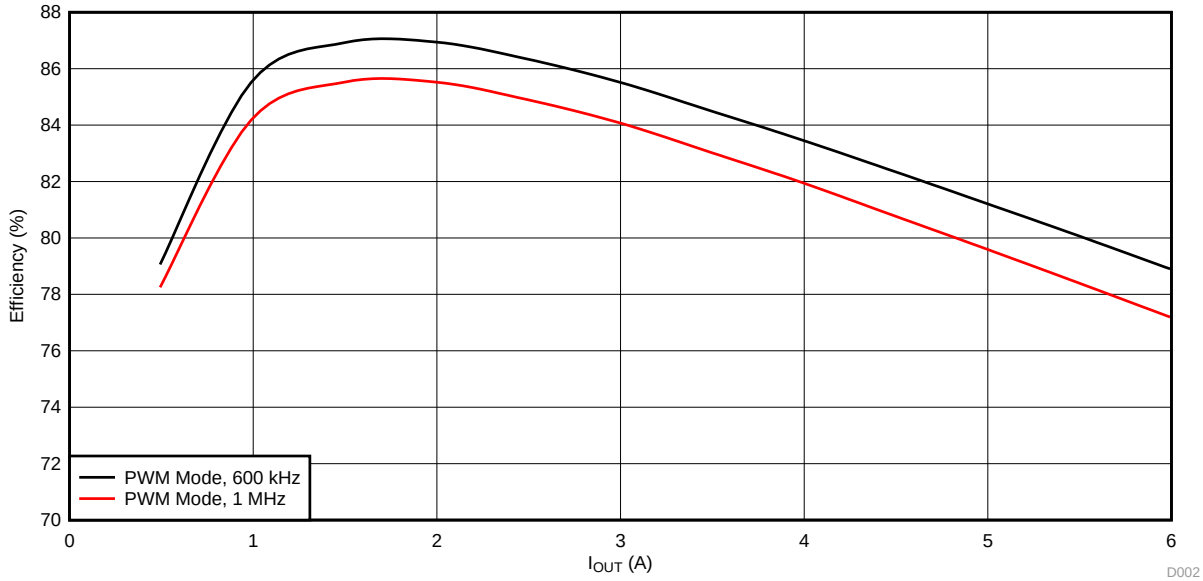

Figure 4. Efficiency

8.2 Load Regulation

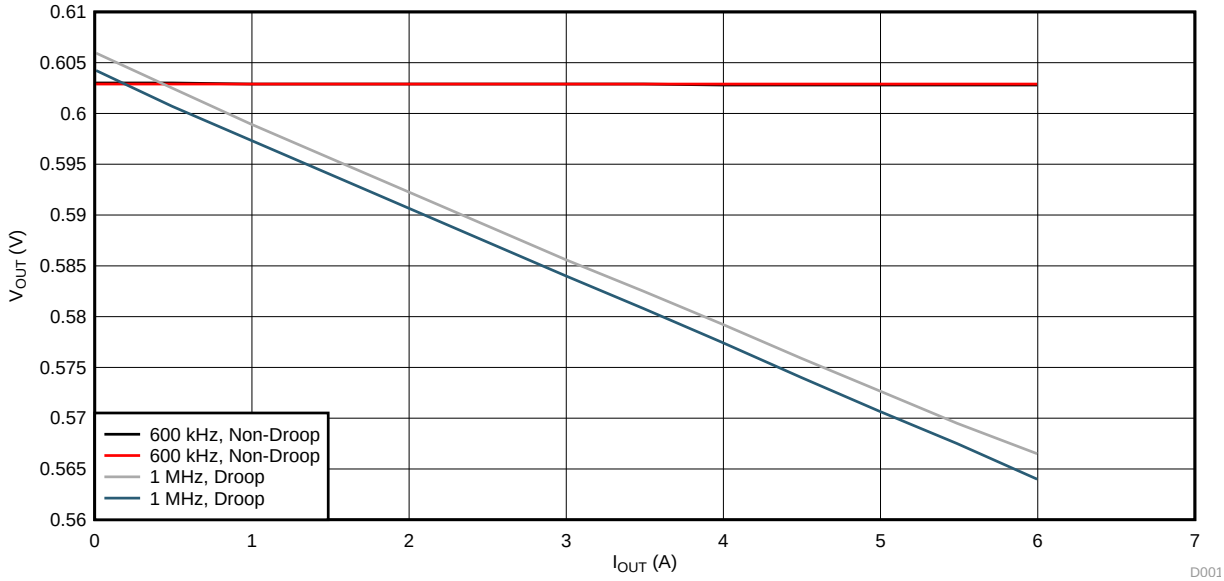

Figure 5. Load Regulation

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8.3 Output Transient

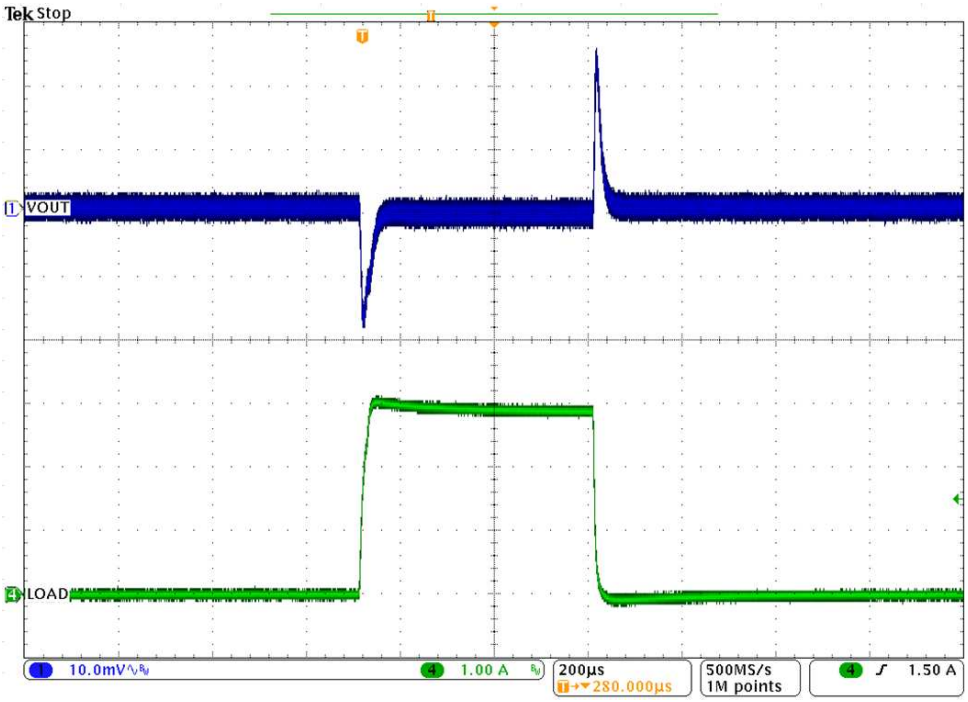

