TPS543B20EVM-054 User Guide

This user's guide describes the characteristics, operation, and use of the TPS543B20EVM-054 Evaluation Module (EVM). The user's guide includes test information, descriptions, and results. A complete schematic diagram, printed-circuit board layouts, and bill of materials are also included in this document. Throughout this user's guide, the abbreviations EVM, TPS543B20EVM-054, and the term evaluation module are synonymous with the TPS543B20EVM-054, unless otherwise noted.

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1 Introduction

The BSR054EVM evaluation module uses the TPS543B20EVM-054 device. The TPS543B20EVM-054 is a highly integrated synchronous buck converter that is designed for up to 25-A current output.

1.1 Before You Begin

The following warnings and cautions are noted for the safety of anyone using or working close to the TPS543B20EVM-054. Observe all safety precautions.

Warning The TPS543B20EVM-054 circuit module may become hot during operation due to dissipation of heat. Avoid contact with the board. Follow all applicable safety procedures applicable to your laboratory.

Caution Do not leave the EVM powered when unattended.

WARNING

The circuit module has signal traces, components, and component leads on the bottom of the board. This may result in exposed voltages, hot surfaces or sharp edges. Do not reach under the board during operation.

CAUTION

The circuit module may be damaged by over temperature. To avoid damage, monitor the temperature during evaluation and provide cooling, as needed, for your system environment.

CAUTION

Some power supplies can be damaged by application of external voltages. If using more than 1 power supply, check your equipment requirements and use blocking diodes or other isolation techniques, as needed, to prevent damage to your equipment.

CAUTION

The communication interface is not isolated on the EVM. Be sure no ground potential exists between the computer and the EVM. Also be aware that the computer is referenced to the Battery- potential of the EVM.

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2 Description

The BSR054EVM is designed as a single output DC-DC converter that demonstrates the TPS543B20EVM-054 in a typical low-voltage application while providing a number of test points to evaluate the performance. It uses a nominal 12-V input bus to produce a regulated 0.9-V output at up to 25-A load current.

2.1 Typical End-User Applications

- Enterprise storage, SSD, NAS
- Wireless and wired communication infrastructure
- Industrial PCs, automation, ATE, PLC, video surveillance
- Enterprise server, switches, routers
- ASIC, SoC, FPGA, DSP core and I/O rails

2.2 EVM Features

- Regulated 0.9-V output up to 25-A, steady-state output current
- Convenient test points for probing critical waveforms

3 EVM Electrical Performance Specifications

Table 1. BSR054EVM Electrical Performance Specifications

Parameter		Test Conditions	Min	Typ	Max	Units
Input Characteristics						
	Voltage range	V_{IN} tied to VDD	5	12	19	V
	Maximum input current	V_{IN} = 12 V, I_O = 25 A, V_{OUT} = 0.9 V, F_{SW} = 500 kHz		3.0		A
	No load input current	V_{IN} = 12 V, I_O = 0 A		40		mA
Output Characteristics						
V_{OUT}	Output voltage	Output current = 0 A to 25 A		0.9		V
I_{OUT}	Output load current	$I_{OUT(min)}$ to $I_{OUT(max)}$	0		25	A
	Output voltage regulation	Line regulation: input voltage = 5 V to 19 V		0.5%		
		Load regulation: output current = 0 A to $I_{OUT(max)}$		0.5%		
V_{OUT}	Output voltage ripple	V_{IN} = 12 V, I_{OUT} = 25 A		10		mV_{PP}
V_{OUT}	Output overcurrent			30		A
Systems Characteristics						
	Switching frequency	F_{SW}		500		kHz
V_{OUT}	Peak efficiency	V_{IN} = 5 V, I_O = 7 A, F_{SW} = 500 kHz		93.7%		
	Operating temperature	T_{oper}	0		85	ºC

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4 Schematic

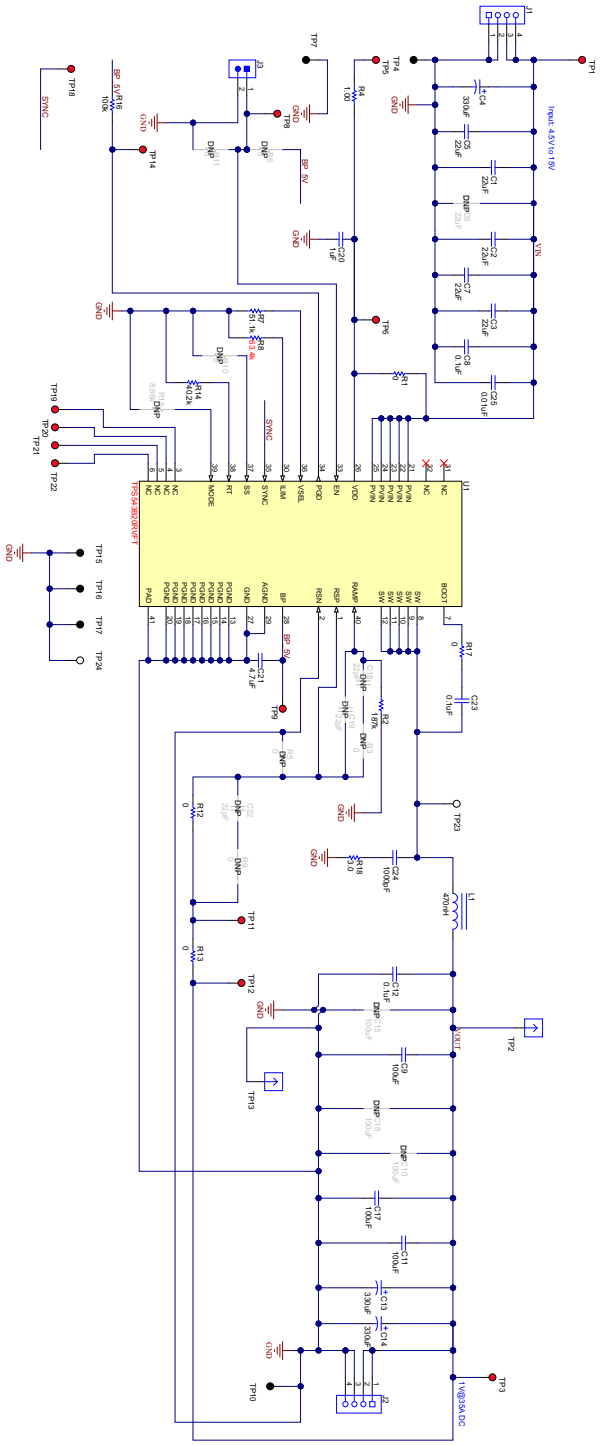

Figure 1. BSR054EVM Schematic

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5 Test Equipment

Voltage Source: The input voltage source VIN must be a 0-V to 20-V variable DC source capable of supplying at least 10 A_{DC}. Also, the output impedance of the external voltage source must be much less than 100 kΩ.

Multimeters: It is recommended to use two separate multimeters Figure 2. One meter is used to measure V_{IN} and one to measure V_{OUT}.

Output Load: A variable electronic load is recommended for testing Figure 2. It must be capable of 25 A at voltages as low as 0.6 V.

Oscilloscope: An oscilloscope is recommended for measuring output noise and ripple. Output ripple must be measured using a tip-and-barrel method or better as shown in Figure 3.The scope must be adjusted to 20-MHz bandwidth, AC coupling at 50 mV/division, and must be set to 1-µs/division.

