Using the TPS53219EVM-690 Wide Input Voltage, Eco Mode, Single Synchronous Step-Down Controller

User's Guide

Texas Instruments

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Wide Input Voltage, Eco Mode, Single Synchronous Step-Down Controller

1 Introduction

The TPS53219EVM-690 evaluation module (EVM) uses the TPS53219. The TPS53219 is a small size single buck controller with adaptive on-time D-CAP ™ mode control. It provides a fixed 1.1V output at up to 25A from a 12V input bus. TPS53219EVM-690 also uses the 5mmx6mm TI power block MOSFET (CSD86350Q5D) for high power density and superior thermal performance.

2 Description

The TPS53219EVM-690 is designed to use a regulated 12V bus to produce a regulated 1.1V output at up to 25A of load current. The TPS53219EVM-690 is designed to demonstrate the TPS53219 in a typical low voltage application while providing a number of test points to evaluate the performance of the TPS53219.

2.1 Typical Applications

- Point of load systems
- Storage Computer
- Server Computer
- Multi-Function Printer
- Embedded Computing

2.2 Features

The TPS53219EVM-690 features:

- 25A DC Steady State Output Current
- Support pre-bias output voltage start-up
- High efficiency and high power density by using TI power block MOSFET
- J1 for selectable switching frequency setting
- J2 for selectable internal voltage servo soft start
- J3 for enable function
- J6 for auto-skip and forced CCM selection
- Convenient test points for probing critical waveforms

3 Electrical Performance Specifications

Table 1: TPS53219EVM-690 Electrical Performance Specifications

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Input Characteristics					
Voltage range	VIN	8	12	14	V
Maximum input current	VIN = 8V, Io = 25 A		4.0		A
No load input current	Vin=14V, Io=0A with auto skip mode		1.0		mA
Output Characteristics					
Output voltage VOUT			1.1		V
Output voltage regulation	Line regulation(Vin=8V-14V)		0.5		%
	Load regulation(Vin=12V, Io=0A-25A)		0.5		%
Output voltage ripple	Vin=12V, Io=25A		25		mVpp
Output load current		0		25	A
Output over current			35		A
Systems Characteristics					
Switching frequency			300		kHz
Peak efficiency	Vin=12V, 1.1V/10A		90.90		%
Full load efficiency	Vin=12V, 1.1V/25A		88.59		%
Operating temperature			25		ºC

Note: Jumpers set to default locations, See section 6 of this user's guide

4 Schematic

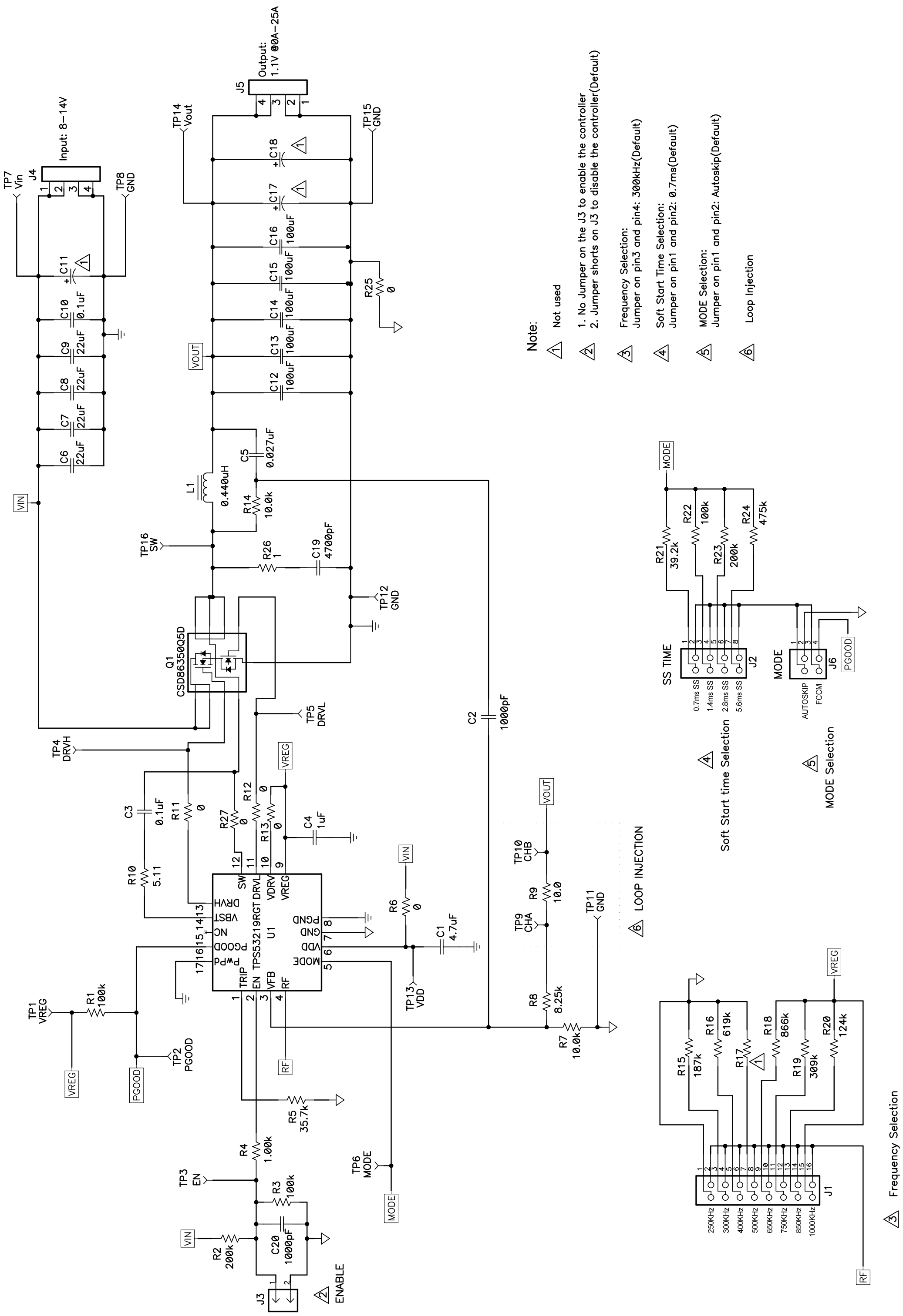


Figure 1: TPS53219EVM-690 Schematic

5 Test Setup

5.1 Test Equipment

Voltage Source: The input voltage source Vin should be a 0-14V variable DC source capable of supplying 10Adc. Connect Vin to J4 as shown in Figure 3.

Multimeters:
V1: Vin at TP7 (Vin) and TP8 (GND).
V2: Vout at TP14 (Vout) and TP15 (GND).
A1: Vin input current

Output Load: The output load should be an electronic constant resistance mode load capable of 0-30Adc at 1.1V.

Oscilloscope: A digital or analog oscilloscope can be used to measure the output ripple. The oscilloscope should be set for 1MΩ impedance, 20MHz Bandwidth, AC coupling, 2us/division horizontal resolution, 50mV/division vertical resolution. Test points TP14 and TP15 can be used to measure the output ripple voltage by placing the oscilloscope probe tip through TP14 and holding the ground barrel on TP15 as shown in Figure 2. Using a leaded ground connection may induce additional noise due to the large ground loop.

