User's Guide

TPS548B22 SWIFT™ Step-Down Converter Evaluation Module User's Guide

TEXAS INSTRUMENTS

ABSTRACT

This user's guide describes the characteristics, operation, and use of the TPS548B22 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, TPS548B22EVM, and the term evaluation module are synonymous with the TPS548B22EVM-847, unless otherwise noted.

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Trademarks

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1 Introduction

The PWR847EVM evaluation module uses the TPS548B22 device. The TPS548B22 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 TPS548B22EVM-847. Observe all safety precautions.

⚠️	**Warning**	The TPS548B22EVM-847 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 PWR847EVM is designed as a single output DC-DC converter that demonstrates the TPS548B22 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 1-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 1-V output up to 25-A, steady-state output current
- Convenient test points for probing critical waveforms

3 EVM Electrical Performance Specifications

Table 3-1. PWR-847EVM Electrical Performance Specifications

Parameter		Test Conditions	Min	Typ	Max	Units
Input Characteristics						
	Voltage range	V_{IN} tied to VDD	5	12	14	V
	Maximum input current	V_{IN} = 12 V, I_O = 25 A			12	A
	No load input current	V_{IN} = 12 V, I_O = 0 A		60		mA
Output Characteristics						
V_{OUT}	Output voltage	Output current = 10 A		1		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 14 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			32		A
Systems Characteristics						
	Switching frequency	F_{SW}		650		kHz
V_{OUT}	Peak efficiency	V_{IN} = 12 V, I_O = 12 A, F_{SW} = 650 kHz		90%		
	Operating temperature	T_{oper}	0		85	°C

4 Schematic

Figure 4-1. PWR-847EVM Schematic
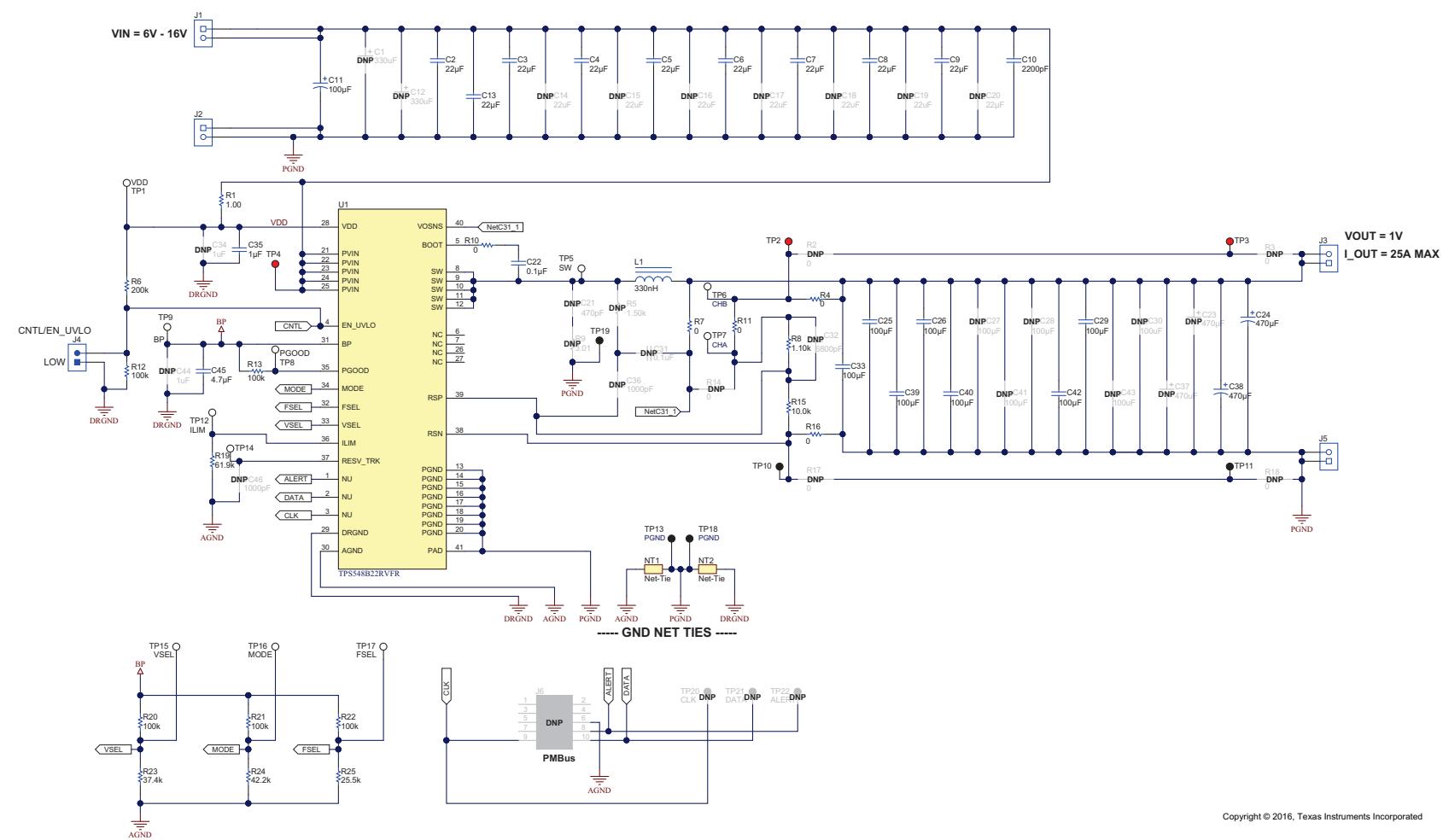
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5 Test Equipment

Voltage Source: The input voltage source VIN must be a 0-V to 18-V variable DC source capable of supplying at least 12 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 6-1. 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 6-1. 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 6-2.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.