Fan: During prolonged operation at high loads, it may be necessary to provide forced air cooling with a small fan aimed at the EVM. Temperature of the devices on the EVM must be maintained below 105°C.

Recommended Wire Gauge: The voltage drop in the load wires must be kept as low as possible in order to keep the working voltage at the load within its operating range. Use the AWG 14 wire (2 wires parallel for VOUT positive and 2 wires parallel for the VOUT negative) of no more than 1.98 feet between the EVM and the load. This recommended wire gauge and length should achieve a voltage drop of no more than 0.2 V at the maximum 25-A load.

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6 BSR054EVM

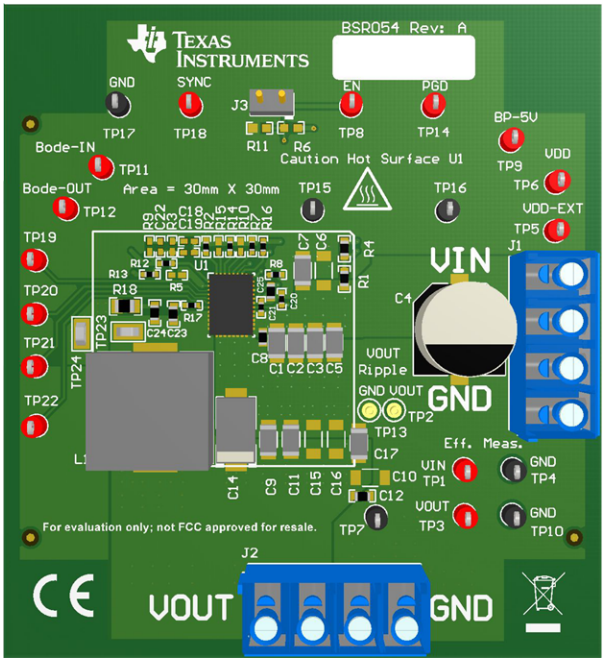

Figure 2. BSR054EVM Overview

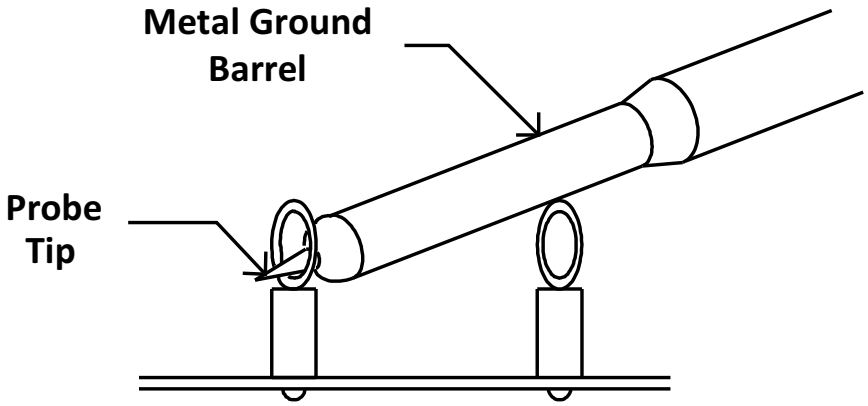

Figure 3. Tip and Barrel Measurement

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7 List of Test Points, Jumpers, and Switch

Table 2. Test Point Functions

Item	Type	Name	Description
TP23	T-H loop	SW	Power supply Switch node
TP11	T-H loop	CH-A	Measure loop stability
TP12	T-H loop	CH-B	Measure loop stability
TP3	T-H loop	LocS+	Sense VOUT + locally across C11. Use for efficiency and ripple measurements
TP10	T-H loop	LocS-	Sense VOUT– locally across C11. Use for efficiency and ripple measurements
TP1	T-H loop	PVIN	Sense VIN + across C8
TP4	T-H loop	PGND	Sense VIN – across C8
TP6	T-H loop	VDD	Supplies the internal circuitry
TP9	T-H loop	BP	LDO output
TP14	T-H loop	PG	Power good
TP7, TP15, TP16, TP17	T-H loop	PGND	Common GND
TP19, TP20, TP21, TP22	T-H loop		Not used
TP18	T-H loop	SYNC	Synchronize with external switching frequency
JP3	2-pin jumper	EN	Enable or disable TPS543B20EVM-054 IC

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8 Test Procedure

8.1 Line and Load Regulation Measurement Procedure

1. Connect VOUT to J2 and VOUT_GND to J2 Figure 2.
2. Ensure that the electronic load is set to draw 0 A_{DC}.
3. Ensure the jumper provided on the EVM shorts on J3 before V_{IN} is applied
4. Connect VIN to J1 and VIN_GND to J1 Figure 2.
5. Increase V_{IN} from 0 V to 12 V using the digital multimeter to measure input voltage.
6. Remove the jumper on J3 to enable the controller.
7. Use the other digital multimeter or the oscilloscope to measure output voltage V_{OUT} at TP3 and TP10.

Table 3. List of Test Points for Line and Load Measurements

Test Point	Node Name	Description
TP3	LocS+	Sense VOUT + locally across C11. Use for efficiency and ripple measurements
TP10	LocS-	Sense VOUT - locally across C11. Use for efficiency and ripple measurements
TP1	PVIN	Sense VIN + across C8
TP4	PGND	Sense VIN - across C8

8. Vary the load from 0 A_{DC} to maximum rated output 25 A_{DC}. V_{OUT} must remain in regulation as defined in Table 1.
9. Vary V_{IN} from 5 V to 19 V. V_{OUT} must remain in regulation as defined in Table 1.
10. Decrease the load to 0 A.
11. Put the jumper back on JP3 to disable the converter.
12. Decrease V_{IN} to 0 V or turn off the supply.

8.2 Efficiency

To measure the efficiency of the power train on the EVM, it is important to measure the voltages at the correct location. This is necessary because otherwise the measurements will include losses in efficiency that are not related to the power train itself. Losses incurred by the voltage drop in the copper traces and in the input and output connectors are not related to the efficiency of the power train, and they must not be included in efficiency measurements.

Table 4. List of Test Points for Efficiency Measurements

Test Point	Node Name	Description
TP3	LocS+	Sense VOUT + locally across C11. Use for efficiency and ripple measurements
TP10	LocS-	Sense VOUT - locally across C11. Use for efficiency and ripple measurements
TP1	PVIN	Sense VIN + across C8
TP4	PGND	Sense VIN - across C8

Input current can be measured at any point in the input wires, and output current can be measured anywhere in the output wires of the output being measured. Using these measurement points result in efficiency measurements that do not include losses due to the connectors and PCB traces.

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8.3 Equipment Shutdown

1. Reduce the load current to 0 A.
2. Reduce input voltage to 0 V.
3. Shut down the external fan if in use.
4. Shut down equipment.

9 Performance Data and Typical Characteristic Curves

Figure 4 through Figure 13 present typical performance curves for the BSR054EVM.