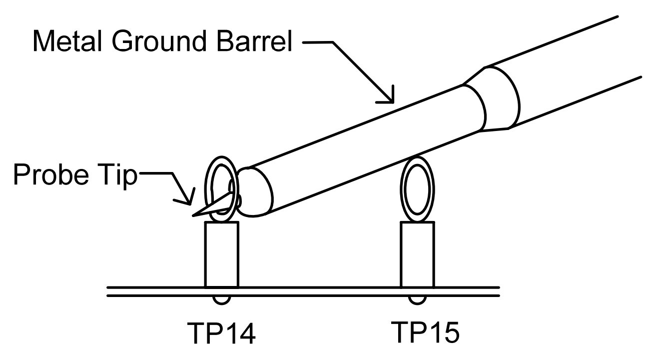


Figure 2: Tip and Barrel Measurement for Vout Ripple

Fan: Some of the components in this EVM may approach temperatures of 60ºC during operation. A small fan capable of 200-400 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:
1. V_{IN} to J4(12V 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).
2. 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)

5.2 Recommended Test Setup

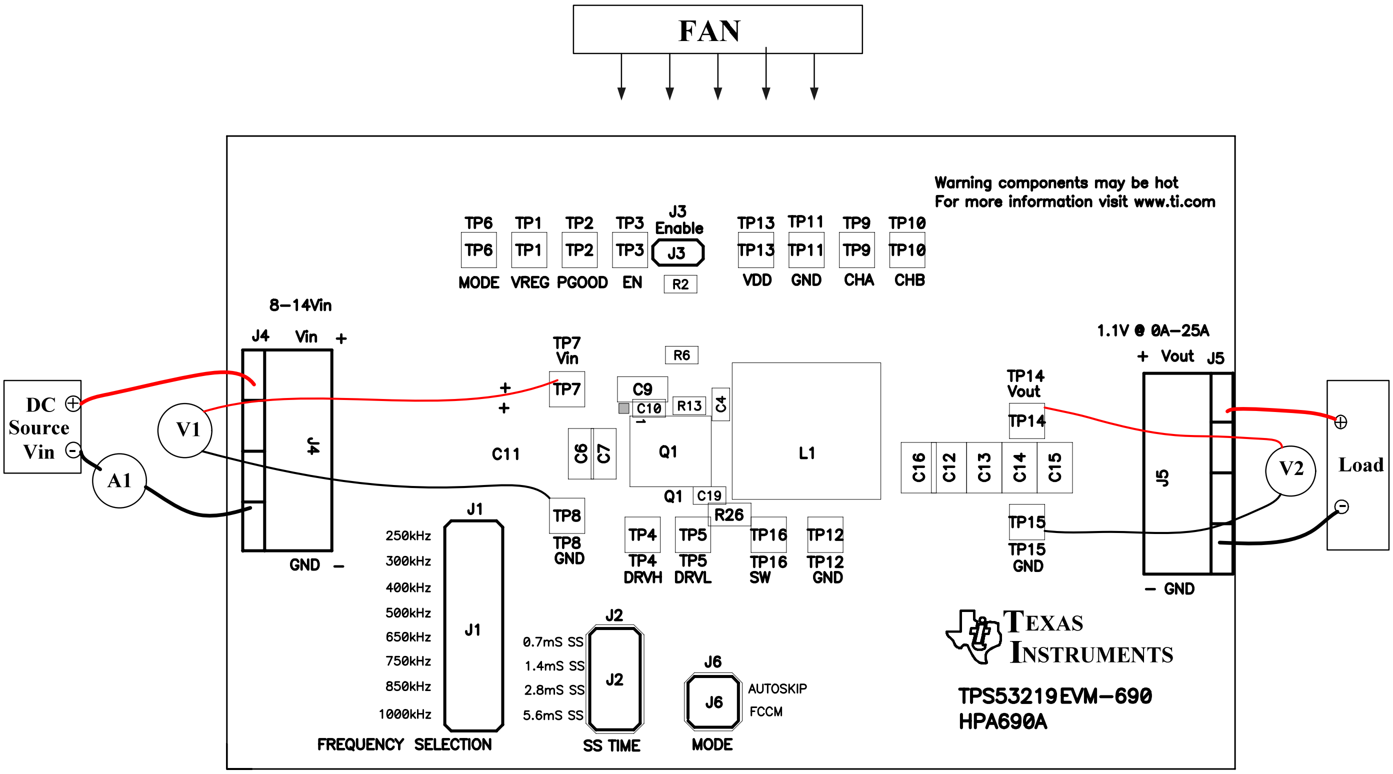


Figure 3: TPS53219EVM-690 Recommended Test Set Up

Figure 3 is the recommended test set up to evaluate the TPS53219EVM-690. 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 Vin, it is advisable to limit the source current from Vin to 10**A** maximum. Make sure Vin is initially set to 0V and connected as shown in Figure 3.
2. Connect a voltmeter V1 at TP7(Vin) and TP8(GND) to measure the input voltage.
3. Connect a current meter A1 to measure the input current.

Output Connections

1. Connect Load to J5 and set Load to constant resistance mode to sink 0Adc before Vin is applied.
2. Connect a voltmeter V2 at TP14 (Vout) and TP15 (GND) 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.

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 Switching Frequency Selection

The switching frequency can be set by J1.

Default setting: 300kHz

Table 2: 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)	**187k**	**300**
3rd(5-6 pin shorted)	619k	400
4th(7-8 pin shorted)	Open	500
5th(9-10 pin shorted)	866k	650
6th(11-12 pin shorted)	309k	750
7th(13-14 pin shorted)	124k	850
Bottom(15-16 pin shorted)	0	1000

6.2 Soft Start Selection

The soft start time can be set by J2.

Default setting: 0.7ms

Table 3: 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

6.3 Mode Selection

The MODE can be set by J6.

Default setting: Auto Skip

Table 4: MODE Selection

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

6.4 Enable Selection

The controller can be enabled and disabled by J3.

Default setting: Jumper shorts on J3 to disable the controller

Table 5: Enable Selection

Jumper set to	Enable Selection
Jumper shorts on J3	**Disable the controller**
No Jumper shorts on J3	Enable the controller

7 Test Procedure

7.1 Line/Load Regulation and Efficiency Measurement Procedure

1. Set up EVM as described in section 5 and Figure 3.
2. Ensure Load is set to constant resistance mode and to sink 0Adc
3. Ensure all jumper configuration settings per section 6.
4. Ensure the jumper provided in the EVM shorts on J3 before Vin is applied.
5. Increase Vin from 0V to 12V. Using V1 to measure input voltage.
6. Remove the jumper on J3 to enable the controller.
7. Use V2 to measure Vout voltage.
8. Vary Load from 0-25Adc, Vout should be remain in load regulation.
9. Vary Vin from 8V to 14V, Vout should remain in line regulation.
10. Put the jumper on J3 to disable the controller.
11. Decrease Load to 0A
12. Decrease Vin to 0V.

7.2 Control Loop Gain and Phase Measurement Procedure

TPS53219EVM-690 contains a 10Ω series resistor in the feedback loop for loop response analysis.

1. Set up EVM as described in section 5 and Figure 3.
2. Connect isolation transformer to test points marked TP9 and TP10.
3. Connect input signal amplitude measurement probe (channel A) to TP9. Connect output signal amplitude measurement probe (channel B) to TP10.
4. Connect ground lead of channel A and channel B to TP11.
5. Inject around 40mV 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).

7.3 *List of Test Points*

Table 6: The functions of each test points

Test Points	Name	Description
TP1	VREG	6.2V LDO Output
TP2	PGOOD	Power Good
TP3	EN	Enable pin
TP4	DRVH	High side driver output
TP5	DRVL	Low side driver output
TP6	MODE	Soft start and Auto skip/FCCM selection pin
TP7	Vin	Vin
TP8	GND	GND for Vin
TP9	CHA	Input A for loop injection
TP10	CHB	Input B for loop injection
TP11	GND	GND
TP12	GND	GND
TP13	VDD	Controller power supply input
TP14	Vout	Output Voltage
TP15	GND	GND for output voltage

7.4 Equipment Shutdown

1. **Shut down Load**
2. **Shut down Vin**
3. **Shut down FAN**

8 Performance Data and Typical Characteristic Curves

Figure 4 through 12 present typical performance curves for TPS53219EVM-690.

