

Using the TPS53355EVM-743, High-Efficiency, 30-A, Synchronous Buck Converter With Eco-mode™ Control Scheme

The TPS53355EVM-743 evaluation module (EVM) allows users to evaluate the TPS53355. The TPS53355 is a D-CAP[™] mode, 30-A synchronous buck converter with integrated MOSFETs. It provides a fixed 1.5-V output at up to 30 A from a 12-V input bus.

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		Contonio	
1	Descri	ption	3
	1.1	Typical Applications	3
	1.2	Features	3
2	Electri	cal Performance Specifications	4
3	Schem	natic	5
4	Test S	etup	6
	4.1	Test Equipment	6
	4.2	Recommended Test Setup	7
5	Config	urations	8
	5.1	Switching Frequency Selection	8
	5.2	Soft-Start Selection	8
	5.3	Mode Selection	8
	5.4	Enable Selection	9
6	Test P	rocedure	9
	6.1	Line/Load Regulation and Efficiency Measurement Procedure	9
	6.2	Control Loop Gain and Phase Measurement Procedure	9
	6.3	Test Point List	10
	6.4	Equipment Shutdown	10
7	Perfor	mance Data and Typical Characteristic Curves	11
	7.1	Efficiency	11
	7.2	Load Regulation	11
	7.3	Line Regulation	12
	7.4	Enable Turnon/Turnoff	12
	7.5	Output Ripple	13
	7.6	Switching Node	13
	7.7	Output Transient With Auto-Skip Mode	14
	7.8	Output Transient With FCCM Mode	14
	7.9	Output 0.75-V Prebias Turnon	15
	7.10	Output Overcurrent and Short-Circuit Protection	15
	7.11	Bode Plot	16
	7.12	Thermal Image	17
8	EVM A	Assembly Drawing and PCB Layout	18
9		Materials	

List of Figures

1 TPS53355EVM-743 Schematic 5 2 Tip and Barrel Measurement for VOUT Ripple 6

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3	TPS53355EVM-743 Recommended Test Setup	7
4	Efficiency	11
5	Load Regulation	11
6	Line Regulation	12
7	Enable Turnon	12
8	Enable Turnoff	12
9	Output Ripple	13
10	Switching Node	13
11	Output Transient From DCM to CCM	14
12	Output Transient From CCM to DCM	14
13	Output Transient With FCCM Mode	14
14	Output 0.75-V Prebias Turnon	15
15	Output Overcurrent Protection	15
16	Output Short Circuit	16
17	Bode Plot at 12 V _{IN} , 1.5 V/30 A	16
18	Top Board at 12 V _{IN} , 1.5 V/30 A, 25°C Ambient Temperature Without Airflow	17
19	TPS53355EVM-743 Top Layer Assembly Drawing	18
20	TPS53355EVM-743 Bottom Assembly Drawing	18
21	TPS53355EVM-743 Top Copper	19
22	TPS53355EVM-743 Layer-2 Copper	19
23	TPS53355EVM-743 Layer-3 Copper	20
24	TPS53355EVM-743 Layer-4 Copper	20
25	TPS53355EVM-743 Layer-5 Copper	21
26	TPS53355EVM-743 Bottom Layer Copper	21

List of Tables

1	TPS53355EVM-743 Electrical Performance Specifications	4
2	Switching Frequency Selection	8
3	Soft-Start Time Selection	8
4	MODE Selection	8
5	Enable Selection	9
6	Test Point Functions	10
7	The EVM Components List According to the Schematic Shown in Figure 1	22



1 Description

The TPS53355EVM-743 is designed to use a regulated 12-V bus to produce a regulated 1.5-V output at up to 30 A of load current. The TPS53355EVM-743 is designed to demonstrate the TPS53355 in a typical, low-voltage application while providing a number of test points to evaluate the performance of the TPS53355.