9.1 Efficiency

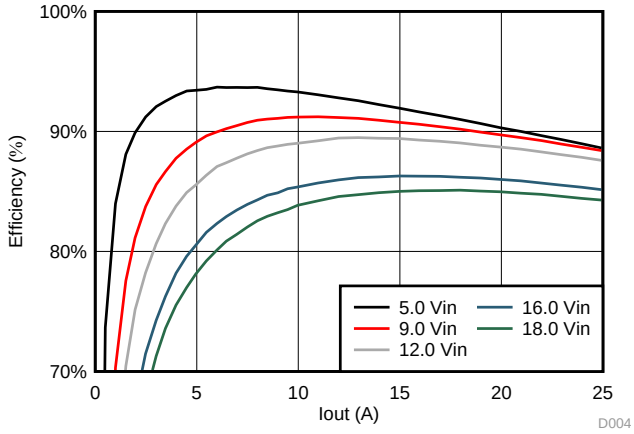

Figure 4. Efficiency of 0.9-V Output vs Load

9.2 Power Loss

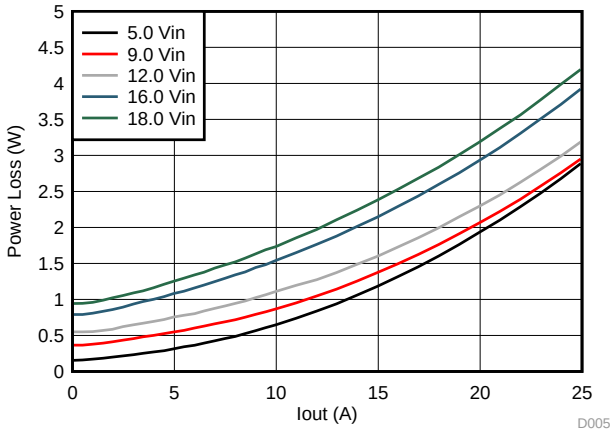

Figure 5. Power Loss of 0.9-V Output vs Load

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9.3 Load Regulation

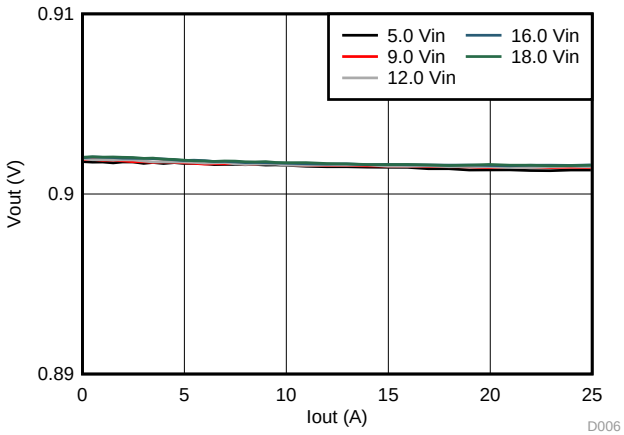

Figure 6. Load Regulation of 0.9-V Output

9.4 Transient Response

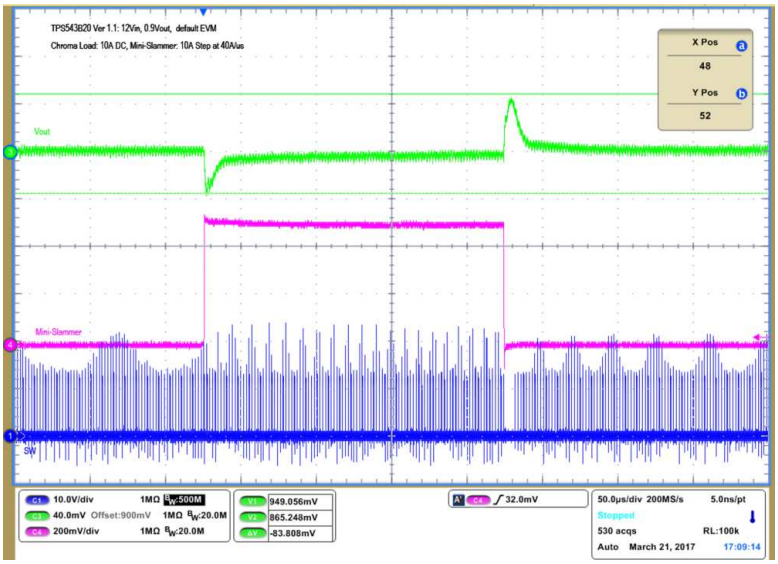

Figure 7. Transient Response of 0.9-V Output at 12-V_{IN}, Transient is 10 A to 20 A to 10 A, at 40 A/µs