8.1 Efficiency

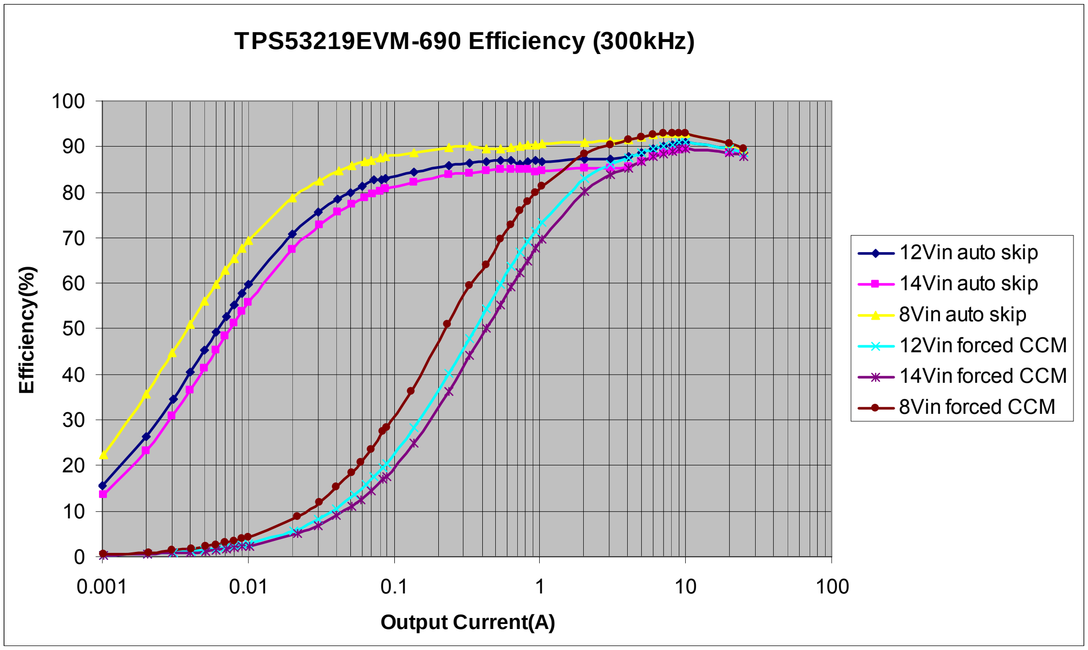


Figure 4: Efficiency

8.2 Load Regulation

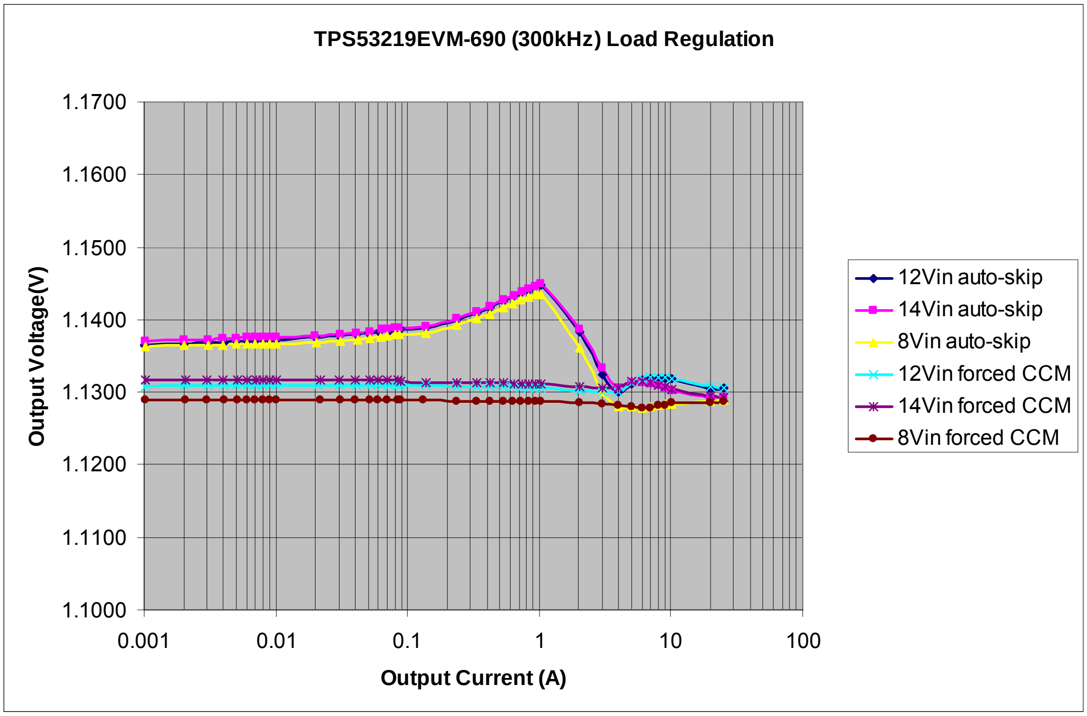
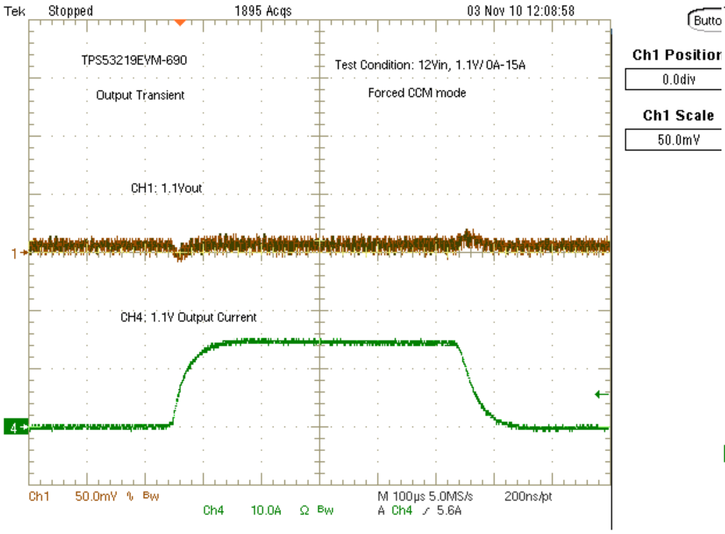
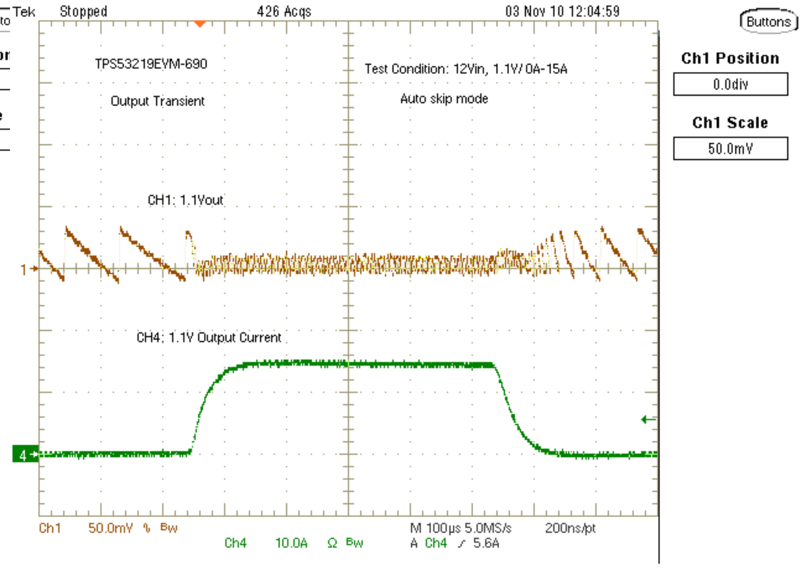