1.1 Typical Applications

- Server/storage
- · Workstations and desktops
- Telecommunication infrastructure

1.2 Features

The TPS53355EVM-743 features:

- 30-Adc, steady-state output current
- Supports prebias output voltage start-up
- J5 for selectable switching frequency setting
- · J4 for selectable soft-start time
- J2 for enable function
- J6 for auto-skip and forced CCM selection
- Convenient test points for probing critical waveforms

2 Electrical Performance Specifications

Parameters	Test Conditions	Min	Тур	Max	Units
Input Characteristics	-	1		1	
Voltage range	V _{IN}	8	12	14	V
Maximum input current	V _{IN} = 8 V, I _O = 30 A		6.3		А
No load input current	V_{IN} = 14 V, I_O = 0 A with auto-skip mode		1		mA
Output Characteristics	-	Ч.		ľ	
Output voltage VOUT			1.5		V
	Line regulation ($V_{IN} = 8 V - 14 V$)		0.1		%
Output voltage regulation	Load regulation ($V_{IN} = 12 \text{ V}$, $I_O = 0 \text{ A} - 30 \text{ A}$)		1		%
Output voltage ripple	V _{IN} = 12 V, I _O = 30 A		20		mVpp
Output load current		0		30	А
Output overcurrent			34		А
Systems Characteristics		Ч.		¹	
Switching frequency			500		kHz
Peak efficiency	V _{IN} = 12 V, 1.5 V/10 A		91.87		%
Ful-load efficiency	V _{IN} = 12 V, 1.5V/30 A		89.46		%
Operating temperature			25		°C

Table 1. TPS53355EVM-743 Electrical Performance Specifications

NOTE: Jumpers are set to default locations; see Section 5 of this user's guide



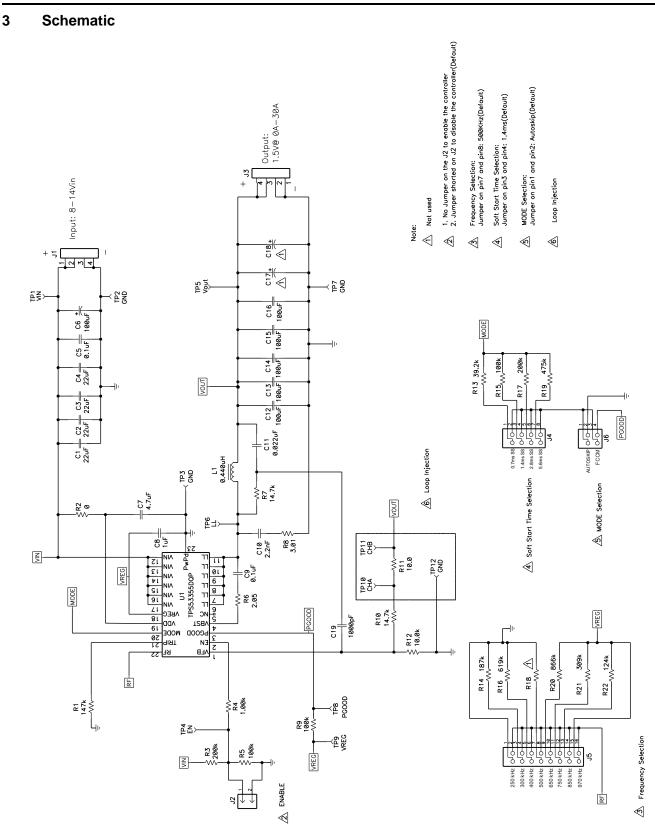


Figure 1. TPS53355EVM-743 Schematic

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Test Setup

4 Test Setup

4.1 Test Equipment

Voltage Source: The input voltage source V_{IN} must be a 0-V to 14-V variable dc source capable of supplying 10 Adc. Connect V_{IN} to J1 as shown in Figure 3.

Multimeters:

- V1: V_{IN} at TP1 (V_{IN}) and TP2 (GND).
- V2: VOUT at TP5 (VOUT) and TP7 (GND).
- A1: V_{IN} input current

Output Load: The output load must be an electronic constant resistance mode load capable of 0 Adc to 30 Adc at 1.5 V.