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9.5 Output Ripple

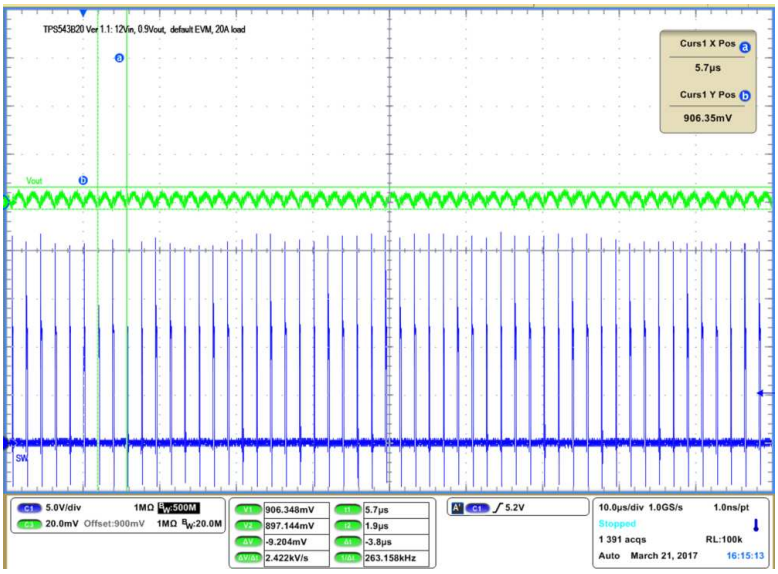

Figure 8. Output Ripple and SW Node of 0.9-V Output at 12-V_{IN}, 20-A Output

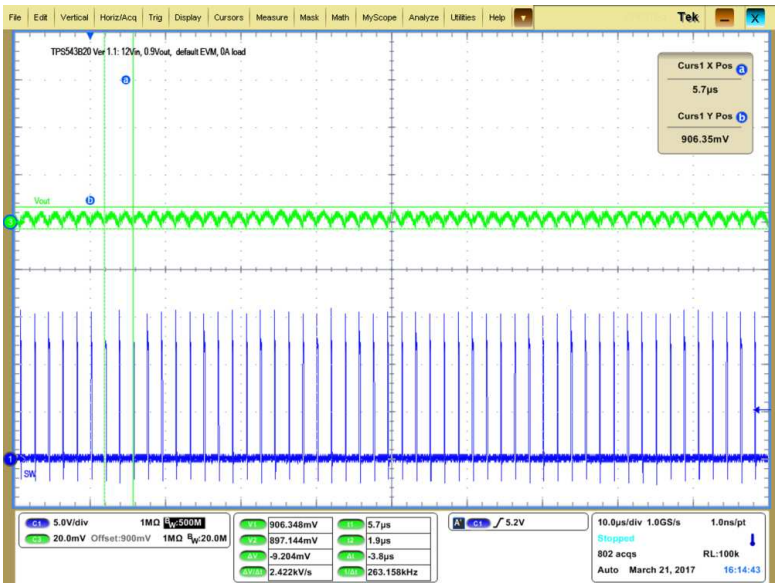

Figure 9. Output Ripple and SW Node of 0.9-V Output at 12-V_{IN}, 0-A Output

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9.6 Control On

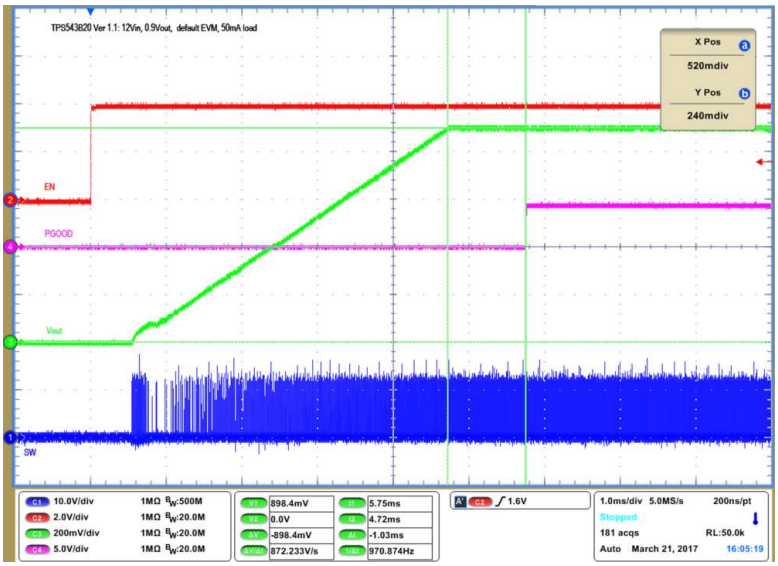

Figure 10. Start up from Enable, 0.9-V Output at 12-V_{IN}, 50-mA Output

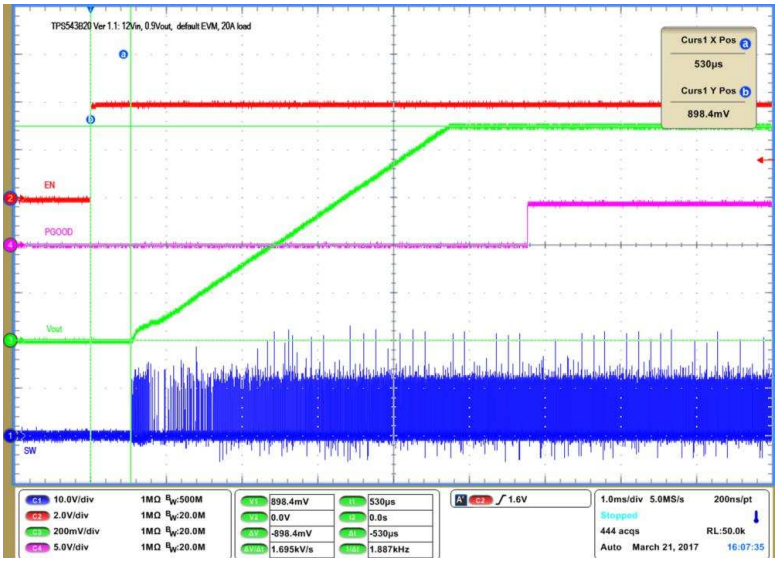

Figure 11. Start up from Enable, 0.9-V Output at 12-V_{IN}, 20-A Output

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9.7 Control On and Off

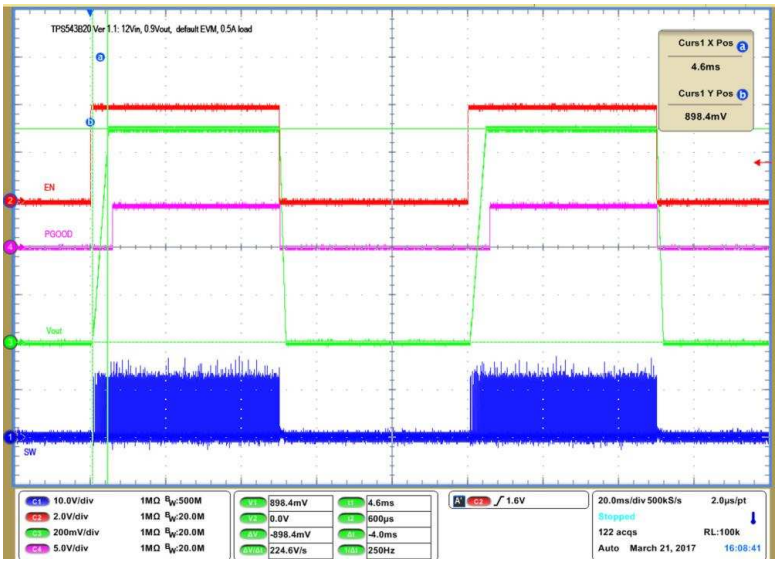

Figure 12. Output Voltage Start-up and Shutdown, 0.9-V Output at 12-V_{IN}, 0.5-A Output

9.8 Thermal Image

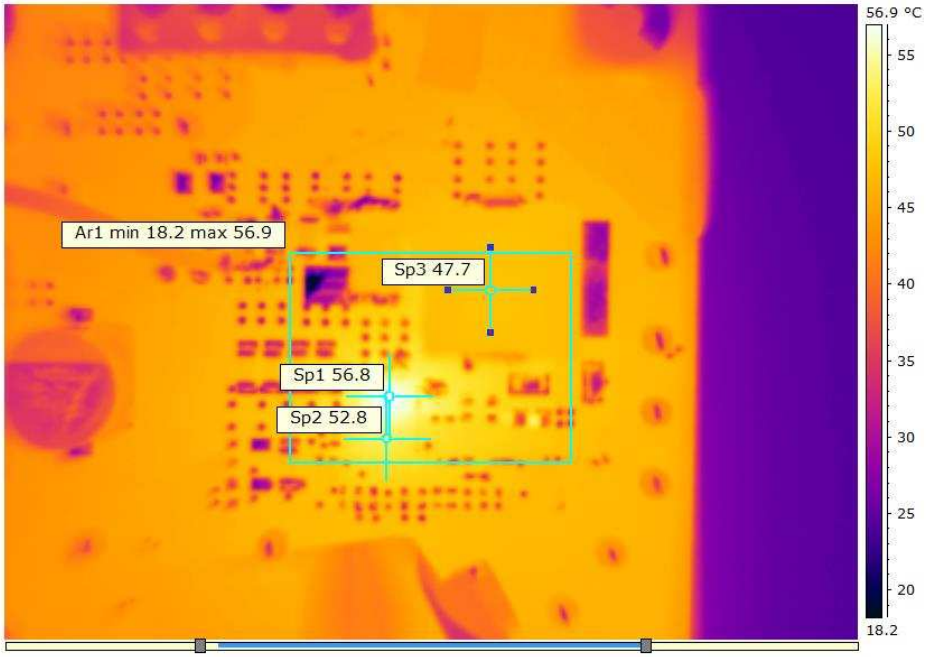

Figure 13. Thermal Image at 0.9-V Output at 12 V_{IN}, 25-A Output, at 25°C Ambient

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10 EVM Assembly Drawing and PCB Layout

Figure 14 through Figure 21 show the design of the BSR054EVM printed-circuit board (PCB). The BSR054EVM has a 2-oz. copper finish for all layers.