Figure 5: Load Regulation

8.3 Output Transient

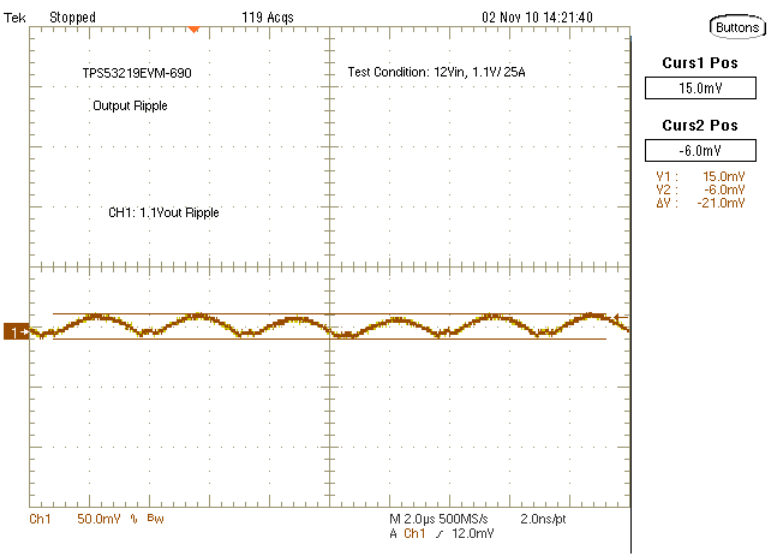


12Vin, 1.1V/0A-15A Forced CCM ModeTransient
Figure 6: Output Load Transient



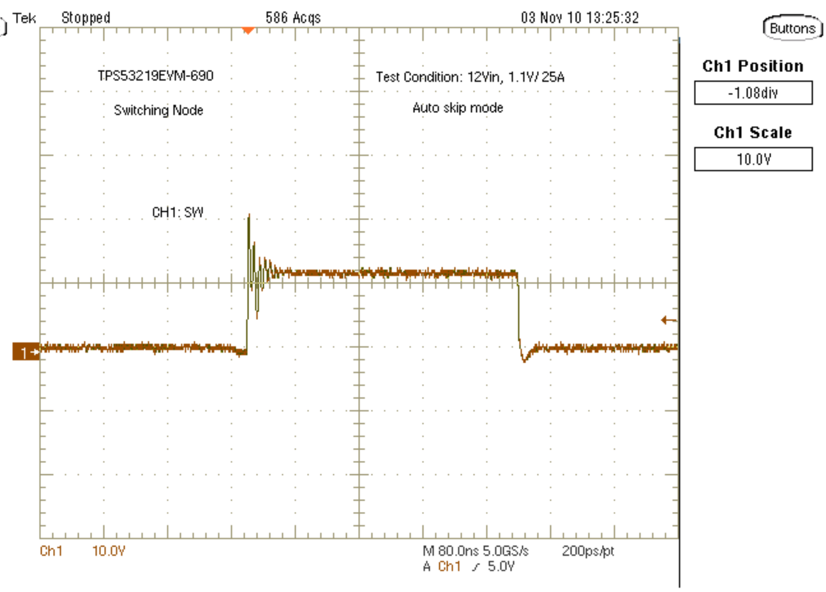
12Vin, 1.1V/0A-15A Auto Skip Mode Transient
Figure 7: Output Load Transient

8.4 Output Ripple



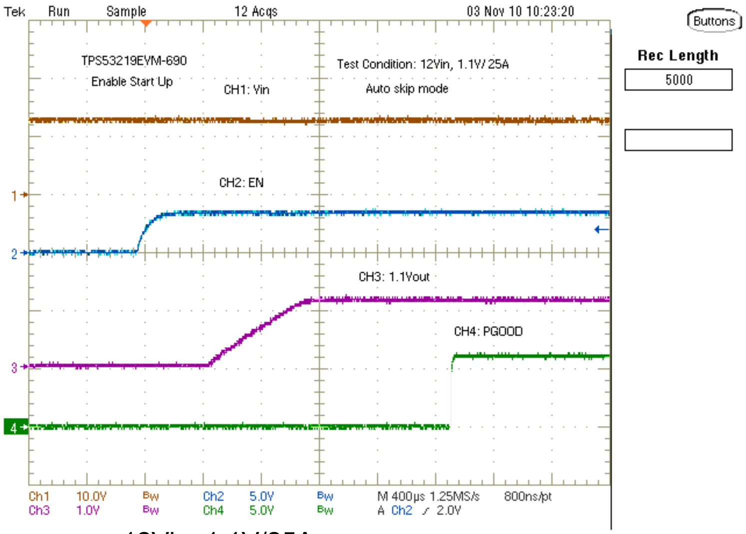
12Vin, 1.1V/25A
Figure 8: Output Ripple

8.5 Switching Node



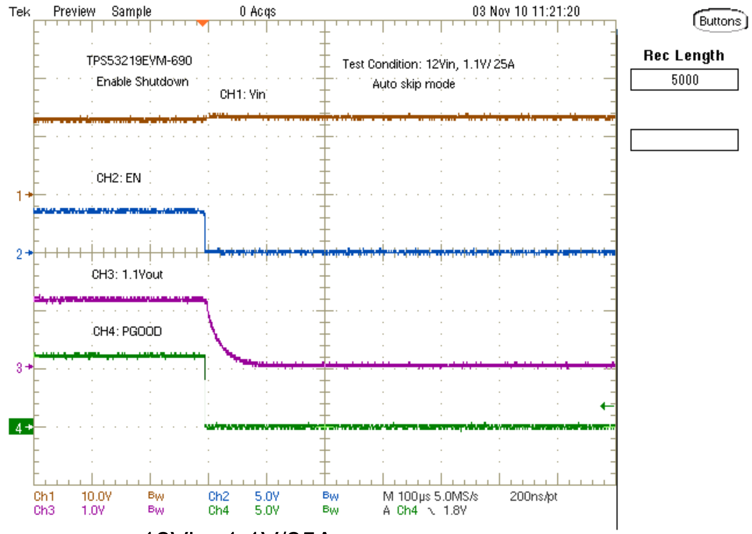
12Vin, 1.1V/25A
Figure 9: Switching Node