## 6 PWR-847EVM
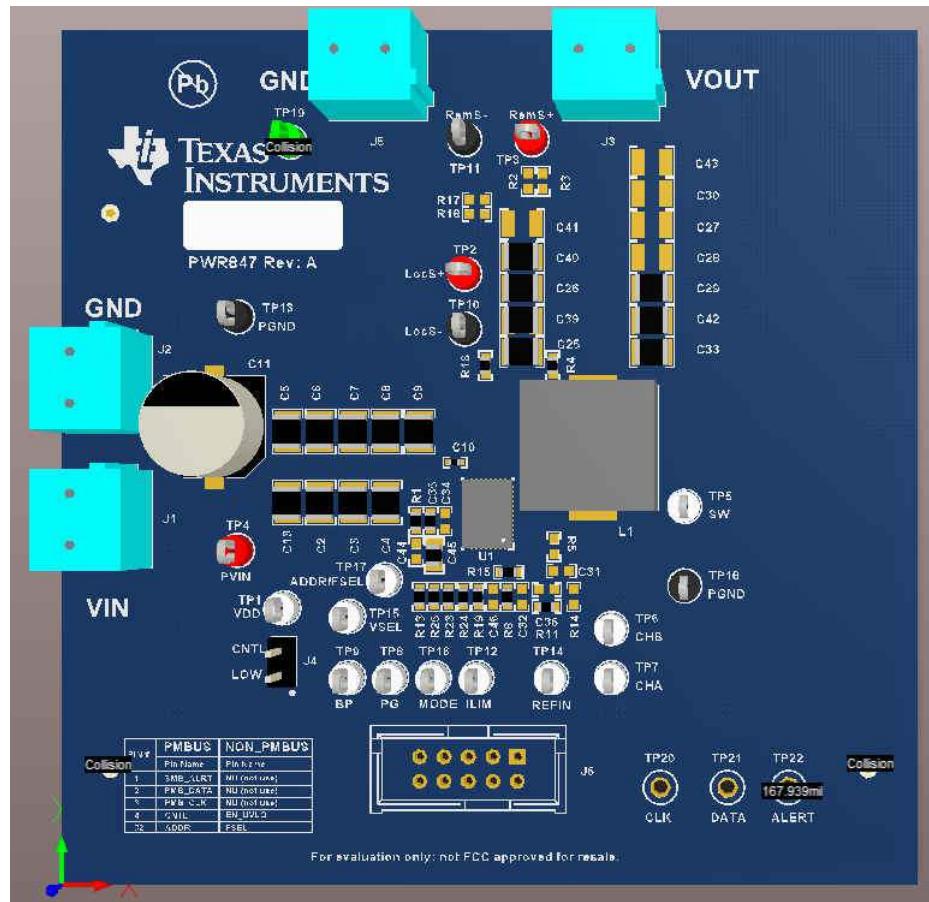
Figure 6-1. PWR-847EVM Overview
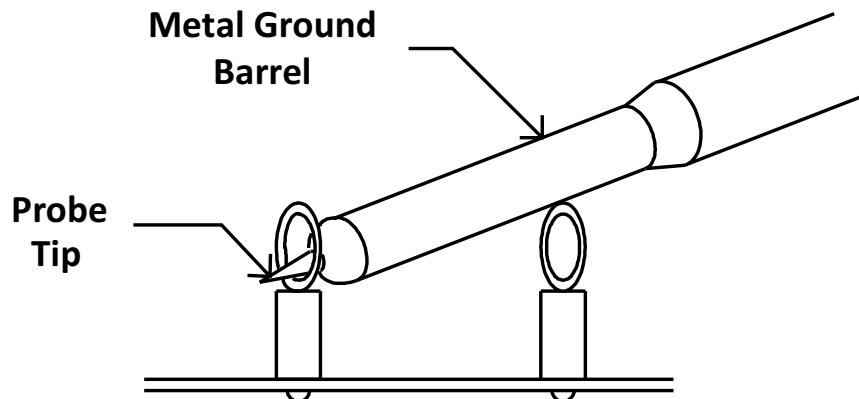
Figure 6-2. Tip and Barrel Measurement

7 List of Test Points, Jumpers, and Switch

Table 7-1. Test Point Functions

Item	Type	Name	Description
TP5	T-H loop	SW	Power supply Switch node
TP7	T-H loop	CH-A	Measure loop stability
TP6	T-H loop	CH-B	Measure loop stability
TP2	T-H loop	LocS+	Sense VOUT + locally across C5. Use for efficiency and ripple measurements
TP10	T-H loop	LocS-	Sense VOUT– locally across C5. Use for efficiency and ripple measurements
TP3	T-H loop	RemS+	Remote sense +
TP11	T-H loop	RemS-	Remote sense –
TP4	T-H loop	PVIN	Sense VIN + across C10
TP13	T-H loop	PGND	Sense VIN – across C10
TP1	T-H loop	VDD	Supplies the internal circuitry
TP17	T-H loop	FSEL	Monitor the FSEL external resistor divider ratio during initial power up.
TP15	T-H loop	VSEL	Monitor the VSEL external resistor divider ratio during initial power up.
TP9	T-H loop	BP	LDO output
TP8	T-H loop	PG	Power good
TP16	T-H loop	MODE	Monitor the MODE external resistor divider ratio during initial power up.
TP12	T-H loop	ILIM	Program over-current limit.
TP14	T-H loop	RESV_TRK	Do not connect.
TP19	T-H loop	PGND	Common GND
TP18	T-H loop	PGND	Common GND
TP20	T-H loop	CLK	Not used
TP21	T-H loop	DATA	Not used
TP22	T-H loop	ALERT	Not used
JP4	2-pin jumper	CNTL	Shunts control pin to GND

8 Test Procedure

8.1 Line and Load Regulation Measurement Procedure

1. Connect VOUT to J3 and VOUT_GND to J5 Figure 6-1.
2. Ensure that the electronic load is set to draw 0 A$_{DC}$.
3. Ensure the jumper provided on the EVM shorts on J4 before V$_{IN}$ is applied
4. Connect VIN to J1 and VIN_GND to J2 Figure 6-1.
5. Increase V$_{IN}$ from 0 V to 12 V using the digital multimeter to measure input voltage.
6. Remove the jumper on J4 to enable the controller.
7. Use the other digital multimeter or the oscilloscope to measure output voltage V$_{OUT}$ at TP2 and TP10.

Table 8-1. List of Test Points for Line and Load Measurements

Test Point	Node Name	Description
TP2	LocS+	Sense VOUT + locally across C5. Use for efficiency and ripple measurements
TP10	LocS-	Sense VOUT - locally across C5. Use for efficiency and ripple measurements
TP4	PVIN	Sense VIN + across C10
TP13	PGND	Sense VIN - across C10

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 3-1.
9. Vary V$_{IN}$ from 5 V to 14 V. V$_{OUT}$ must remain in regulation as defined in Table 3-1.
10. Decrease the load to 0 A.
11. Put the jumper back on J4 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 8-2. List of Test Points for Efficiency Measurements

Test Point	Node Name	Description
TP2	LocS+	Sense VOUT + locally across C25. Use for efficiency and ripple measurements
TP10	LocS-	Sense VOUT - locally across C25. Use for efficiency and ripple measurements
TP4	PVIN	Sense VIN + across C10
TP13	PGND	Sense VIN - across C10

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.

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 9-1 through Figure 9-10 present typical performance curves for the PWR-847EVM.