Oscilloscope: A digital or analog oscilloscope can be used to measure the output ripple. The oscilloscope must be set for $1-M\Omega$ impedance, 20-MHz bandwidth, ac coupling, $2-\mu$ s/division horizontal resolution, 50-mV/division vertical resolution. Test points TP5 and TP7 can be used to measure the output ripple voltage by placing the oscilloscope probe tip through TP5 and holding the ground barrel on TP7 as shown in Figure 2. Using a leaded ground connection may induce additional noise due to the large ground loop.

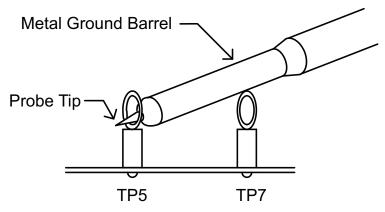


Figure 2. Tip and Barrel Measurement for VOUT Ripple

Fan: Some of the components in this EVM may approach temperatures of 60°C during operation. A small fan capable of 200–400 LFM is recommended to reduce component temperatures while the EVM is operating. Only probe the EVM when the fan is running.

Recommended Wire Gauge:

1. VIN to J1 (12-V input):

The recommended wire size is 1x AWG 14 per input connection, with the total length of wire less than 4 feet (2-foot input, 2-foot return).

2. J3 to LOAD:

6

The minimum recommended wire size is 2x AWG 14, with the total length of wire less than 4 feet (2-foot output, 2-foot return)



4.2 Recommended Test Setup

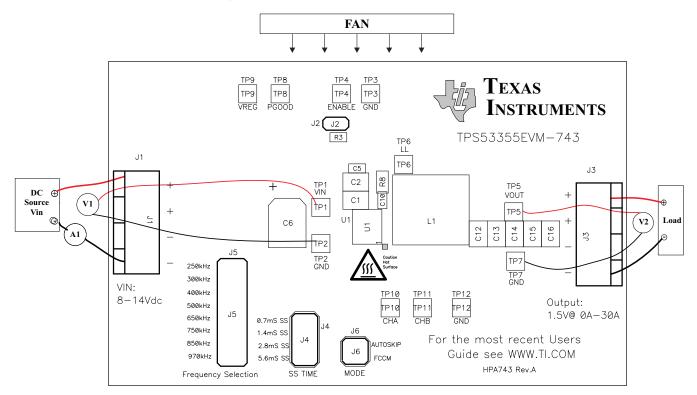


Figure 3. TPS53355EVM-743 Recommended Test Setup

Figure 3 is the recommended test setup to evaluate the TPS53355EVM-743. Working at an ESD workstation, ensure 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 V_{IN} to 10 A maximum. Ensure that V_{IN} is initially set to 0 V and connected as shown in Figure 3.
- 2. Connect a voltmeter V1 at TP1 (V_{IN}) and TP2 (GND) to measure the input voltage.
- 3. Connect a current meter A1 to measure the input current.

Output Connections:

- 1. Connect Load to J3, and set Load to constant resistance mode to sink 0 Adc before V_{IN} is applied.
- 2. Connect a voltmeter V2 at TP5 (VOUT) and TP7 (GND) to measure the output voltage.

Other Connections:

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



5 Configurations

All jumper selections must be made prior to applying power to the EVM. Users can configure this EVM per the following configurations.

5.1 Switching Frequency Selection

The switching frequency can be set by J5.

Default setting: 500 kHz

Jumper Set to	Resistor (RF) Connections (kΩ)	Switching Frequency (kHz)
Top (1–2 pin shorted)	0	250
Second (3–4 pin shorted)	187	300
Third (5–6 pin shorted)	619	400
Fourth (7–8 pin shorted)	Open	500
Fifth (9–10 pin shorted)	866	650
Sixth (11–12 pin shorted)	309	750
Seventh (13–14 pin shorted)	124	850
Bottom (15–16 pin shorted)	0	970

Table 2. Switching Frequency Selection

5.2 Soft-Start Selection

The soft-start time can be set by J4.