8.6 Enable Turn On / Turn Off



12Vin, 1.1V/25A

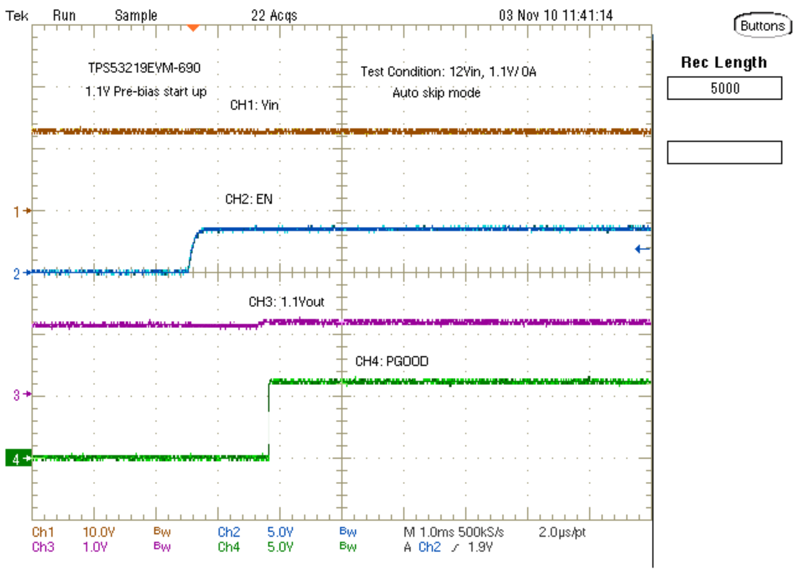
Figure 10: Enable Turn On



12Vin, 1.1V/25A

Figure 11: Enable Turn Off

8.7 Output 1.1V Pre-bias turn on



12Vin, 1.1V/0A with 1.1Vout pre-bias

Figure 12: Output 1.1V Pre-bias turn on

8.8 Bode Plot

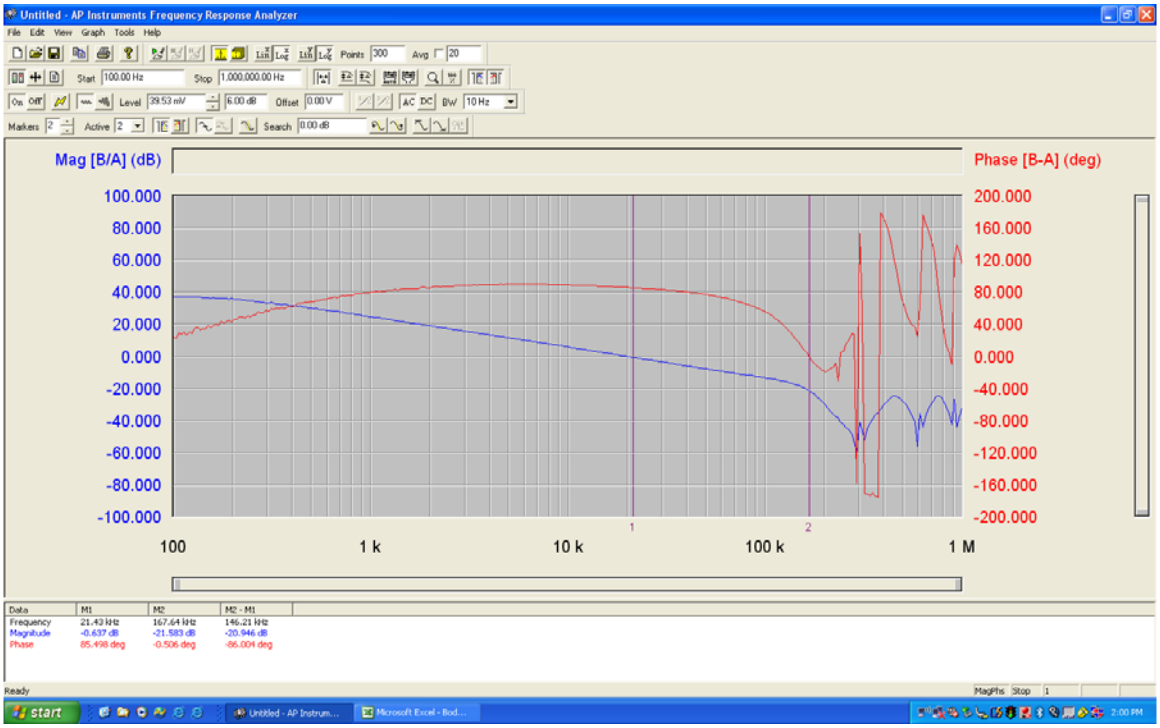


Figure 13: Bode plot at 12Vin, 1.1V/25A

8.9 Thermal Image

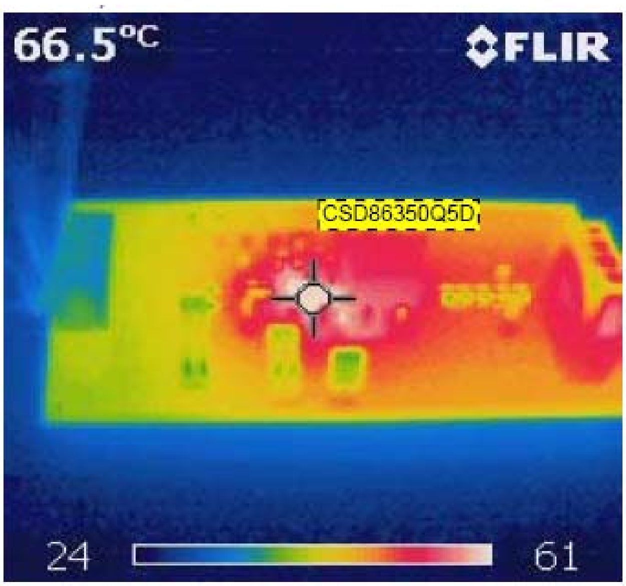


Figure 14: Top Board at 12Vin, 1.1V/25A

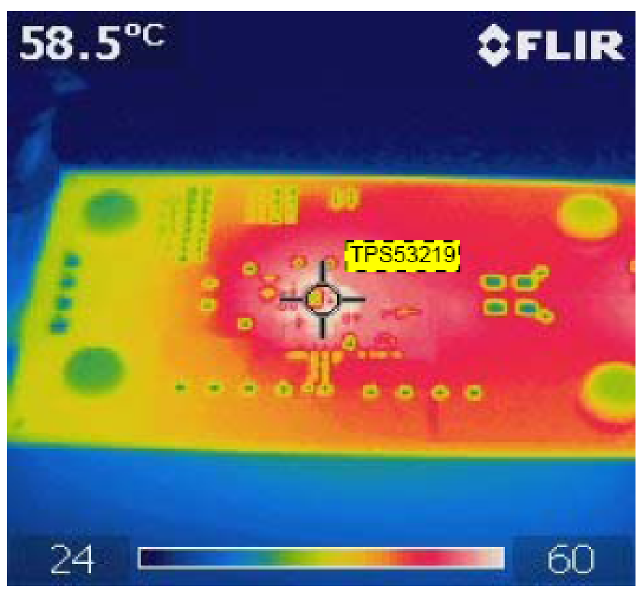


Figure 15: Bottom Board at 12Vin, 1.1V/25A

9 EVM Assembly Drawing and PCB Layout

The following figures (Figure 16 through Figure 23) show the design of the TPS53219EVM-690 printed circuit board. The EVM has been designed using 6 Layers, 2oz copper circuit board.

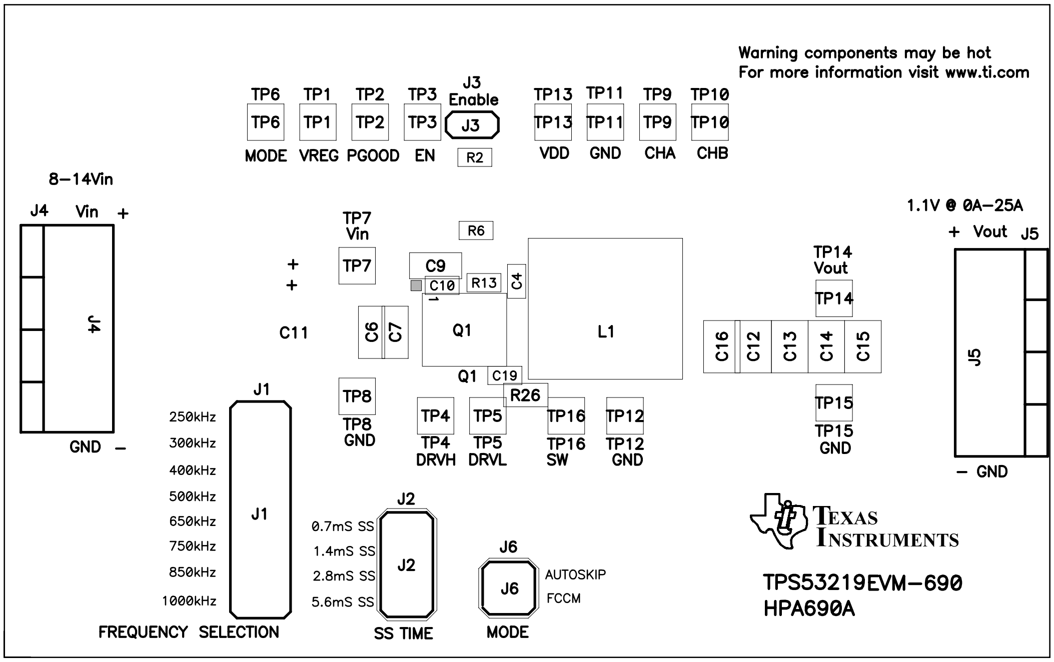


Figure 16: TPS53219EVM-690 Top Layer Assembly Drawing (Top view)

