User's Guide

TPS53318 Step-Down Converter Evaluation Module User's Guide

ABSTRACT

The TPS53319EVM-136 is designed to use a regulated 12-V bus to produce a regulated 1.5-V output at up to 14 A of load current. The TPS53319EVM-136 is designed to demonstrate the TPS53319 in a typical low voltage application while providing a number of test points to evaluate the performance of the TPS53319.

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1 Introduction

The TPS53319EVM-136 evaluation module (EVM) uses the TPS53319. The TPS53319 is a D-CAP mode, 14-A synchronous buck converter with integrated MOSFETs. The device provides a fixed 1.5-V output at up to 14 A from a 12-V input bus.

1.1 Typical Applications

- Server/storage
- Workstations and desktops
- Telecommunication infrastructure

1.2 Features

The TPS53319EVM-136 features:

- 14-A DC steady state output current
- Support pre-bias output voltage start-up
- J3 for selectable switching frequency setting
- J4 for selectable soft-start time
- J5 for auto-skip and forced CCM selection
- J6 for enable function
- Convenient test points for probing critical waveforms

2 Electrical Performance Specifications

Table 2-1. TPS53319EVM-136 Electrical Performance Specifications

PARAMETER[(1)]	TEST CONDITIONS	MIN	TYP	MAX	UNITS
INPUT CHARACTERISTICS					
Voltage range	V_{IN}	8	12	20	V
Maximum input current	V_{IN} = 8 V, I_O = 14 A		2.874		A
No load input current	V_{IN} = 20 V, I_O = 0 A with auto skip mode		0.7		mA
OUTPUT CHARACTERISTICS					
Output voltage VOUT			1.5		V
Output voltage regulation	Line regulation (V_{IN} = 8 V–20 V)		0.1%		
	Load regulation (V_{IN} = 12 V, I_O = 0 A–14 A), auto-skip		1%		
Output voltage ripple	V_{IN} = 12 V, I_O = 14 A		15		mVpp
Output load current		0		14	A
Output over current			16		A
SYSTEMS CHARACTERISTICS					
Switching frequency			500		kHz
Peak efficiency	V_{IN} = 12 V, 1.5 V/8 A		91.68%		
Full load efficiency	V_{IN} = 12 V, 1.5 V/14 A		90.04%		
Operating temperature			25		°C

(1) **Note**: Jumpers set to default locations. See Section 6.

3 Schematic

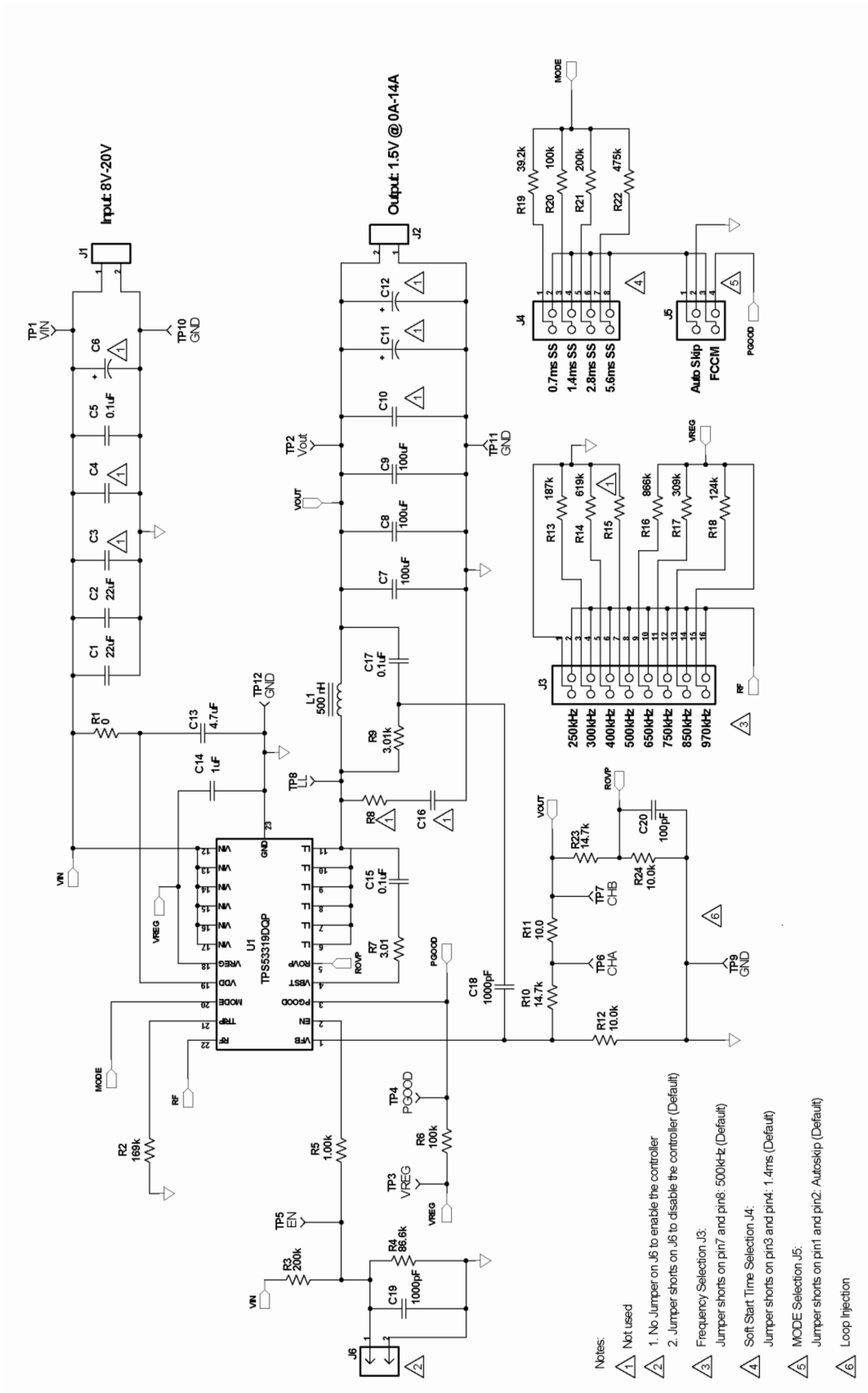

Figure 3-1. TPS53319EVM-136 Schematic

4 Test Setup

4.1 Test Equipment

Voltage Source:
The input voltage source, V_{IN}, should be a 0-V to 20-V variable DC source capable of supplying 10 A_{DC}. Connect V_{IN} to J1 as shown in Figure 4-2.

Multimeters:
V1: VIN at TP1 (V_{IN}) and TP10 (GND). V2: VOUT at TP2 (V_{OUT}) and TP11 (GND). A1: V_{IN} input current

Output Load:
The output load should be an electronic constant resistance mode load capable of 0 A_{DC} to 16 A_{DC} at 1.5 V.

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
- 20-mV/division vertical resolution

Test points TP2 and TP11 can be used to measure the output ripple voltage by placing the oscilloscope probe tip through TP2 and holding the ground barrel on TP11 as shown in Figure 4-1. Using a leaded ground connection can induce additional noise due to the large ground loop.

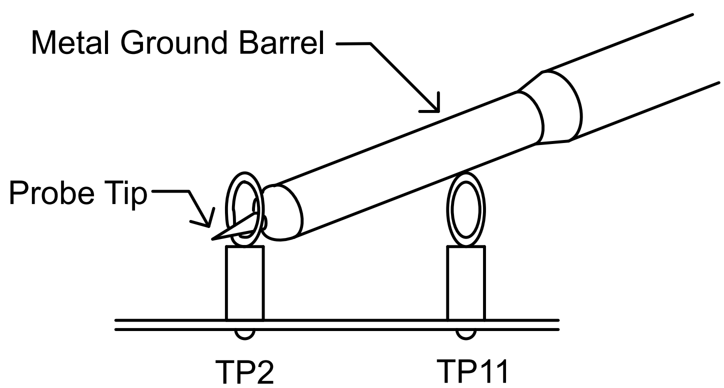

Figure 4-1. Tip and Barrel Measurement for V_{OUT} Ripple

Recommended Wire Gauge:

1. V_{IN} to J1 (12-V input):
   The recommended wire size is AWG #16 per input connection, with the total length of wire less than four feet (two feet input, two feet return).
2. J2 to LOAD:
   The minimum recommended wire size is AWG #14, with the total length of wire less than four feet (two feet output, two feet return).