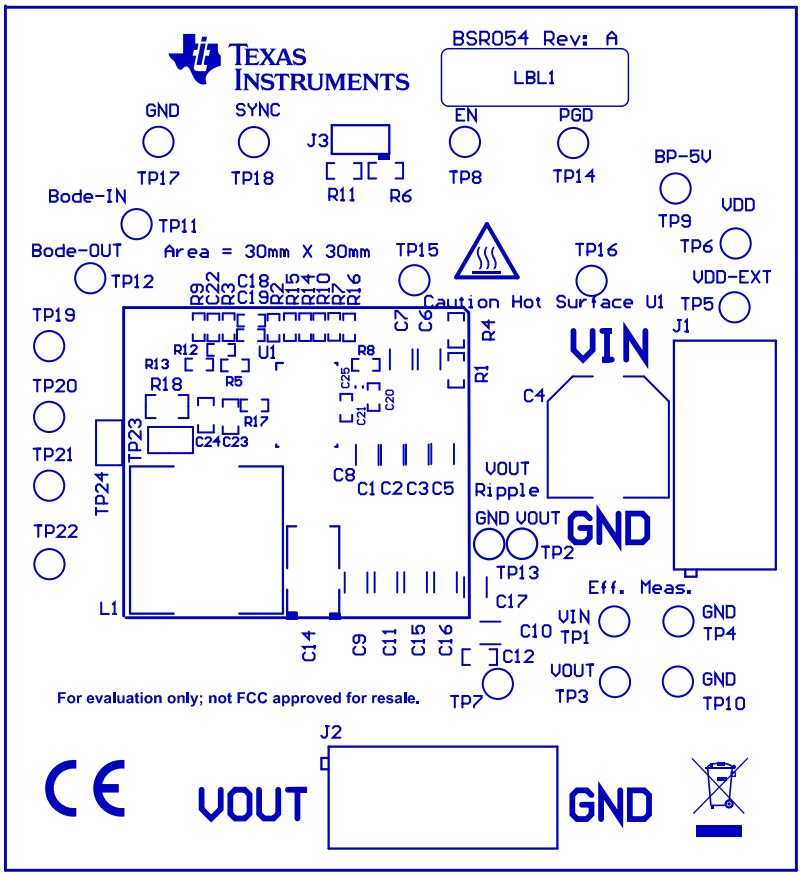

Figure 14. BSR054EVM Top Layer Assembly Drawing (Top View)

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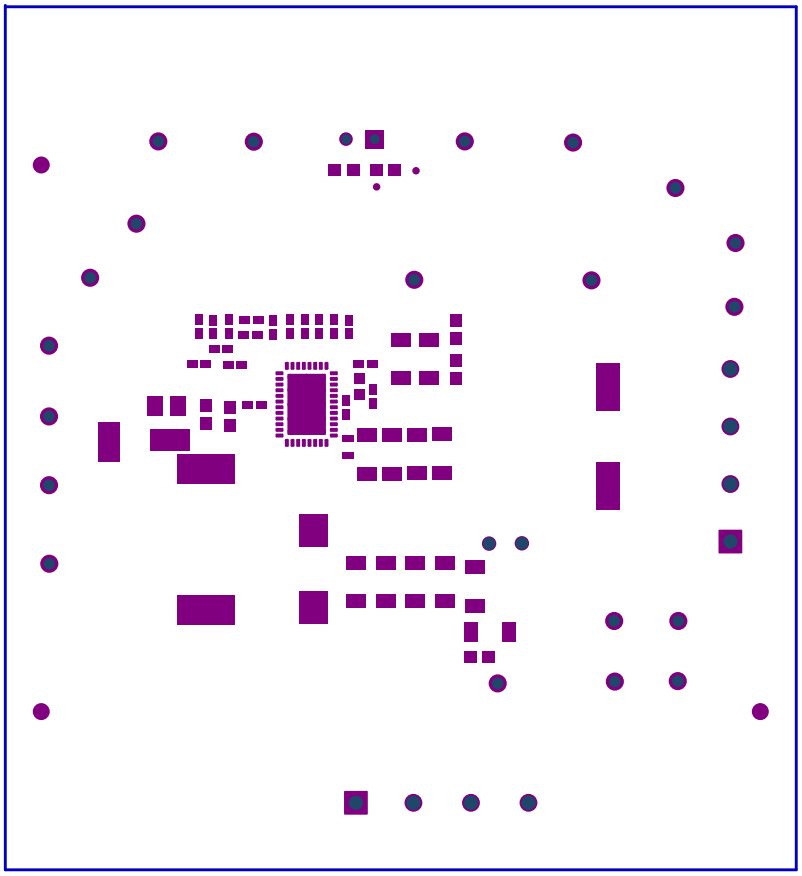

Figure 15. BSR054EVM Top Solder Mask (Top View)

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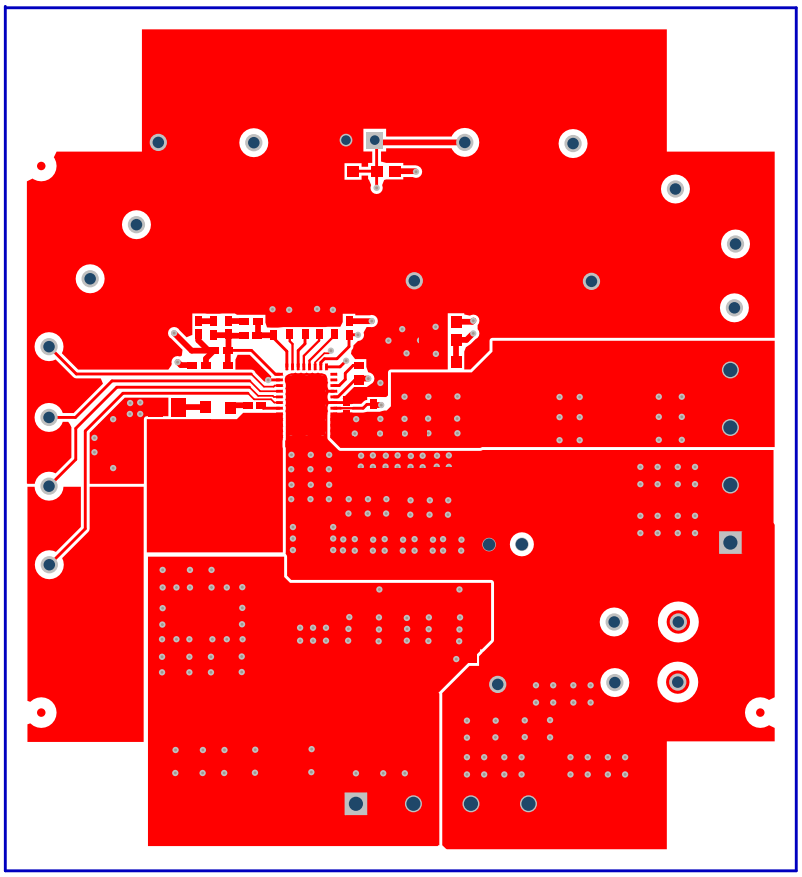

Figure 16. BSR054EVM Top Layer (Top View)

