EVM User's Guide: TPS7H6003EVM-CVAL, TPS7H6013EVM-CVAL, TPS7H6023EVM-CVAL, TPS7H6005EVM, TPS7H6015EVM, TPS7H6025EVM

TPS7H60x3EVM-CVAL and TPS7H60x5EVM Evaluation Module

Description

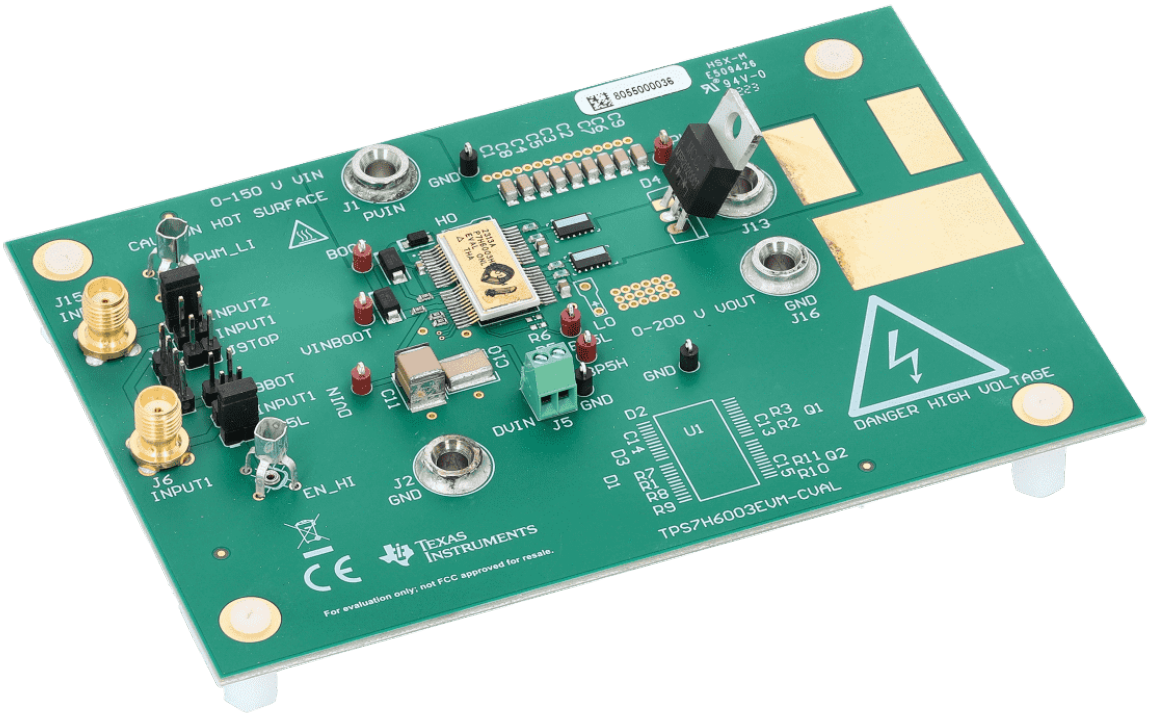
The TPS7H60x3EVM-CVAL and TPS7H60x5EVM uses an input voltage rail on J1/J2 to power the PVIN of a half-bridge FET stack. The user can either run the device without the rest of the power stage or add an inductor and capacitor on the provided pads. By default, the device runs PWM mode and IIM mode can be used with minimal changes. Inputting a 0-5V waveform on J9 or J6/J15 can be connected to the inputs of the TPS7H60x3-SP or TPS7H60x5-SEP to run the driver.

Features

- PWM and IIM modes supported
- Large pads to place own inductors and capacitors
- Integrated dead time for PWM mode

Applications

- Communications payload
- Command and data handling
- Satellite electrical power system
- Space satellite point of load supply for FPGA core voltage rails



1 Evaluation Module Overview

1.1 Introduction

The TPS7H60x3EVM-CVAL and TPS7H60x5EVM user's guide provides comprehensive instructions for operating the TPS7H6003-SP, TPS7H6013-SP, TPS7H6023-SP, TPS7H6005-SEP, TPS7H6015-SEP, and TPS7H6025-SEP evaluation module. By default, the evaluation module is set up to run with the PWM mode of TPS7H60X3-SP and TPS7H60X5-SEP, which accepts an input of one switching signal and internally generates a complementary signal. This can be changed to the IIM mode of the device, in which the two outputs work independently of one another.

1.2 Kit Contents

The kit includes one TPS7H60x3EVM-CVAL or TPS7H60x5EVM board that is used for TPS7H60X3-SP or TPS7H60X5-SEP device evaluation.

1.3 Specification

The TPS7H60x3EVM-CVAL has the following ratings.

Table 1-1. EVM Rating Specifications

Name	Test Points/Connectors	TPS7H6003EVM-CVAL / TPS7H6005EVM	TPS7H6013EVM-CVAL / TPS7H6015EVM	TPS7H6023EVM-CVAL / TPS7H6025EVM
PVIN	J1/J2	0-150 V	0-45 V	0-14 V
DVIN	J5	0-14 V	0-14 V	0-14 V
PWM_LI	Pin 1 of J9	0-14 V	0-14 V	0-14 V
EN_HI	Pin 4 of J9	0-14 V	0-14 V	0-14 V
Temperature	N/A	25 C	25 C	25 C
Frequency	N/A	500kHz	500kHz	500kHz

The following connections are used to switch between different input connectors for the input waveform.

Table 1-2. Input Connector Switchovers

TPS7H60X3 Input	Connection	Connector
EN_HI	Pin 4 of J9	J8
EN_HI	J6	J4
EN_HI	BP5L	J3
PWM_LI	Pin 1 of J9	J10
PWM_LI	J6	J12
PWM_LI	J15	J14

The frequency of the boards has been optimized to 500kHz. While other frequencies can be used, special care must be taken that GaNFETs do not overheat.

The following edits have to be made to switch between PWM mode and IIM mode.

Table 1-3. PWM/IIM Mode Changes

Component Name	PWM Mode	IIM Mode (interlock disabled)	IIM Mode (interlock enabled)
R5	Not Fitted	0 Ohm	Not Fitted
R6	Not Fitted	Not Fitted	0 Ohm
R8	Used to set dead time	100 kOhm to 220 kOhm	Not Fitted
R9	Used to set dead time	Not Fitted	100 kOhm to 220 kOhm

1.4 Device Information

The device used on the TPS7H60x3EVM-CVAL is the TPS7H60X3-SP which is a half-bridge GaN FET driver capable of supplying the gate voltage signals for the GaN FETs. The TPS7H60x5EVM uses a similar device of TPS7H60X5-SEP.

2 Hardware

2.1 Power Requirements

Table 2-1. Power Requirements for Different Input Connectors

Name	Test Points/Connectors	Voltage Rating	Approximate Current Draw
PVIN	J1/J2	14V /45V/ 150V depending on device	50mA
DVIN	J5	0-14 V	20mA
PWM_LI	Pin 1 of J9	0-14 V	10mA
EN_HI	Pin 4 of J9	0-14 V	10mA

Note

Approximate current draw is for the base board. Values can increase based on usage.

2.2 Best Practices

CAUTION

Do not leave EVM powered when unattended.

WARNING

Hot surface! Contact can cause burns. Do not touch!

Some components can reach high temperatures >55℃ when the board is powered on. Do not touch the board at any point during operation or immediately after operating, as high temperatures can be present.

General Texas Instruments High Voltage Evaluation (TI HV EVM) User Safety Guidelines

WARNING

Always follow TI's set-up and application instructions, including use of all interface components within the recommended electrical rated voltage and power limits. Always use electrical safety precautions to help ensure your personal safety and those working around you. Contact TI's Product Information Center http://ti.com/customer support for further information.

Save all warnings and instructions for future reference.

WARNING

Failure to follow warnings and instructions can result in personal injury, property damage or death due to electrical shock and burn hazards.

The term TI HV EVM refers to an electronic device typically provided as an open framed, unenclosed printed circuit board assembly. It is *intended strictly for use in development laboratory environments, solely for qualified professional users having training, expertise and knowledge of electrical safety risks in development and application of high voltage electrical circuits. Any other use and/or application are strictly prohibited by Texas Instruments.* If you are not suitably qualified, then immediately stop from further use of the HV EVM.

1. Work Area Safety:
   a. Keep work area clean and orderly.
   b. Qualified observers must be present anytime circuits are energized.

c. Effective barriers and signage must be present in the area where the TI HV EVM and the interface electronics are energized, indicating operation of accessible high voltages can be present, for the purpose of protecting inadvertent access.
d. All interface circuits, power supplies, evaluation modules, instruments, meters, scopes, and other related apparatus used in a development environment exceeding 50Vrms/75VDC must be electrically located within a protected Emergency Power Off EPO protected power strip.
e. Use stable and non-conductive work surface.
f. Use adequately insulated clamps and wires to attach measurement probes and instruments. No freehand testing whenever possible.

2. Electrical Safety:
   a. As a precautionary measure, a good engineering practice is to assume that the entire EVM has fully accessible and active high voltages.
   b. De-energize the TI HV EVM and all the inputs, outputs and electrical loads before performing any electrical or other diagnostic measurements. Revalidate that TI HV EVM power has been safely de-energized.
   c. With the EVM confirmed de-energized, proceed with required electrical circuit configurations, wiring, measurement equipment hook-ups and other application needs, while still assuming the EVM circuit and measuring instruments are electrically live.
   d. Once EVM readiness is complete, energize the EVM as intended.

> **WARNING**
>
> While the EVM is energized, never touch the EVM or the electrical circuits, as the circuits can be at high voltages capable of causing electrical shock hazard.

3. Personal Safety
   a. Wear personal protective equipment e.g. latex gloves or safety glasses with side shields or protect EVM in an adequate lucent plastic box with interlocks from accidental touch.

Limitation for safe use:

EVMs are not to be used as all or part of a production unit.

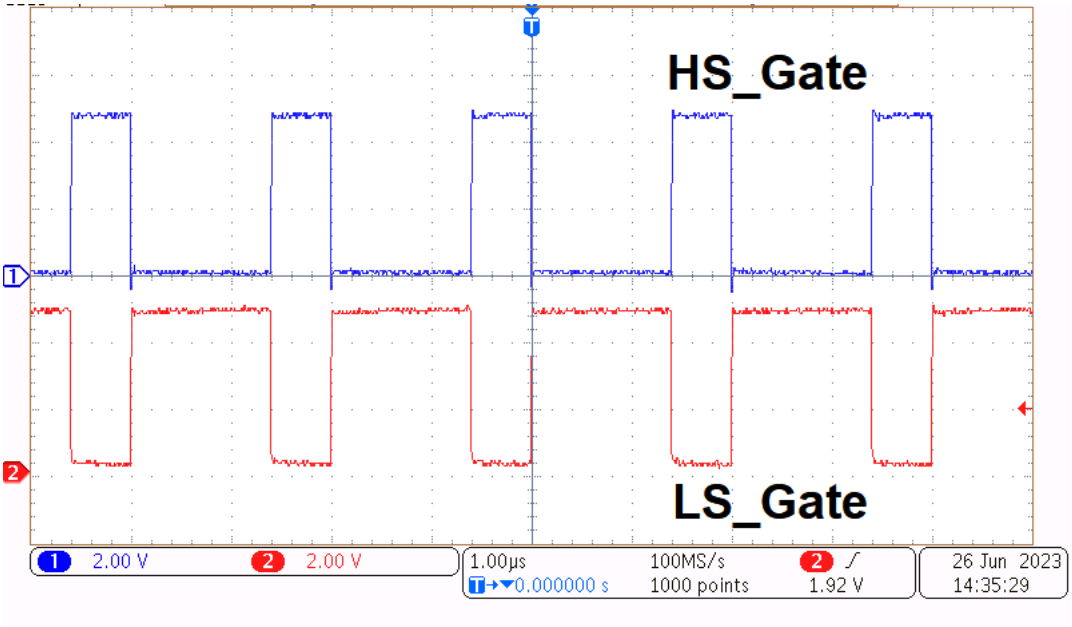
3 Implementation Results

3.1 Evaluation Setup

The information in this section was obtained with the following set-up

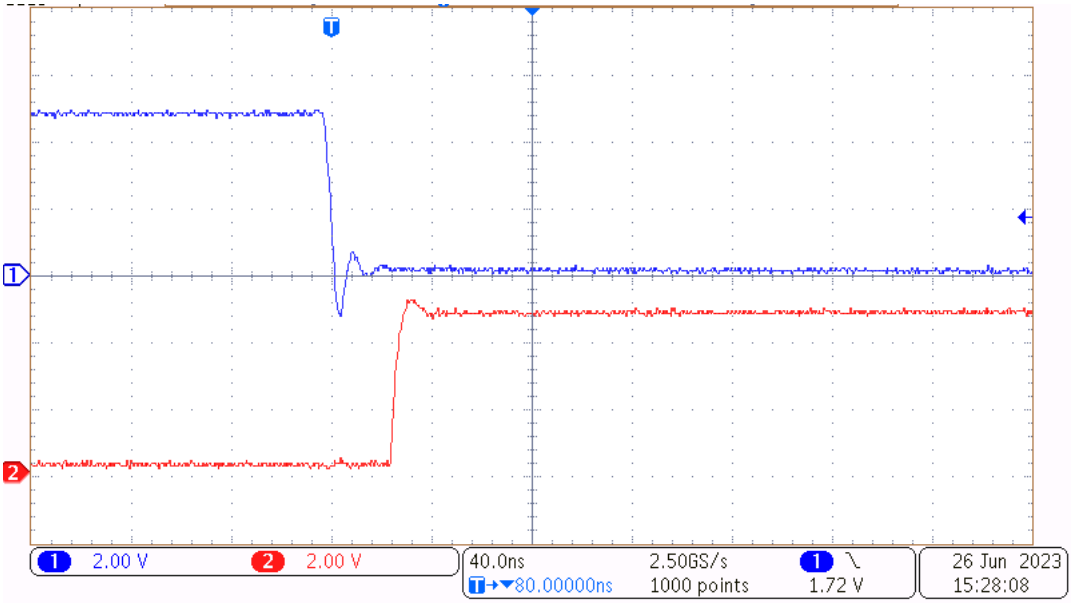
Name	Connector	Voltage
Input voltage (+)	J1	100V
Input voltage (-)	J2	0V
EN_HI	J3	Shorted
PWM_LI	J10	Shorted
PWM_LI	J9[1:2]	0-5 V at 500kHz/30 % duty cycle signal

3.2 Performance Data and Results



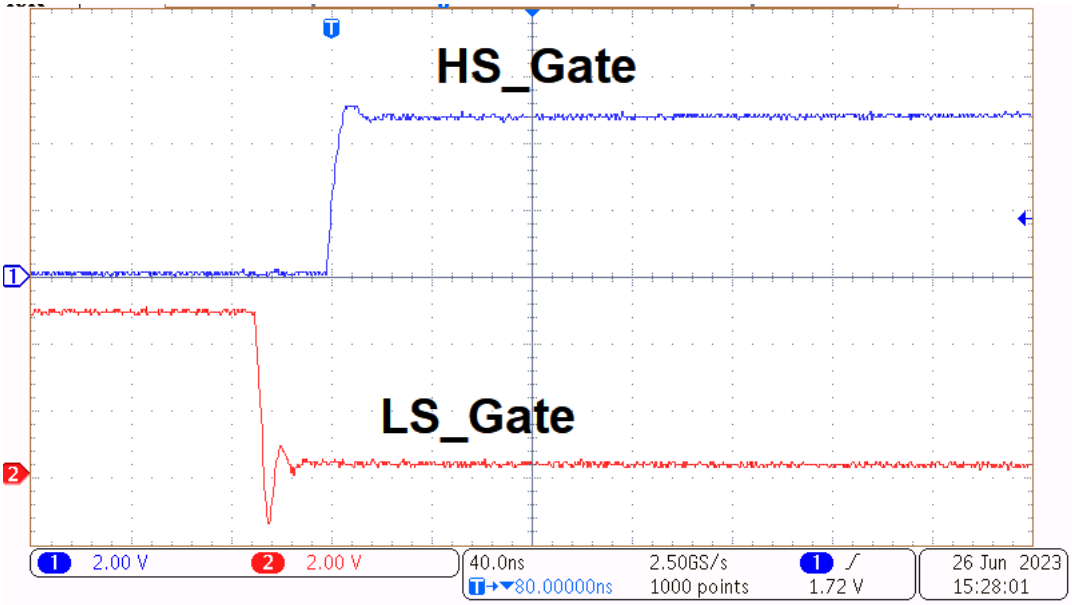
A. Image shows gate voltage without phase node energized.