4.2 Recommended Test Setup

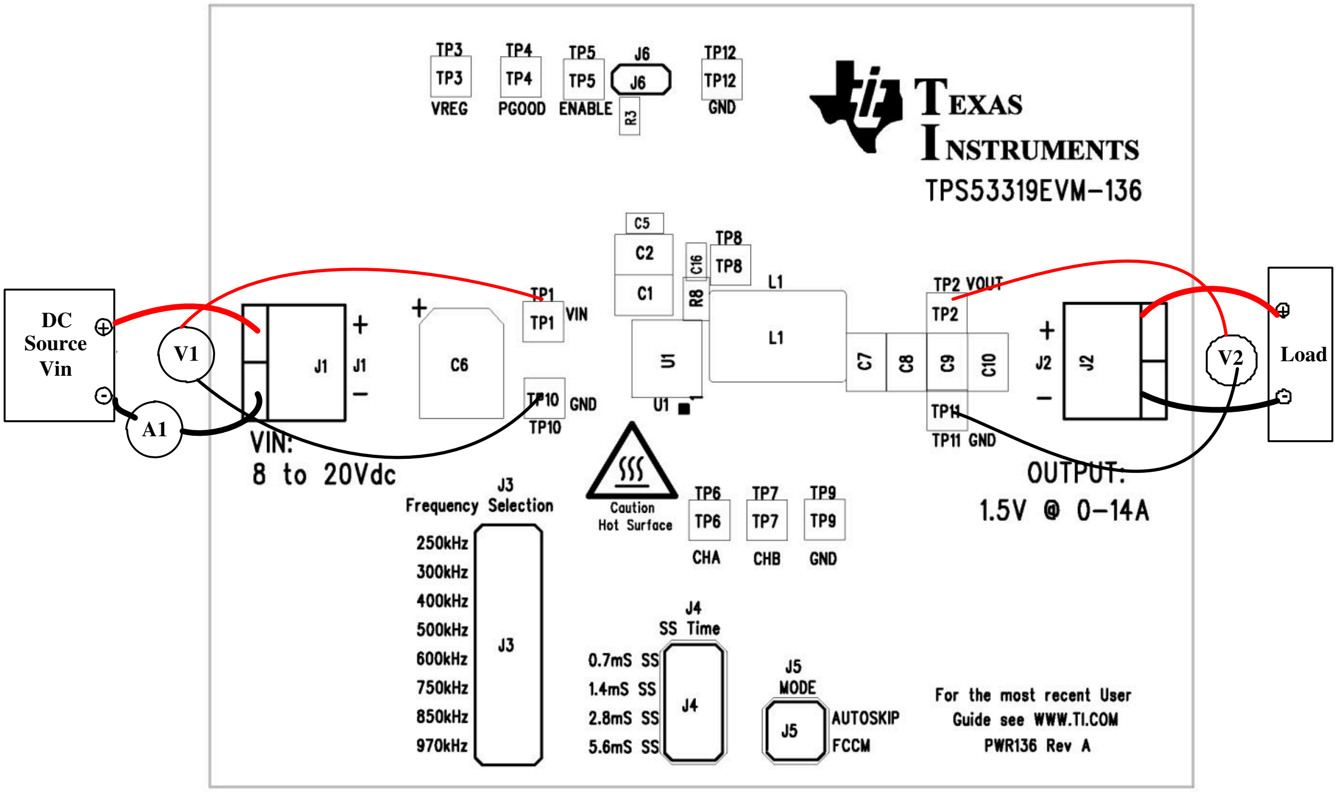

Figure 4-2. TPS53319EVM-136 Recommended Test Setup

Figure 4-2 is the recommended test setup to evaluate the TPS53319EVM-136. 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.

Input Connections:

1. Prior to connecting the DC input source V_{IN}, it is advisable to limit the source current from VIN to 10-A maximum. Make sure VIN is initially set to 0 V and connected as shown in Figure 4-2.
2. Connect a voltmeter V1 at TP1 (V_{IN}) and TP10 (GND) to measure the input voltage.
3. Connect a current meter A1 to measure the input current.

Output Connections

1. Connect the load to J2 and set the load to constant resistance mode to sink 0 A_{DC} before V_{IN} is applied.
2. Connect a voltmeter V2 at TP2 (V_{OUT}) and TP11 (GND) to measure the output voltage.

5 Configurations

All jumper selections should be made prior to applying power to the EVM. The user can configure this EVM per the following configurations.

5.1 Switching Frequency Selection

The switching frequency can be set by J3.
Default setting: 500 kHz

Table 5-1. Switching Frequency Selection

JUMPER SET TO	RESISTOR (RF) CONNECTIONS (Ω)	SWITCHING FREQUENCY (kHz)
Top (1–2 pin shorted)	0	250
2nd (3–4 pin shorted)	187 k	300
3rd (5–6 pin shorted)	619 k	400
4th (7–8 pin shorted)	**Open**	**500**
5th (9–10 pin shorted)	866 k	600
6th (11–12 pin shorted)	309 k	750
7th (13–14 pin shorted)	124 k	850
Bottom (15–16 pin shorted)	0	970

5.2 Soft Start Selection

The soft start time can be set by J4.
Default setting: 1.4ms

Table 5-2. Soft Start Time Selection

Jumper set to	R_{MODE} Connections(Ω)	Soft Start Time(ms)
Top(1-2 pin shorted)	39.2k	0.7
2nd (3-4 pin shorted)	100k	1.4
3rd(5-6 pin shorted)	200k	2.8
Bottom(7-8 pin shorted)	475k	5.6

5.3 Mode Selection

The MODE can be set by J5.
Default setting: Auto Skip

Table 5-3. MODE Selection

Jumper set to	MODE Selection
Top(1-2 pin shorted)	**Auto Skip**
Bottom(3-4 pin shorted)	Forced CCM

5.4 Enable Selection

The controller can be enabled and disabled by J6.
Default setting: Jumper shorts on J6 to disable the controller

Table 5-4. Enable Selection

Jumper set to	Enable Selection
Jumper shorts on J6	**Disable the controller**
No Jumper shorts on J6	Enable the controller

6 Test Procedure

6.1 Line/Load Regulation and Efficiency Measurement Procedure

1. Set up EVM as described in Section 4 and Figure 4-2.
2. Ensure Load is set to constant resistance mode and to sink 0Adc
3. Ensure all jumpers configuration settings per section 5.
4. Ensure the jumper provided in the EVM shorts on J6 before Vin is applied.
5. Increase Vin from 0V to 12V. Using V1 to measure input voltage.
6. Remove the jumper on J6 to enable the controller.
7. Use V2 to measure Vout voltage.
8. Vary Load from 0-14Adc, Vout should be remain in load regulation.
9. Vary Vin from 8V to 20V, Vout should remain in line regulation.
10. Put the jumper on J6 to disable the controller.
11. Decrease Load to 0A
12. Decrease Vin to 0V.

6.2 Control Loop Gain and Phase Measurement Procedure

TPS53319EVM-136 contains a 10Ω series resistor in the feedback loop for loop response analysis.

1. Set up EVM as described in Section 4 and Figure 4-2.
2. Connect isolation transformer to test points marked TP6 and TP7.
3. Connect input signal amplitude measurement probe (channel A) to TP6. Connect output signal amplitude measurement probe (channel B) to TP7.
4. Connect ground lead of channel A and channel B to TP9.
5. Inject around 20mV or less signal through the isolation transformer.
6. Sweep the frequency from 100Hz to 1MHz with 10Hz 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).

6.3 List of Test Points

Table 6-1. The Functions of Each Test Points

Test Points	Name	Description
TP1	VIN	Controller input
TP2	Vout	Output Voltage
TP3	VREG	5V LDO output
TP4	PGOOD	Power Good
TP5	EN	Enable
TP6	CHA	Input A for loop injection
TP7	CHB	Input B for loop injection
TP8	LL	Switching node
TP9	GND	Ground
TP10	GND	Ground
TP11	GND	Ground
TP12	GND	Ground

6.4 Equipment Shutdown

1. Shut down the load.
2. Shut down V_{IN}.

7 Performance Data and Typical Characteristic Curves

Figure 7-1 through Figure 7-15 present typical performance curves for TPS53319EVM-136.