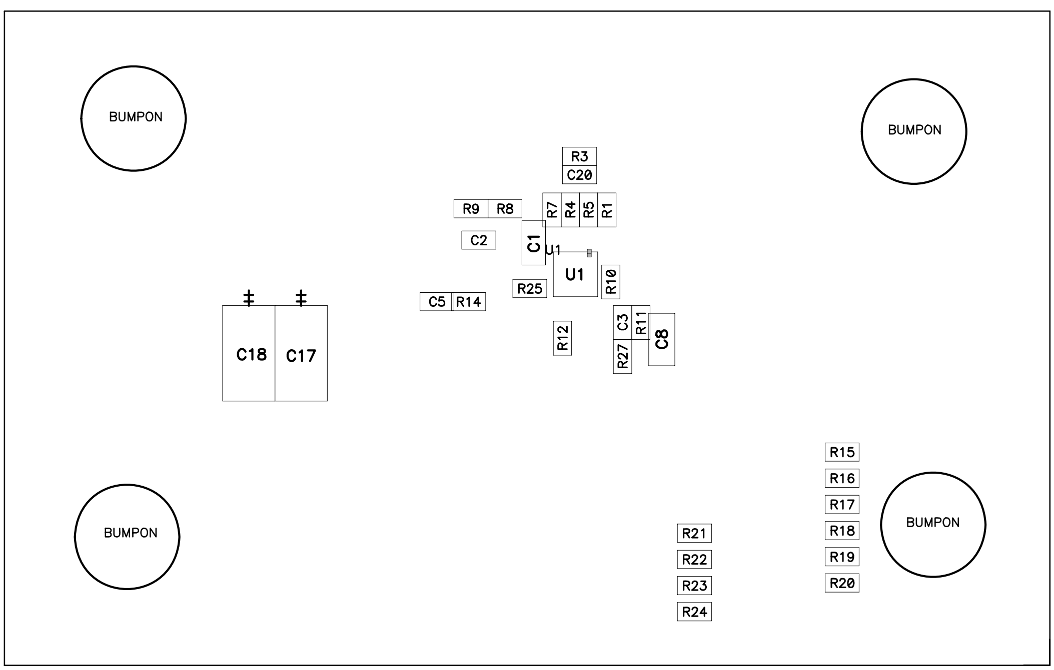


Figure 17: TPS53219EVM-690 Bottom Assembly Drawing (Bottom view)

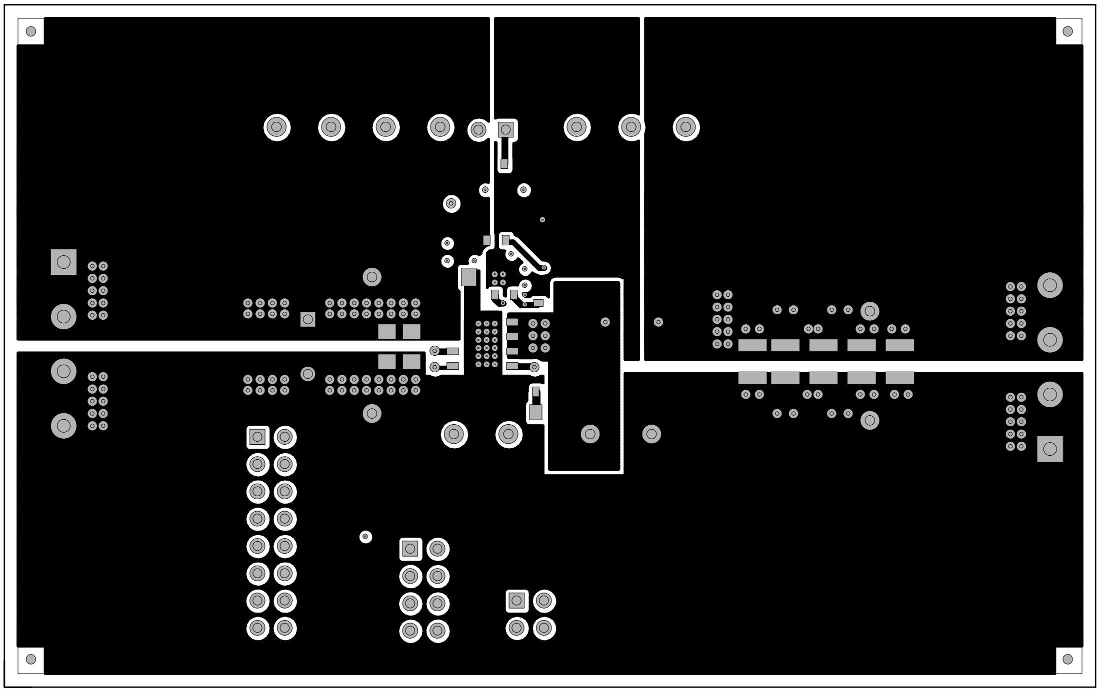


Figure 18: TPS53219EVM-690 Top Copper (Top View)

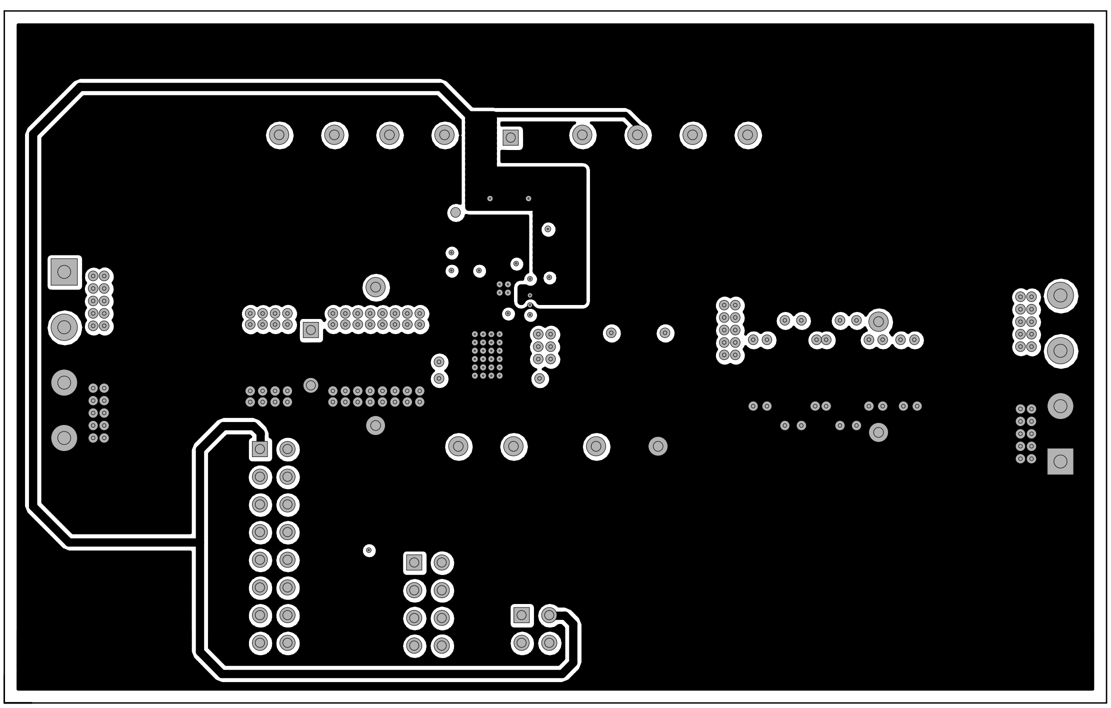


Figure19: TPS53219EVM-690 Layer 2 Copper (Top View)