Default setting: 1.4 ms

Table 3. Soft-Start Time Selection

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

5.3 Mode Selection

8

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 (7–8 pin shorted)	Forced CCM

5.4 Enable Selection

The controller can be enabled and disabled by J2.

Default setting: Jumper shorts on J2 to disable the controller

Table 5. Enable Selection

Jumper Set to	Enable Selection
Jumper shorts on J2	Disable the controller
No jumper shorts on J2	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 3.
- 2. Ensure Load is set to constant resistance mode and to sink 0 Adc.
- 3. Ensure that all jumpers configuration settings are per Section 5.
- 4. Ensure that the jumper provided in the EVM shorts on J2 before Vin is applied.
- 5. Increase V_{IN} from 0 V to 12 V. Use V1 to measure input voltage.
- 6. Remove the jumper on J2 to enable the controller.
- 7. Use V2 to measure VOUT voltage
- 8. Vary Load from 0 Adc to 30 Adc; Vout must remain in load regulation.
- 9. Vary V_{IN} from 8 V to 14 V; Vout must remain in line regulation.
- 10. Put the jumper on J2 to disable the controller.
- 11. Decrease Load to 0 A
- 12. Decrease V_{IN} to 0 V.

6.2 Control Loop Gain and Phase Measurement Procedure

TPS53355EVM-743 contains a $10-\Omega$ series resistor in the feedback loop for loop response analysis.

- 1. Set up the EVM as described in Section 4 and Figure 3.
- 2. Connect isolation transformer to test points marked TP10 and TP11.
- 3. Connect input signal amplitude measurement probe (channel A) to TP10. Connect output signal amplitude measurement probe (channel B) to TP11.
- 4. Connect ground lead of channel A and channel B to TP12.
- 5. Inject an approximate 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.)

6.3 Test Point List

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

Table 6. Test Point Functions

6.4 Equipment Shutdown

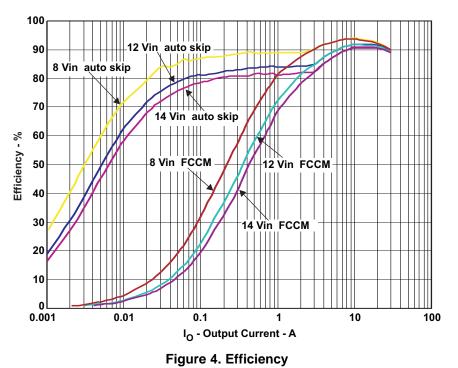
- 1. Shut down Load.
- 2. Shut down Load.
- 3. Shut down fan.



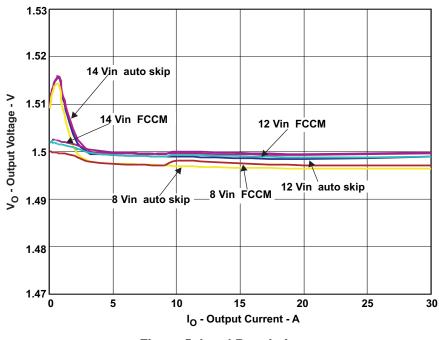
7 Performance Data and Typical Characteristic Curves

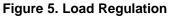
Figure 4 through Figure 18 present typical performance curves for TPS53355EVM-743.