7.1 Efficiency

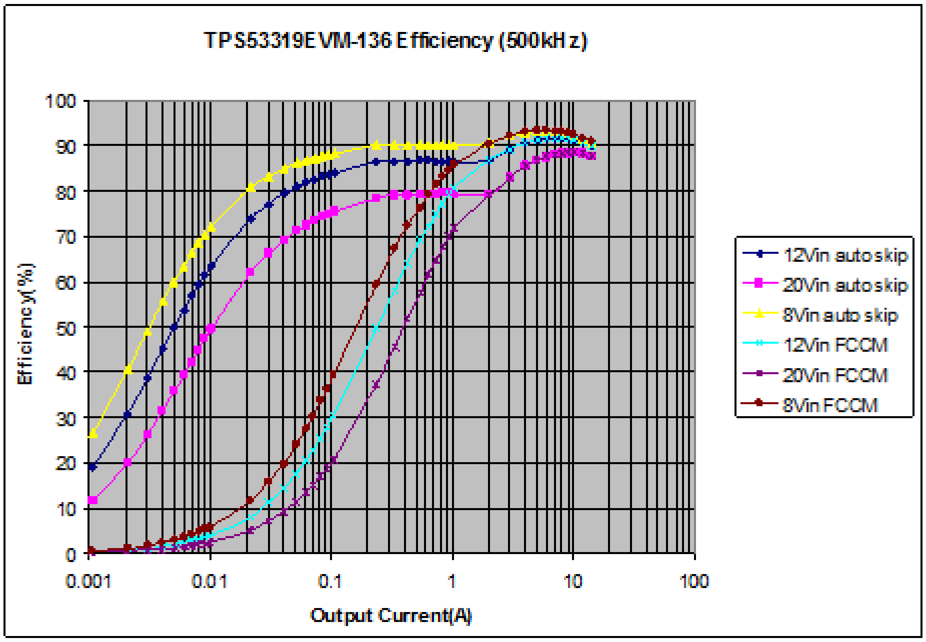

Figure 7-1. Efficiency

7.2 Load Regulation

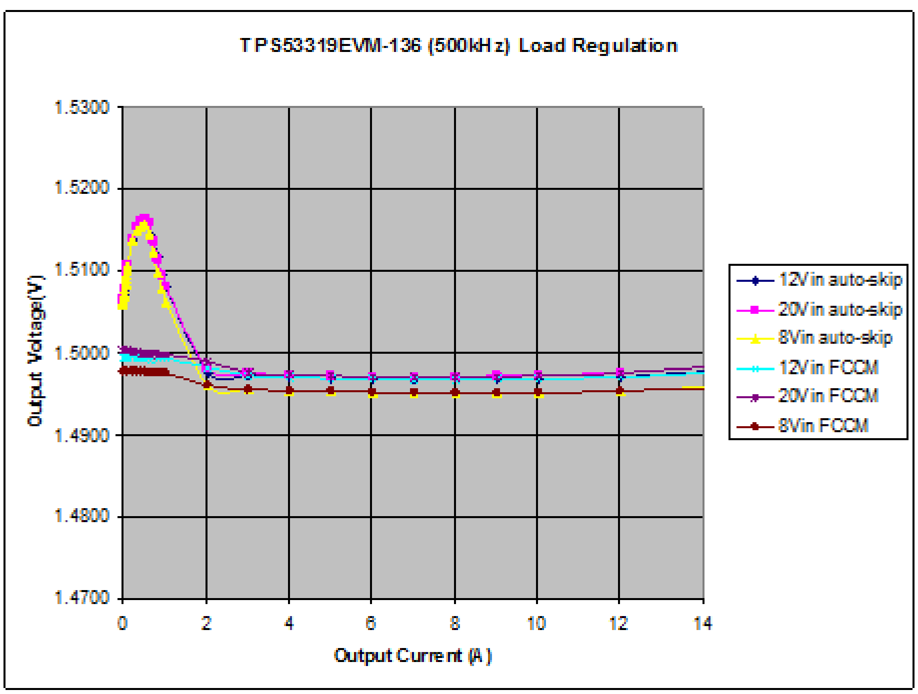

Figure 7-2. Load Regulation

7.3 Line Regulation

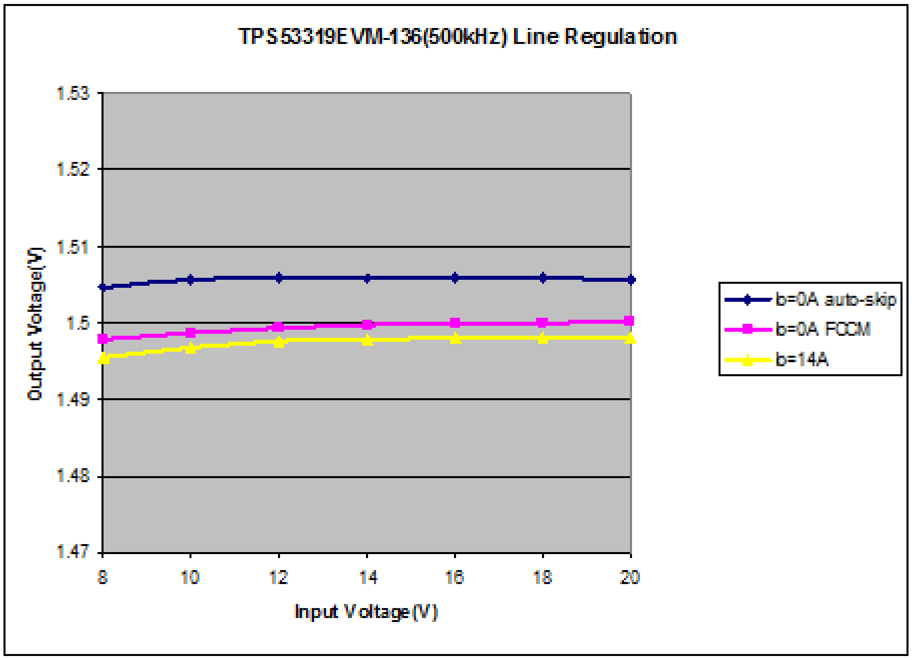

Figure 7-3. Line Regulation

7.4 Enable Turn-On/ Turn-Off

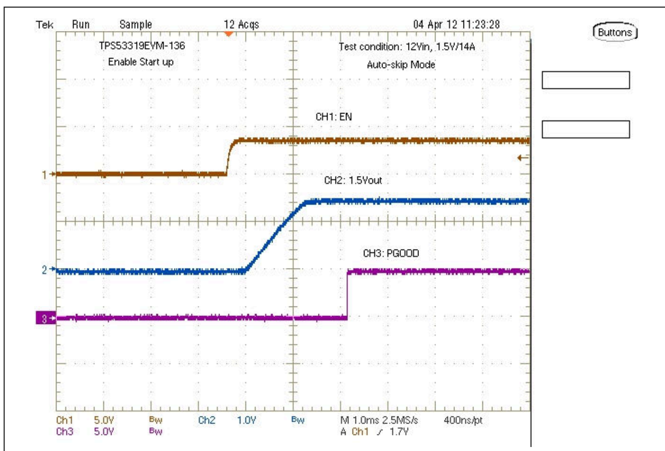

Figure 7-4. Enable Turn-On

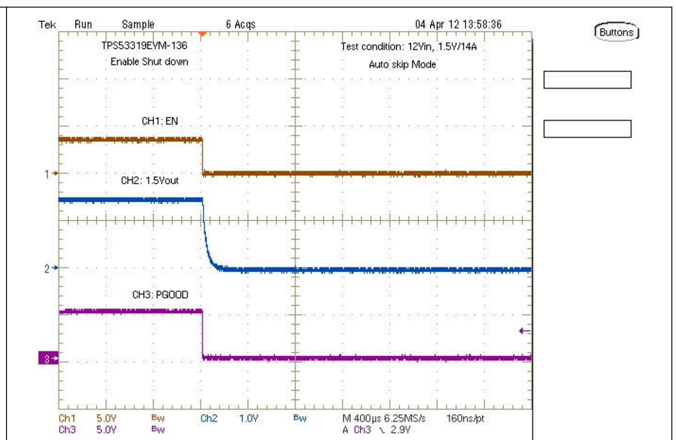

Figure 7-5. Enable Turn-Off

7.5 Output Ripple

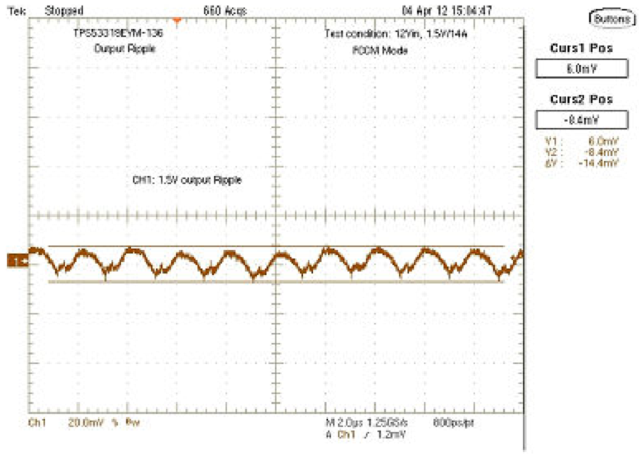

Figure 7-6. Output Ripple

7.6 Switching Node

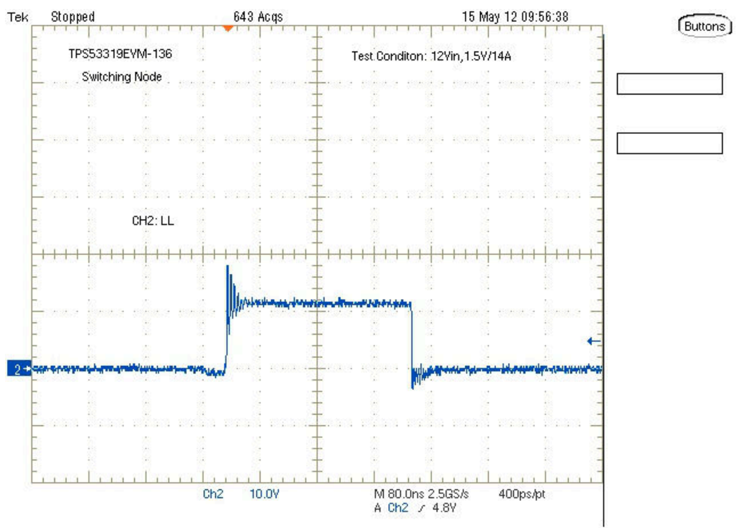

Figure 7-7. Switching Node

7.7 Output Transient with Auto-skip Mode

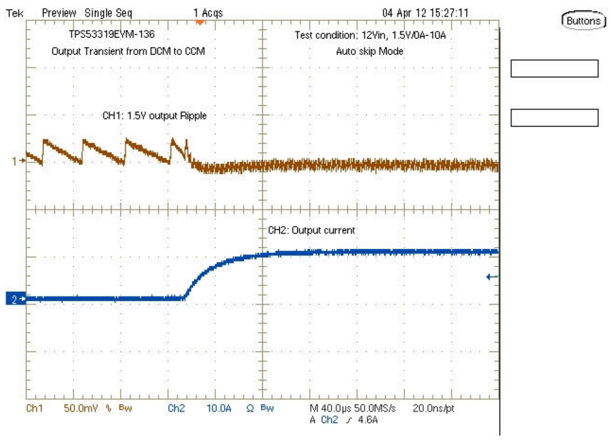

Figure 7-8. Output Transient from DCM to CCM

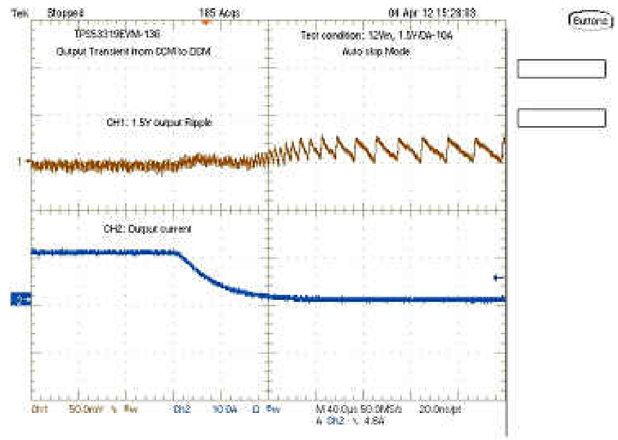

Figure 7-9. Output Transient from CCM to DCM

7.8 Output Transient with FCCM mode