Figure 3-1. Gate Voltage of GaN FETs



A. Image shows gate voltage without phase node energized.

Figure 3-2. High to Low Transition of Gate Voltage



A. Image shows gate voltage without phase node energized.

Figure 3-3. Low to High Transition of Gate Voltage

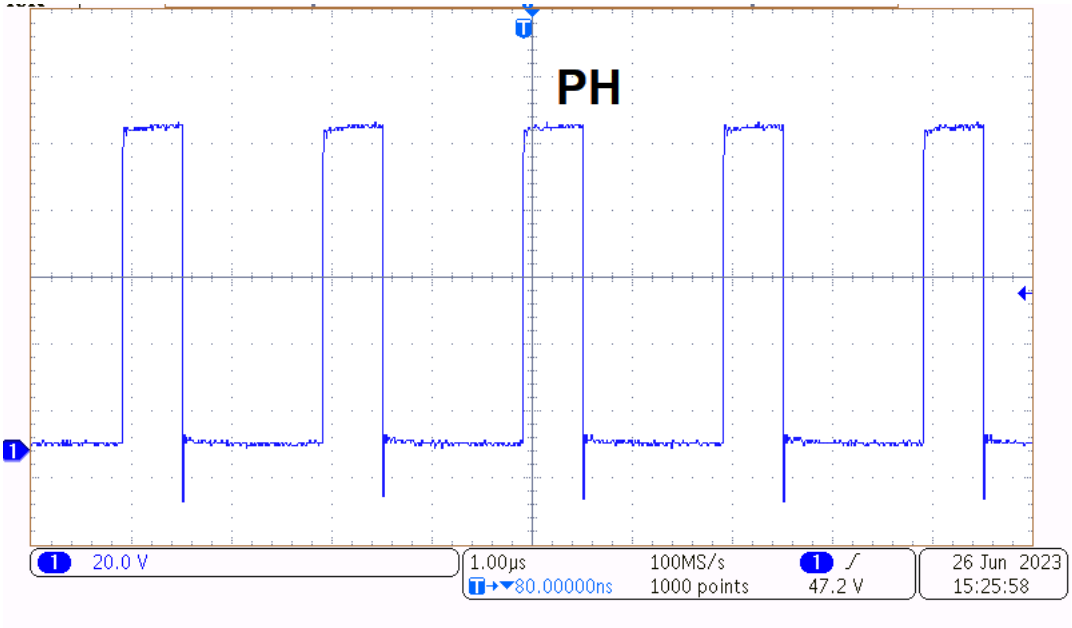


Figure 3-4. Phase Node Voltage

4 Hardware Design Files

4.1 Schematics

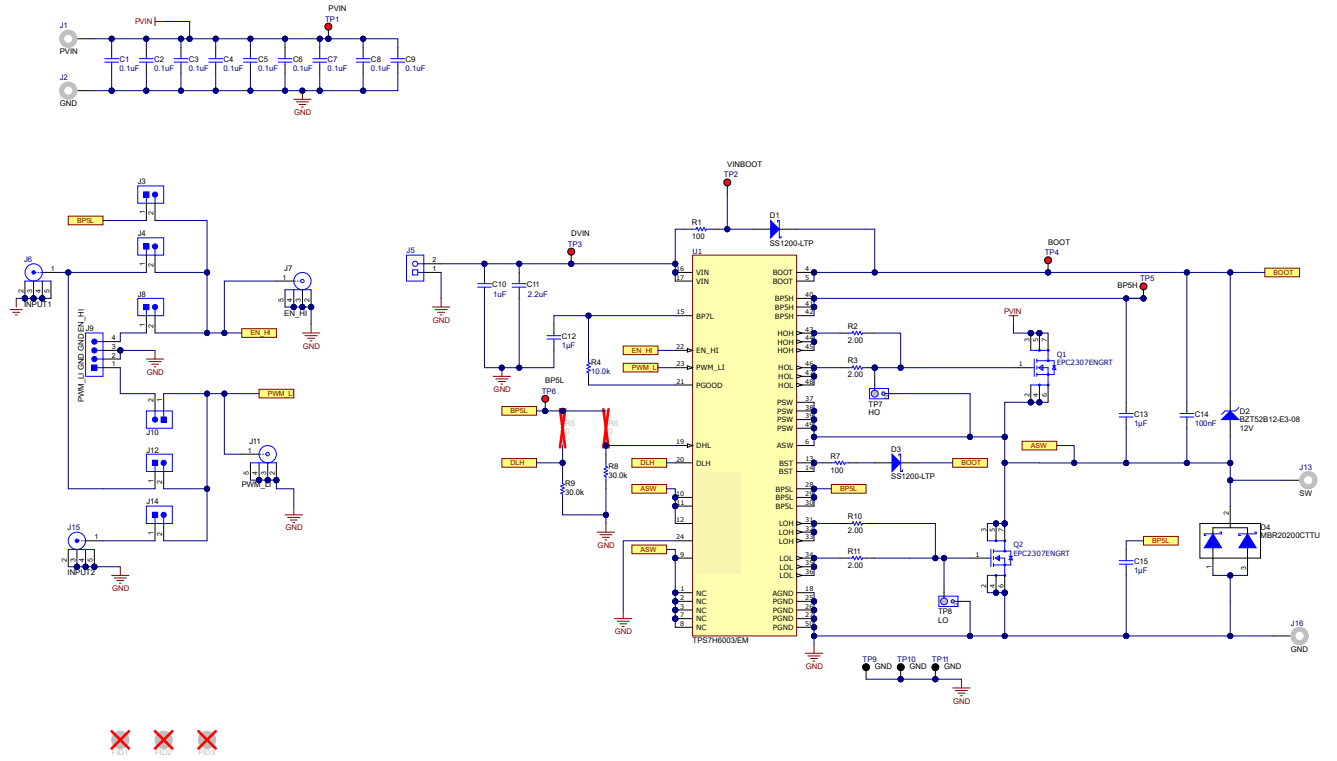


Figure 4-1. TPS7H6003EVM-CVAL Schematic

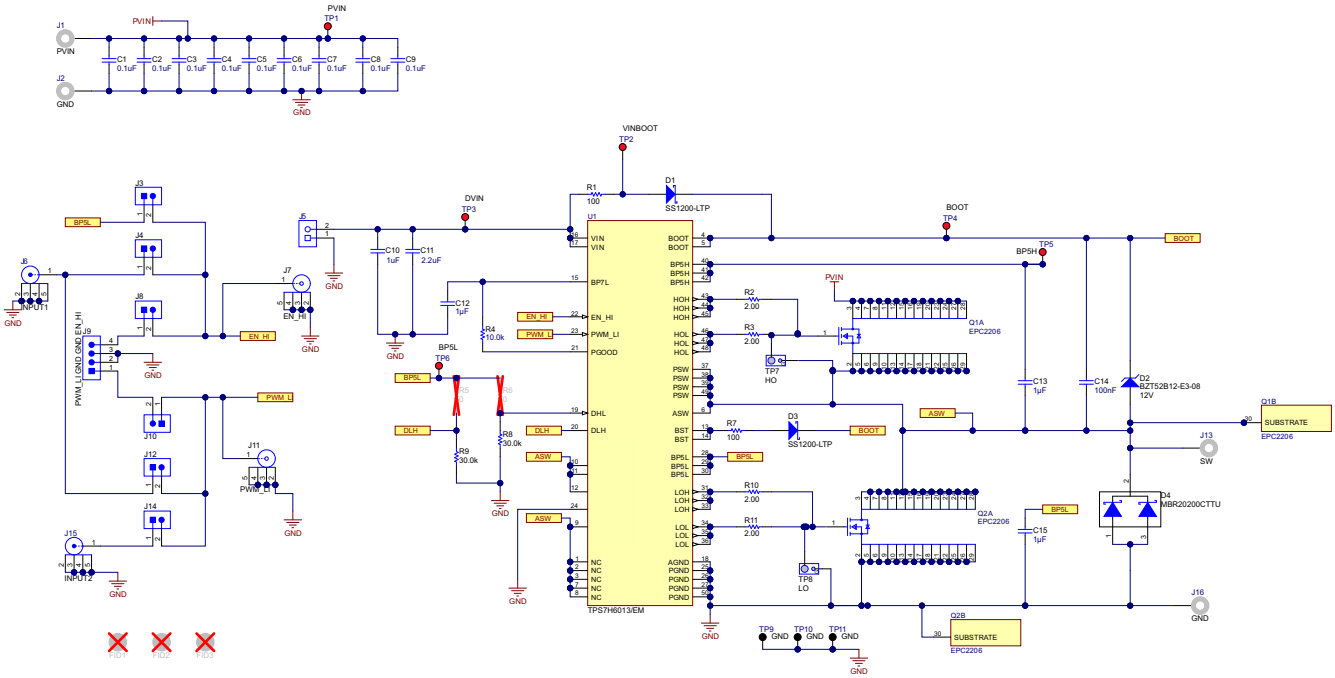


Figure 4-2. TPS7H6013EVM-CVAL Schematic

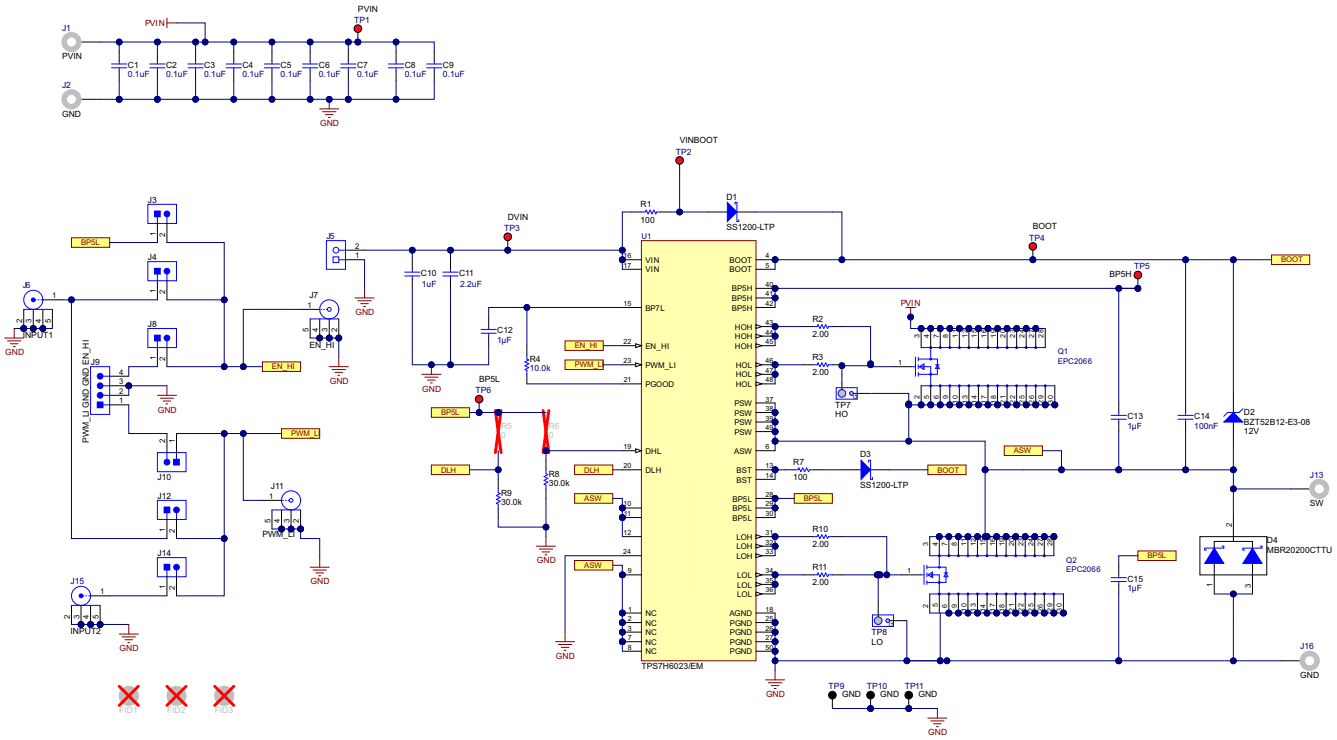