9.1 Efficiency
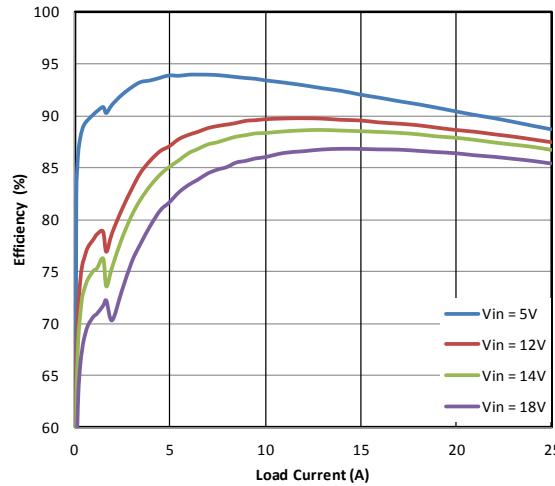
**Figure 9-1. Efficiency of 1-V Output vs Load**

9.2 Power Loss
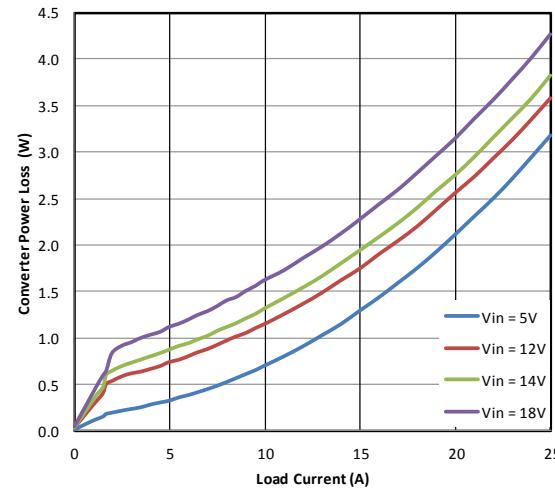
Figure 9-2. Power Loss of 1-V Output vs Load

9.3 Load Regulation
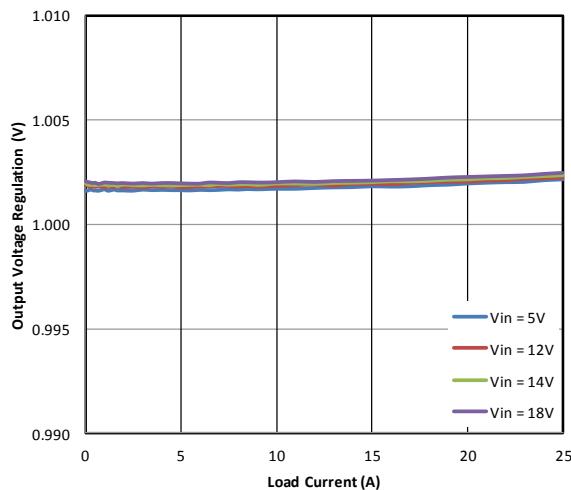
Figure 9-3. Load Regulation of 1-V Output

9.4 Transient Response

Figure 9-4. Transient Response of 1-V Output at 12 V$_{IN}$, Transient is 0.5 A to 15.5 A, the Step is 15 A at 40 A/μs
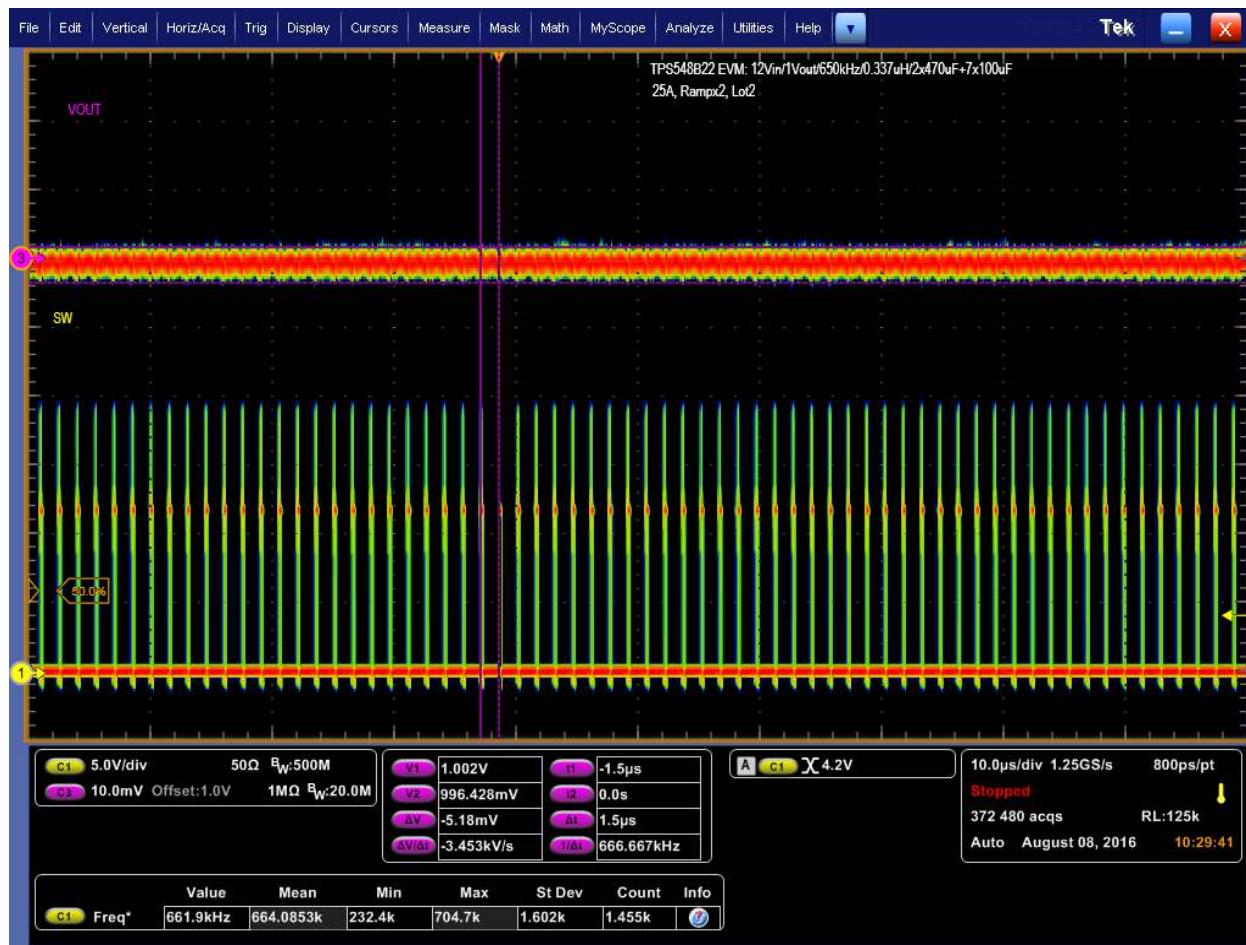
9.5 Output Ripple

Figure 9-5. Output Ripple and SW Node of 1-V Output at 12 V$_{IN}$, 25-A Output
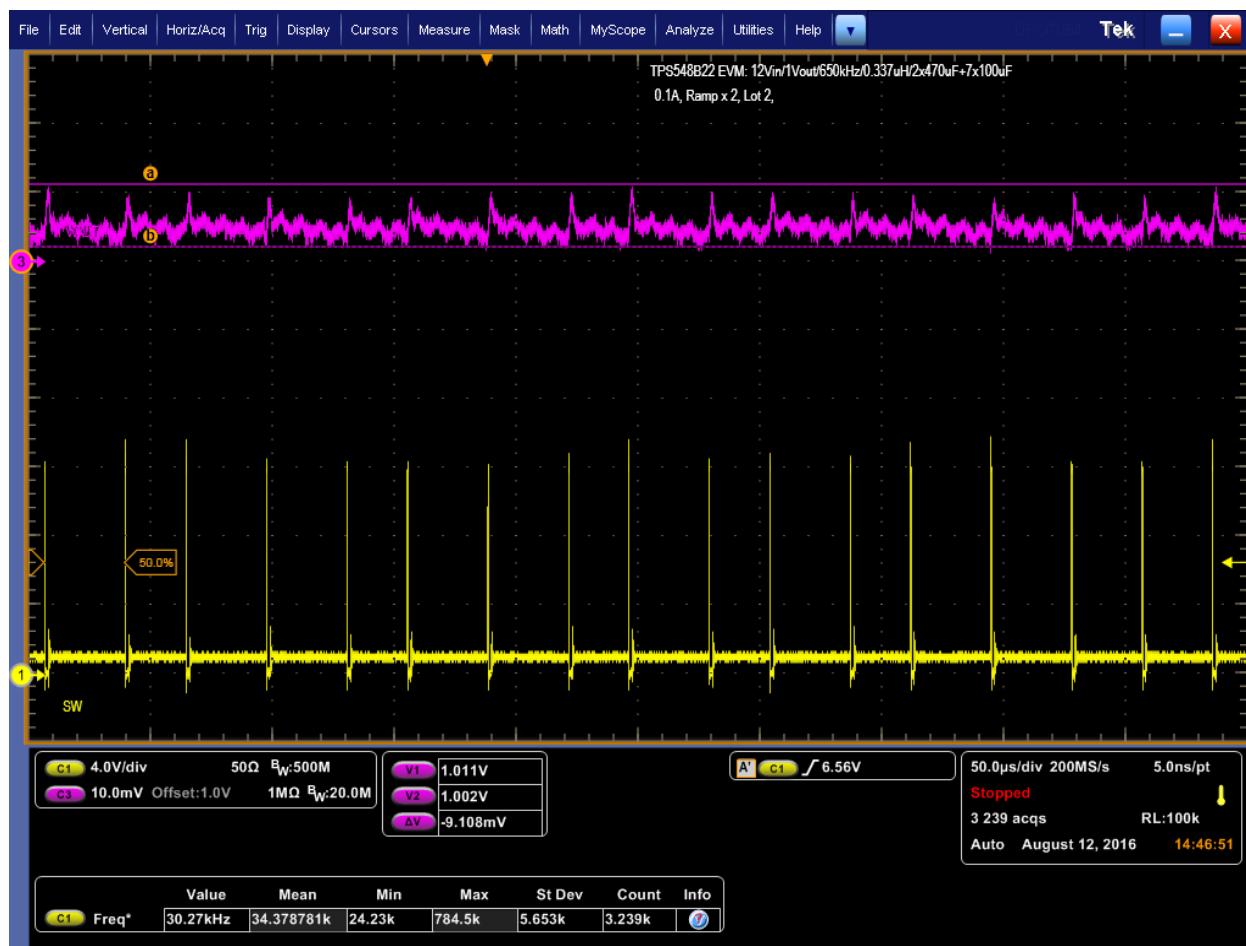
Figure 9-6. Output Ripple and SW Node of 1-V Output at 12 V$_{IN}$, 0-A Output