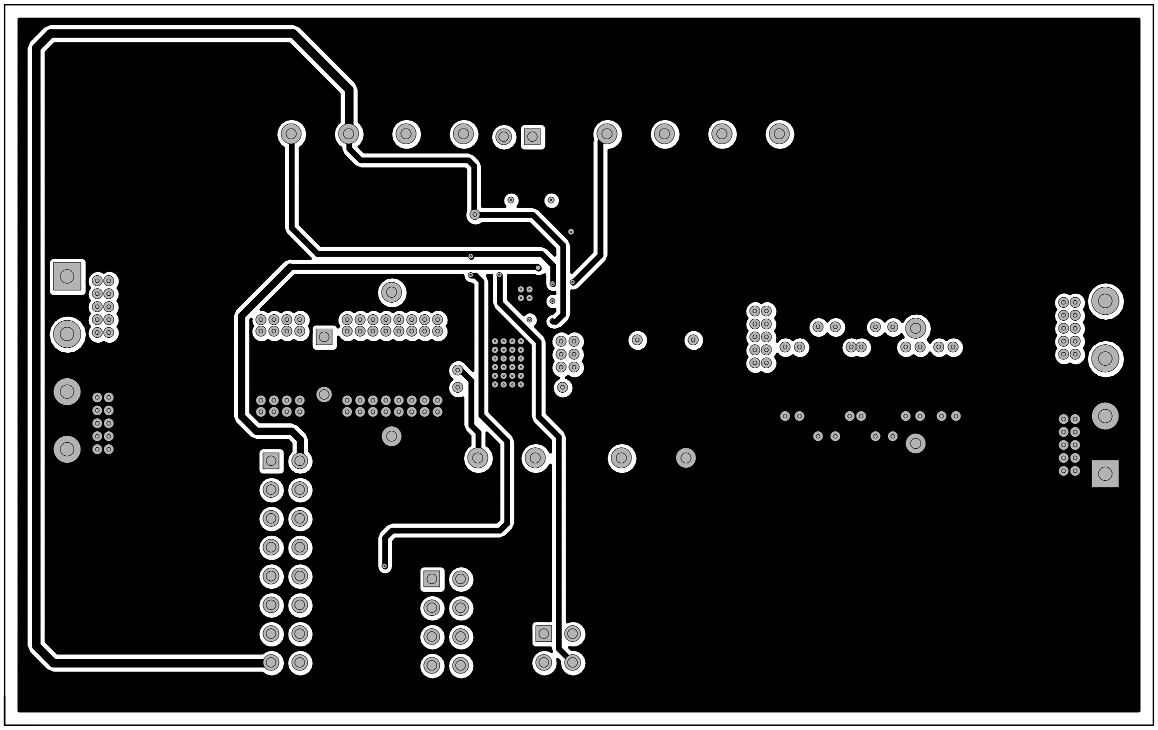


Figure20: TPS53219EVM-690 Layer 3 Copper (Top View)

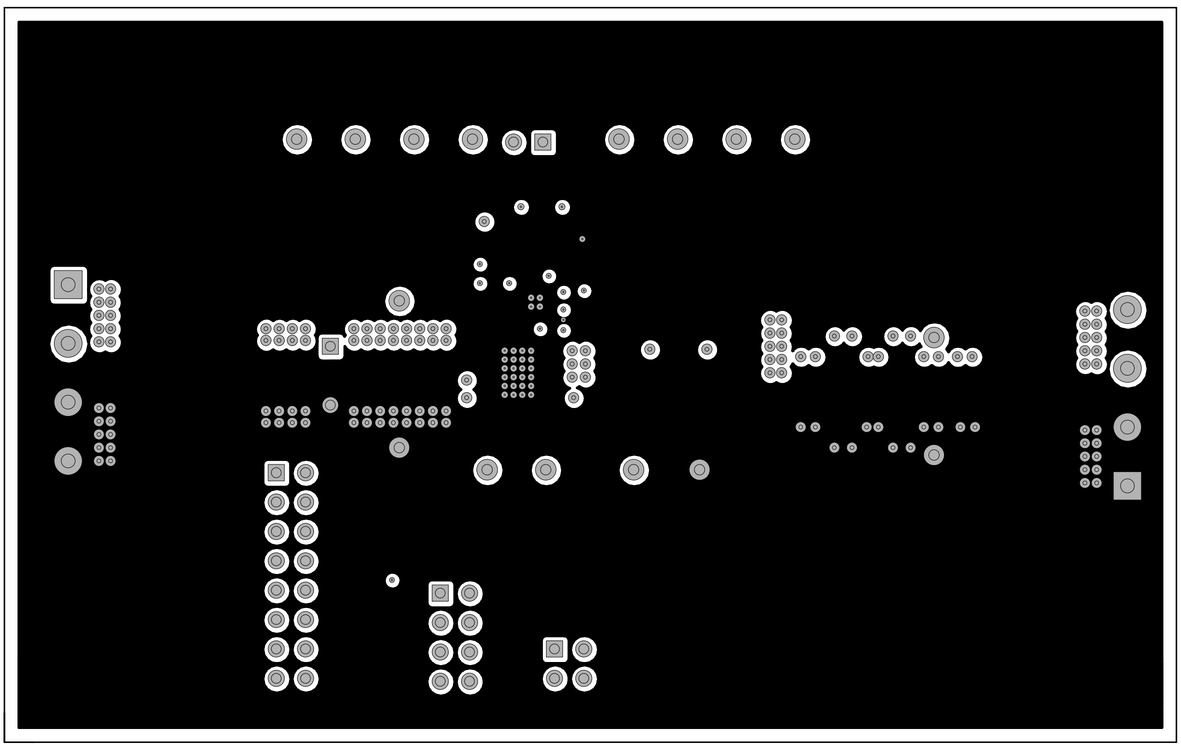


Figure 21: TPS53219EVM-690 Layer 4 Copper (Top View)