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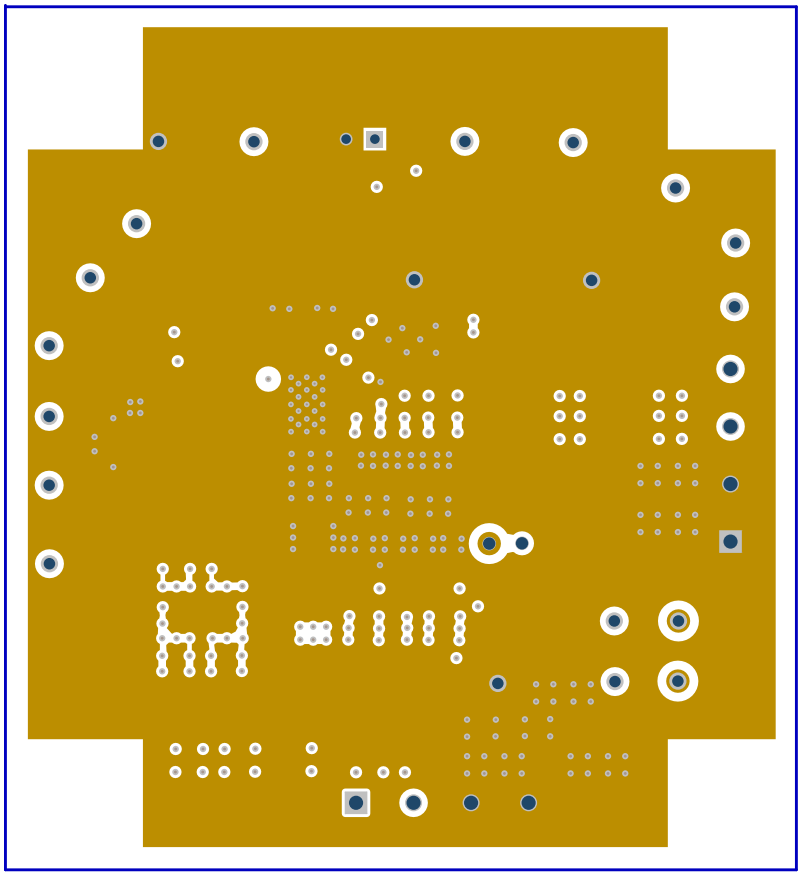

Figure 17. BSR054EVM Inner Layer 1 (Top View)

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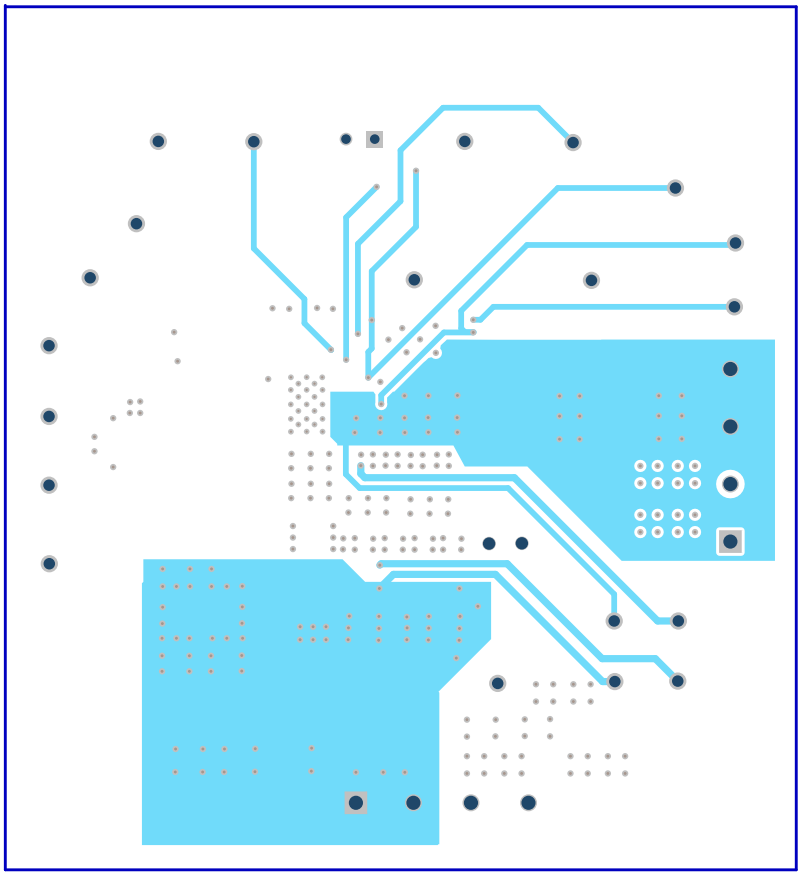

Figure 18. BSR054EVM Inner Layer 2 (Top View)

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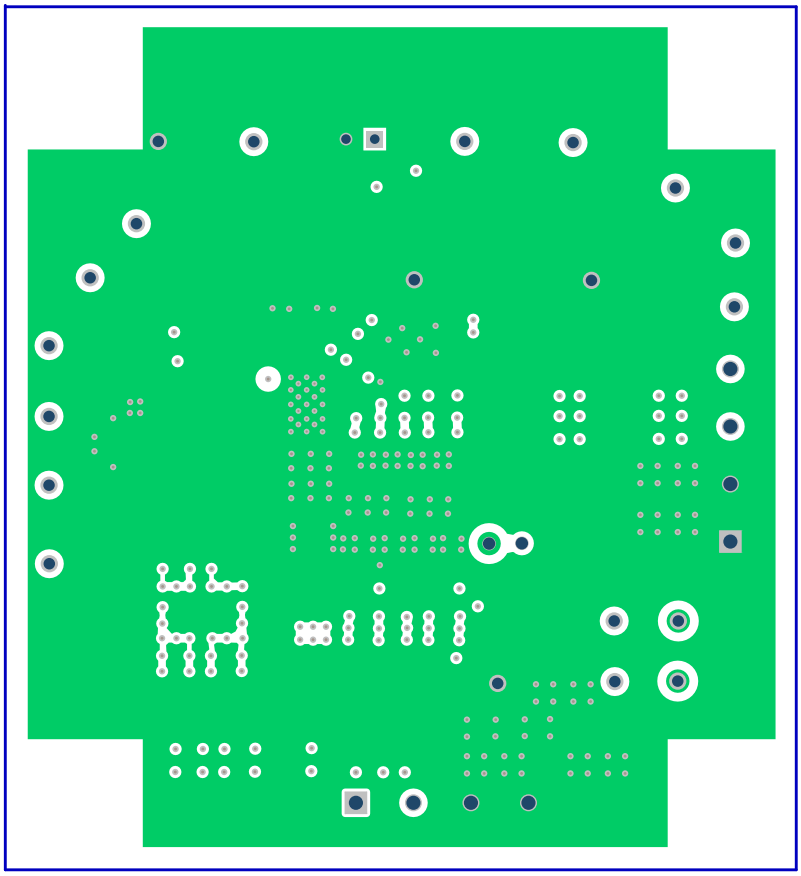

Figure 19. BSR054EVM Inner Layer 3 (Top View)

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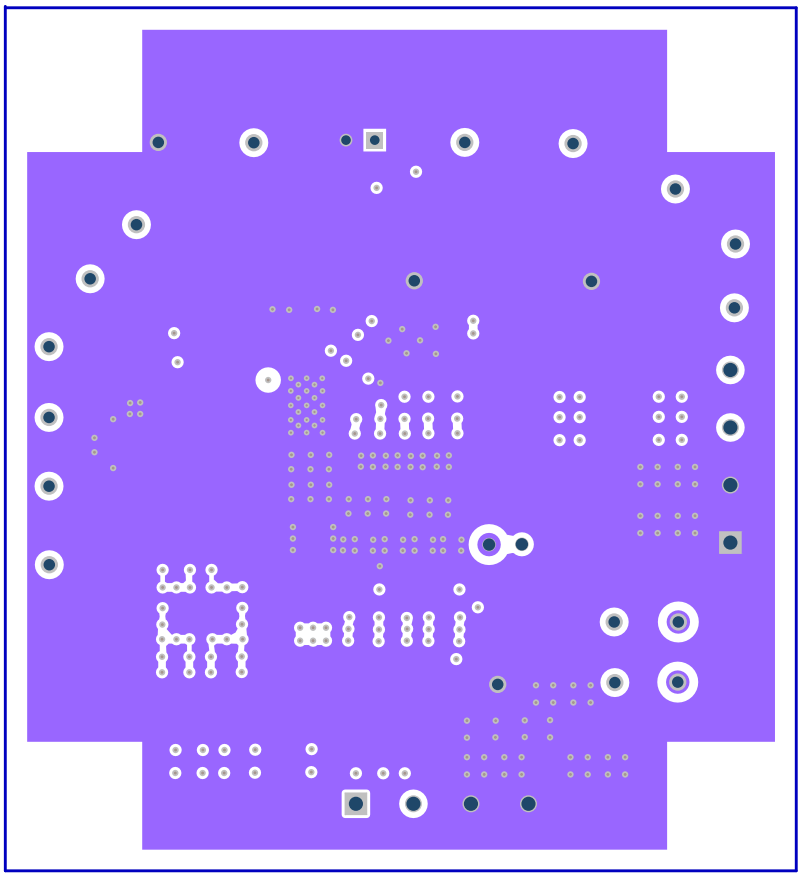