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9.6 Control On

Figure 9-7. Start up from Control, 1-V Output at 12 V$_{IN}$, 0-A Output
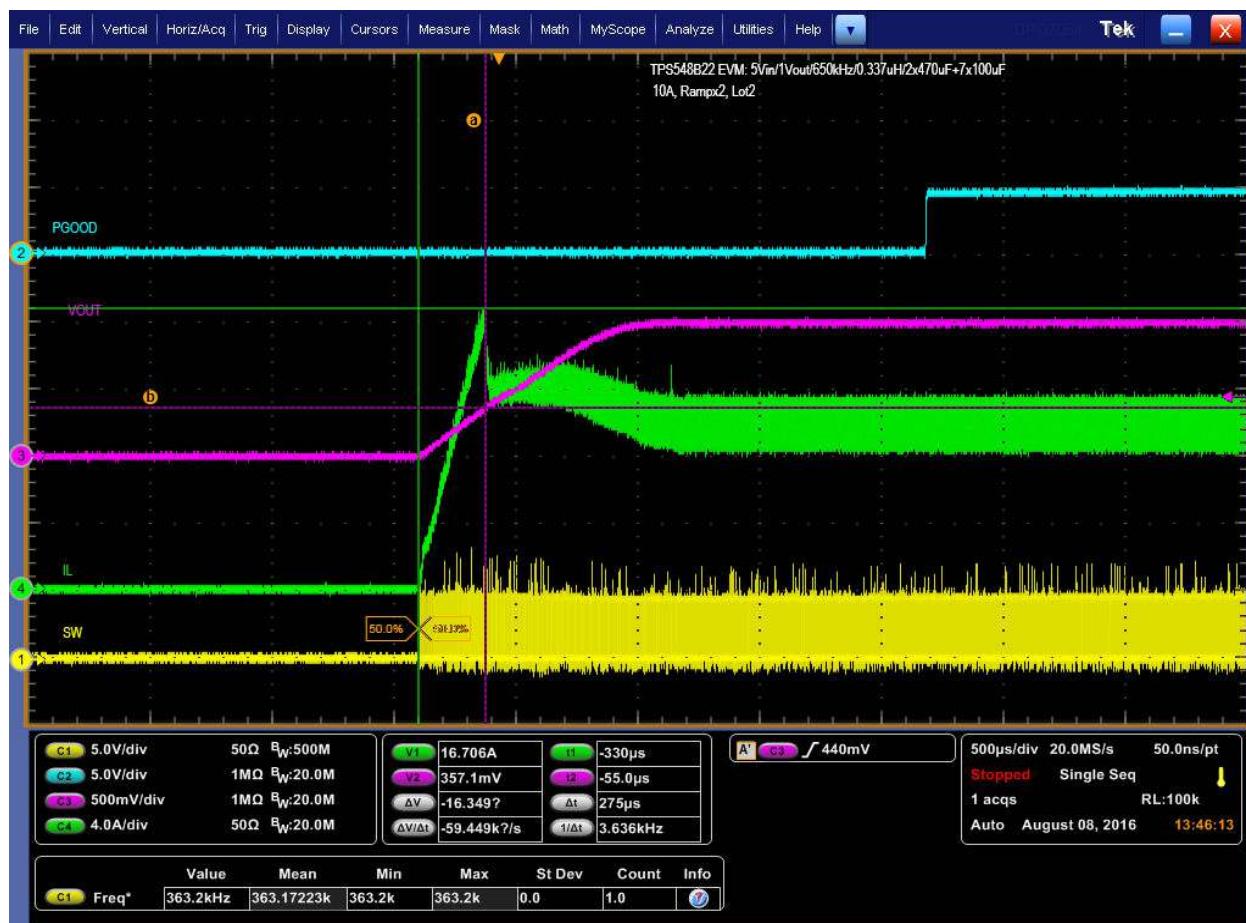
Figure 9-8. 0.5-V Pre-bias start up from Control, 1-V Output at 12 V$_{IN}$, 10-A Output