Figure 6. Output Load 0-A to 3-A Transient (1.2-V V_{IN}, 0.6-V V_{OUT}, PWM Mode, f_{SW} = 600 kHz)

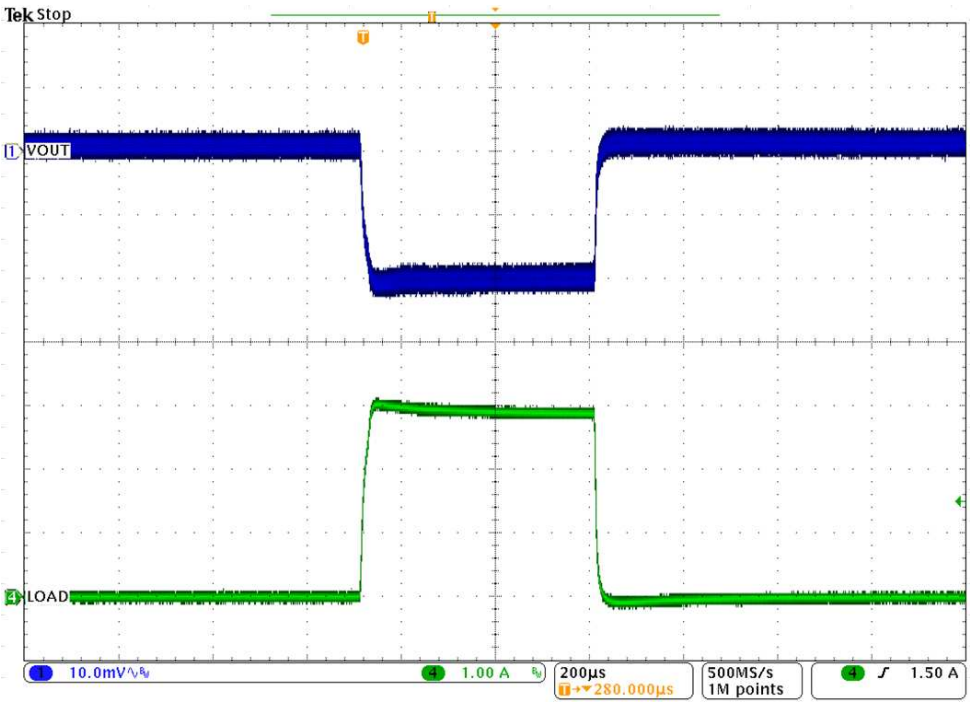

Figure 7. Output Load 0-A to 3-A Transient with Droop (1.2-V V_{IN}, 0.6-V V_{OUT}, PWM Mode, f_{SW} = 600 kHz)