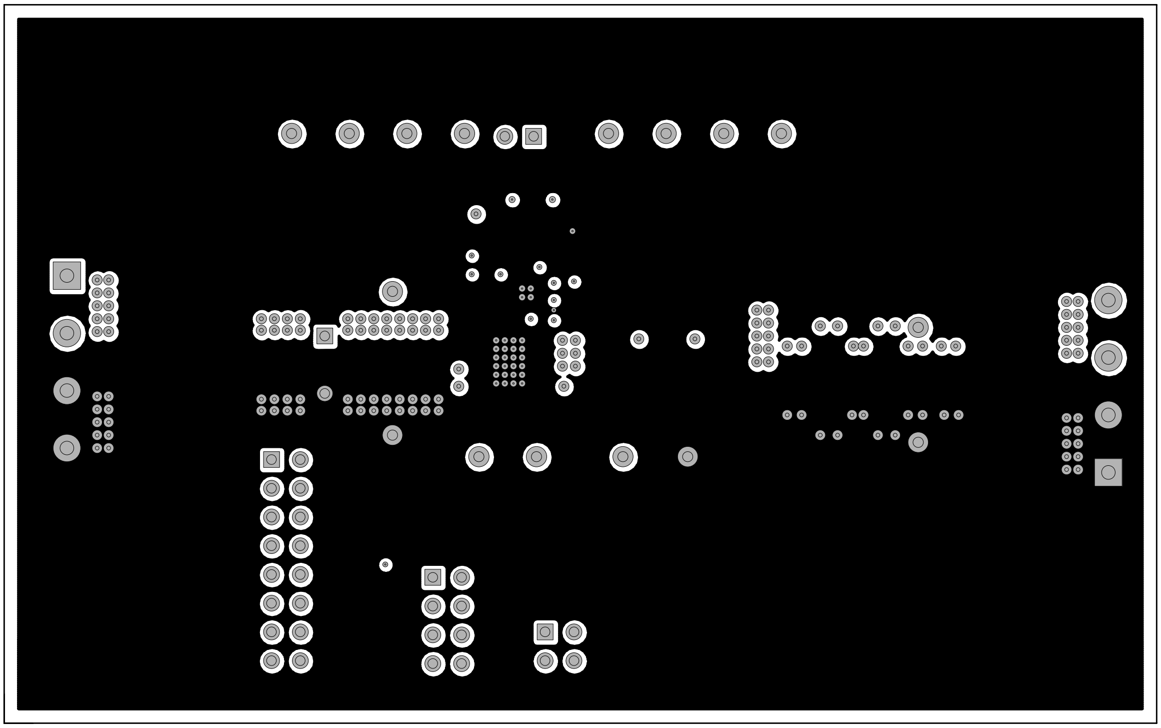


Figure 22: TPS53219EVM-690 Layer 5 Copper (Top View)

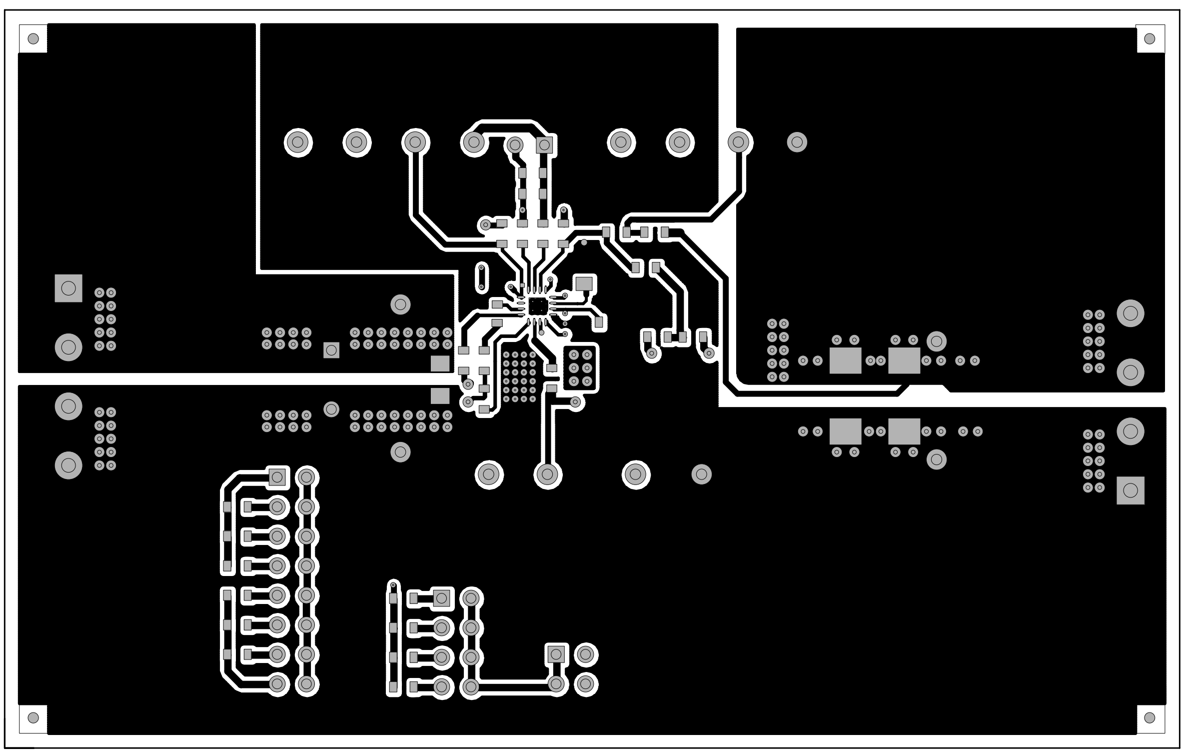


Figure 23: TPS53219EVM-690 Bottom Layer Copper (Top View)

10 Bill of Materials

Table 7: The EVM components list according to the schematic shown in Figure 1

QTY	REFDES	DESCRIPTION	MFR	PART NUMBER
1	C1	Capacitor, Ceramic, 4.7uF, 16V, X5R, 20%, 0805	STD	STD
5	C12, C13, C14, C15, C16	Capacitor, Ceramic, 100uF, 6.3V, X5R, 20%, 1210	MURATA	GRM32ER60J107ME20L
1	C19	Capacitor, Ceramic, 4700pF, 50V, X7R, 20%, 0603	STD	STD
2	C2, C20	Capacitor, Ceramic, 1000pF, 25V, X7R, 10%, 0603	STD	STD
2	C3, C10	Capacitor, Ceramic, 0.1uF, 50V, X7R, 10%, 0603	STD	STD
1	C5	Capacitor, Ceramic, 0.027uF, 50V, X7R, 10%, 0603	STD	STD
1	C4	Capacitor, Ceramic, 1uF, 16V, X7R, 10%, 0603	STD	STD
4	C6, C7, C8, C9	Capacitor, Ceramic, 22uF, 16V, X5R, 20%, 1206	MURATA	GRM31CR61C226ME15L
1	L1	Inductor, SMT, 0.44uH, 30A, 0.0032ohms, 0.530”x0.510”	Pulse or E&E Magnetic	PA0513-441NLT or 831-02990F
1	Q1	MOSFET, Dual N-chan, Power Block, 25V, 40A, QFN-8 Power	TI	CSD86350Q5D
3	R1, R3, R22	Resistor, Chip, 100k, 1/16W, 1%, 0603	STD	STD
1	R15	Resistor, Chip, 187k, 1/16W, 1%, 0603	STD	STD
1	R16	Resistor, Chip, 619k, 1/16W, 1%, 0603	STD	STD
1	R18	Resistor, Chip, 866k, 1/16W, 1%, 0603	STD	STD
1	R19	Resistor, Chip, 309k, 1/16W, 1%, 0603	STD	STD
2	R2, R23	Resistor, Chip, 200k, 1/16W, 1%, 0603	STD	STD
1	R20	Resistor, Chip, 124k, 1/16W, 1%, 0603	STD	STD
1	R21	Resistor, Chip, 39.2k, 1/16W, 1%, 0603	STD	STD
1	R24	Resistor, Chip, 475k, 1/16W, 1%, 0603	STD	STD
1	R26	Resistor, Chip, 1, 1/10W, 5%, 0805	STD	STD
1	R4	Resistor, Chip, 1.00k, 1/16W, 1%, 0603	STD	STD
1	R5	Resistor, Chip, 35.7k, 1/16W, 1%, 0603	STD	STD
6	R6, R11, R12, R13, R25, R27	Resistor, Chip, 0, 1/16W, 5%, 0603	STD	STD
1	R10	Resistor, Chip, 5.11, 1/16W, 1%, 0603	STD	STD
2	R7, R14	Resistor, Chip, 10.0k, 1/16W, 1%, 0603	STD	STD
1	R8	Resistor, Chip, 8.25k, 1/16W, 1%, 0603	STD	STD
1	R9	Resistor, Chip, 10, 1/16W, 1%, 0603	STD	STD
1	U1	IC, Single Synchronous Step-Down Controller, QFN-16	TI	TPS53219RGT

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EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of 10VDC to 14VDC and the output current range of 0ADC to 22ADC.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. 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 +100°C. The EVM is designed to operate properly with certain components above +100°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265