9.7 Control On and Off
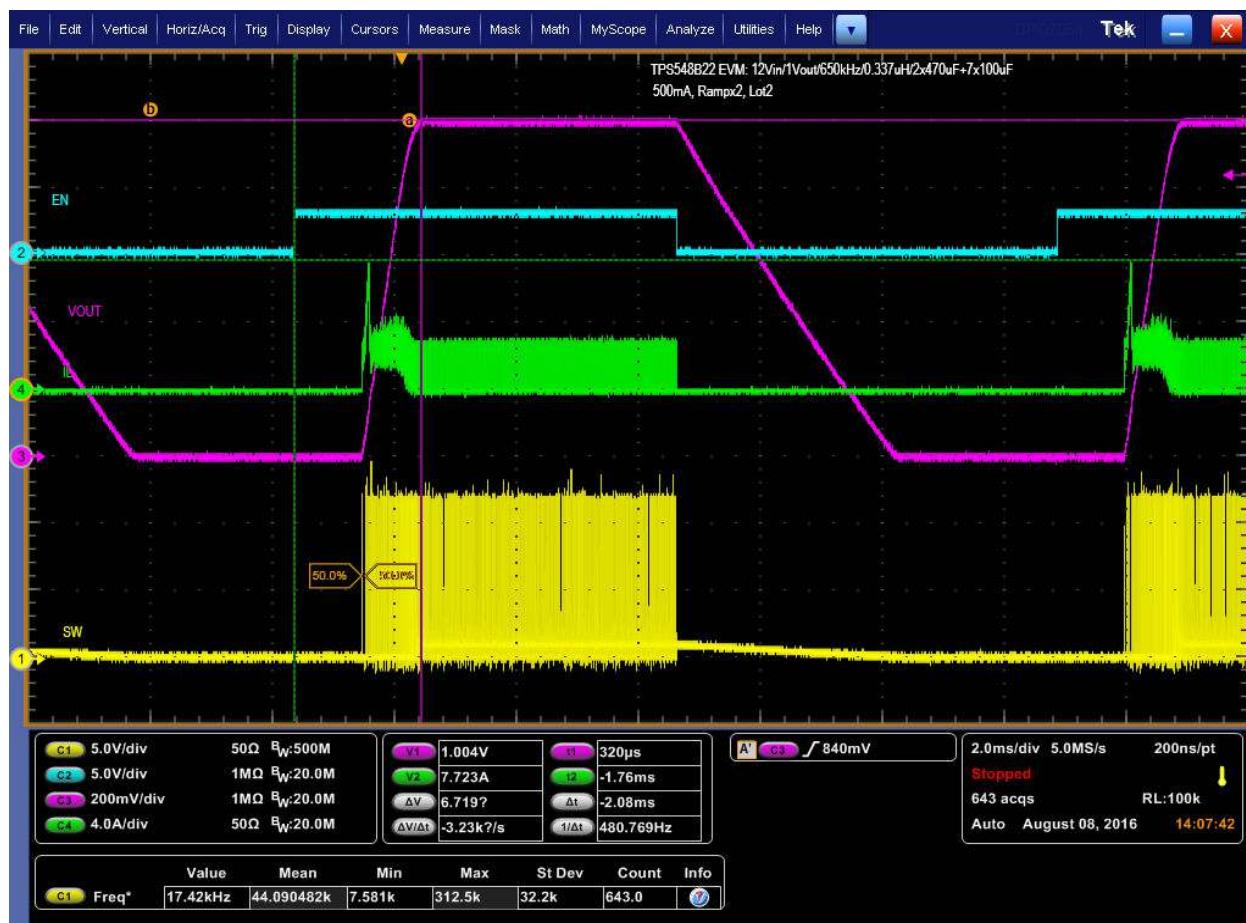
Figure 9-9. Output Voltage Start-up and Shutdown, 1-V Output at 1 2V$_{IN}$, 0.5-A Output

9.8 Thermal Image
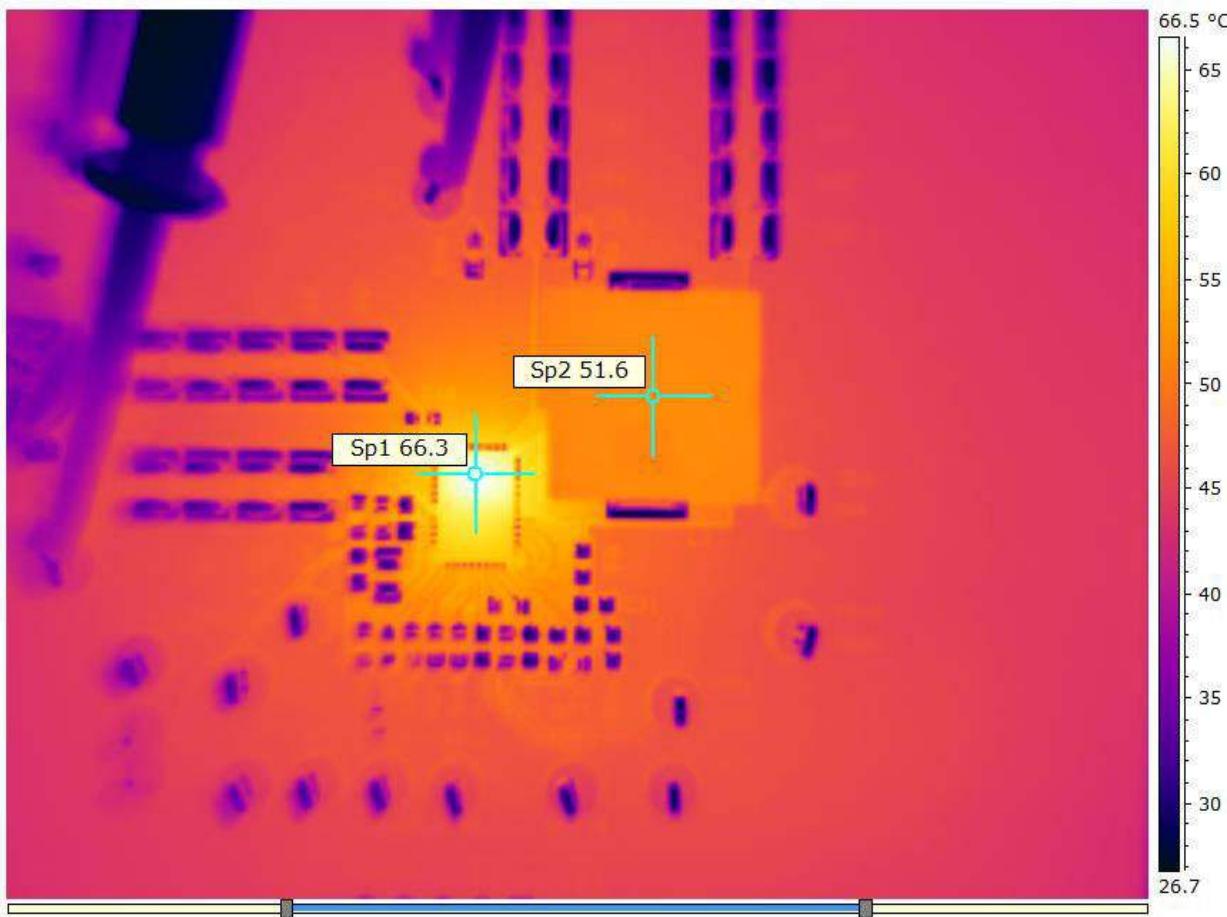
Figure 9-10. Thermal Image at 1-V Output at 12 V$_{IN}$, 25-A Output, at 25°C Ambient