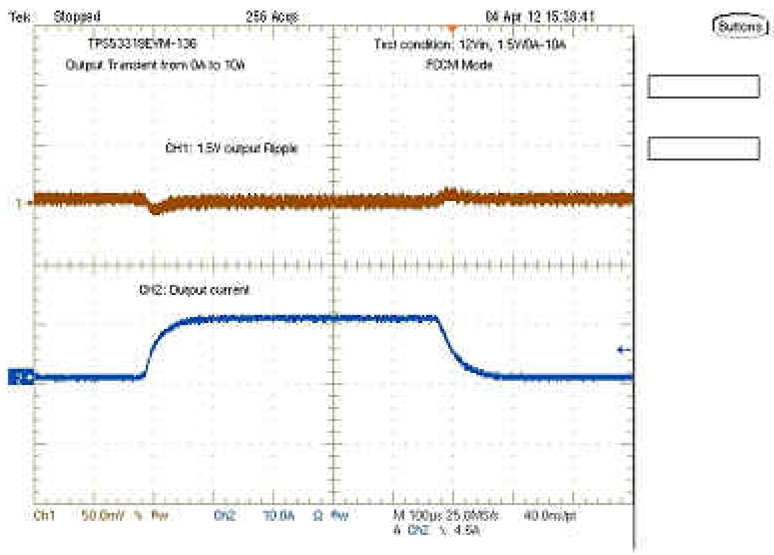

Figure 7-10. Output Transient with FCCM mode

7.9 Output 0.75-V Pre-bias Turn-On

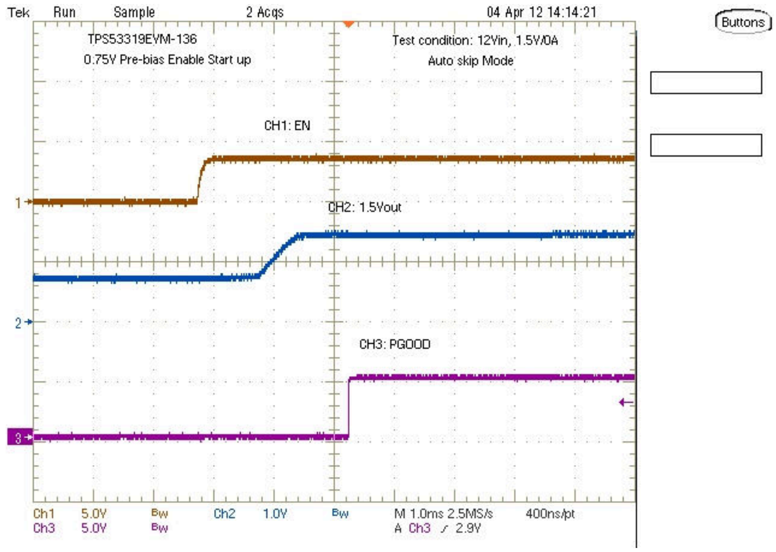

Figure 7-11. Output 0.75-V Pre-bias Turn-On

7.10 Output Overcurrent and Short Circuit Protection

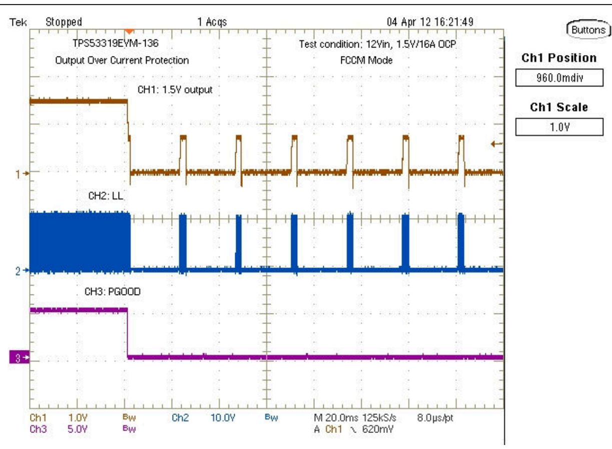

Figure 7-12. Output Overcurrent Protection

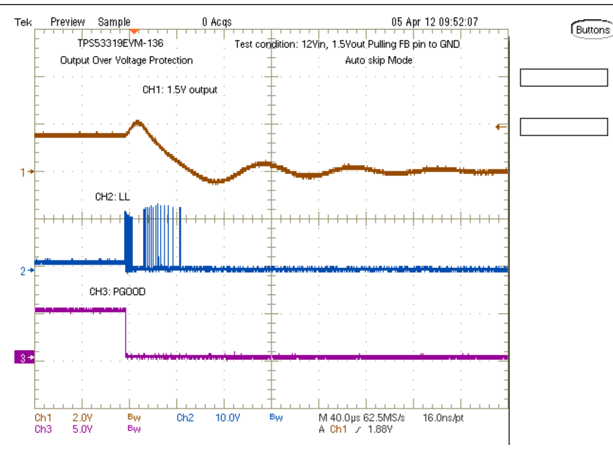

Figure 7-13. Output Overvoltage Protection

7.11 Bode plot

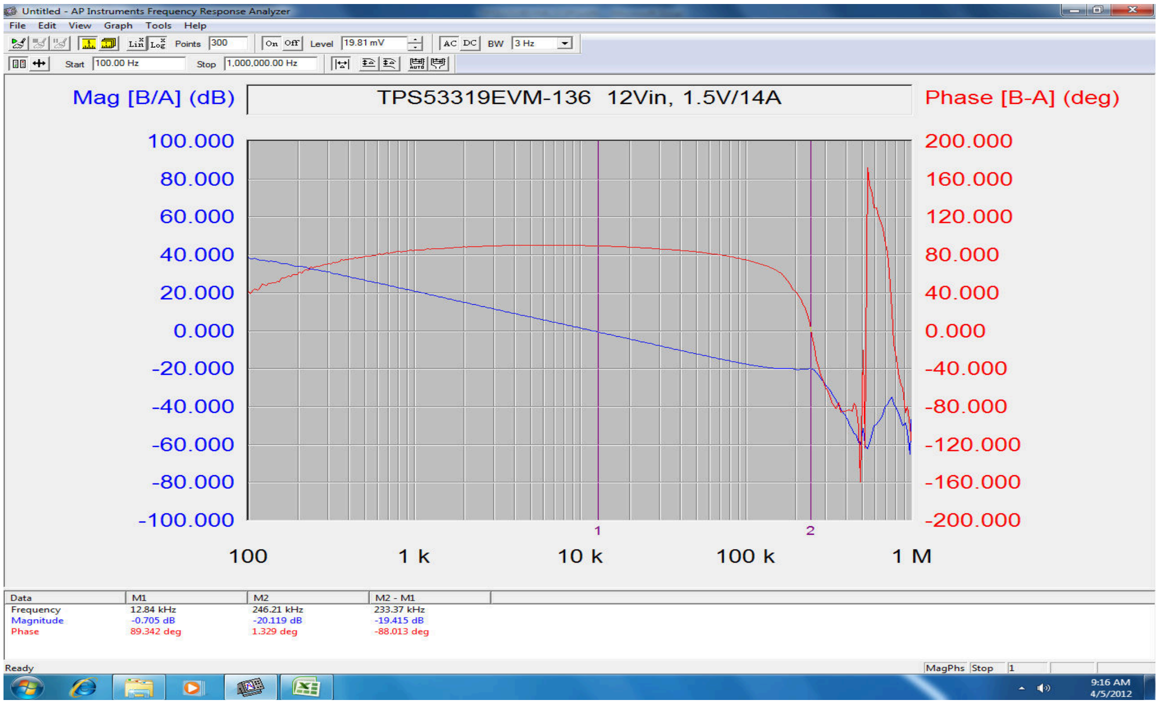

Figure 7-14. Bode plot at 12Vin, 1.5V/14A

7.12 Thermal Image

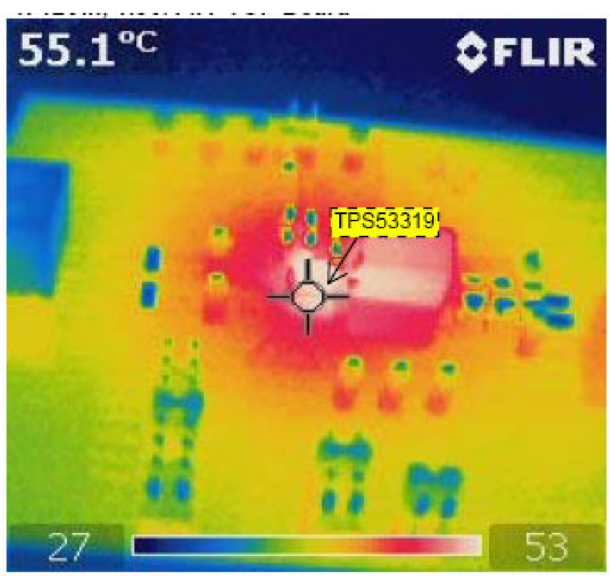

Figure 7-15. Top Board at 12 V_{IN}, 1.5 V/14 A, 25°C Ambient Without Airflow

8 EVM Assembly Drawing and PCB Layout

Figure 8-1 through Figure 8-8 show the design of the TPS53319EVM-136 printed circuit board. The EVM has been designed using a 6-layer, 2-oz copper circuit board.