Figure 4-3. TPS7H6023EVM-CVAL Schematic

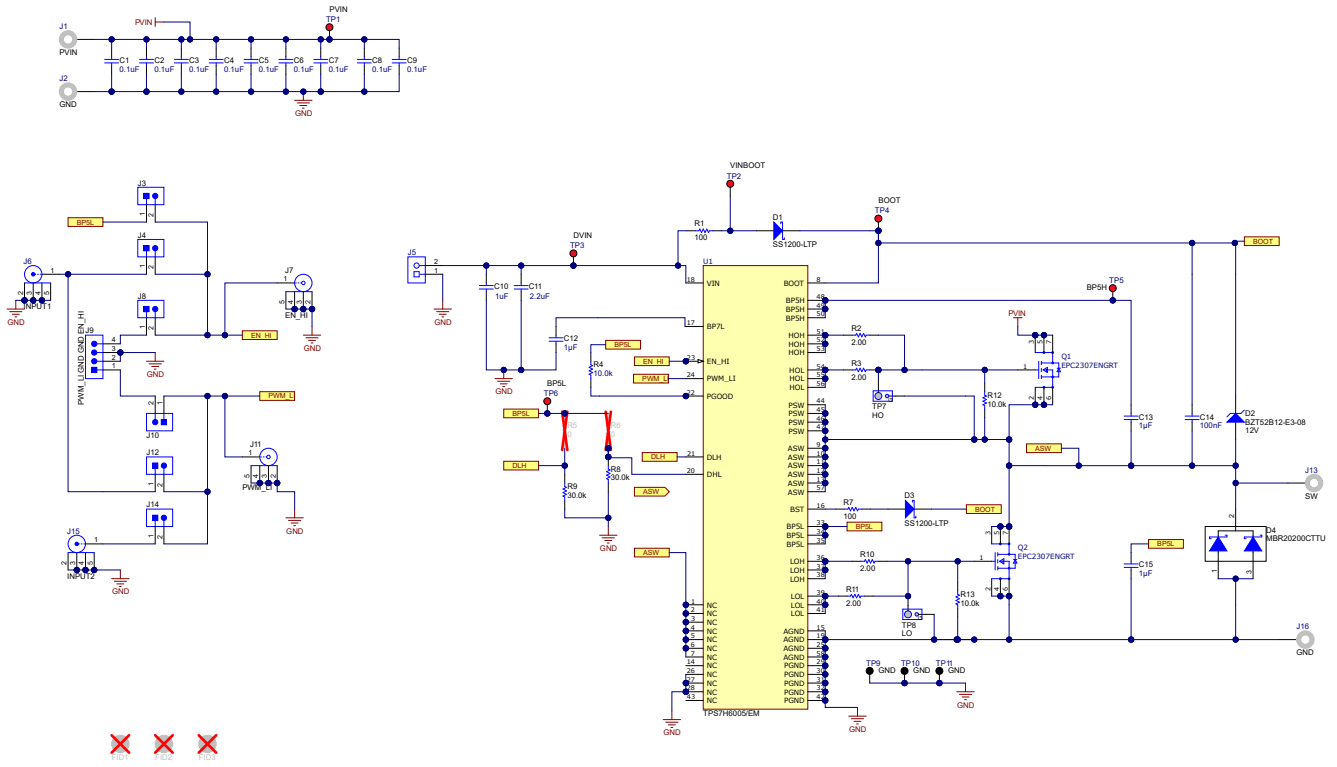


Figure 4-4. TPS7H6005EVM Schematic

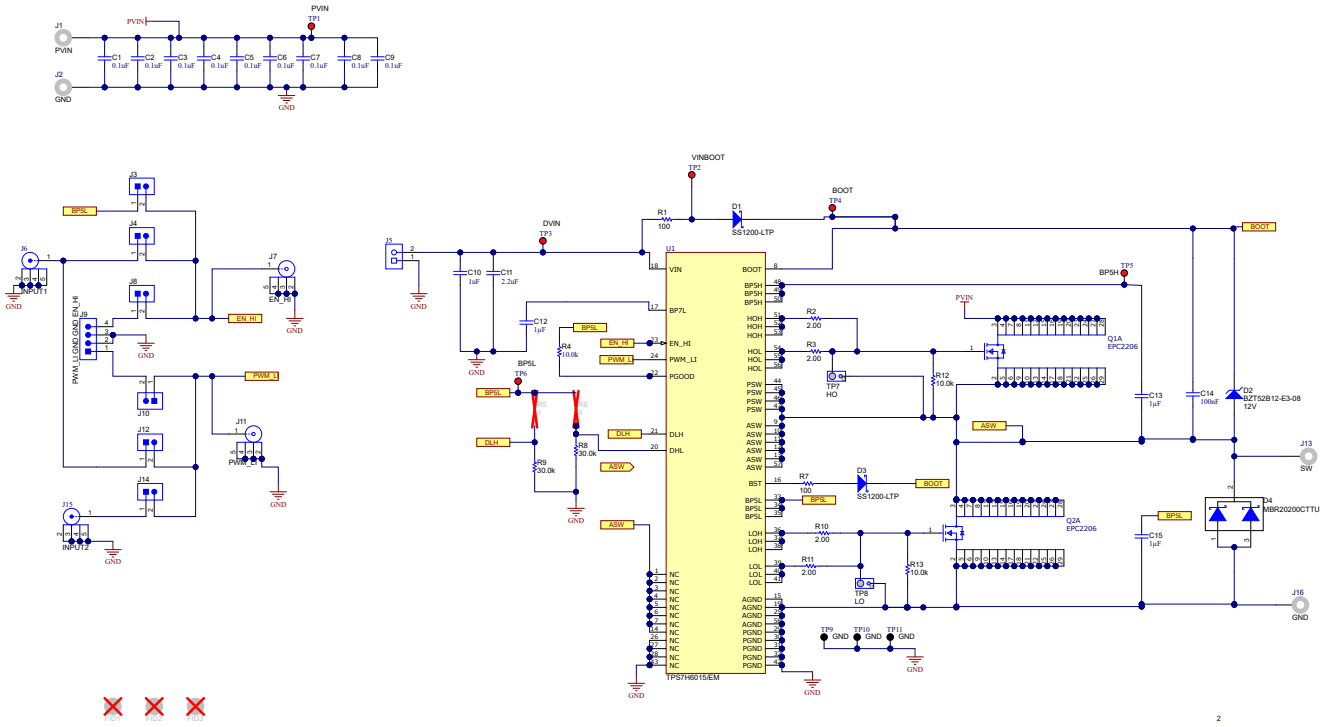


Figure 4-5. TPS7H6015EVM Schematic

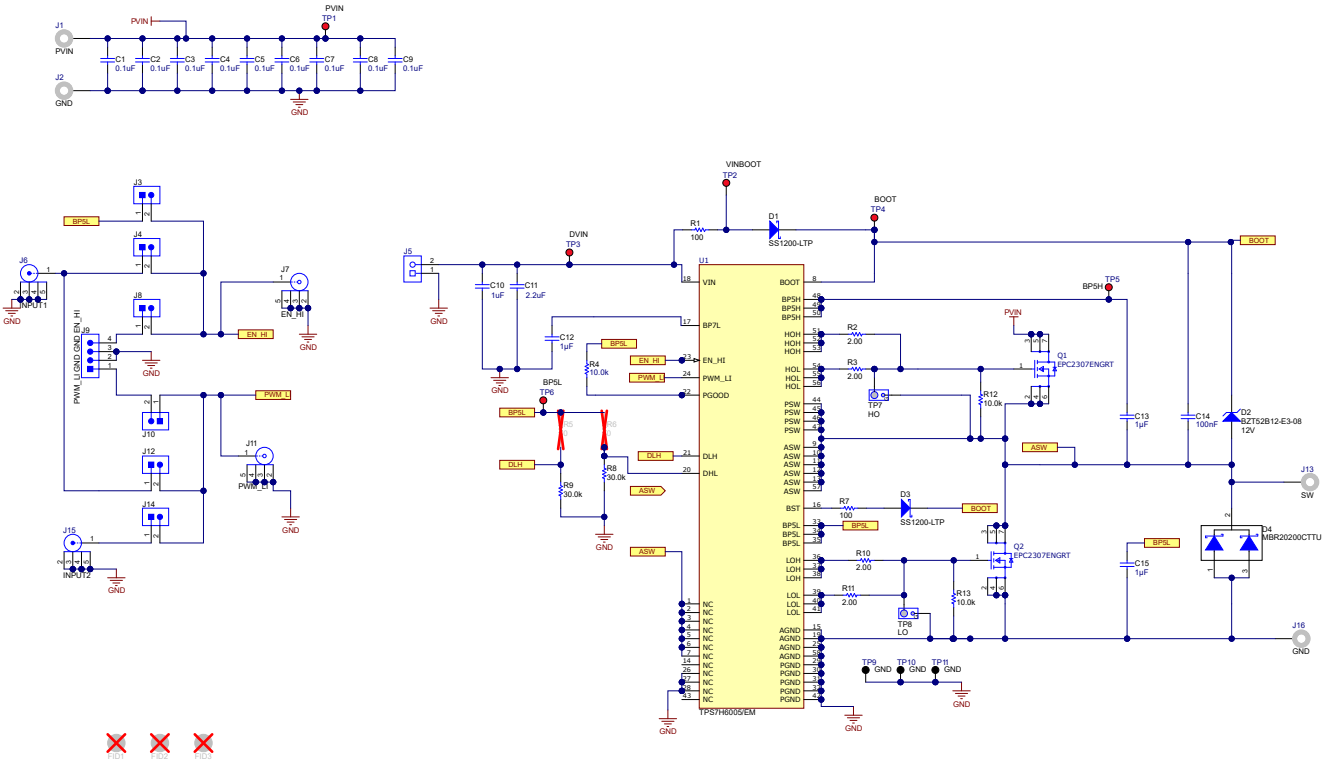


Figure 4-6. TPS7H6025EVM Schematic

4.2 PCB Layouts

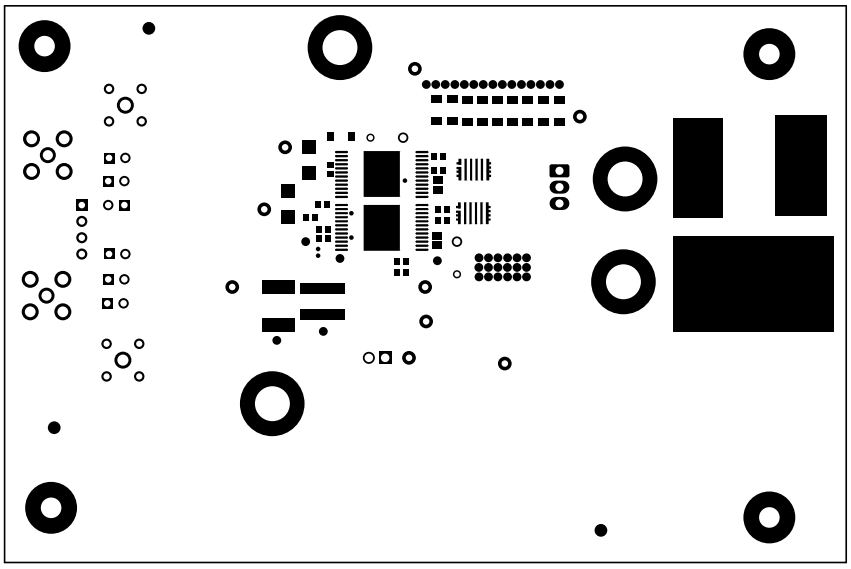


Figure 4-7. Top Solder Mask (TPS7H6003EVM-CVAL)

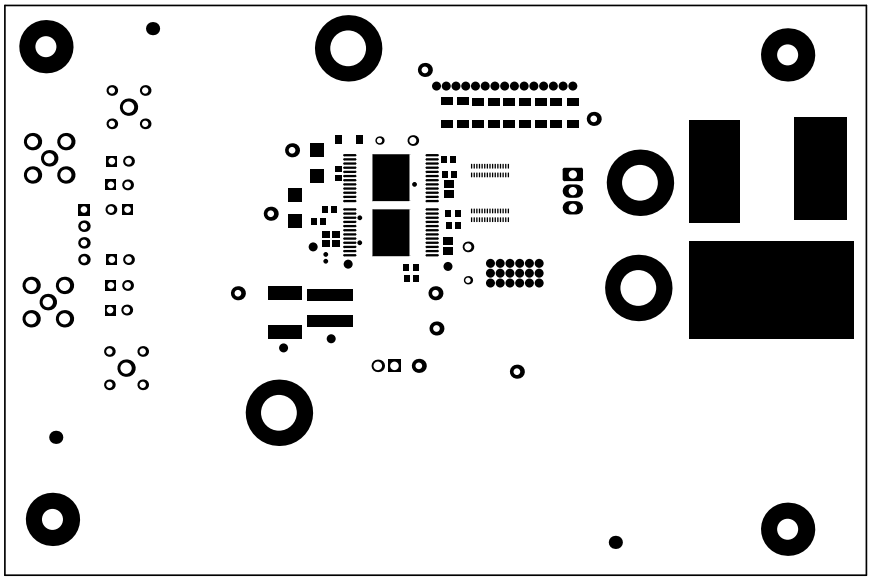


Figure 4-8. Top Solder Mask (TPS7H6013EVM-CVAL)

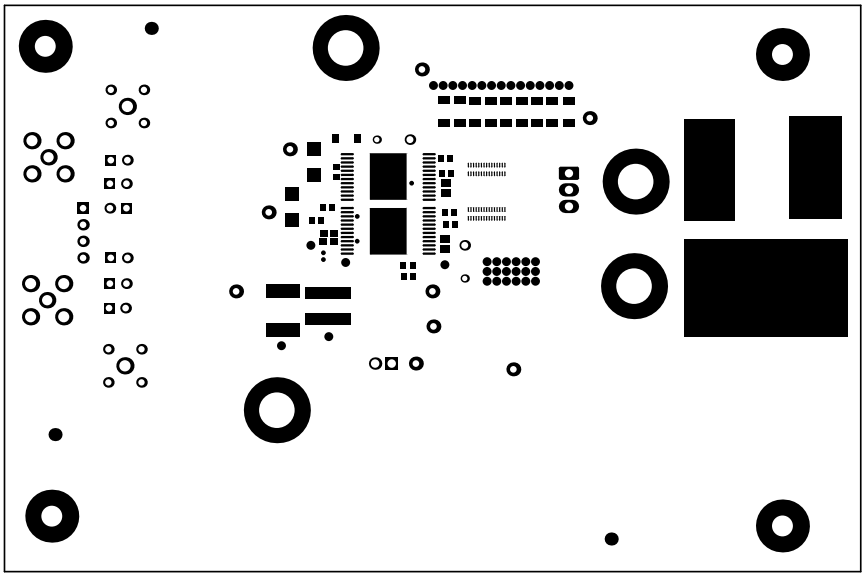


Figure 4-9. Top Solder Mask (TPS7H6023EVM-CVAL)