10 EVM Assembly Drawing and PCB Layout

Figure 10-1 through Figure 10-8 show the design of the PWR-847EVM printed-circuit board (PCB). The PWR-847EVM has a 2-oz. copper finish for all layers.
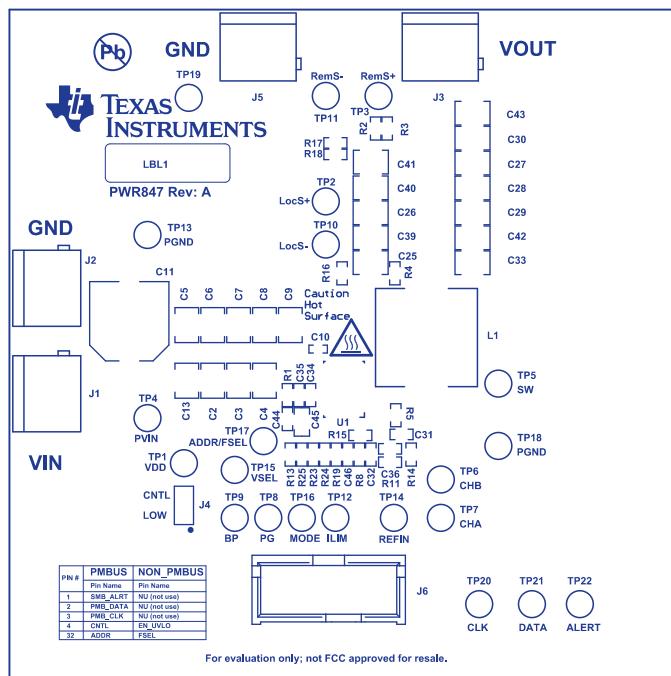
Figure 10-1. PWR-847EVM Top Layer Assembly Drawing (Top View)
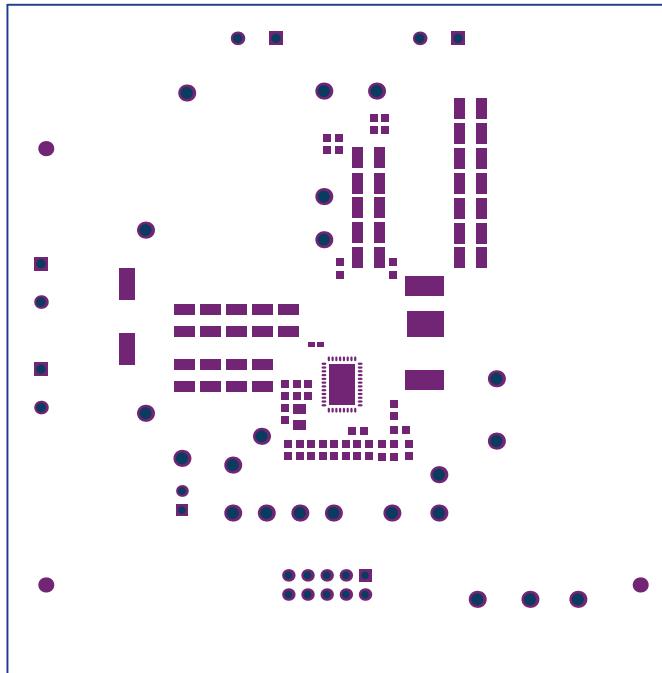
Figure 10-2. PWR-847EVM Top Solder Mask (Top View)
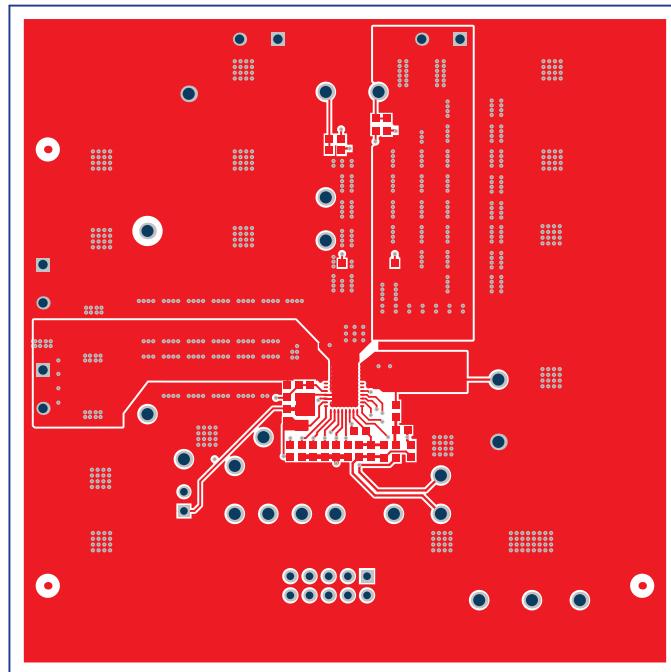
Figure 10-3. PWR-847EVM Top Layer (Top View)
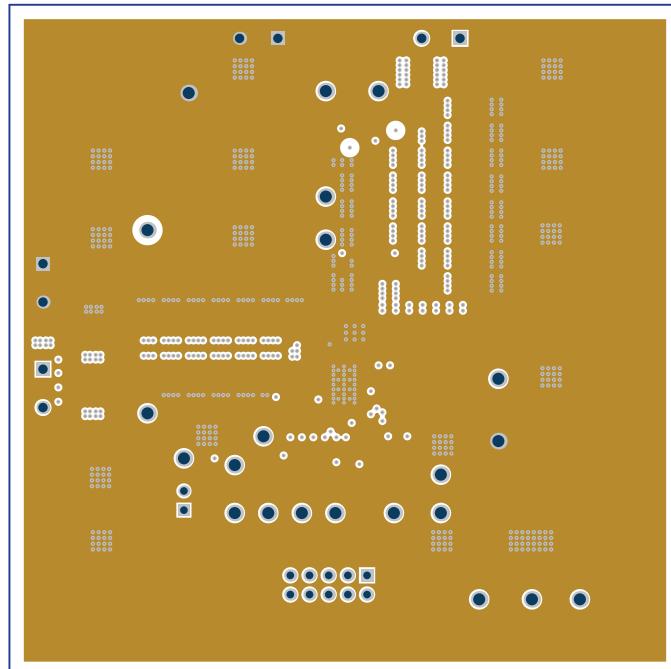
Figure 10-4. PWR-847EVM Inner Layer 1 (Top View)
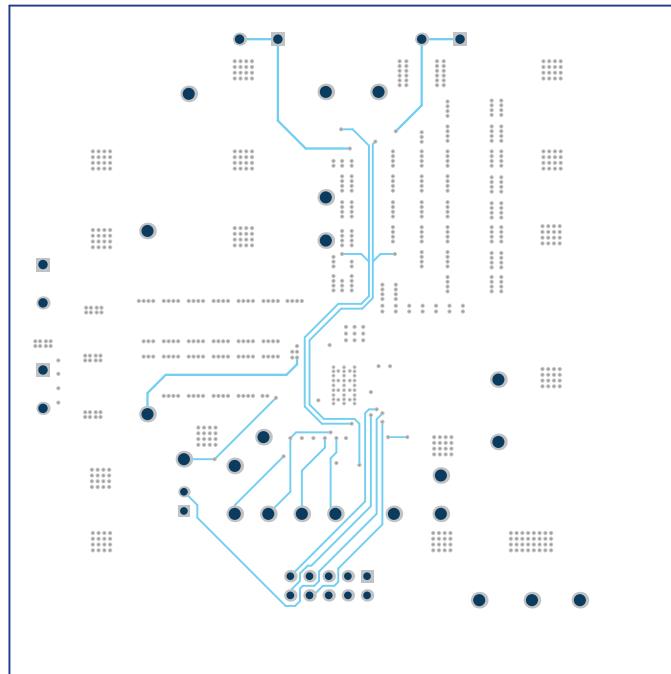
Figure 10-5. PWR-847EVM Inner Layer 2 (Top View)
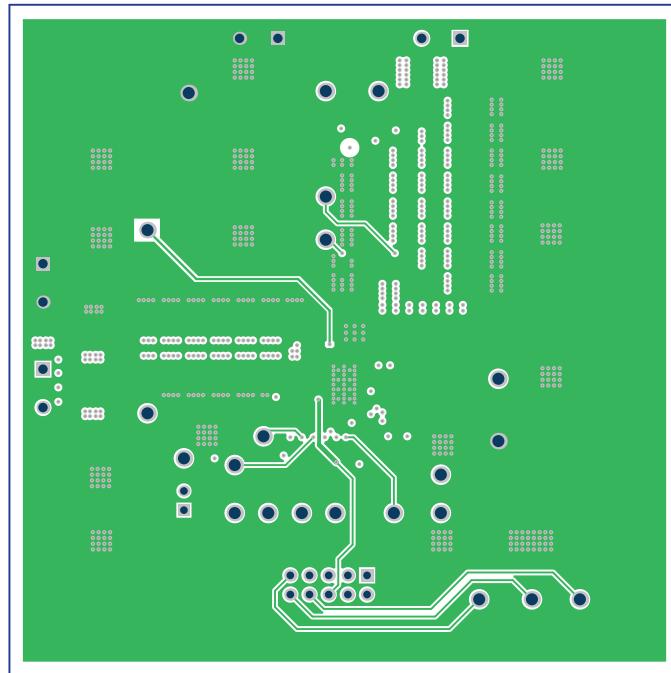
Figure 10-6. PWR-847EVM Inner Layer 3 (Top View)
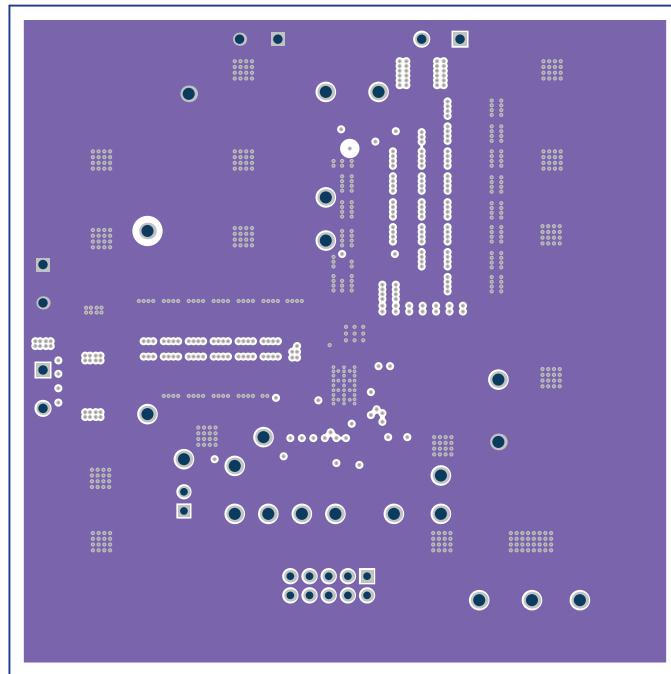
**Figure 10-7. PWR-847EVM Inner Layer 4 (Top View)**
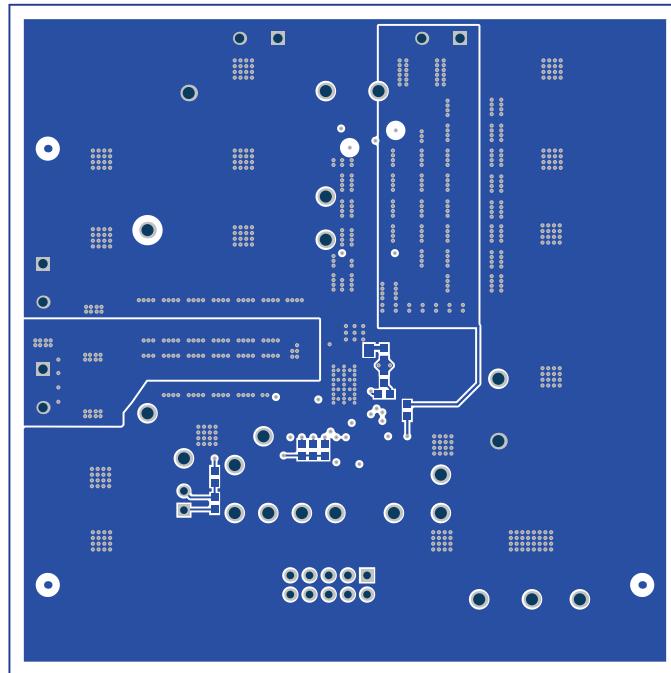