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8.4 Output Ripple

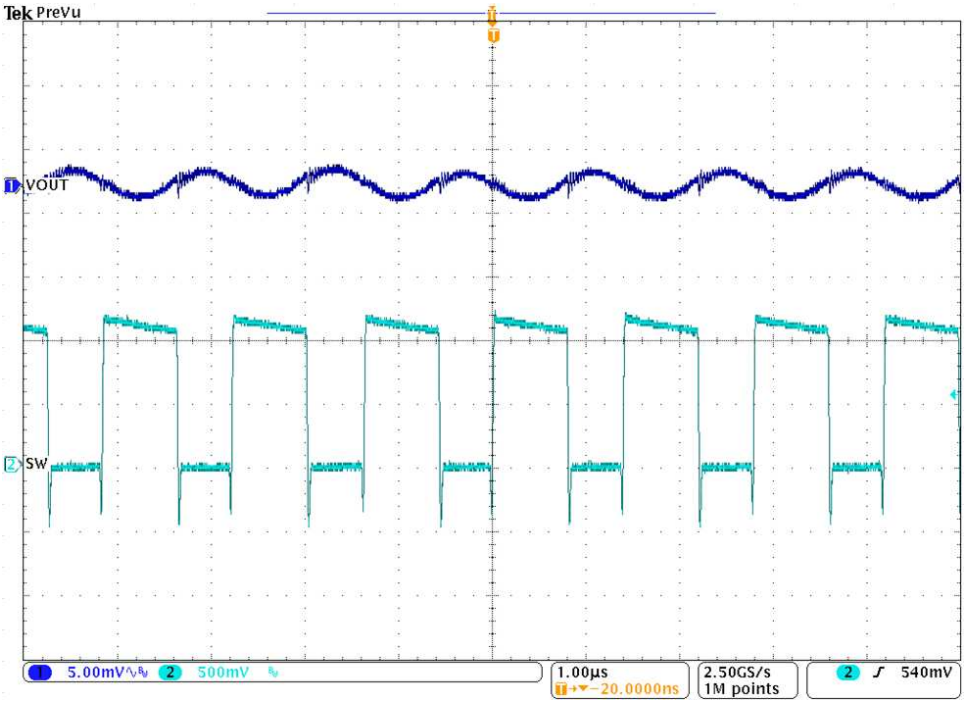

Figure 8. Output Ripple
(1.2-V V_{IN}, 0.6-V V_{OUT}, 3-A I_{OUT}, f_{SW} = 600 kHz)

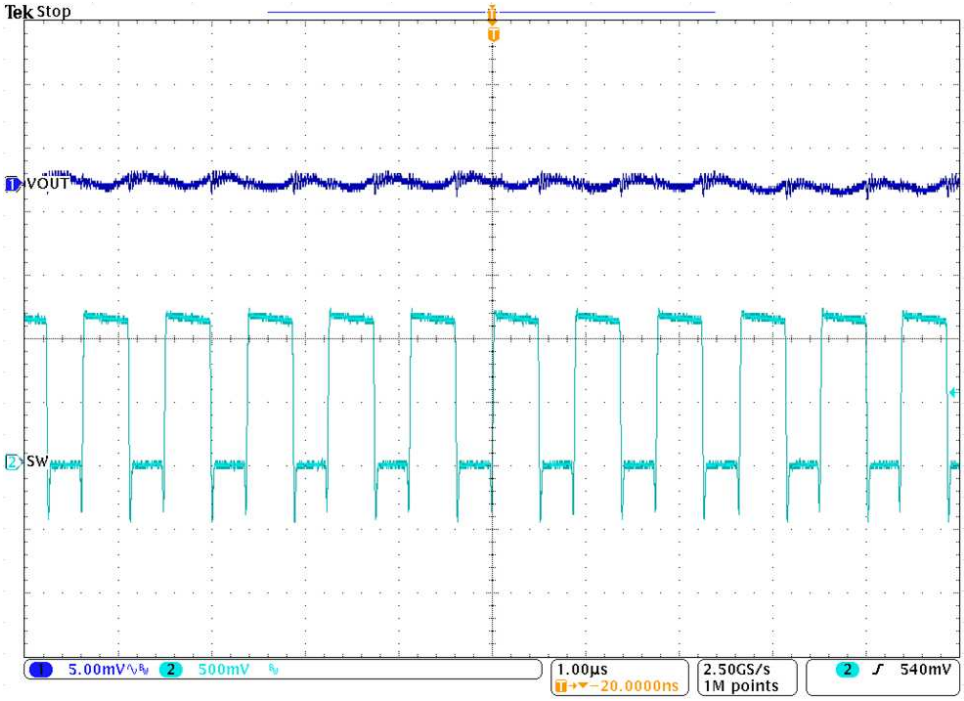

Figure 9. Output Ripple
(1.2-V V_{IN}, 0.6-V V_{OUT}, 3-A I_{OUT}, f_{SW} = 1 MHz)