7.1 Efficiency



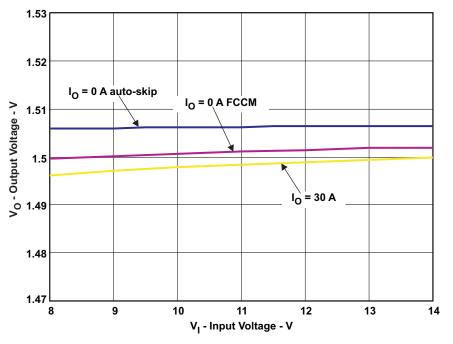
7.2 Load Regulation





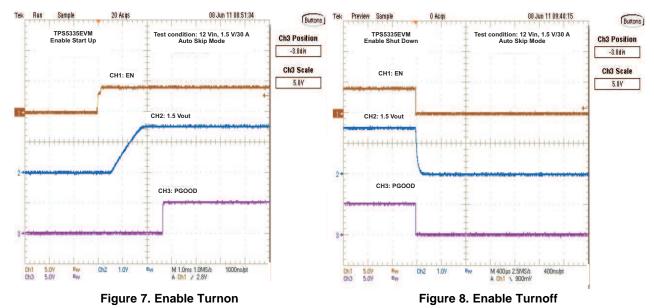


7.3 Line Regulation





7.4 Enable Turnon/Turnoff





7.5 Output Ripple

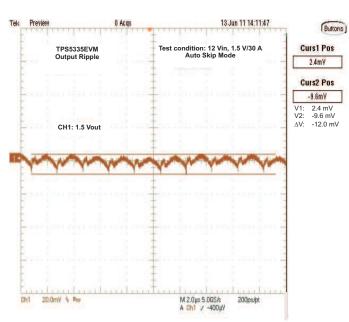
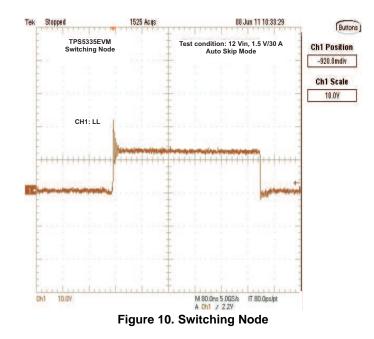