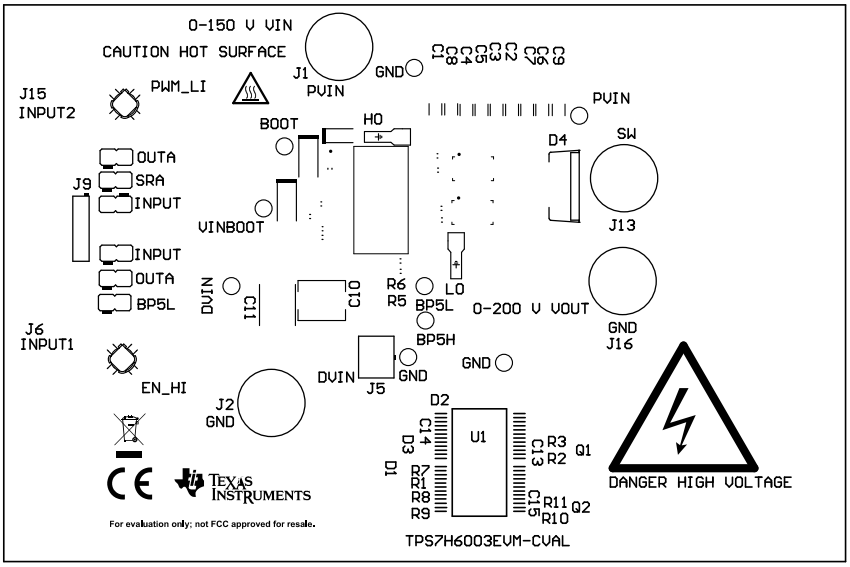


Figure 4-10. Top Overlay (TPS7H6003EVM-CVAL)

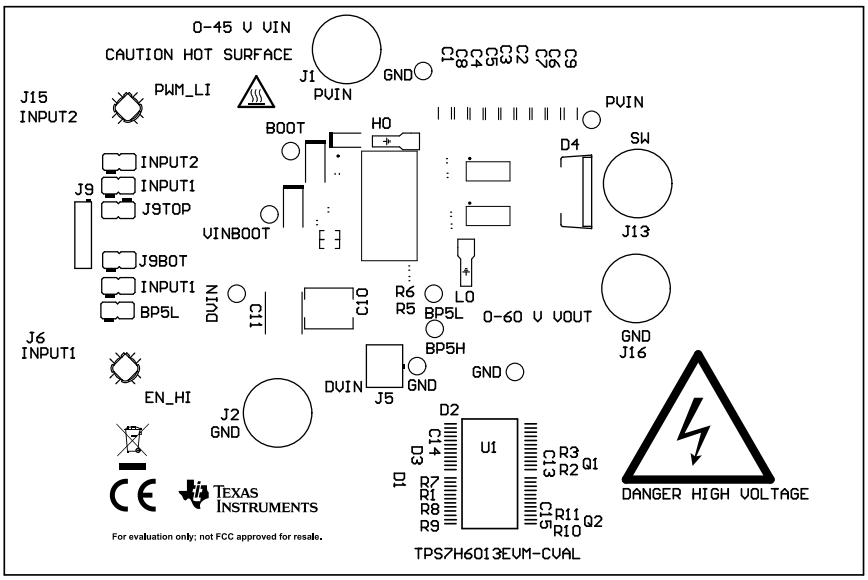


Figure 4-11. Top Overlay (TPS7H6013EVM-CVAL)

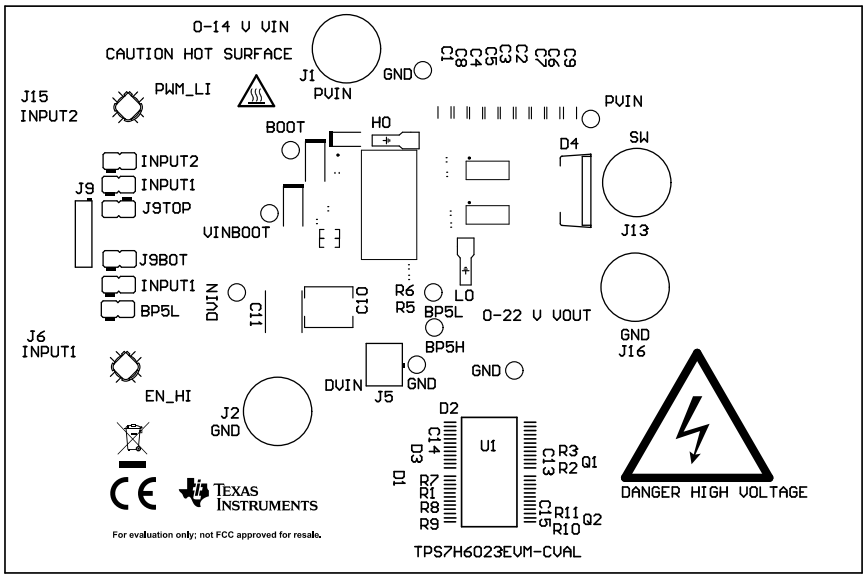


Figure 4-12. Top Overlay (TPS7H6023EVM-CVAL)

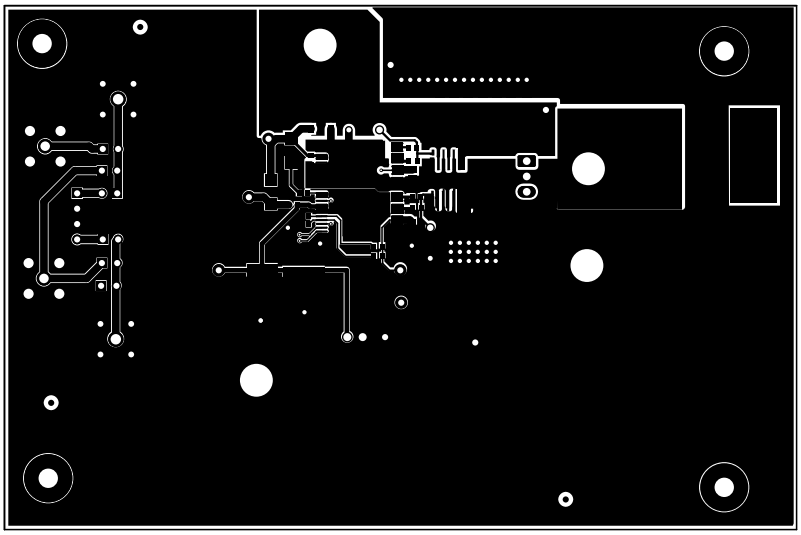


Figure 4-13. Top Layer (TPS7H6003EVM-CVAL)

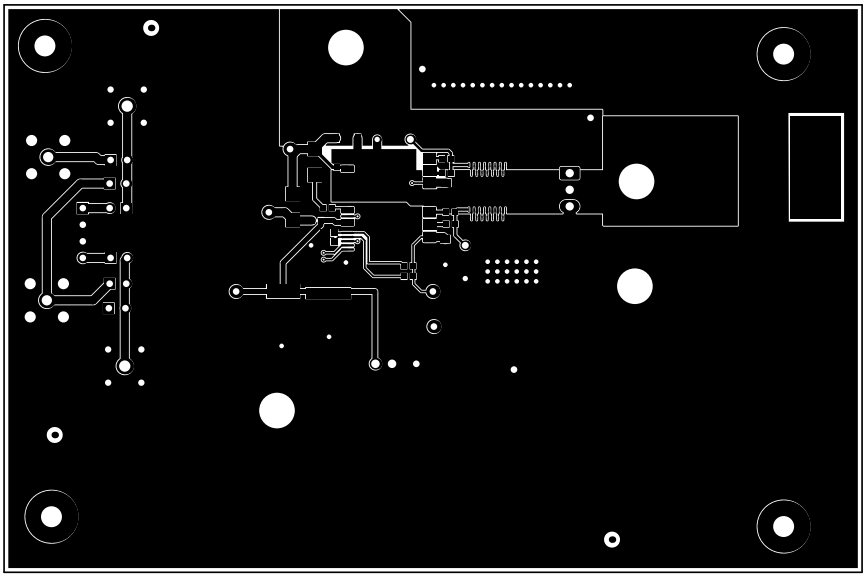


Figure 4-14. Top Layer (TPS7H6013EVM-CVAL)

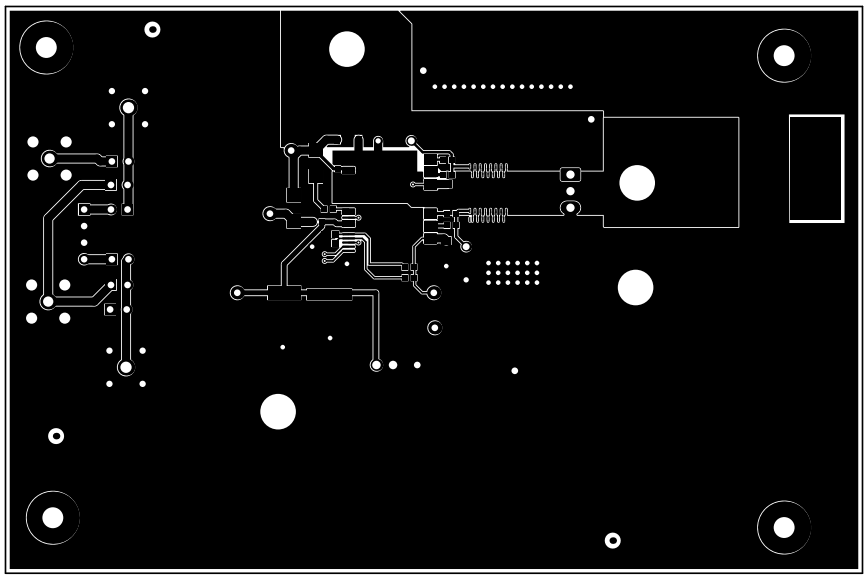


Figure 4-15. Top Layer (TPS7H6023EVM-CVAL)

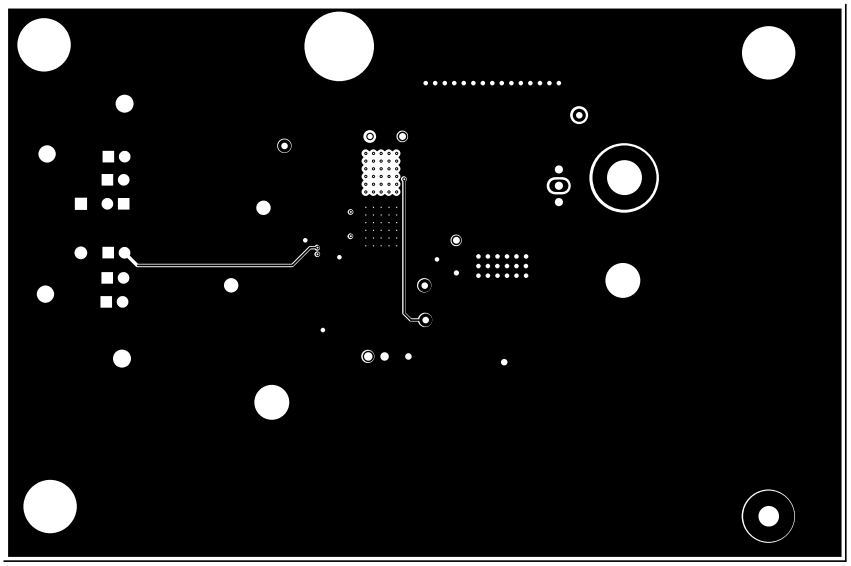


Figure 4-16. Signal Layer 1 (TPS7H60x3EVM-CVAL)

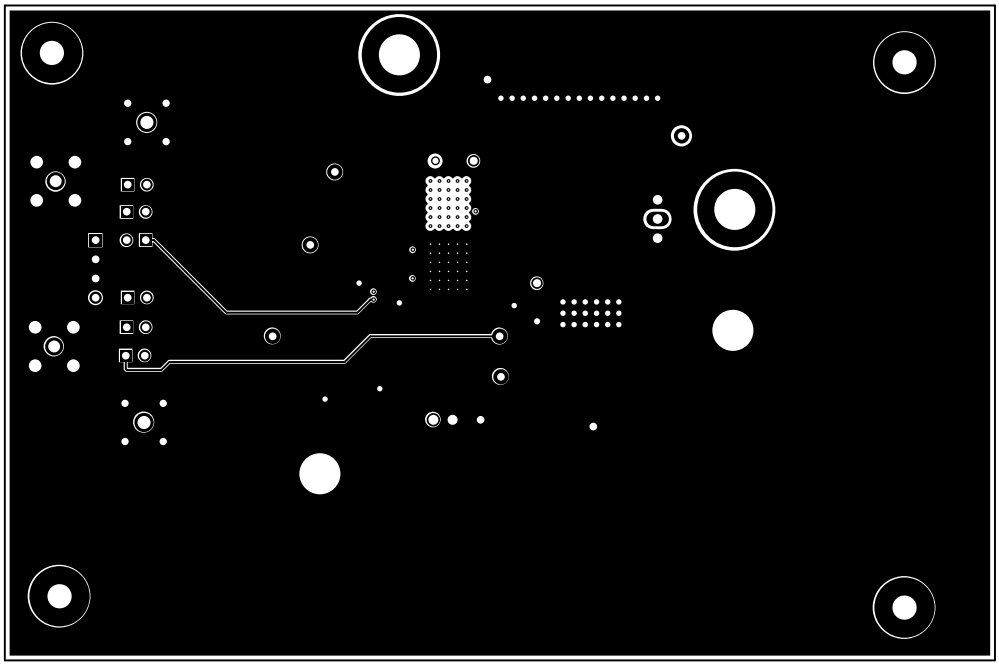


Figure 4-17. Signal Layer 2 (TPS7H60x3EVM-CVAL)

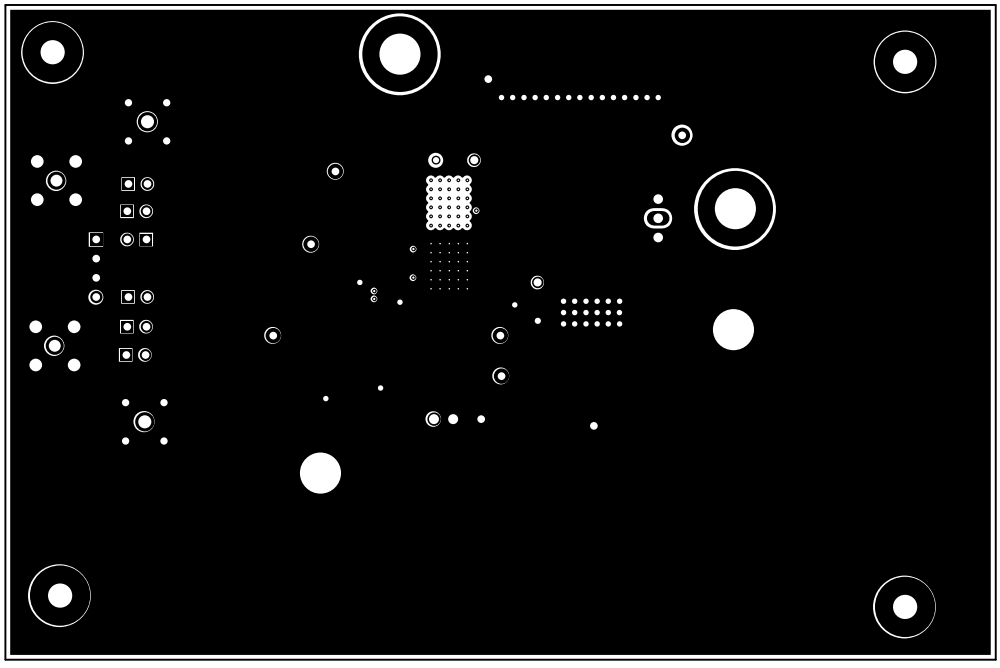


Figure 4-18. Signal Layer 3 (TPS7H60x3EVM-CVAL)