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8.5 Switching Node

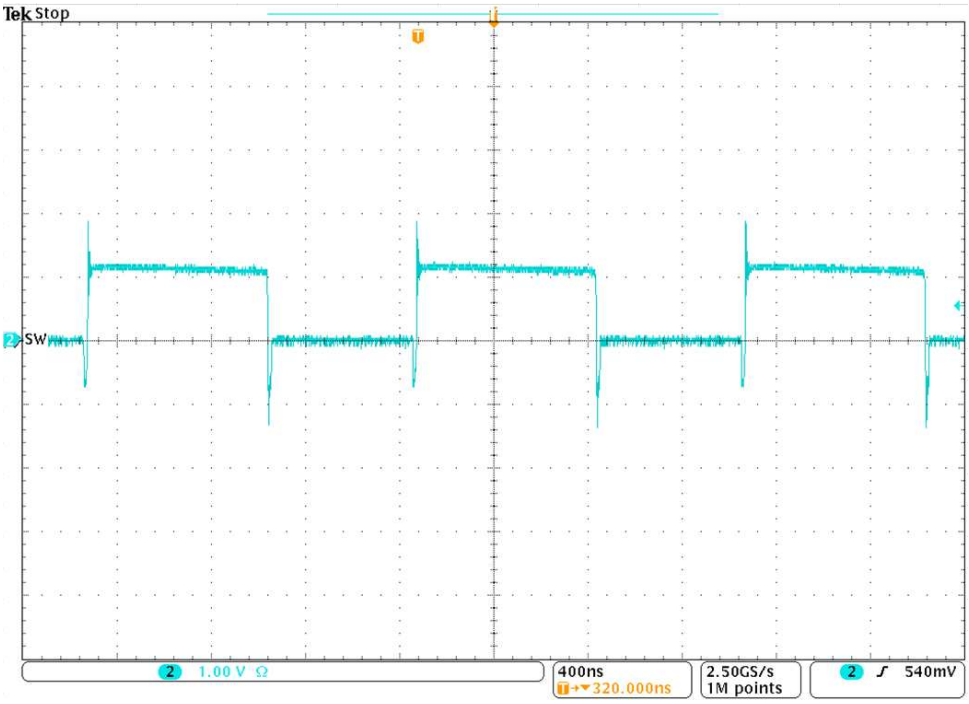

Figure 10. Switching Node
(1.2-V V_{IN}, 0.6-V V_{OUT}, 3-A I_{OUT}, f_{SW} = 600 kHz)

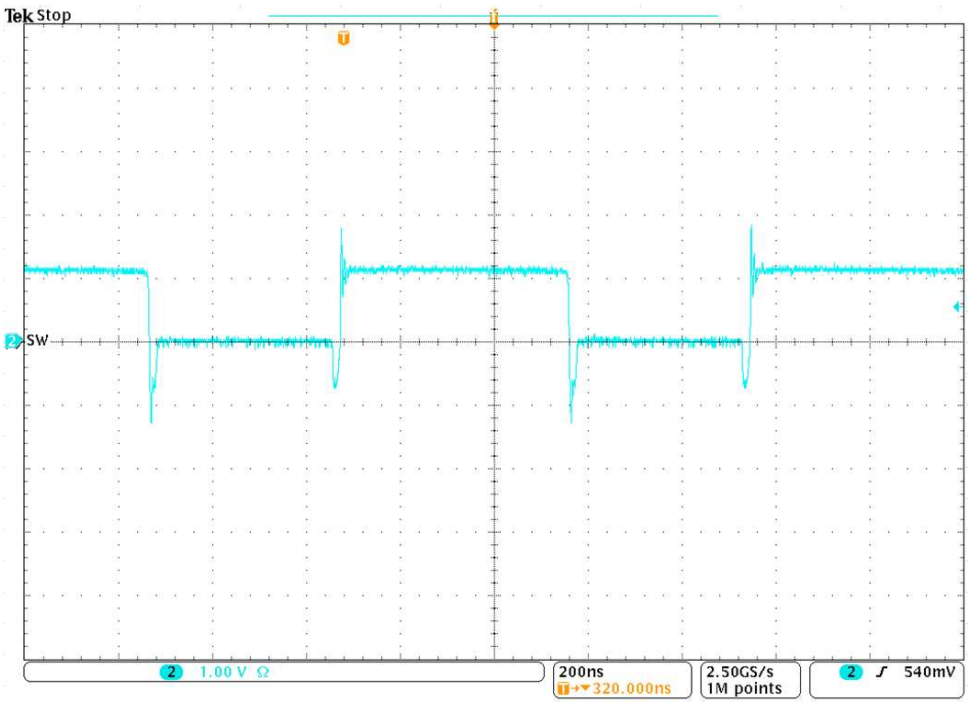

Figure 11. Switching Node
(1.2-V V_{IN}, 0.6-V V_{OUT}, 3-A I_{OUT}, f_{SW} = 1 MHz)

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8.6 Enable Turn On / Turn Off