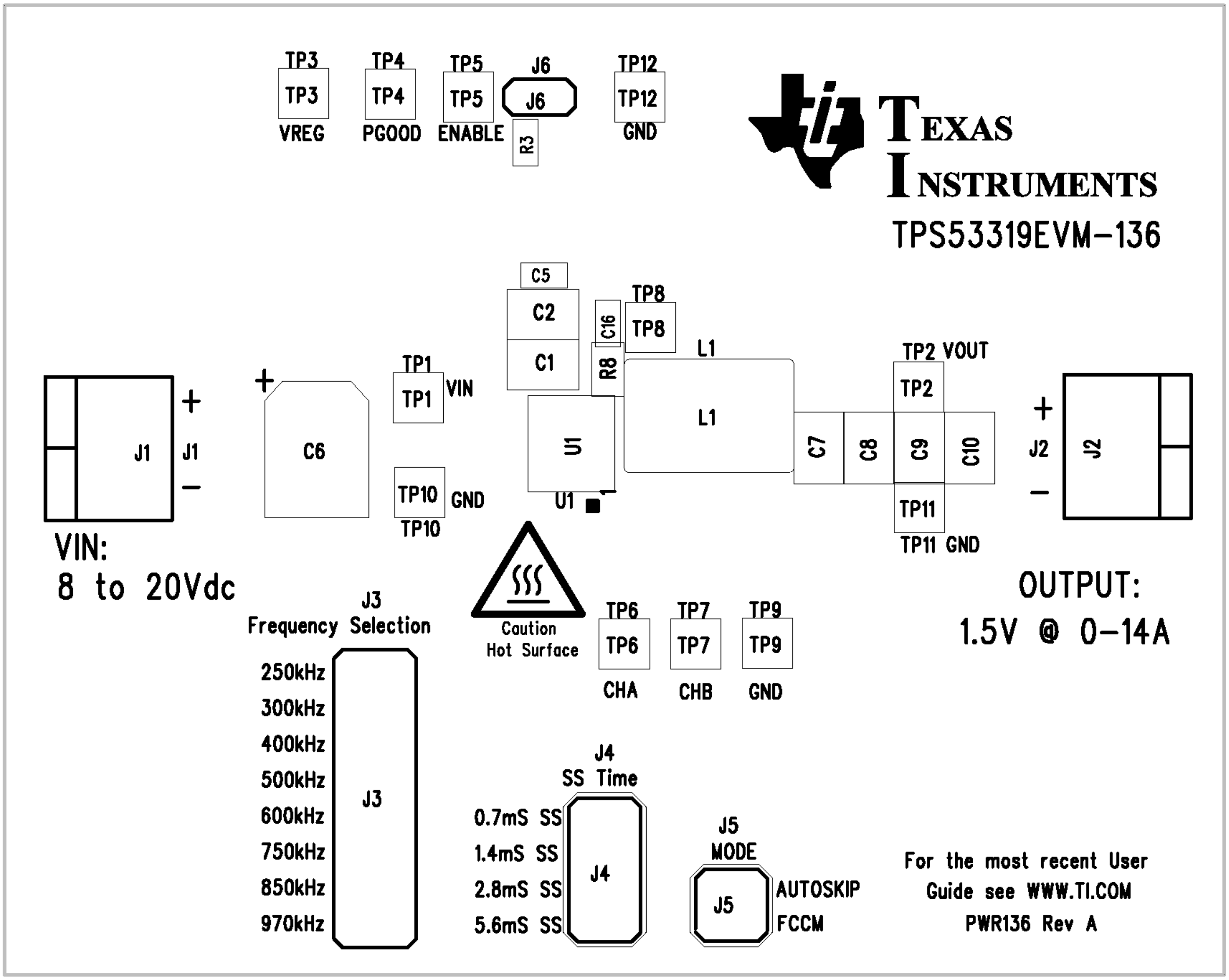

Figure 8-1. TPS53319EVM-136 Top Layer Assembly Drawing

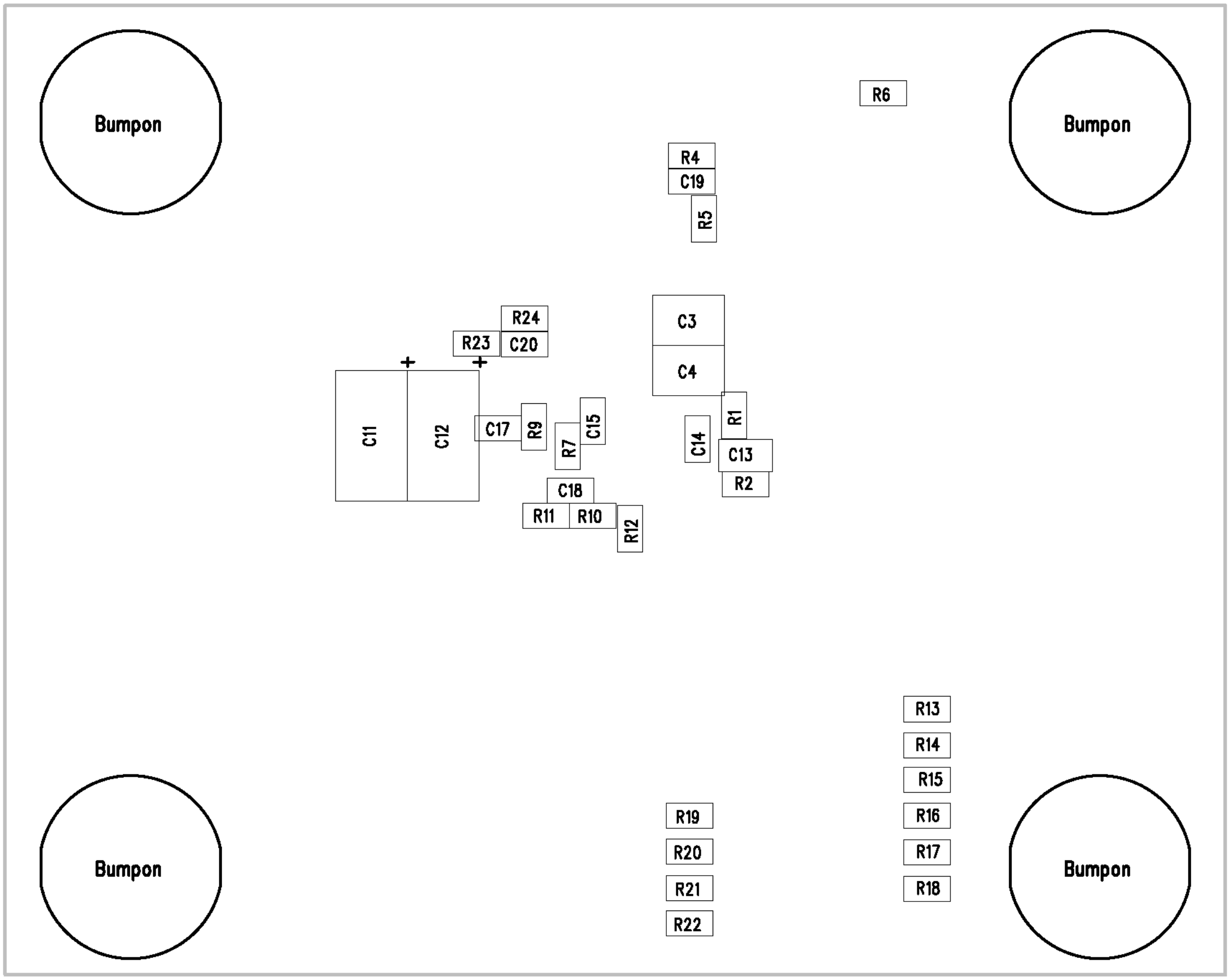

Figure 8-2. TPS53319EVM-136 Bottom Assembly Drawing

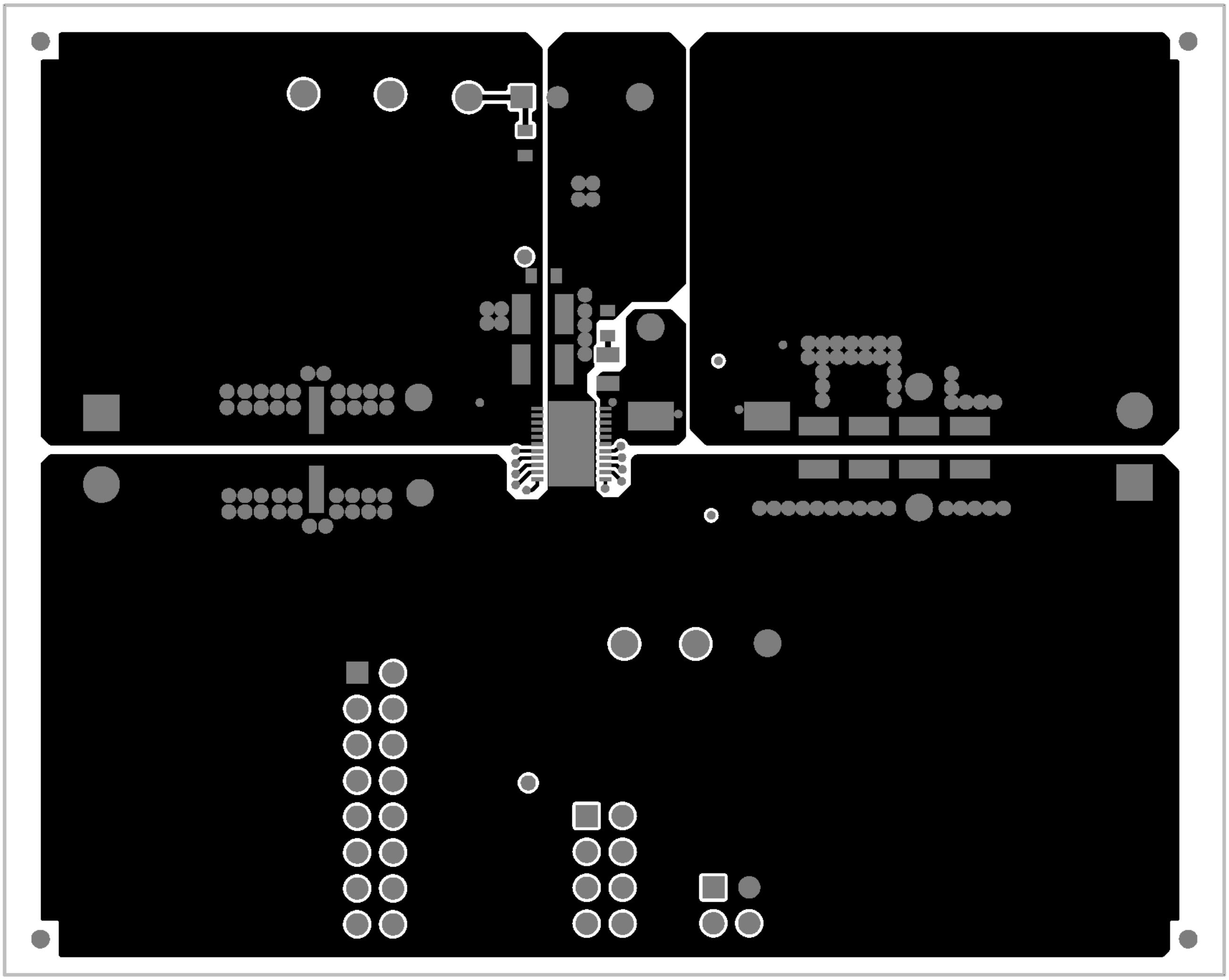

Figure 8-3. TPS53319EVM-136 Top Copper

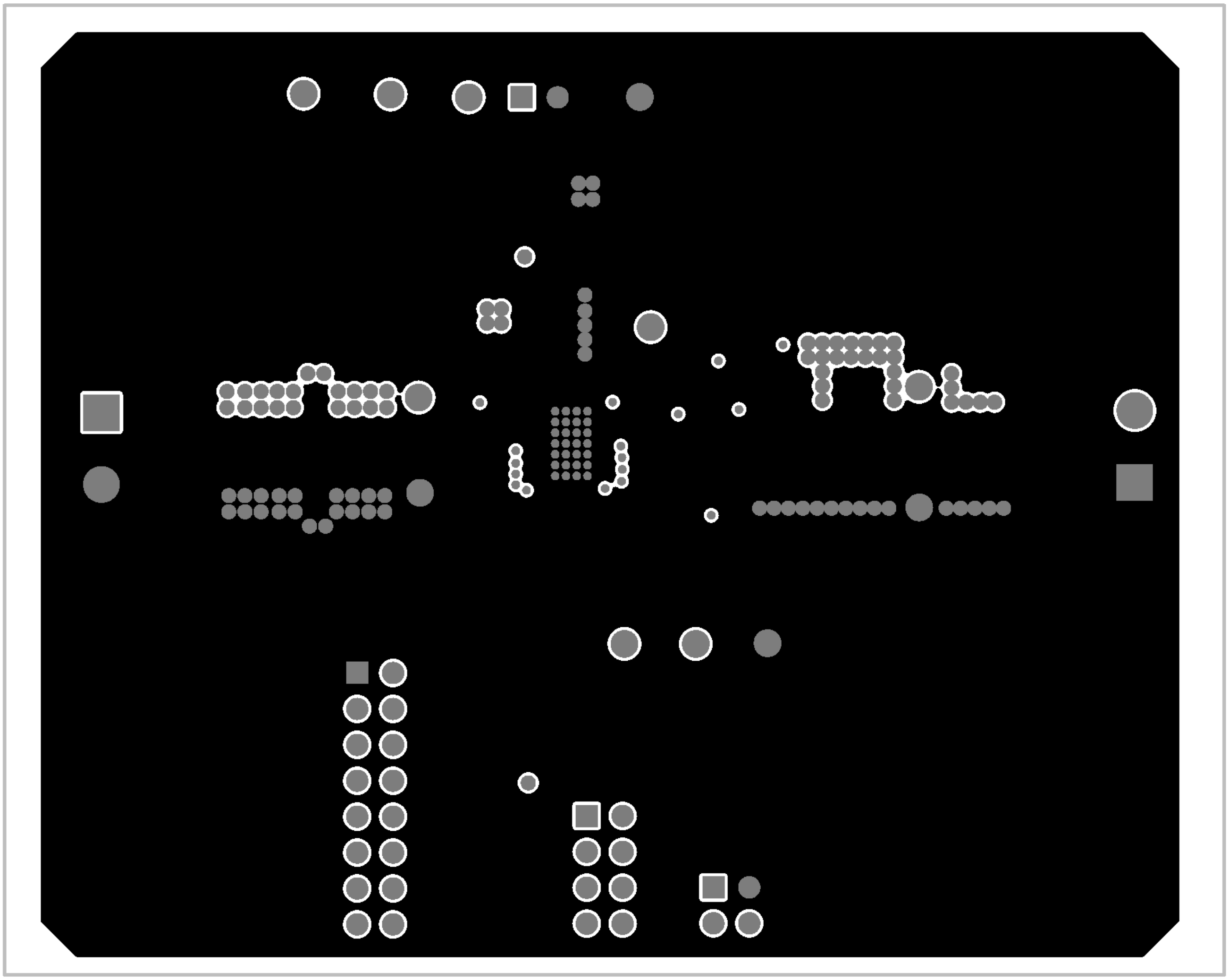

Figure 8-4. TPS53319EVM-136 Layer 2 Copper

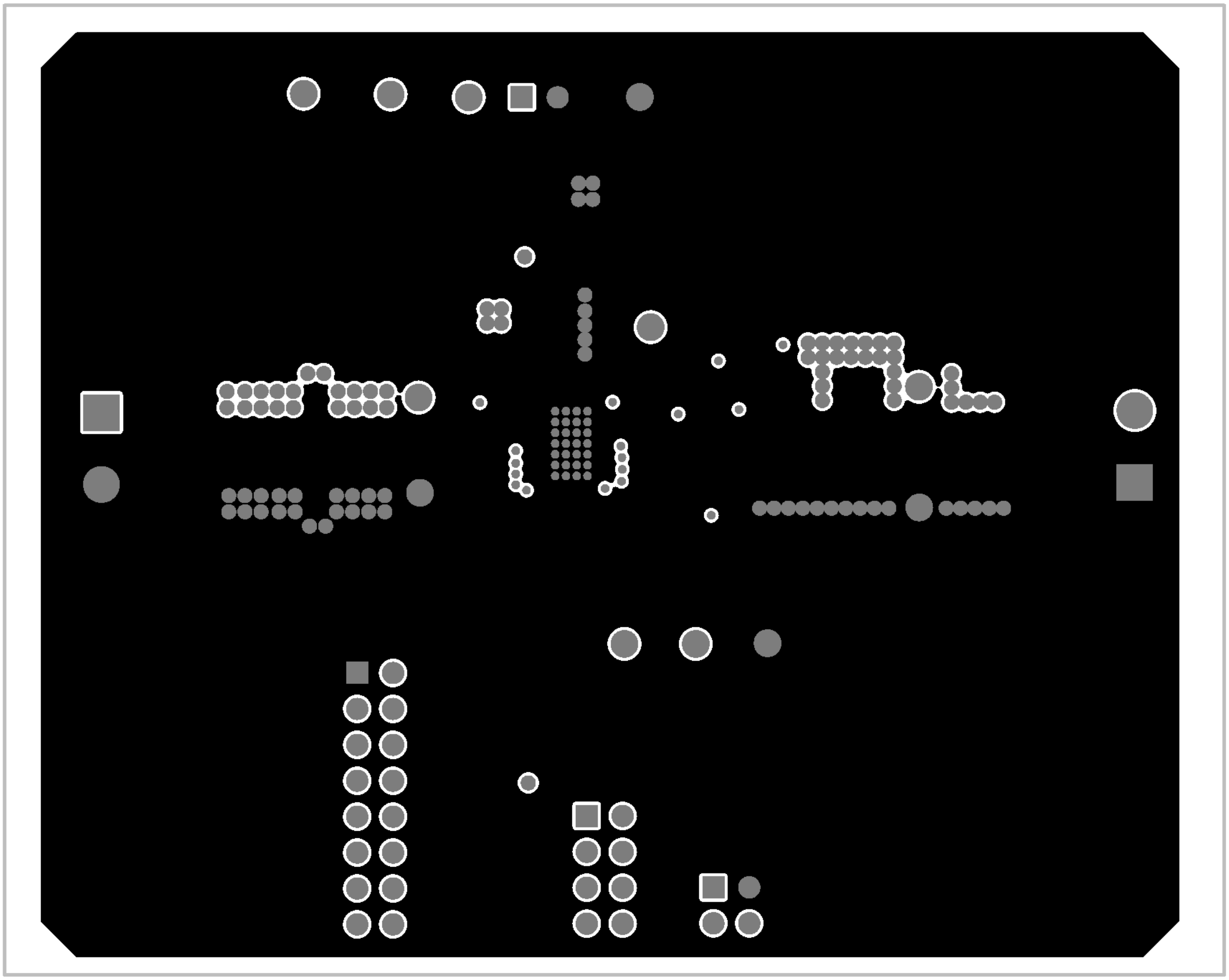

Figure 8-5. TPS53319EVM-136 Layer 3 Copper

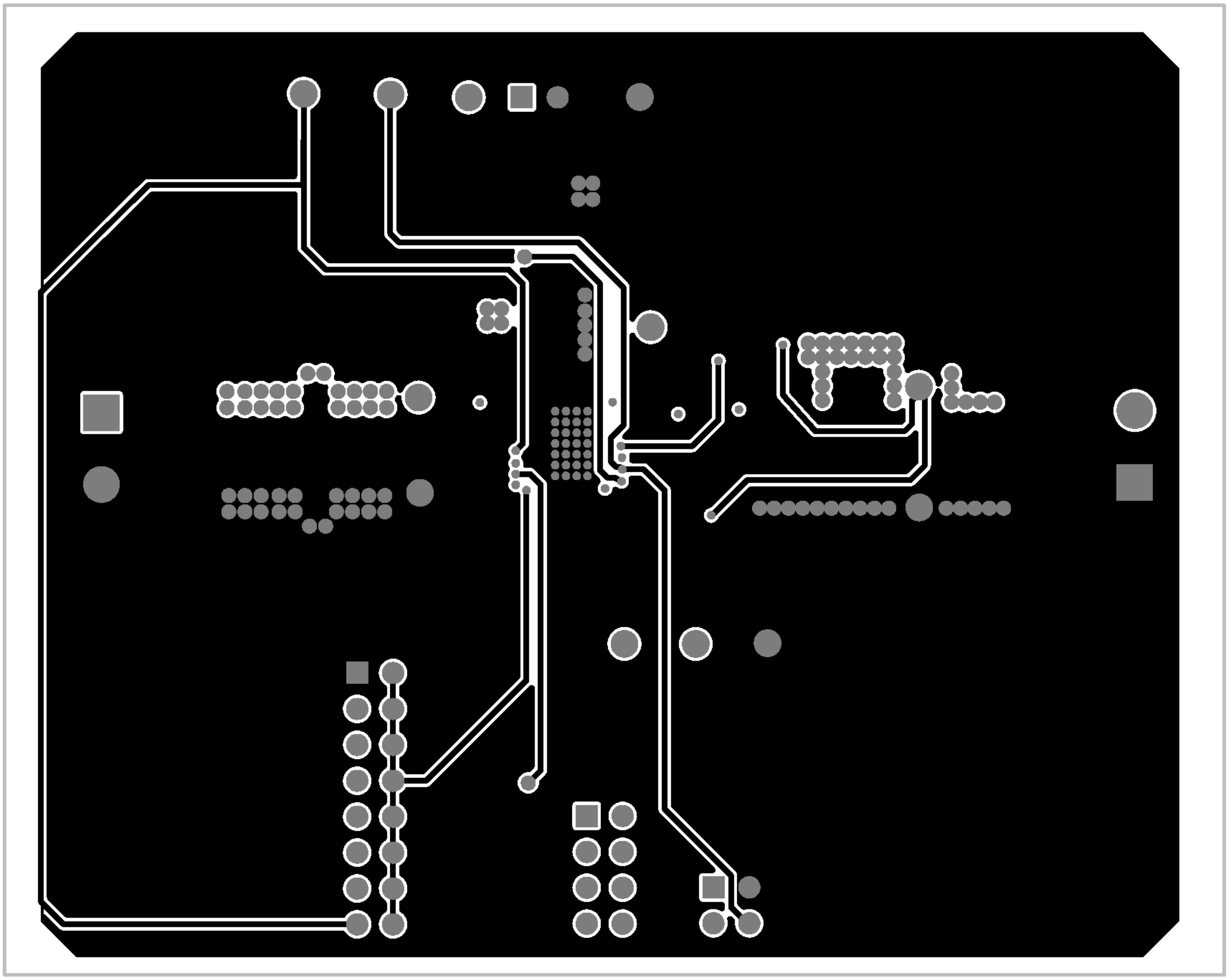

Figure 8-6. TPS53319EVM-136 Layer 4 Copper

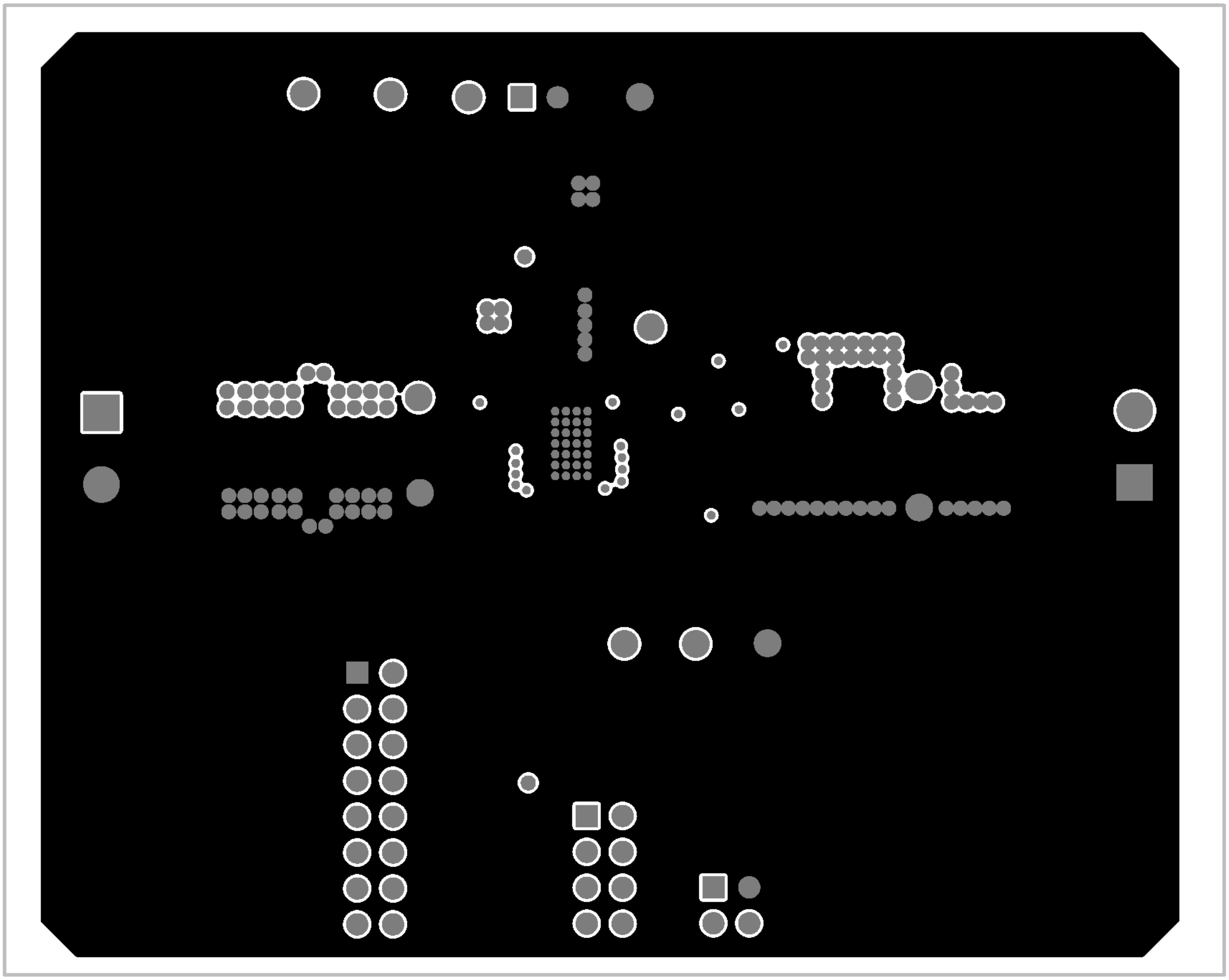

Figure 8-7. TPS53319EVM-136 Layer 5 Copper

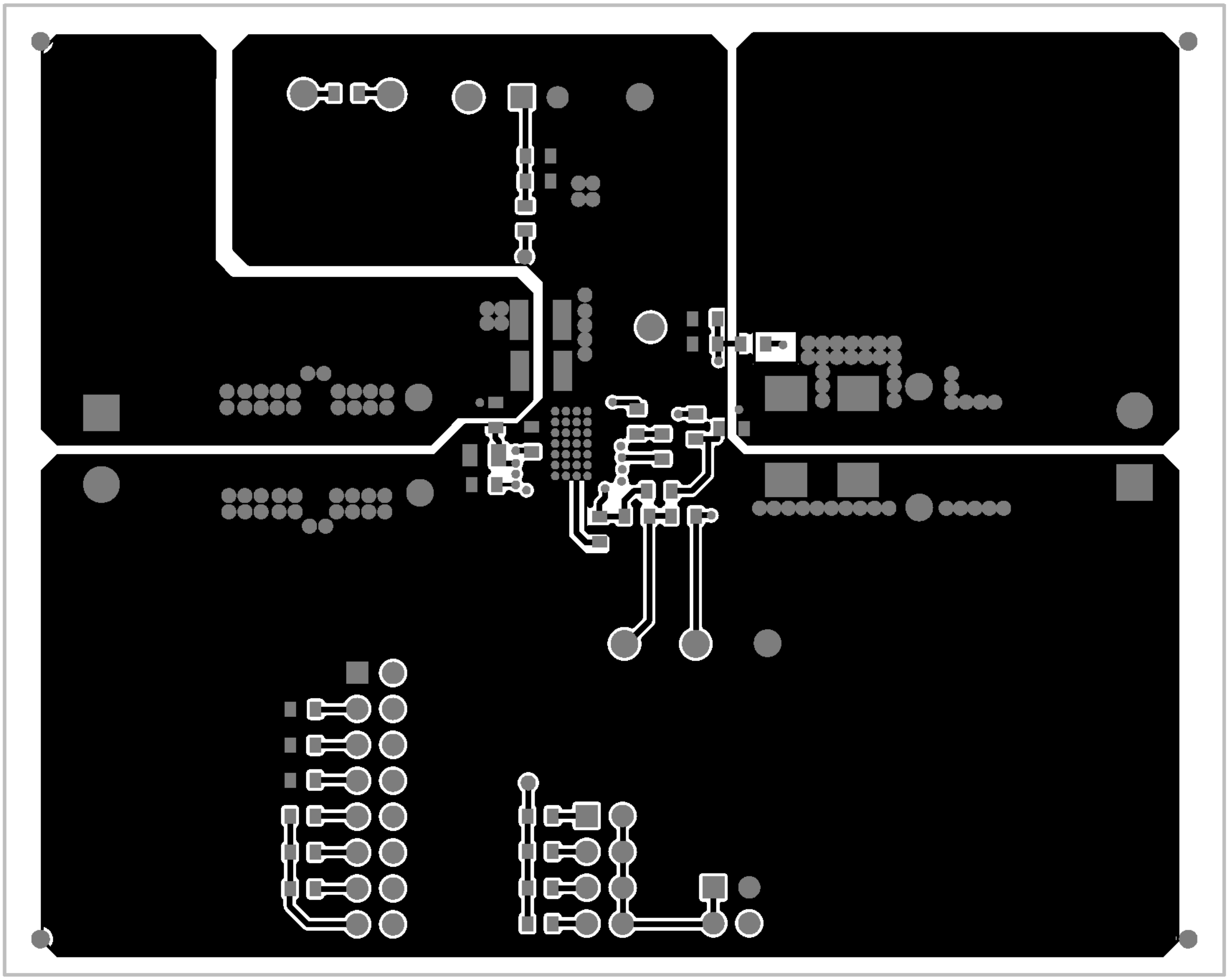

Figure 8-8. TPS53319EVM-136 Bottom Layer Copper