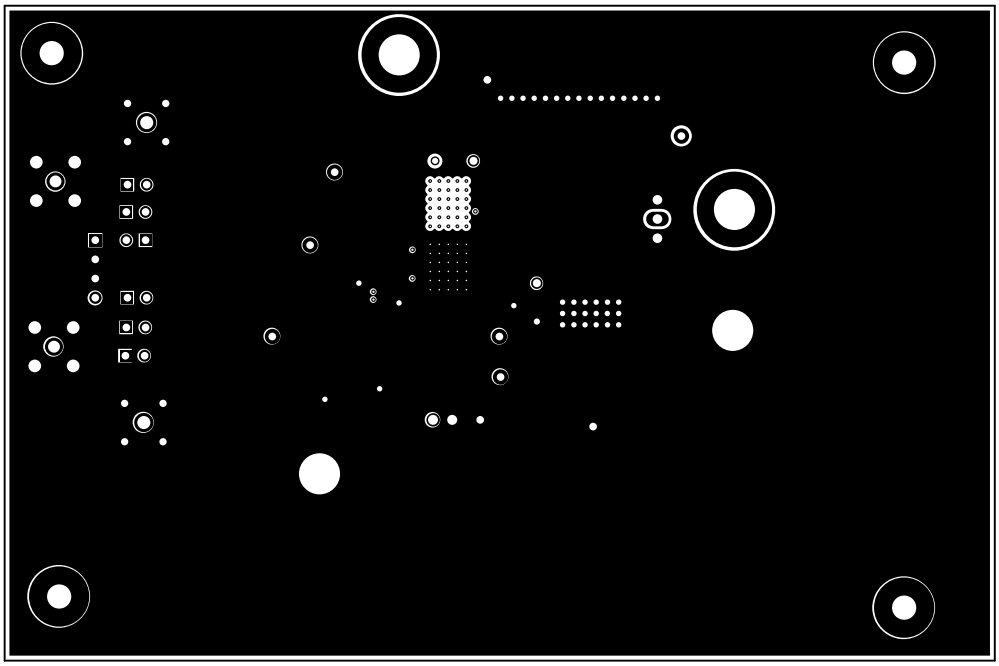


Figure 4-19. Signal Layer 4 (TPS7H60x3EVM-CVAL)

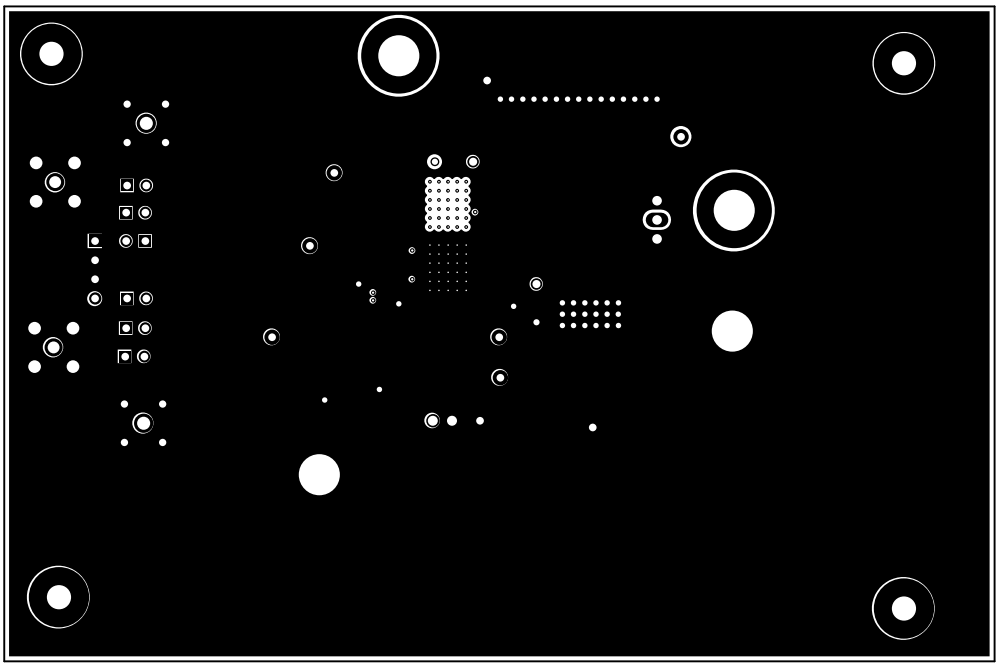


Figure 4-20. Signal Layer 5 (TPS7H60x3EVM-CVAL)

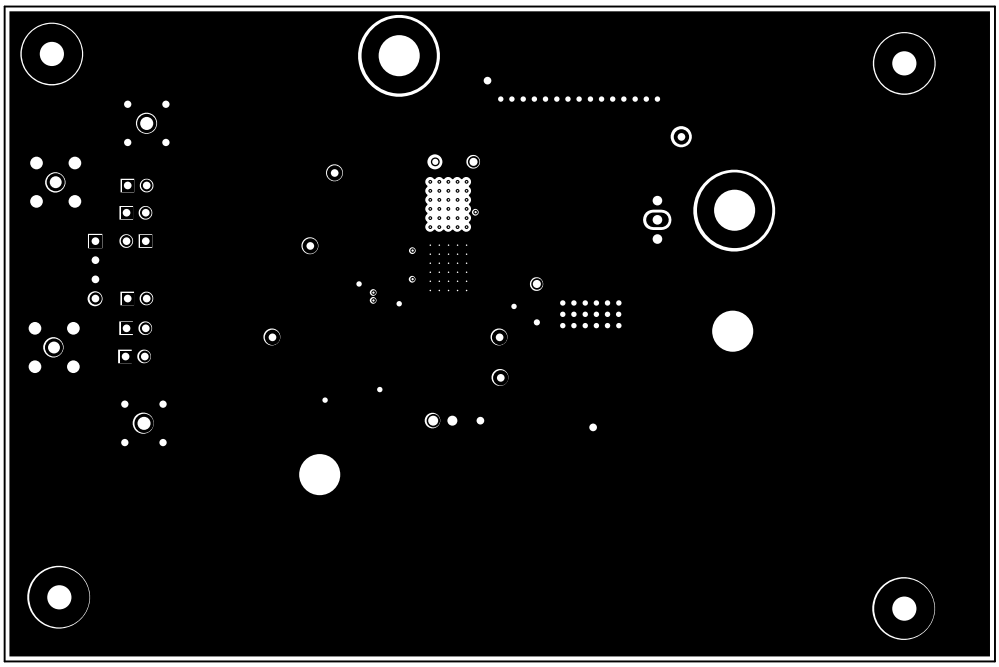


Figure 4-21. Signal Layer 6 (TPS7H60x3EVM-CVAL)

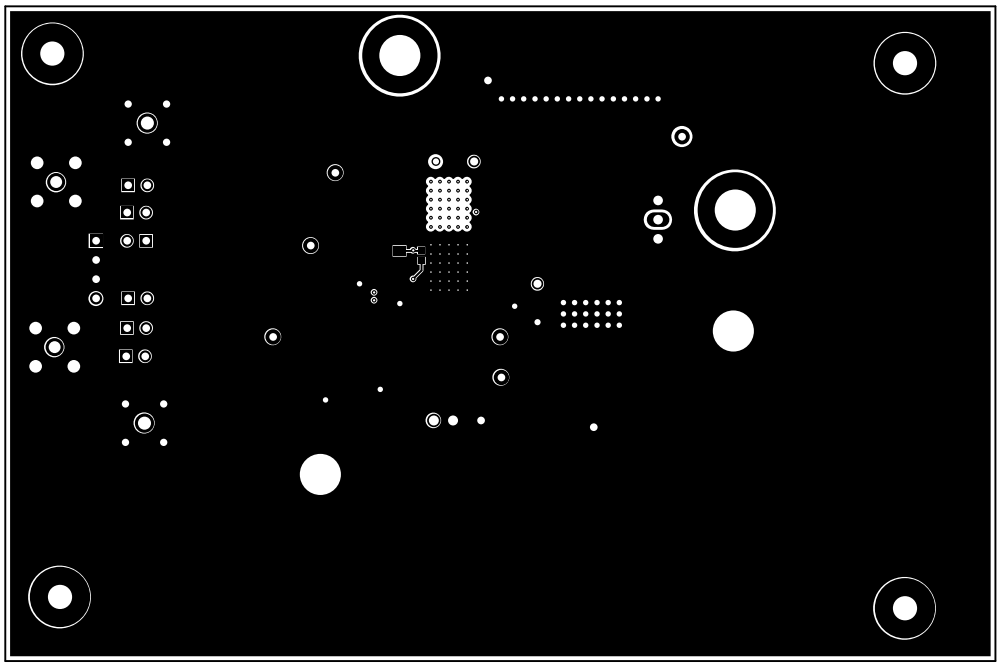


Figure 4-22. Bottom Layer (TPS7H60x3EVM-CVAL)

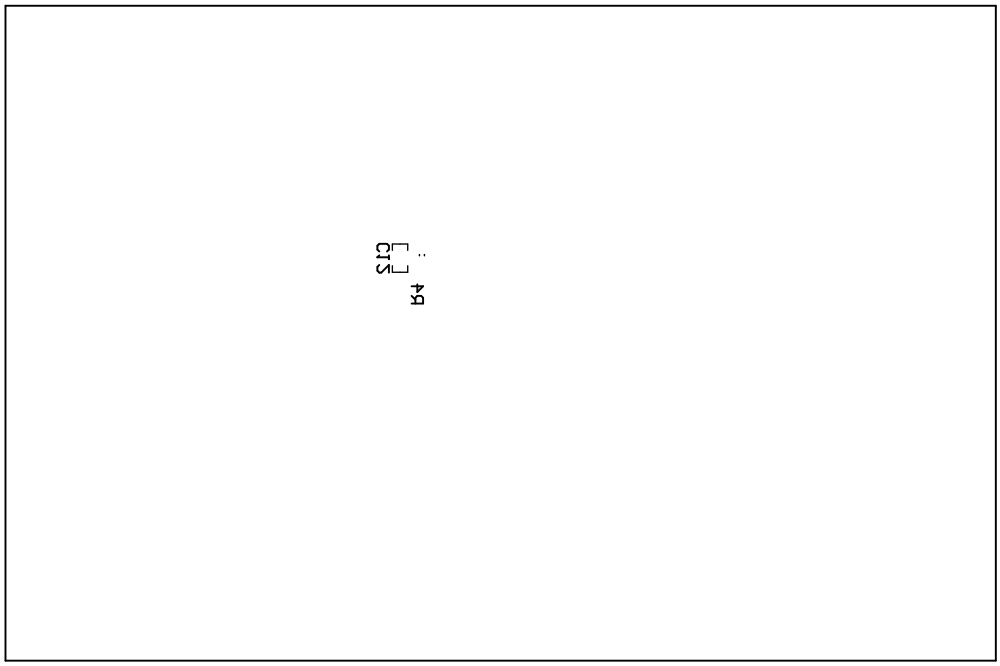


Figure 4-23. Bottom Overlay (TPS7H60x3EVM-CVAL)

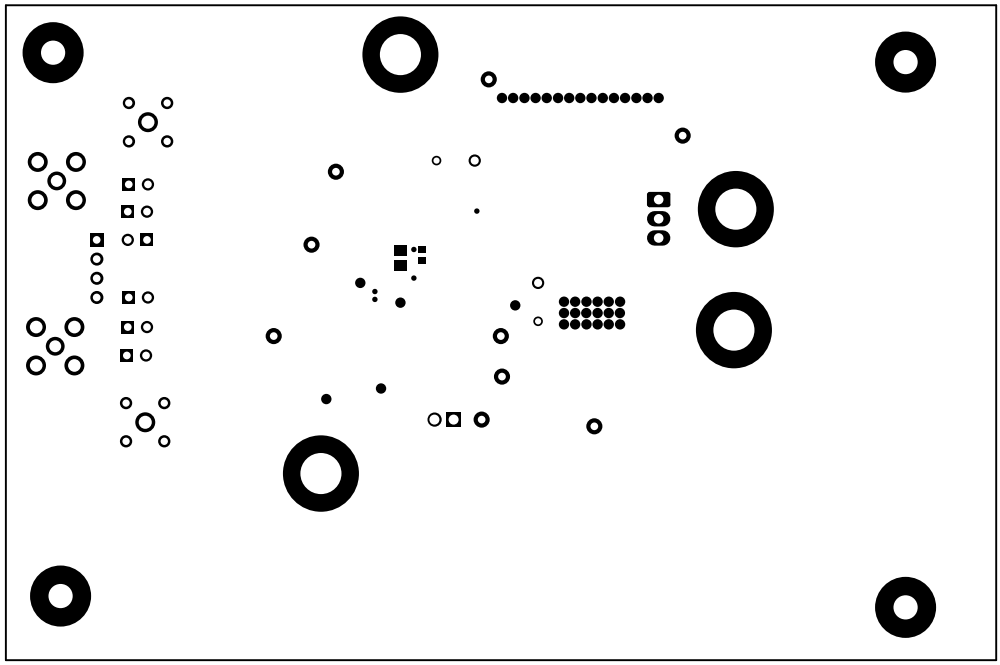


Figure 4-24. Bottom Solder Mask (TPS7H60x3EVM-CVAL)