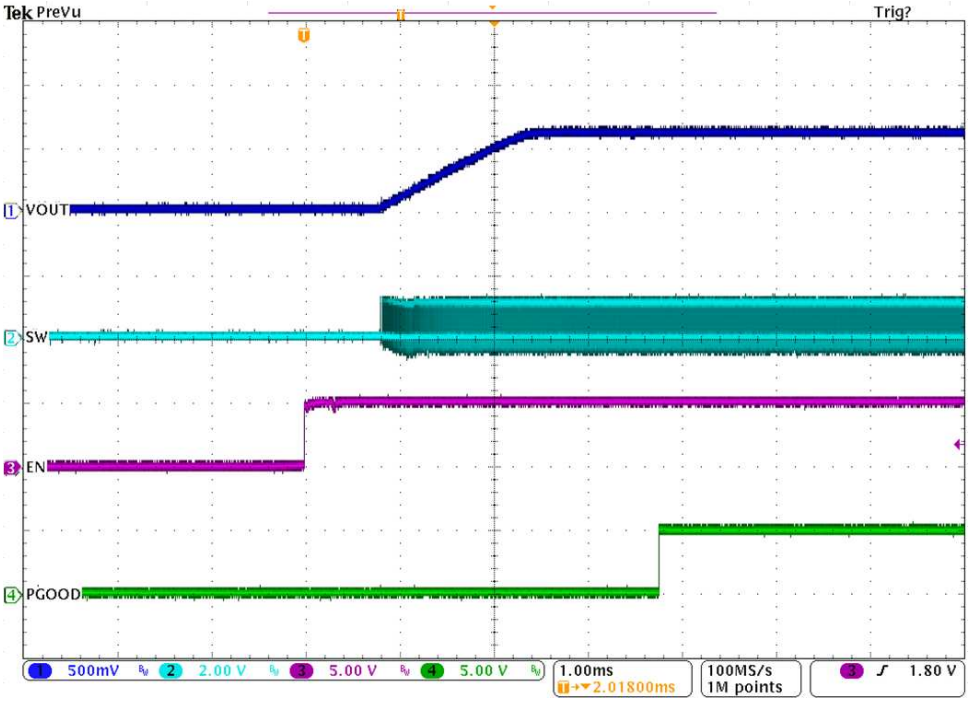

Figure 12. Turn-On Waveform ($1.2\text{-V } V_{IN}$, $0.6\text{-V } V_{OUT}$, $3\text{-A } I_{OUT}$)

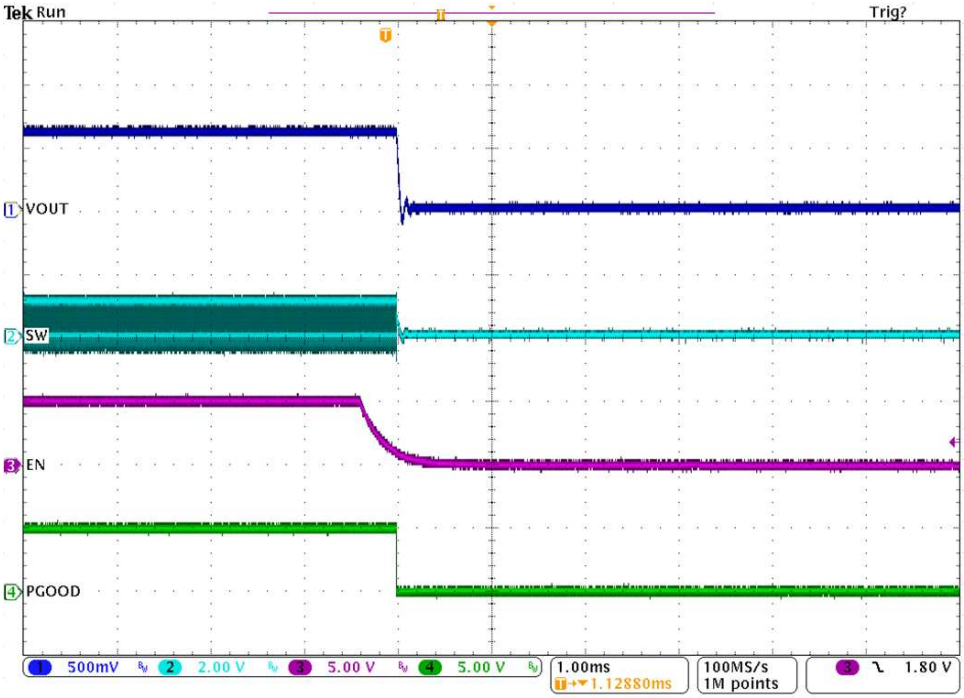

Figure 13. Turn-Off Waveform ($1.2\text{-V } V_{IN}$, $0.6\text{-V } V_{OUT}$, $3\text{-A } I_{OUT}$)

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8.7 Pre-Bias Turn-On

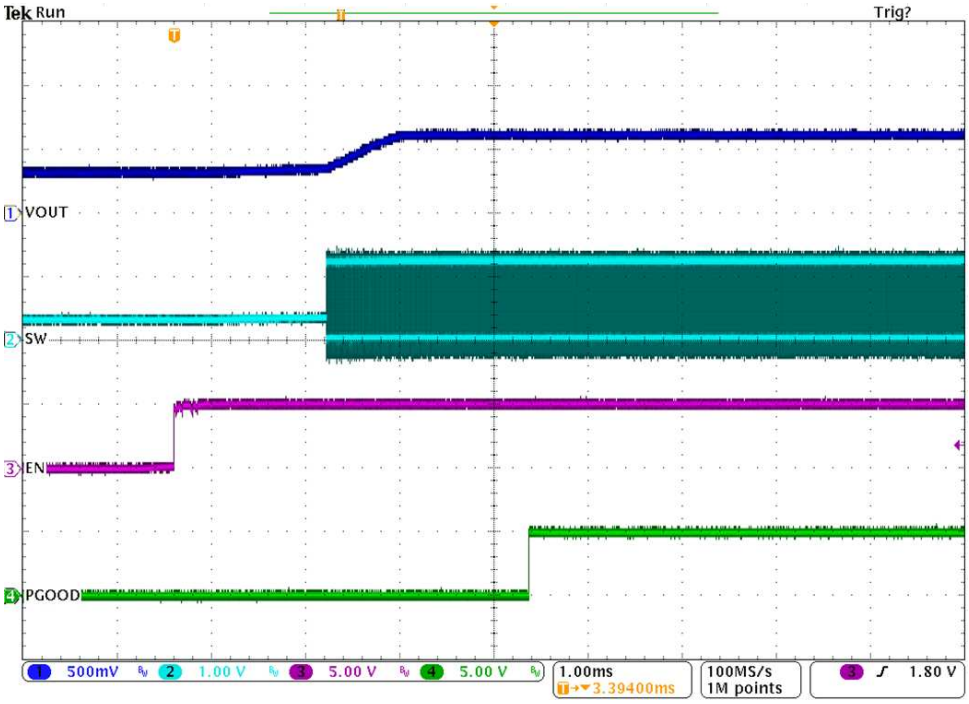

Figure 14. Pre-Bias Turn-On Waveform
(1.2-V V_{IN}, 0.6-V V_{OUT}, 0-A I_{OUT}, 0.3-V Pre-Bias)