Figure 9. Output Ripple

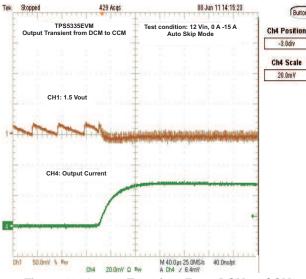
7.6 Switching Node

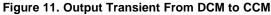


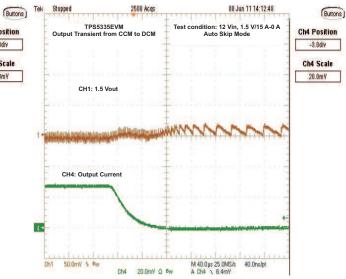


Performance Data and Typical Characteristic Curves

7.7 **Output Transient With Auto-Skip Mode**

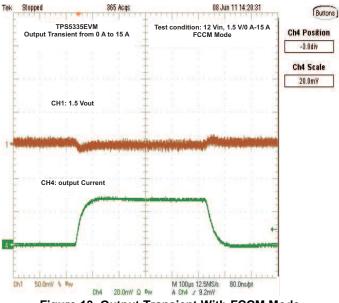








7.8 **Output Transient With FCCM Mode**



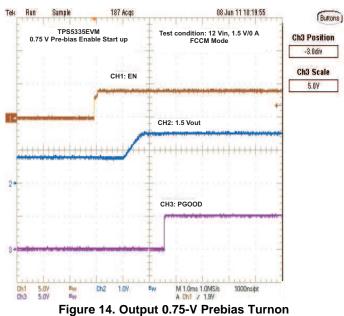
-3.0div

20.0mV

Figure 13. Output Transient With FCCM Mode



7.9 Output 0.75-V Prebias Turnon



7.10 Output Overcurrent and Short-Circuit Protection

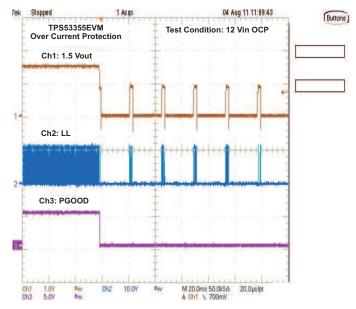


Figure 15. Output Overcurrent Protection



Performance Data and Typical Characteristic Curves

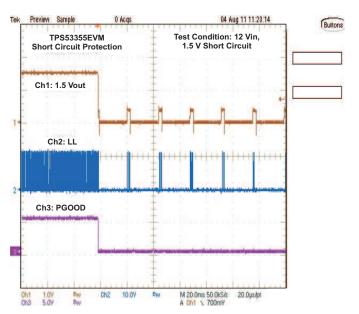


Figure 16. Output Short Circuit

7.11 Bode Plot

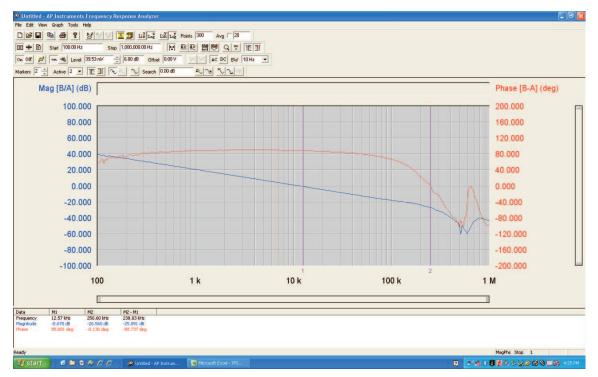


Figure 17. Bode Plot at 12 V_{IN} , 1.5 V/30 A

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Performance Data and Typical Characteristic Curves

7.12 Thermal Image

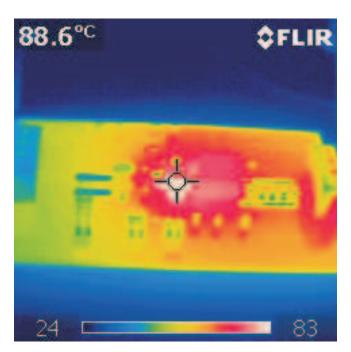


Figure 18. Top Board at 12 V_{IN}, 1.5 V/30 A, 25°C Ambient Temperature Without Airflow



8 EVM Assembly Drawing and PCB Layout

The following illustrations (Figure 19 through Figure 26) show the design of the TPS53355EVM-743 printed-circuit board. The EVM was designed using a 6-layer, 2-oz copper circuit board.

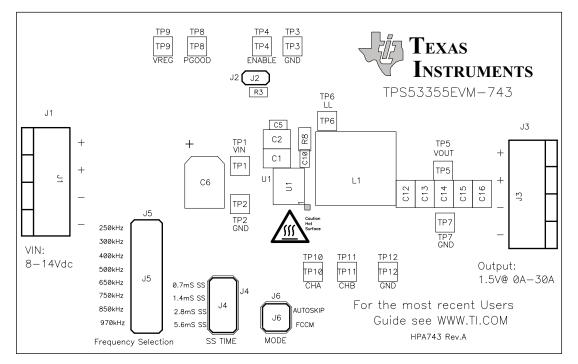
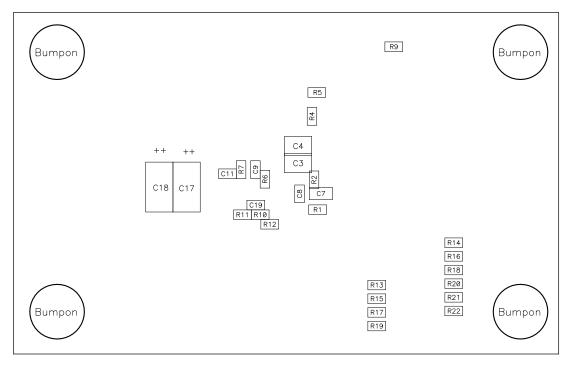
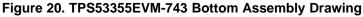