Figure 20. BSR054EVM Inner Layer 4 (Top View)

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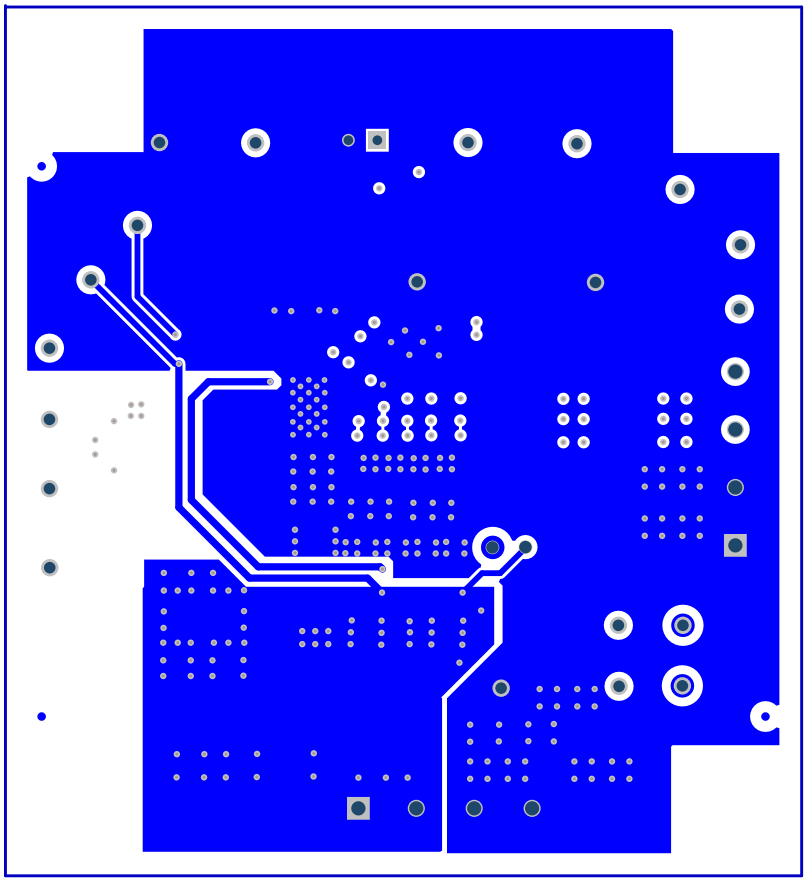

Figure 21. BSR054EVM Bottom Layer (Top View)

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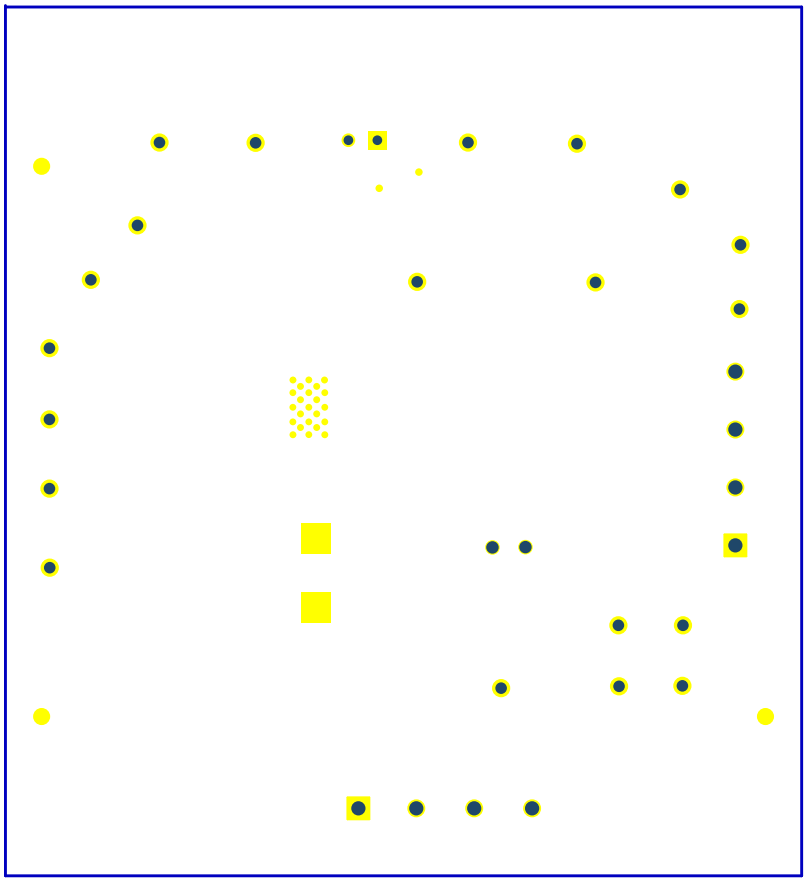

Figure 22. BSR054EVM Bottom Solder Mask (Top View)

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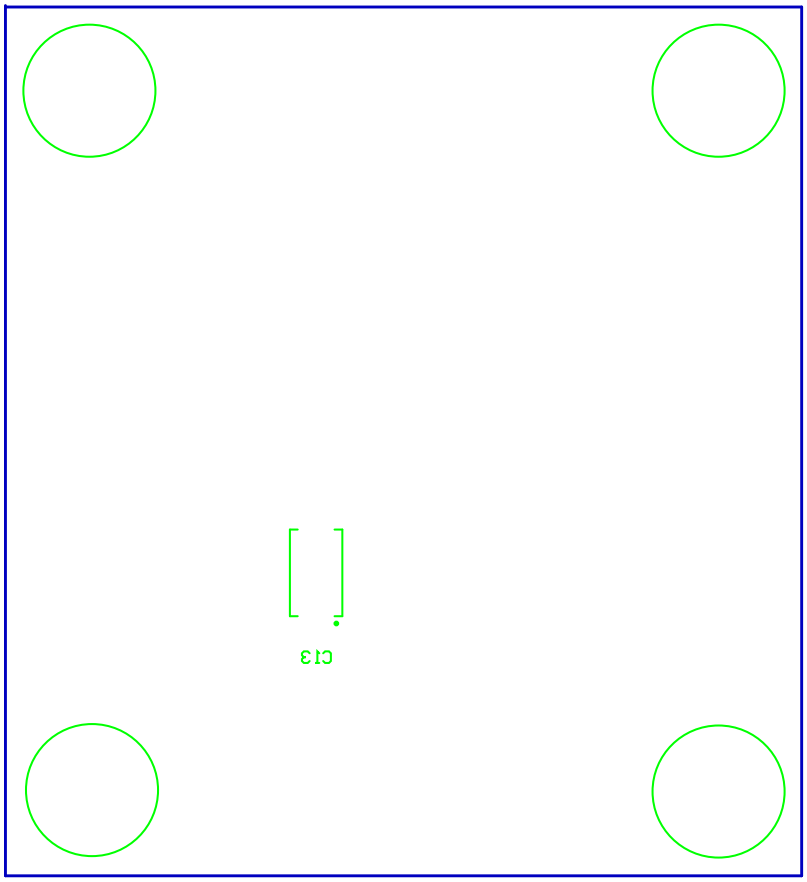

Figure 23. BSR054EVM Bottom Overlay Layer (Top View)

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11 List of Materials

The EVM components list, according to the schematic, is shown in Table 5.