8.8 Bode Plot

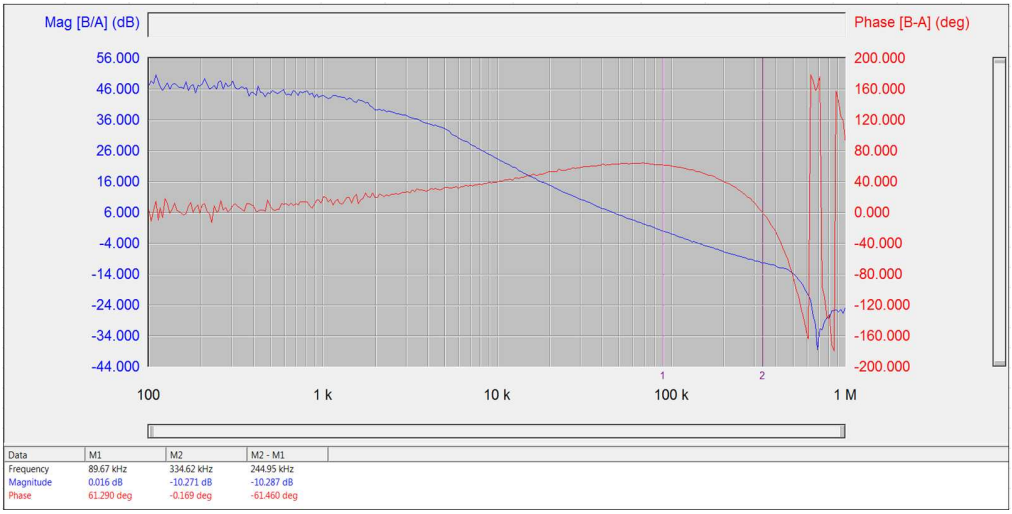

Figure 15. Loop Gain
(1.2-V V_{IN}, 0.6-V V_{OUT}, 3-A I_{OUT}, PWM Mode, f_{SW} = 600 kHz, Non-Droop)

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8.9 Thermal Image

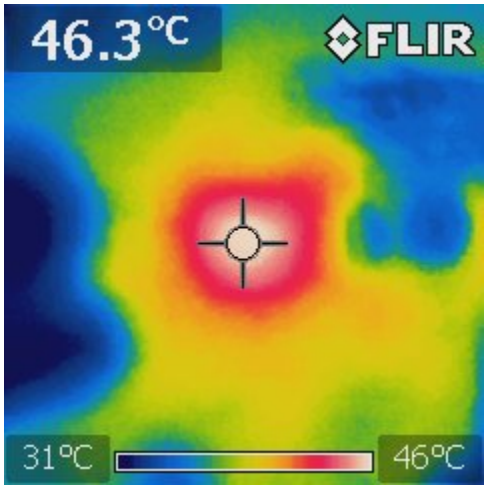

Figure 16. Thermal Image
(1.2-V V_{IN}, 0.6-V V_{OUT}, 6-A I_{OUT}, PWM Mode, f_{SW} = 600 kHz)

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9 EVM Assembly Drawing and PCB Layout

The following figures (Figure 17 through Figure 22) show the design of the TPS53317AEVM-726 printed circuit board. The EVM has been designed using 4-Layers, 2-oz copper circuit board.

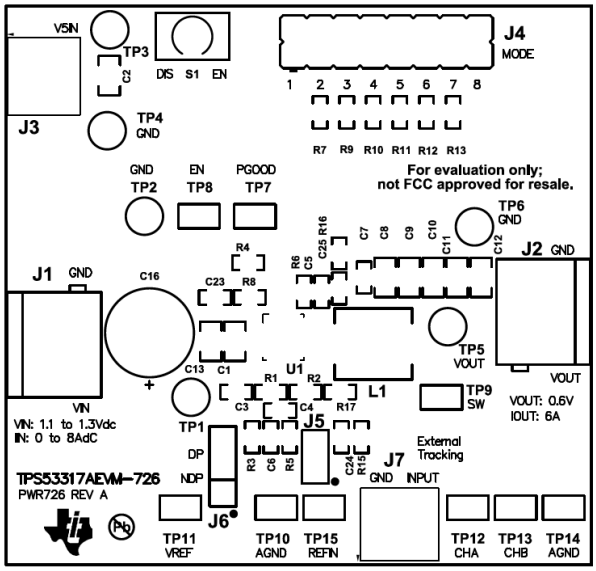

Figure 17. TPS53317AEVM-726 Top Layer Assembly Drawing (Top View)