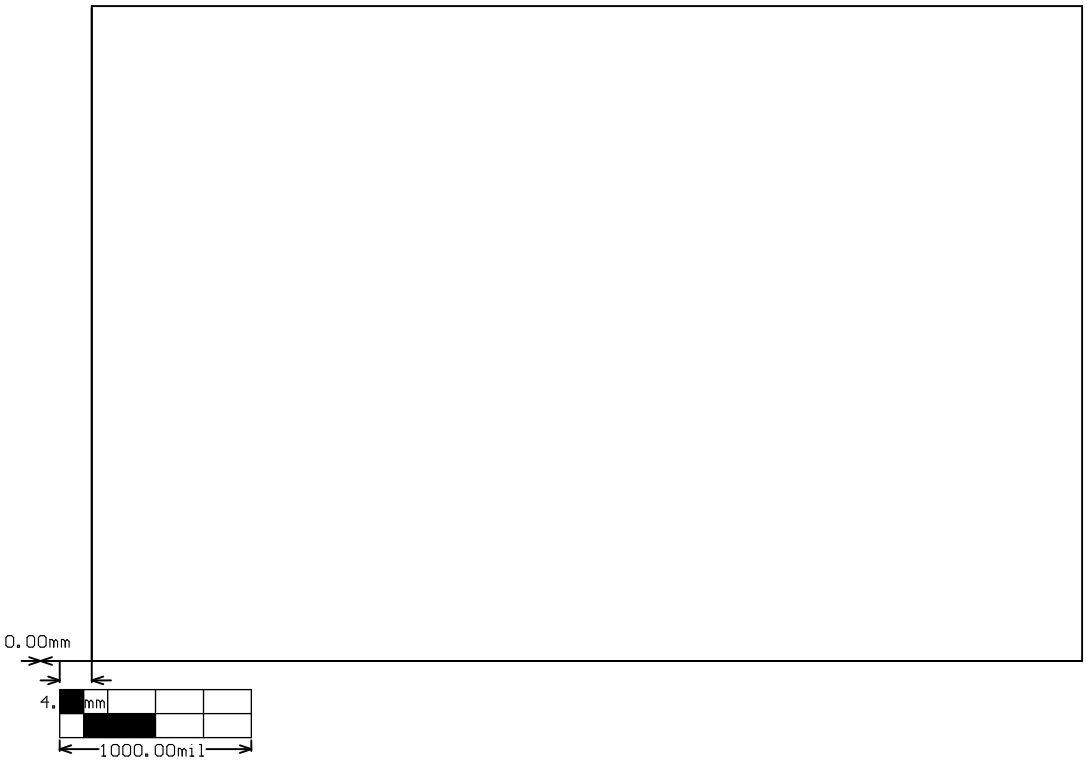


Figure 4-25. Board Dimensions (TPS7H60x3EVM-CVAL)

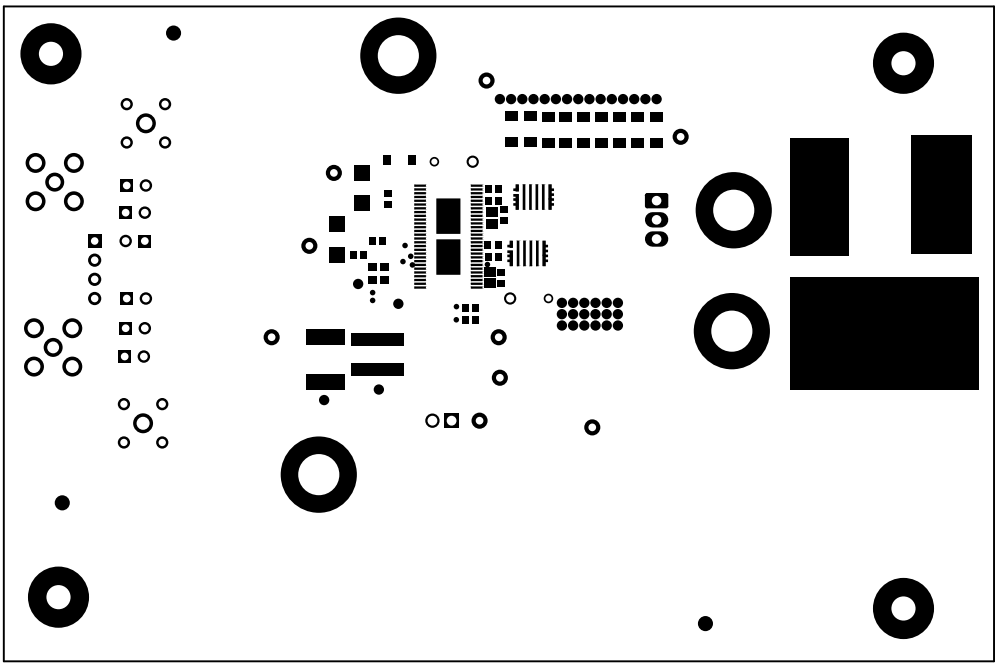


Figure 4-26. Top Solder (TPS7H6005EVM)

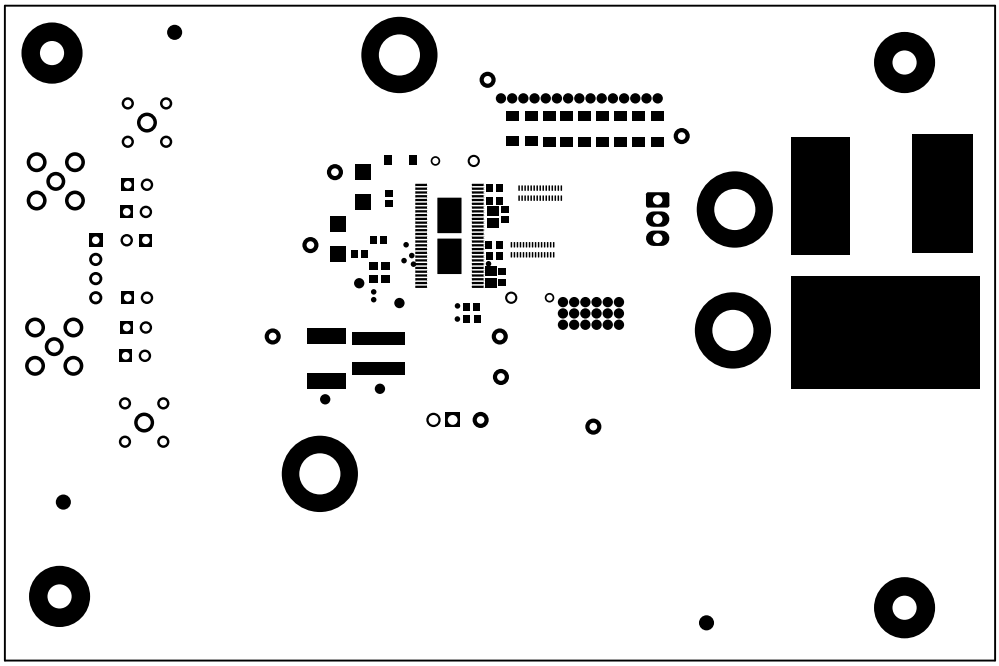


Figure 4-27. Top Solder (TPS7H6015EVM)

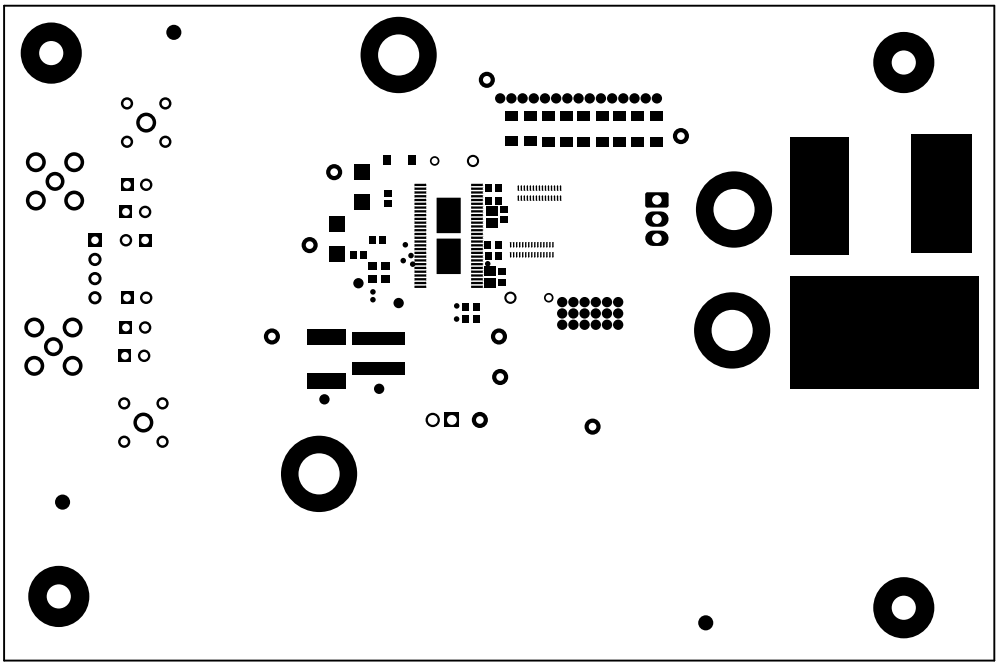


Figure 4-28. Top Solder (TPS7H6025EVM)

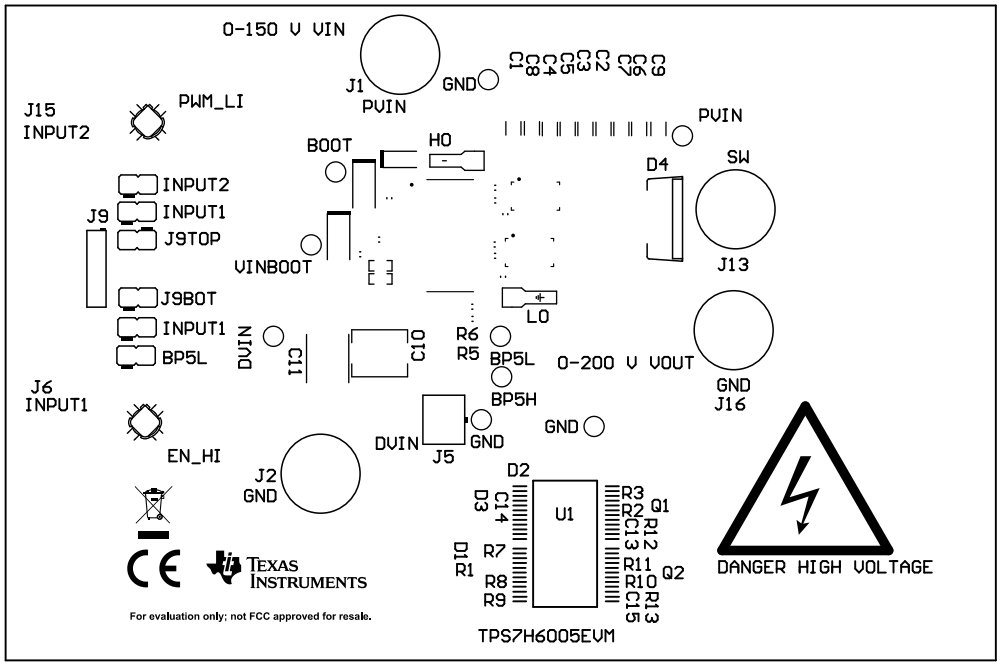


Figure 4-29. Top Overlay (TPS7H6005EVM)

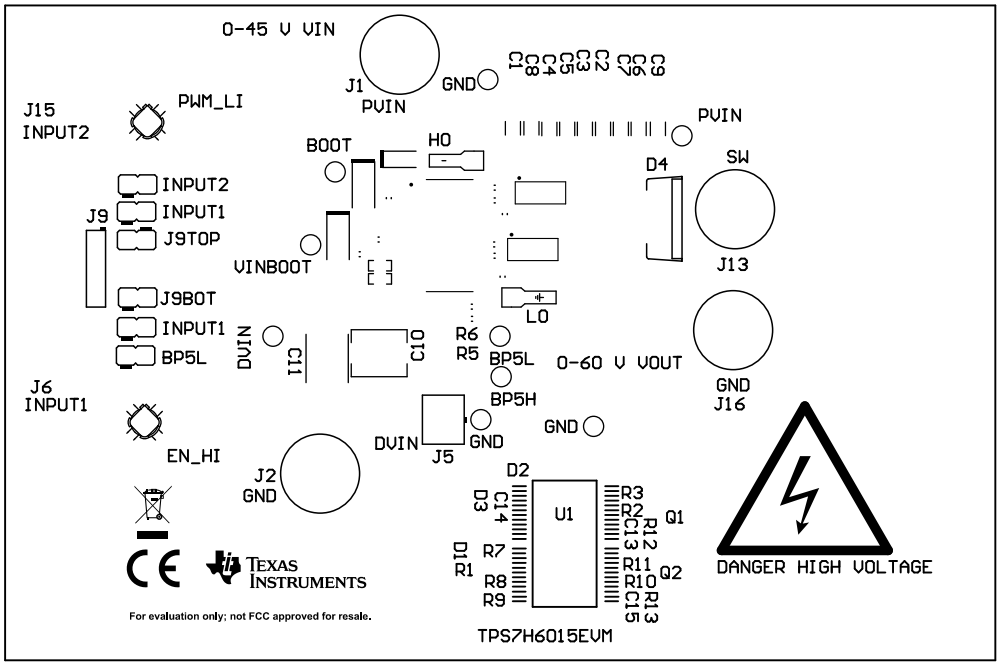


Figure 4-30. Top Overlay (TPS7H6015EVM)

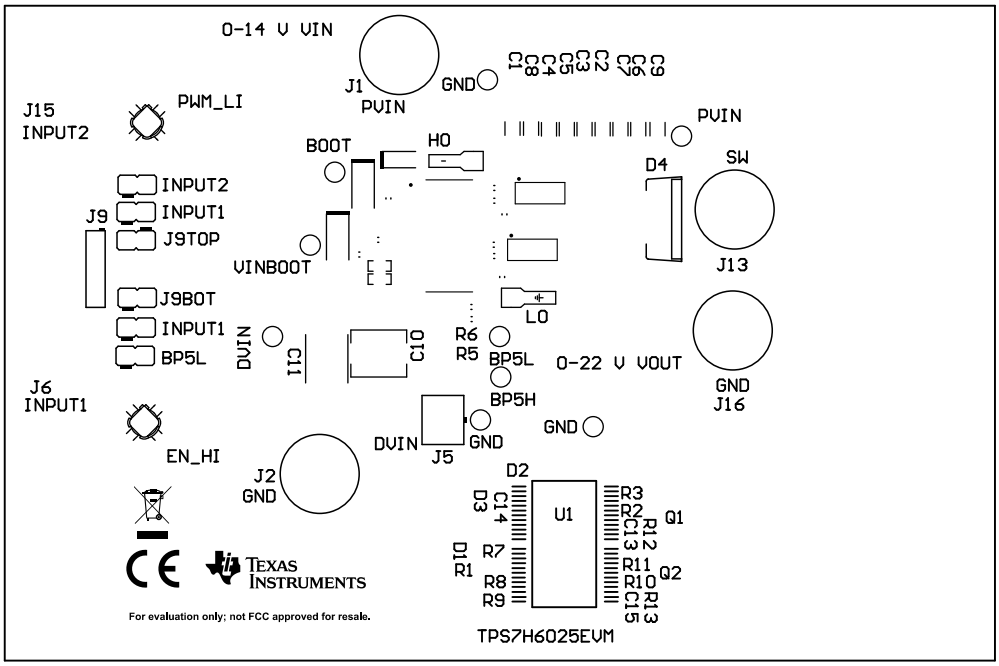


Figure 4-31. Top Overlay (TPS7H6025EVM)