Table 5. BSR054EVM List of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number(1)	Alternate Manufacturer(1)
!PCB	1		Printed Circuit Board		BSR054	Any	-	-
C1, C2, C3, C5, C7	5	22uF	CAP, CERM, 22 µF, 25 V, +/- 20%, X5R, 1206_190	1206_190	C3216X5R1E226M160AB	TDK		
C4	1	330uF	CAP, AL, 330 µF, 25 V, +/- 20%, 0.15 ohm, SMD	SMT Radial G	EEE-FC1E331P	Panasonic	865230457008	Wurth Elektronik
C8	1	0.1uF	CAP, CERM, 0.1 µF, 25 V, +/- 10%, X7R, 0603	0603	GRM188R71E104KA01D	MuRata	885012206071	Wurth Elektronik
C9, C11, C17	3	100uF	CAP, CERM, 100 µF, 6.3 V, +/- 20%, X5R, 1206	1206	GRM31CR60J107ME39L	MuRata	885012108005	
C12	1	0.1uF	CAP, CERM, 0.1 µF, 10 V, +/- 10%, X7R, 0603	0603	C0603X104K8RACTU	Kemet	885012206020	Wurth Elektronik
C13	1	330uF	CAP, Tantalum Polymer, 330 µF, 2 V, +/- 20%, 0.006 ohm, 7343-20 SMD	7343-20	2TPF330M6	Panasonic	EEFGX0D331R	Panasonic
C14	1	330uF	CAP, Aluminum Polymer, 330 µF, 2 V, +/- 20%, 3 mohm, 7.3x1.8x4.3mm SMD	7.3x1.8x4.3mm	EEFGX0D331R	Panasonic		
C20	1	1uF	CAP, CERM, 1 µF, 25 V, +/- 10%, X5R, 0402	0402	GRM155R61E105KA12D	MuRata		
C21	1	4.7uF	CAP, CERM, 4.7 µF, 16 V, +/- 10%, X5R, 0603	0603	GRM188R61C475KAAJ	MuRata		
C23	1	0.1uF	CAP, CERM, 0.1 µF, 50 V, +/- 10%, X7R, 0603	0603	06035C104KAT2A	AVX	885012206095	Wurth Elektronik
C24	1	1000pF	CAP, CERM, 1000 pF, 50 V, +/- 10%, C0G/NP0, 0603	0603	06035A102KAT2A	AVX	885012006062	Wurth Elektronik
C25	1	0.01uF	CAP, CERM, 0.01 uF, 50 V, +/- 5%, X7R, 0402	0402	C0402C103J5RACTU	Kemet		
H9, H10, H11, H12	4		Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon	SJ-5303 (CLEAR)	3M		
J1, J2	2		Terminal Block, 5.08 mm, 4x1, Brass, TH	4x1 5.08 mm Terminal Block	ED120/4DS	On-Shore Technology	61300211121	Wurth Elektronik
J3	1		Header, 100mil, 2x1, TH	Header, 2x1, 100mil, TH	800-10-002-10-001000	Mill-Max	691242510004	Wurth Elektronik
L1	1	470nH	Inductor, Shielded Drum Core, Ferrite, 470 nH, 40.5 A, 0.000165 ohm, SMD	12.5x13mm	744309047	Wurth Elektronik		
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650"H x 0.200"W	THT-14-423-10	Brady		
R1	1	0	RES, 0, 5%, 0.1 W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale		
R2	1	187k	RES, 187 k, 1%, 0.063 W, 0402	0402	CRCW0402187KFKED	Vishay-Dale		
R4	1	1.00	RES, 1.00, 1%, 0.1 W, 0603	0603	CRCW06031R00FKEA	Vishay-Dale		
R7	1	51.1k	RES, 51.1 k, 1%, 0.063 W, 0402	0402	CRCW040251K1FKED	Vishay-Dale		
R8	1	69.8k	RES, 69.8 k, 1%, 0.063 W, 0402	0402	CRCW040269K8FKED	Vishay-Dale		
R12, R13, R17	3	0	RES, 0, 5%, 0.063 W, 0402	0402	CRCW04020000Z0ED	Vishay-Dale		
R14	1	40.2k	RES, 40.2 k, 1%, 0.063 W, 0402	0402	CRCW040240K2FKED	Vishay-Dale		
R16	1	100k	RES, 100 k, 5%, 0.063 W, 0402	0402	CRCW0402100KJNED	Vishay-Dale		

(1) Unless otherwise noted in the Alternate PartNumber and/or Alternate Manufacturer columns, all parts may be substituted with equivalents.

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Table 5. BSR054EVM List of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number(1)	Alternate Manufacturer(1)
R18	1	3.0	RES, 3.0 ohm, 5%, 0.125W, 0805	0805	RC0805JR-073RL	Yageo America		
TP1, TP3, TP5, TP6, TP8, TP9, TP11, TP12, TP14, TP18, TP19, TP20, TP21, TP22	14	Red	Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone		
TP2, TP13	2		PCB Pin, 0.04" DIA, TH	PCB Pin, 0.04" DIA, TH	3102-2-00-21-00-00-08-0	Mill-Max		
TP4, TP7, TP10, TP15, TP16, TP17	6	Black	Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone		
TP23, TP24	2	SMT	Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone		
U1	1		25A FIXED FREQUENCY NON-COMPENSATON STACKABLE SYNCHRONOUS BUCK CONVERTER, RVF0040A (LQFN-CLIP-40)	RVF0040A	TPS543B20EVM-054RVFT	Texas Instruments		Texas Instruments
C6	0	22uF	CAP, CERM, 22 µF, 25 V, +/- 20%, X5R, 1206_190	1206_190	C3216X5R1E226M160AB	TDK		
C10, C15, C16	0	100uF	CAP, CERM, 100 µF, 6.3 V, +/- 20%, X5R, 1206	1206	GRM31CR60J107ME39L	MuRata	885012108005	Wurth Elektronik
C18, C19, C22	0	22pF	CAP, CERM, 22 pF, 50 V, +/- 5%, C0G/NP0, 0402	0402	C1005C0G1H220J050BA	TDK	885012005057	Wurth Elektronik
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A		
R3, R5, R9, R10	0	0	RES, 0, 5%, 0.063 W, 0402	0402	ERJ-2GE0R00X	Panasonic		
R6, R11	0	0	RES, 0, 5%, 0.1 W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale		
R15	0	8.66k	RES, 8.66 k, 1%, 0.063 W, 0402	0402	CRCW04028K66FKED	Vishay-Dale		

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