Figure 10-8. PWR-847EVM Bottom Layer (Top View)
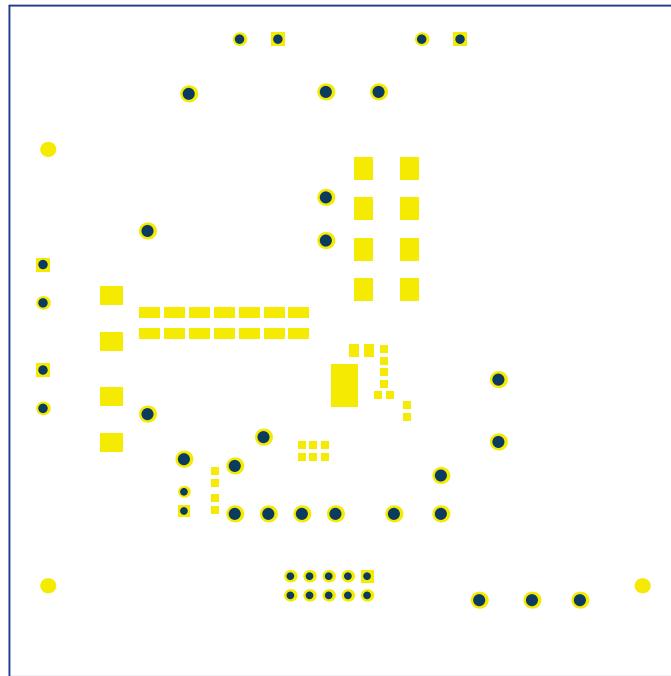
**Figure 10-9. PWR-847EVM Bottom Solder Mask (Top View)**
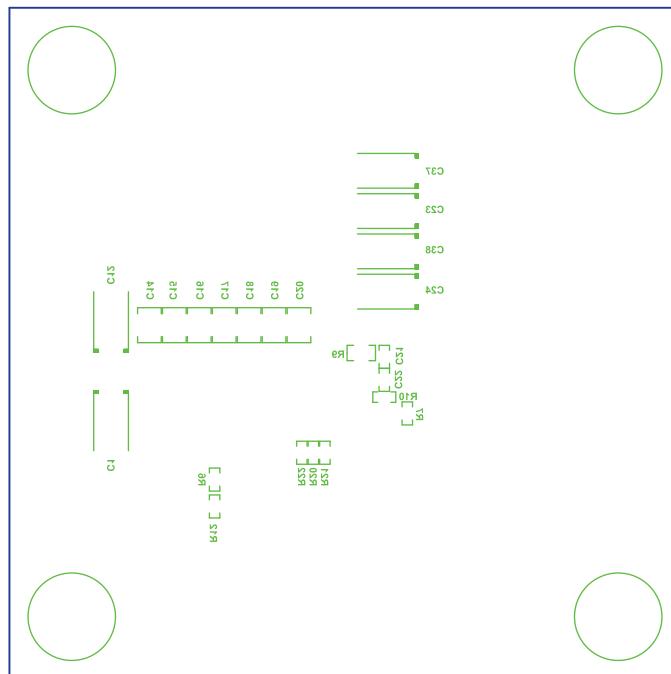
Figure 10-10. PWR-847EVM Bottom Overlay Layer (Top View)

11 List of Materials

The EVM components list, according to the schematic, is shown in Table 11-1.