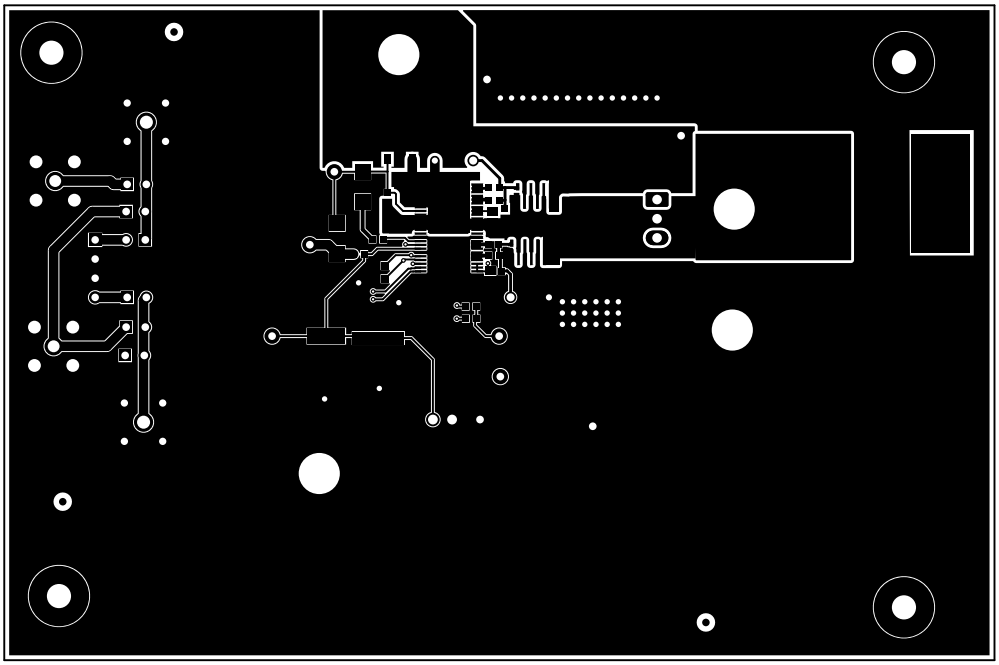


Figure 4-32. Top Layer (TPS7H6005EVM)

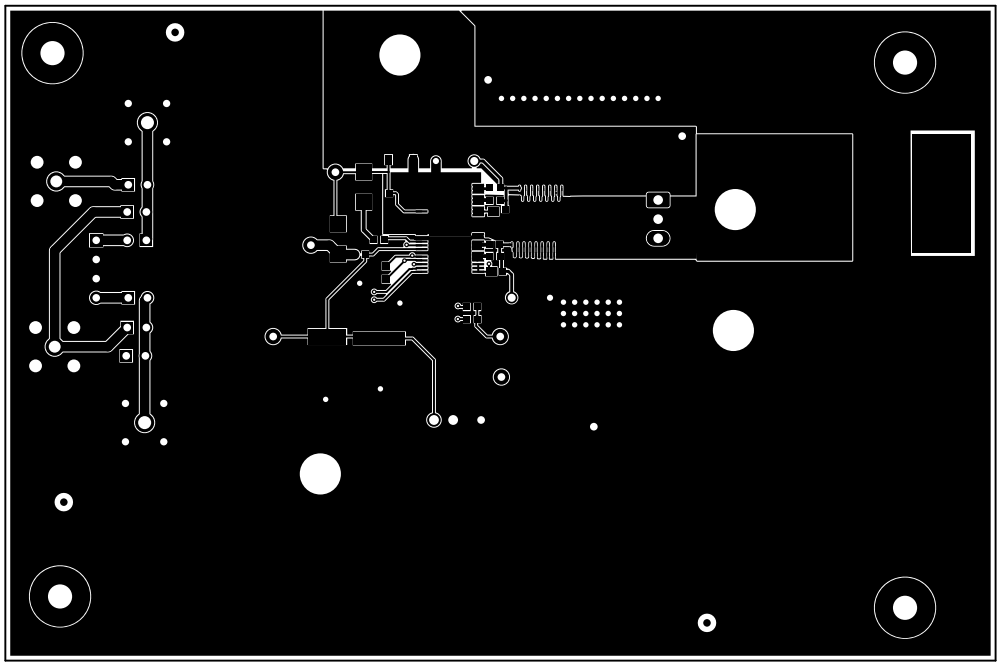


Figure 4-33. Top Layer (TPS7H6015EVM)

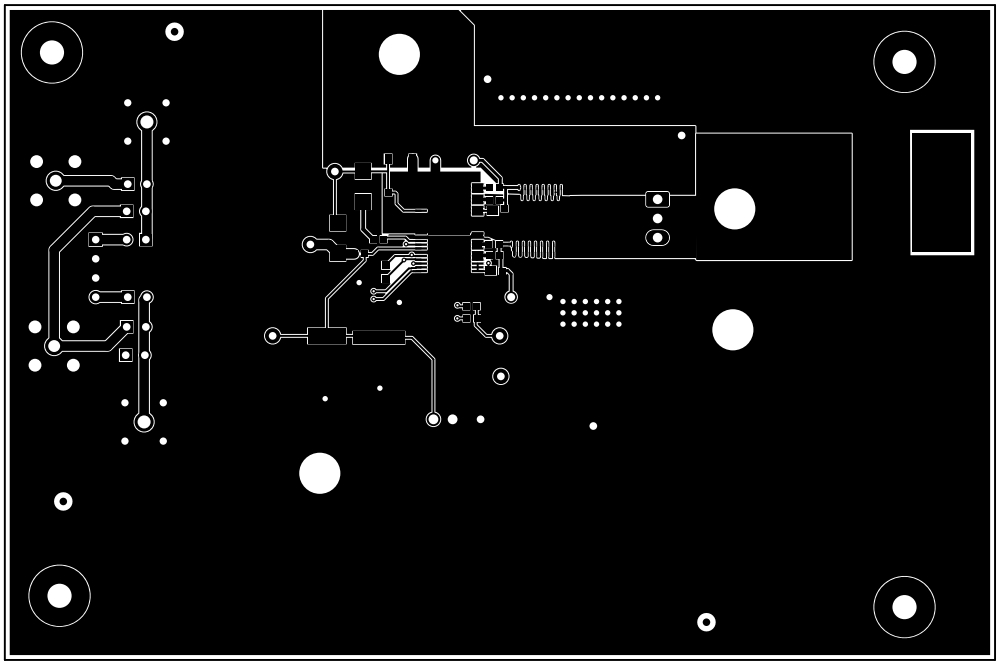


Figure 4-34. Top Layer (TPS7H6025EVM)

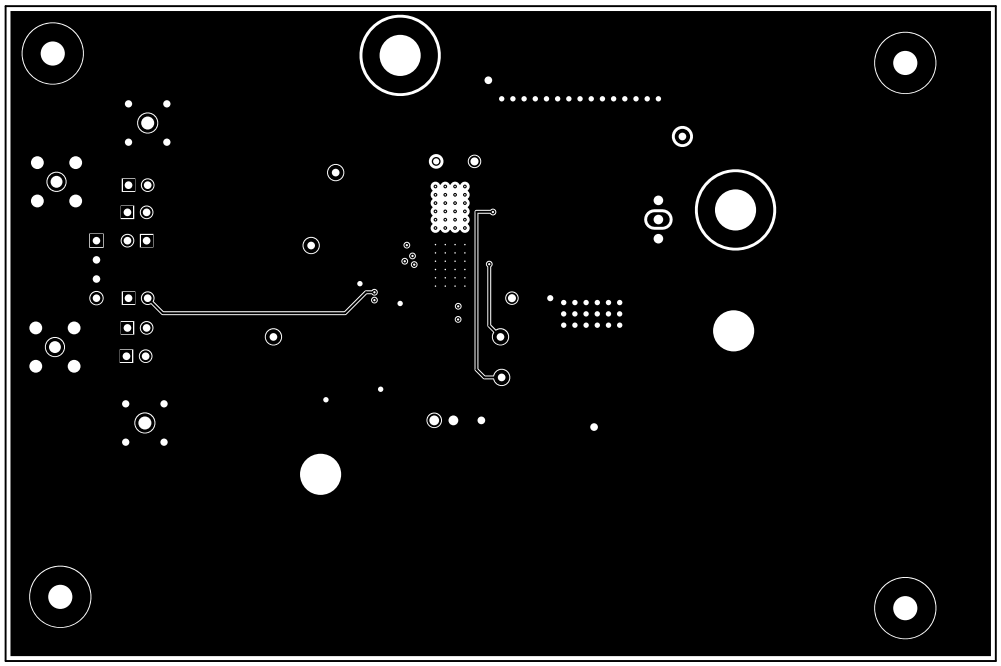


Figure 4-35. Signal Layer 1 (TPS7H60x5EVM)

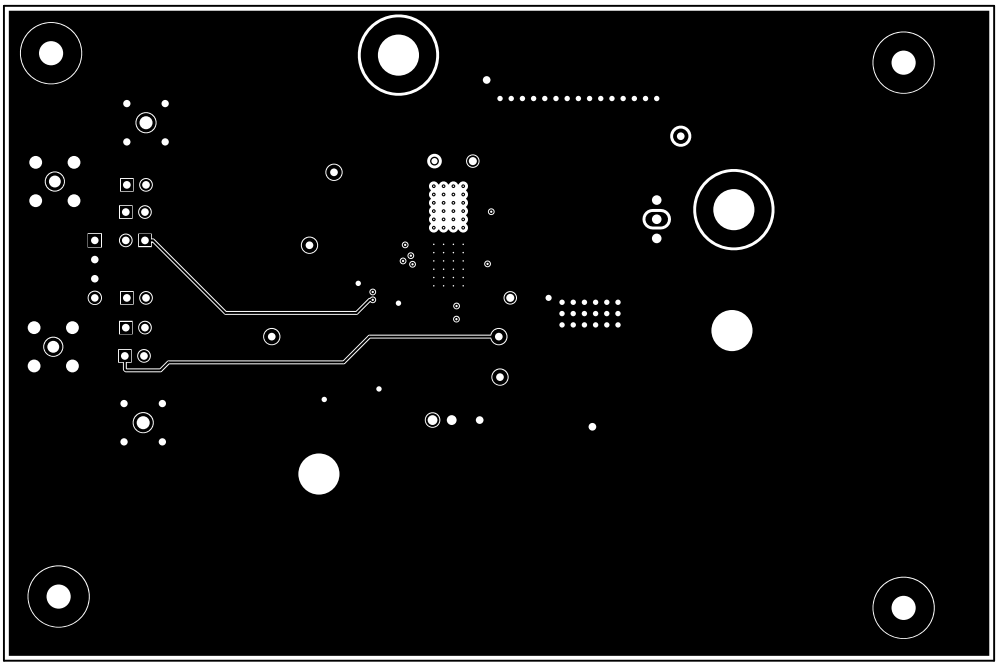


Figure 4-36. Signal Layer 2 (TPS7H60x5EVM)

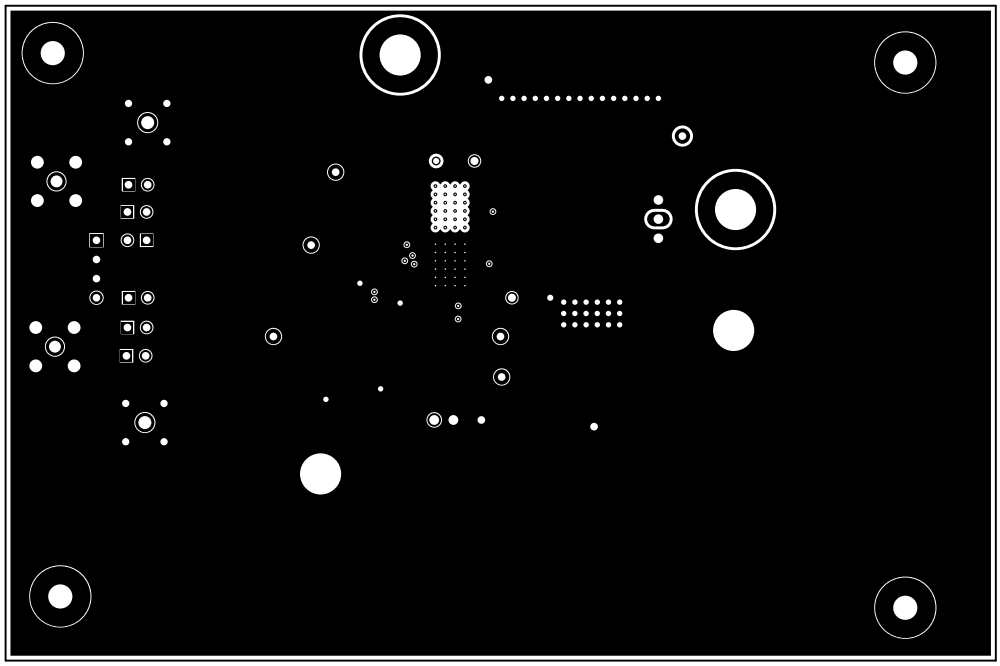


Figure 4-37. Signal Layer 3 (TPS7H60x5EVM)

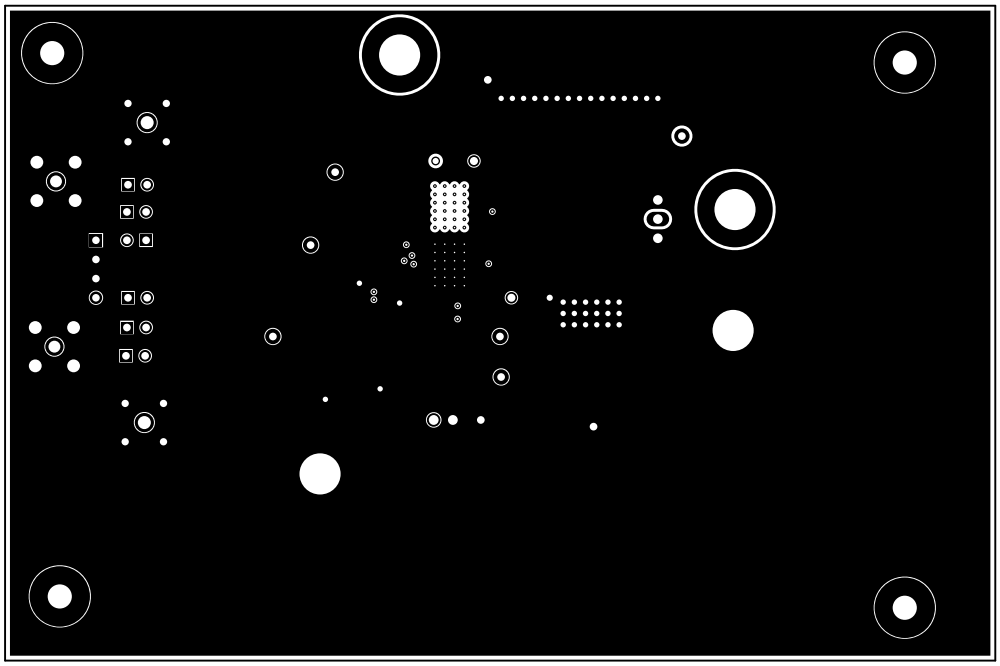


Figure 4-38. Signal Layer 4 (TPS7H60x5EVM)