9 Bill of Materials

Table 9-1 list the EVM components according to the schematic shown in Figure 3-1.

Table 9-1. Components List

QTY.	RefDes	Description	MFR	Part Number
2	C1, C2	Capacitor, Ceramic, 22 µF, 25 V, X5R, 20%, 1210	STD	STD
3	C7, C8, C9	Capacitor, Ceramic, 100 µF, 6.3 V, X5R, 20%, 1210	STD	STD
1	C13	Capacitor, Ceramic, 4.7 µF, 25 V, X5R, 20%, 0805	STD	STD
1	C14	Capacitor, Ceramic, 1 µF, 50 V, X7R, 10%, 0603	STD	STD
2	C18, C19	Capacitor, Ceramic, 1000 pF, 50 V, X7R, 10%, 0603	STD	STD
3	C5, C15, C17	Capacitor, Ceramic, 0.1 µF, 50 V, X7R, 10%, 0603	STD	STD
1	C20	Capacitor, Ceramic, 100 pF, 50 V, X7R, 10%, 0603	STD	STD
1	L1	Inductor, SMT, 500 nH±15%, 17 A, DCR: 0.29 mΩ±10%, 7 mm × 11 mm	Delta	HCB1175-501TI
1	R1	Resistor, Chip, 0, 1/16W, 1%, 0603	STD	STD
1	R7	Resistor, Chip, 3.01, 1/16W, 1%, 0603	STD	STD
2	R10, R23	Resistor, Chip, 14.7 k, 1/16W, 1%, 0603	STD	STD
1	R11	Resistor, Chip, 10, 1/16W, 1%, 0603	STD	STD
1	R13	Resistor, Chip, 187 k, 1/16W, 1%, 0603	STD	STD
1	R14	Resistor, Chip, 619 k, 1/16W, 1%, 0603	STD	STD
1	R16	Resistor, Chip, 866 k, 1/16W, 1%, 0603	STD	STD
1	R17	Resistor, Chip, 309 k, 1/16W, 1%, 0603	STD	STD
1	R18	Resistor, Chip, 124 k, 1/16W, 1%, 0603	STD	STD
1	R19	Resistor, Chip, 39.2 k, 1/16W, 1%, 0603	STD	STD
1	R2	Resistor, Chip, 169 k, 1/16W, 1%, 0603	STD	STD
1	R22	Resistor, Chip, 475 k, 1/16W, 1%, 0603	STD	STD
2	R3, R21	Resistor, Chip, 200 k, 1/16W, 5%, 0603	STD	STD
1	R4	Resistor, Chip, 86.6 k, 1/16W, 1%, 0603	STD	STD
1	R5	Resistor, Chip, 1.00 k, 1/16W, 1%, 0603	STD	STD
2	R6, R20	Resistor, Chip, 100 k, 1/16W, 1%, 0603	STD	STD
1	R9	Resistor, Chip, 3.01 k, 1/16W, 1%, 0603	STD	STD
2	R12, R24	Resistor, Chip, 10.0 k, 1/16W, 1%, 0603	STD	STD
1	U1	IC, 14-A synchronous buck converter with integrated MOSFETs, DQP-22	TI	TPS53319DQP

10 Revision History

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

Changes from Revision * (May 2012) to Revision A (December 2021) **Page**

- Updated the numbering format for tables, figures, and cross-references throughout the document. 3
- Updated the user's guide title... 3