Table 11-1. PWR847 List of Materials

Item#	Designator	Qty	Value	Part Number	Manufacturer	Description	Package Reference
2	C2, C3, C4, C5, C6, C7, C8, C9, C13	9	22uF	GRM32ER71E226KE15L	MuRata	CAP, CERM, 22 µF, 25 V, +/- 10%, X7R, 1210	1210
3	C10	1	2200pF	GRM155R61E222KA01D	MuRata	CAP, CERM, 2200 pF, 25 V, +/- 10%, X5R, 0402	0402
4	C11	1	100uF	EEE-FC1V101P	Panasonic	CAP, AL, 100uF, 35V, +/-20%, 0.15 ohm, SMD	SMT Radial G
5	C22	1	0.1uF	GRM188R71H104KA93D	MuRata	CAP, CERM, 0.1 µF, 50 V, +/- 10%, X7R, 0603	0603
6	C24, C38	2	470uF	2R5TPF470M6L	Panasonic	CAP, Tantalum Polymer, 470 µF, 2.5 V, +/- 20%, 0.006 ohm, 7.3x2.8x4.3mm SMD	7.3x2.8x4.3mm
7	C25, C26, C29, C33, C39, C40, C42	7	100uF	GRM32ER60J107ME20L	MuRata	CAP, CERM, 100 µF, 6.3 V, +/- 20%, X5R, 1210	1210
8	C35	1	1uF	C0603C105K4PACTU	Kemet	CAP, CERM, 1 µF, 16 V, +/- 10%, X5R, 0603	0603
9	C45	1	4.7uF	GRM21BR71C475KA73L	MuRata	CAP, CERM, 4.7 µF, 16 V, +/- 10%, X7R, 0805	0805
10	H9, H10, H11, H12	4		SJ-5303 (CLEAR)	3M	Bumpon, Hemisphere, 0.44 X 0.20, Clear	Transparent Bumpon
11	J1, J2, J3, J5	4		ED120/2DS	On-Shore Technology	TERMINAL BLOCK 5.08MM VERT 2POS, TH	TERM_BLK, 2pos, 5.08mm
12	J4	1		PEC02SAAN	Sullins Connector Solutions	Header, 100mil, 2x1, Tin, TH	Header, 2 PIN, 100mil, Tin
13	L1	1	330nH	744309033	Wurth Elektronik	Inductor, Shielded Drum Core, Ferrite, 330 nH, 50 A, 0.000165 ohm, SMD	12.5x13mm
14	LBL1	1		THT-14-423-10	Brady	Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650"H x 0.200"W
15	R1	1	1.00	RC0603FR-071RL	Yageo America	RES, 1.00, 1%, 0.1 W, 0603	0603
16	R4, R7, R10, R11, R16	5	0	CRCW06030000Z0EA	Vishay-Dale	RES, 0, 5%, 0.1 W, 0603	0603
17	R6	1	200k	CRCW0603200KFKEA	Vishay-Dale	RES, 200 k, 1%, 0.1 W, 0603	0603
18	R8	1	1.10k	CRCW06031K10FKEA	Vishay-Dale	RES, 1.10 k, 1%, 0.1 W, 0603	0603
19	R12, R13, R20, R21, R22	5	100k	CRCW0603100KFKEA	Vishay-Dale	RES, 100 k, 1%, 0.1 W, 0603	0603
20	R15	1	10.0k	CRCW060310K0FKEA	Vishay-Dale	RES, 10.0k ohm, 1%, 0.1W, 0603	0603
21	R19	1	61.9k	CRCW060361K9FKEA	Vishay-Dale	RES, 61.9 k, 1%, 0.1 W, 0603	0603
22	R23	1	37.4k	CRCW060337K4FKEA	Vishay-Dale	RES, 37.4 k, 1%, 0.1 W, 0603	0603
23	R24	1	42.2k	CRCW060342K2FKEA	Vishay-Dale	RES, 42.2 k, 1%, 0.1 W, 0603	0603
24	R25	1	25.5k	CRCW060325K5FKEA	Vishay-Dale	RES, 25.5 k, 1%, 0.1 W, 0603	0603
25	TP1, TP5, TP6, TP7, TP8, TP9, TP12, TP14, TP15, TP16, TP17	11	White	5012	Keystone	Test Point, Multipurpose, White, TH	White Multipurpose Testpoint
26	TP2, TP3, TP4	3	Red	5010	Keystone	Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint
27	TP10, TP11, TP13, TP18, TP19	5	Black	5011	Keystone	Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint
28	U1	1		TPS548B22RVFR	Texas Instruments	1.5-V to 16-V VIN, 4.5-V to 22-V VDD, 25-A SWIFT Synchronous Step-Down Converter with Full Differential Sense, RVF0040A (LQFN-CLIP-40)	RVF0040A
29	C1, C12	0	330uF	6TPE330ML	Sanyo	CAP, TA, 330 µF, 6.3 V, +/- 20%, 0.025 ohm, SMD	7.3x2.8x4.3mm
30	C14, C15, C16, C17, C18, C19, C20	0	22uF	GRM32ER71E226KE15L	MuRata	CAP, CERM, 22 µF, 25 V, +/- 10%, X7R, 1210	1210
31	C21	0	470pF	GRM188R71H471KA01D	MuRata	CAP, CERM, 470 pF, 50 V, +/- 10%, X7R, 0603	0603

Table 11-1. PWR847 List of Materials (continued)

Item#	Designator	Qty	Value	Part Number	Manufacturer	Description	Package Reference
32	C23, C37	0	470uF	2R5TPF470M6L	Panasonic	CAP, Tantalum Polymer, 470 µF, 2.5 V, +/- 20%, 0.006 ohm, 7.3x2.8x4.3mm SMD	7.3x2.8x4.3mm
33	C27, C28, C30, C41, C43	0	100uF	GRM32ER60J107ME20L	MuRata	CAP, CERM, 100 µF, 6.3 V, +/- 20%, X5R, 1210	1210
34	C31	0	0.1uF	GRM188R71H104KA93D	MuRata	CAP, CERM, 0.1 µF, 50 V, +/- 10%, X7R, 0603	0603
35	C32	0	6800pF	GRM188R71H682KA01D	MuRata	CAP, CERM, 6800 pF, 50 V, +/- 10%, X7R, 0603	0603
36	C34, C44	0	1uF	C0603C105K4PACTU	Kemet	CAP, CERM, 1 µF, 16 V, +/- 10%, X5R, 0603	0603
37	C36	0	1000pF	GRM188R71E102KA01D	MuRata	CAP, CERM, 1000 pF, 25 V, +/- 10%, X7R, 0603	0603
38	C46	0	1000pF	C0603C102J5GACTU	Kemet	CAP, CERM, 1000 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603
39	FID1, FID2, FID3, FID4, FID5, FID6	0		N/A	N/A	Fiducial mark. There is nothing to buy or mount.	Fiducial
40	J6	0		5103308-1	TE Connectivity	Header (shrouded), 100mil, 5x2, Gold, TH	5x2 Shrouded header
41	R2, R3, R14, R17, R18	0	0	CRCW06030000Z0EA	Vishay-Dale	RES, 0, 5%, 0.1 W, 0603	0603
42	R5	0	1.50k	RC0603FR-071K5L	Yageo America	RES, 1.50 k, 1%, 0.1 W, 0603	0603
43	R9	0	3.01	CRCW08053R01FKEA	Vishay-Dale	RES, 3.01 ohm, 1%, 0.125W, 0805	0805
44	TP20, TP21, TP22	0	White	5012	Keystone	Test Point, Multipurpose, White, TH	White Multipurpose Testpoint

12 Revision History

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

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