Figure 19. TPS53355EVM-743 Top Layer Assembly Drawing









EVM Assembly Drawing and PCB Layout

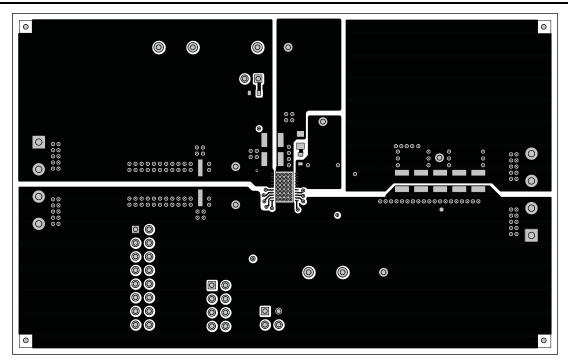


Figure 21. TPS53355EVM-743 Top Copper

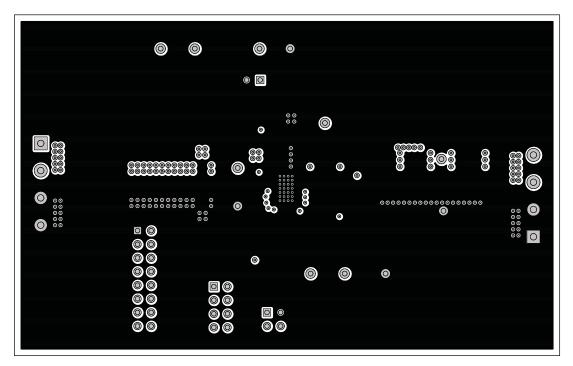


Figure 22. TPS53355EVM-743 Layer-2 Copper



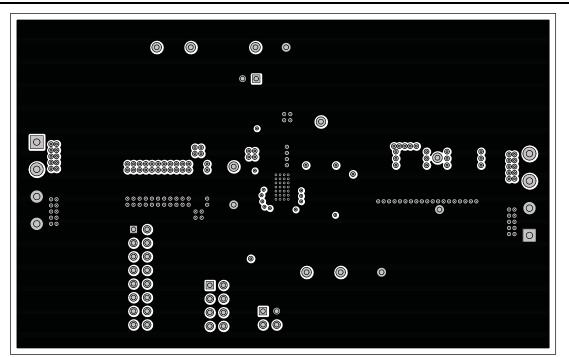


Figure 23. TPS53355EVM-743 Layer-3 Copper

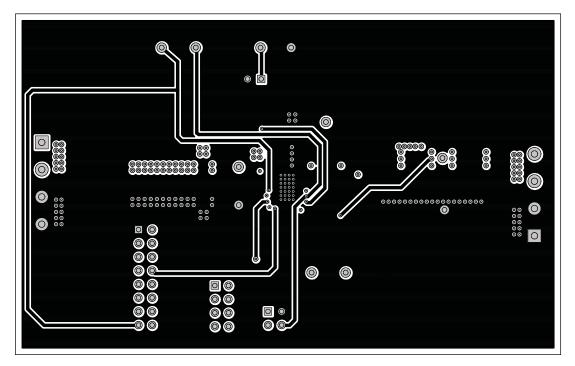


Figure 24. TPS53355EVM-743 Layer-4 Copper



EVM Assembly Drawing and PCB Layout

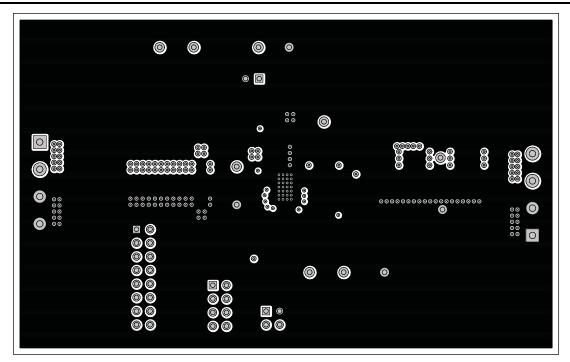


Figure 25. TPS53355EVM-743 Layer-5 Copper

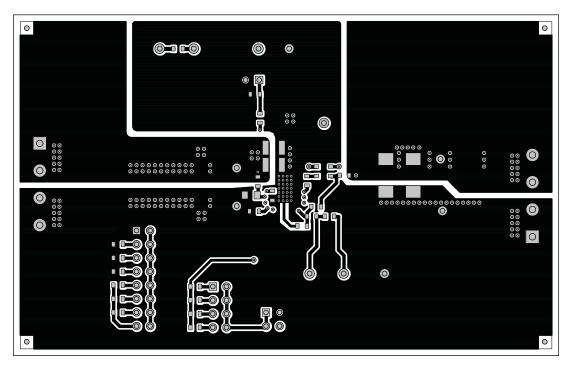


Figure 26. TPS53355EVM-743 Bottom Layer Copper

9 Bill of Materials

Table 7. The EVM Components List According to the Schematic Shown in Figure 1

QTY	REFDES	DESCRIPTION	MFR	PART NUMBER
4	C1, C2, C3, C4	Capacitor, Ceramic, 22uF, 16V, X5R, 20%, 1210	MURATA	GRM32ER61C226KE20L
5	C12, C13, C14, C15, C16	Capacitor, Ceramic, 100uF, 6.3V, X5R, 20%, 1210	MURATA	GRM32ER60J107ME20L
1	C10	Capacitor, Ceramic, 2.2nF, 50V, X7R, 20%, 0603	STD	STD
1	C11	Capacitor, Ceramic, 0.022uF, 50V, X7R, 20%, 0603	STD	STD
1	C19	Capacitor, Ceramic, 1000pF, 50V, X7R, 20%, 0603	STD	STD
2	C5, C9	Capacitor, Ceramic, 0.1uF, 50V, X7R, 20%, 0603	STD	STD
1	C6	Capacitor, Aluminum, 100uF, 16VDC, 20%, Code D8	Panasonic	EEEFP1C101AP
1	C7	Capacitor, Ceramic, 4.7uF, 25V, X5R, 20%, 0805	STD	STD
1	C8	Capacitor, Ceramic, 1uF, 50V, X7R, 20%, 0603	STD	STD