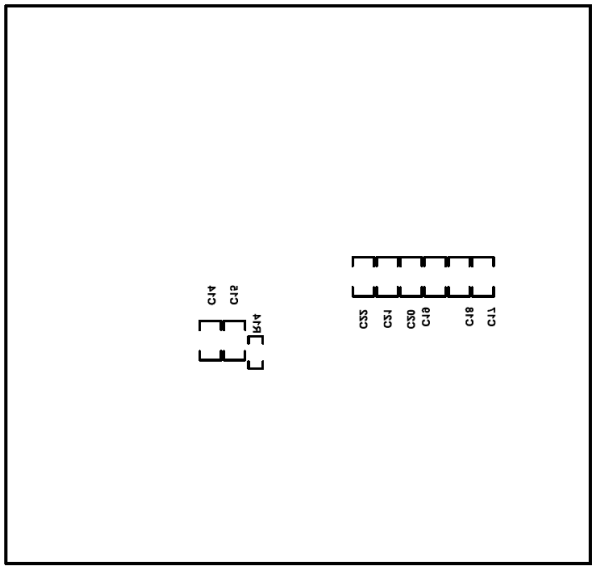

Figure 18. TPS53317AEVM-726 Bottom Assembly Drawing (Bottom View)

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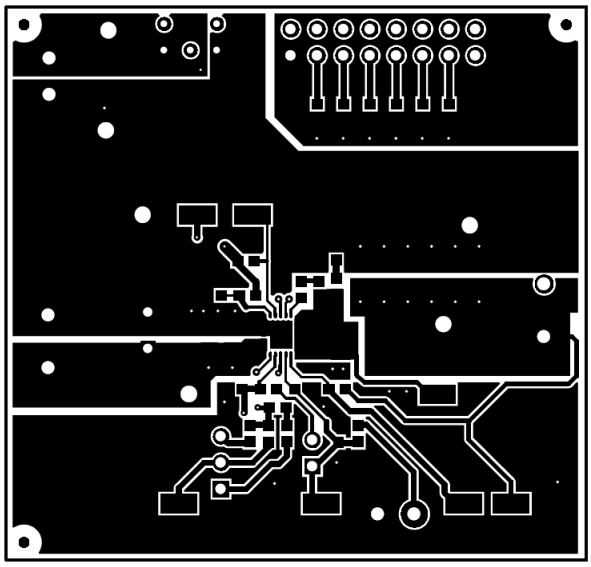

Figure 19. TPS53317AEVM-726 Top Copper (Top View)

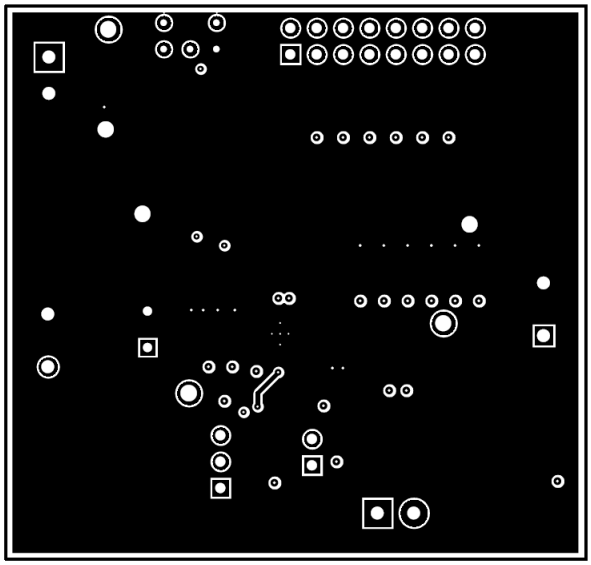

Figure 20. TPS53317AEVM-726 Layer 2 (Top View)

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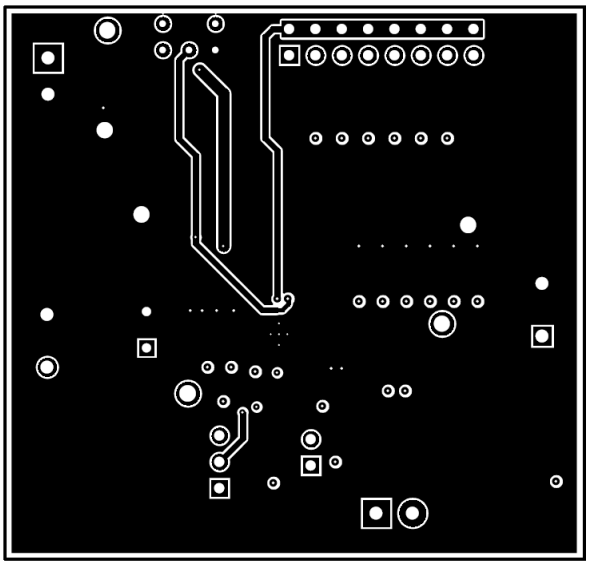

Figure 21. TPS53317AEVM-726 Layer 3 (Top View)

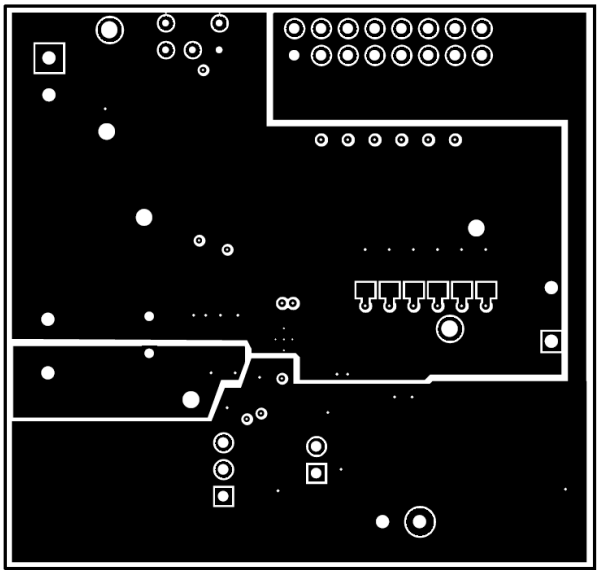

Figure 22. TPS53317AEVM-726 Bottom Layer (Top View)

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10 List of Materials

The EVM components list according to the schematic shown in Figure 1.

Table 7. TPS53317AEVM-726 List of Materials

Qty	Designator	Description	Part Number	Manufacturer
4	C1, C13, C14, C15	CAP, CERM, 10 µF, 16 V, +/- 10%, X5R, 0805	STD	STD
1	C2	CAP, CERM, 10 µF, 10 V, +/- 10%, X5R, 0805	STD	STD
2	C3, C7	CAP, CERM, 1 µF, 25 V, +/- 10%, X5R, 0603	STD	STD
1	C4	CAP, CERM, 2200 pF, 16 V, +/- 10%, X7R, 0603	STD	STD
1	C5	CAP, CERM, 0.1 µF, 25 V, +/- 10%, X7R, 0603	STD	STD
1	C6	CAP, CERM, 68 pF, 50 V, +/- 5%, C0G/NP0, 0603	STD	STD
11	C8, C9, C10, C11, C12, C17, C18, C19, C20, C21, C22	CAP, CERM, 22 µF, 6.3 V, +/- 20%, X5R, 0805	STD	STD
1	C16	CAP, Aluminum Polymer, 330 µF, 10 V, +/- 20%, 0.017 ohm, TH	STD	STD
1	C23	CAP, CERM, 2.2 µF, 10 V, +/- 10%, X5R, 0603	STD	STD
1	C24	CAP, CERM, 0.01 µF, 25 V, +/- 10%, X7R, 0603	STD	STD
2	J1, J2	TERMINAL BLOCK 5.08MM VERT 2POS, TH	ED120/2DS	On-Shore Technology
2	J3, J7	Terminal Block, 6A, 3.5mm Pitch, 2-Pos, TH	ED555/2DS	On-Shore Technology
1	J4	Header, 2.54 mm, 8x2, Tin, Vertical, TH	PEC08DAAN	Sullins Connector Solutions
1	J5	Header, 100mil, 2x1, Tin, TH	PEC02SAAN	Sullins Connector Solutions
1	J6	Header, 100mil, 3x1, Tin, TH	PEC03SAAN	Sullins Connector Solutions
1	L1	Inductor, Shielded, Ferrite, 250 nH, 19.2 A, 0.0023 ohm, SMD	SPM6530T-R25M230	TDK
1	R1	RES, 23.2 k, 1%, 0.1 W, 0603	STD	STD
2	R2, R15	RES, 10.0 k, 1%, 0.1 W, 0603	STD	STD
1	R3	RES, 7.87 k, 1%, 0.1 W, 0603	STD	STD
1	R4	RES, 100 k, 1%, 0.1 W, 0603	STD	STD
1	R5	RES, 3.92 k, 1%, 0.1 W, 0603	STD	STD
3	R6, R8, R14	RES, 0, 5%, 0.1 W, 0603	STD	STD
1	R7	RES, 12.0 k, 1%, 0.1 W, 0603	STD	STD
1	R9	RES, 22.0 k, 1%, 0.1 W, 0603	STD	STD
1	R10	RES, 33.0 k, 1%, 0.1 W, 0603	STD	STD
1	R11	RES, 47.0 k, 1%, 0.1 W, 0603	STD	STD
1	R12	RES, 68.0 k, 1%, 0.1 W, 0603	STD	STD
1	R13	RES, 100 k, 1%, 0.1 W, 0603	STD	STD
1	R17	RES, 10.0, 1%, 0.1 W, 0603	STD	STD
1	S1	Switch, Toggle, SPDT 1Pos, TH	G12AP	NKK Switches
3	SH-J4, SH-J5, SH-J6	Shunt, 100mil, Gold plated, Black	969102-0000-DA	3M
3	TP1, TP3, TP5	Test Point, Multipurpose, Red, TH	5010	Keystone
3	TP2, TP4, TP6	Test Point, Multipurpose, Black, TH	5011	Keystone
9	TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15	Test Point, Miniature, SMT	5015	Keystone

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Table 7. TPS53317AEVM-726 List of Materials (continued)

Qty	Designator	Description	Part Number	Manufacturer
1	U1	6-A Output D-CAP+ Mode Synchronous Step-Down, Integrated-FET Converter for DDR Memory Termination	TPS53317ARGBR	Texas Instruments

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- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
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2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
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Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

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