1	L1	Inductor, SMT, 0.44uH, 30A, 0.0032ohms, 0.530"x0.510"	Pulse	PA0513-441NLT
1	R1	Resistor, Chip, 147k, 1/16W, 1%, 0603	STD	STD
1	R11	Resistor, Chip, 10, 1/16W, 1%, 0603	STD	STD
1	R12	Resistor, Chip, 10.0k, 1/16W, 1%, 0603	STD	STD
1	R13	Resistor, Chip, 39.2k, 1/16W, 1%, 0603	STD	STD
1	R14	Resistor, Chip, 187k, 1/16W, 1%, 0603	STD	STD
1	R16	Resistor, Chip, 619k, 1/16W, 1%, 0603	STD	STD
1	R19	Resistor, Chip, 475k, 1/16W, 1%, 0603	STD	STD
1	R2	Resistor, Chip, 0, 1/16W, 1%, 0603	STD	STD
1	R20	Resistor, Chip, 866k, 1/16W, 1%, 0603	STD	STD
1	R21	Resistor, Chip, 309k, 1/16W, 1%, 0603	STD	STD
1	R22	Resistor, Chip, 124k, 1/16W, 1%, 0603	STD	STD
2	R3, R1	Resistor, Chip, 200k, 1/16W, 1%, 0603	STD	STD
3	7 R5, R9, R15	Resistor, Chip, 100k, 1/16W, 5%, 0603	STD	STD
1	R4	Resistor, Chip, 1.00k, 1/16W, 1%, 0603	STD	STD
1	R6	Resistor, Chip, 2.05, 1/16W, 1%, 0603	STD	STD
2	R7, R10	Resistor, Chip, 14.7k, 1/16W, 1%, 0603	STD	STD
1	R8	Resistor, Chip, 3.01, 1/16W, 1%, 0805	STD	STD
1	U1	IC, 30A Synchronous Buck converter with integrated MOSFETs, DQP-22	ті	TPS53355DQP

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EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 8 V to 14 V and the output voltage range of 0 V to 1.5 V. 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 80°C. The EVM is designed to operate properly with certain components above 80°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.

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