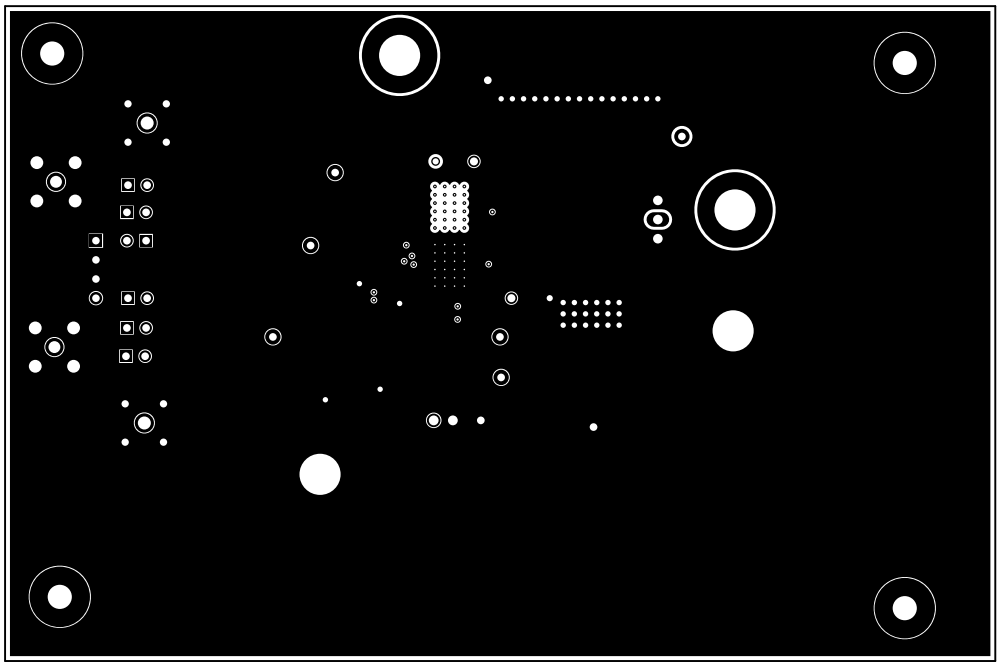


Figure 4-39. Signal Layer 5 (TPS7H60x5EVM)

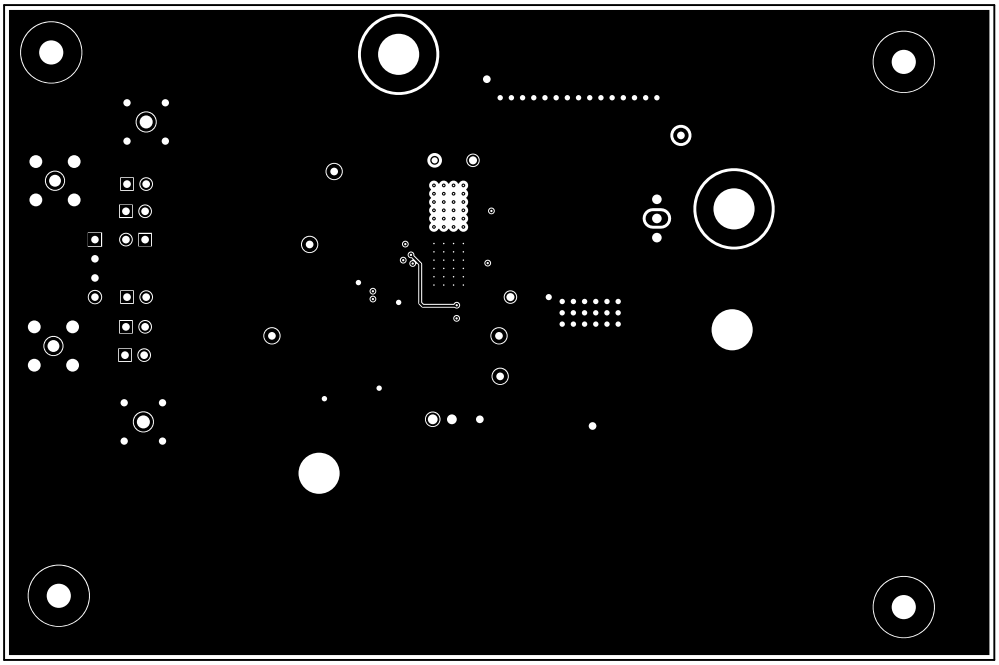


Figure 4-40. Signal Layer 6 (TPS7H60x5EVM)

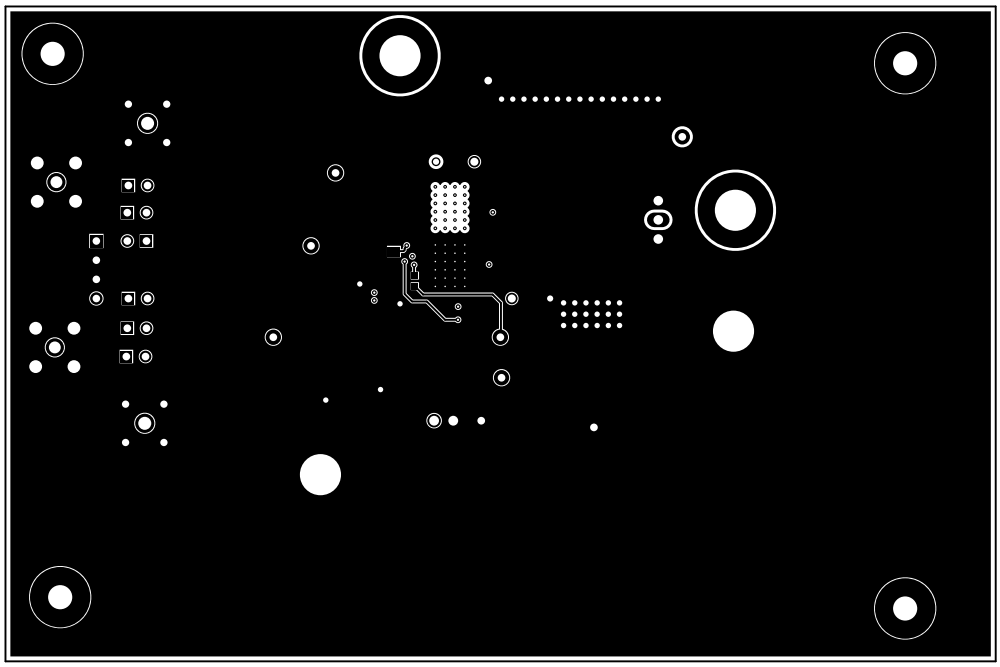


Figure 4-41. Bottom Layer (TPS7H60x5EVM)

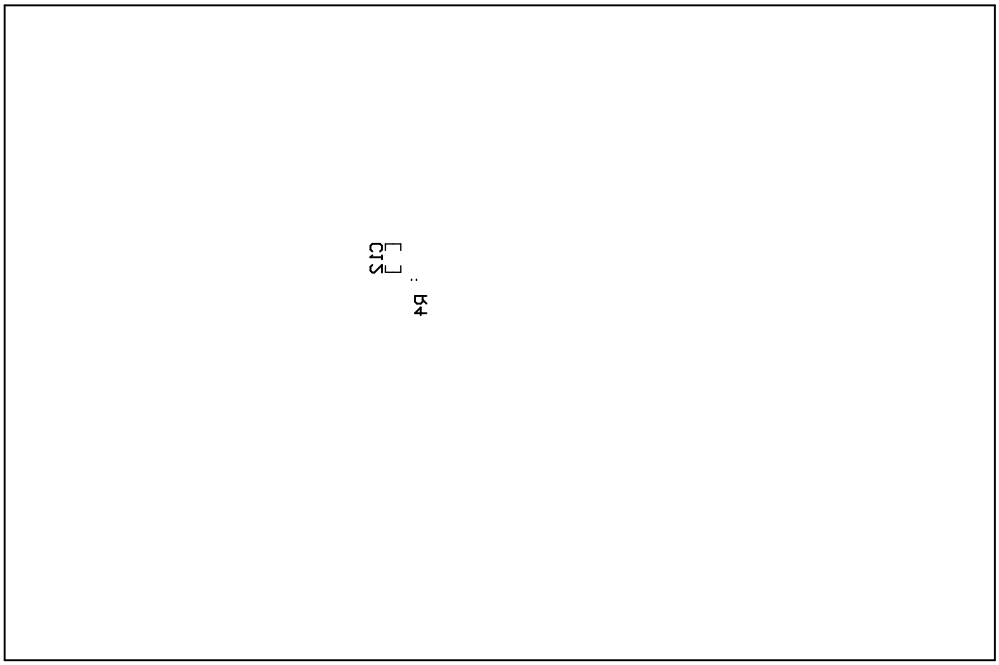


Figure 4-42. Bottom Overlay (TPS7H60x5EVM)

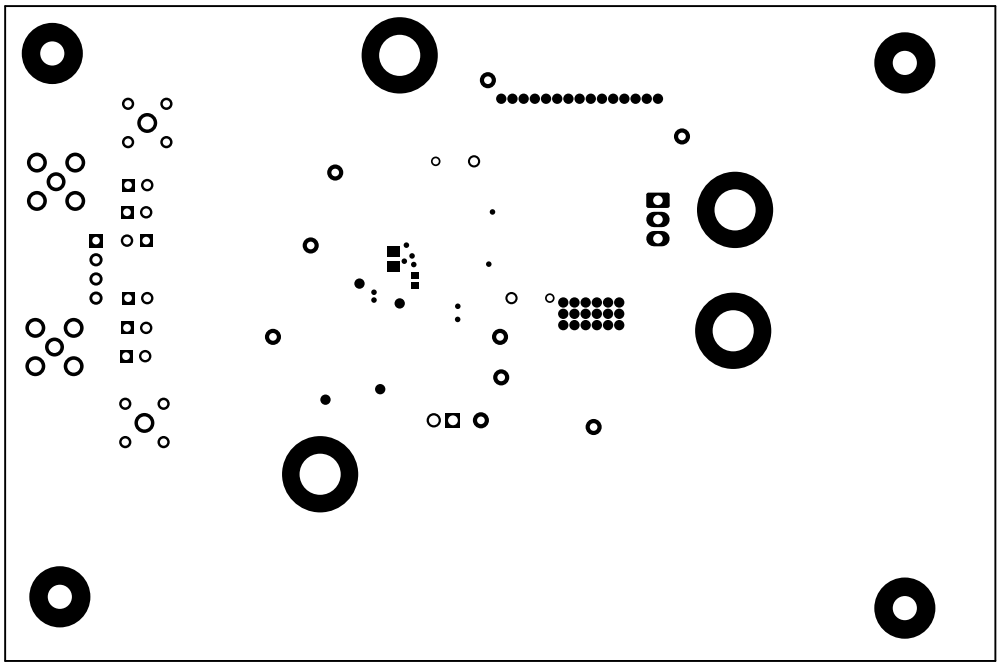


Figure 4-43. Bottom Solder (TPS7H60x5EVM)

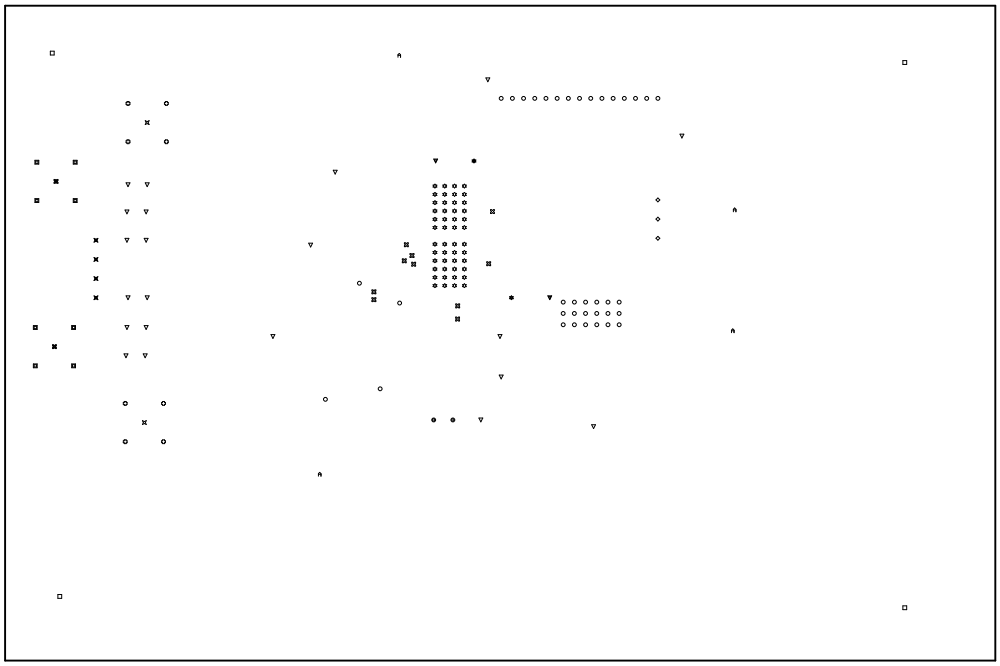


Figure 4-44. Drill Drawing (TPS7H60x5EVM)

4.3 Bill of Materials (BOM)

Table 4-1. Bill of Materials (BOM)

Designator	Qty	Value	Description	Package Reference	Part Number TPS7H6003EVM-CVAL	TPS7H6013EVM-CVAL Alternate Part	TPS7H6023EVM-CVAL Alternate Part	Manufacturer
!PCB1	1		Printed Circuit Board		LP079			Any
C1, C2, C3, C4, C5, C6, C7, C8, C9	9	0.1uF	CAP, CERM, 0.1uF, 250V, +/- 10%, X7R, 1206	1206	GRM31CR72E104KW03L			MuRata
C10	1	1uF	CAP, CERM, 1uF, 250V, +/- 10%, X7R, 1825	1825	1825PC105KAT1A			AVX
C11	1	2.2uF	CAP, CERM, 2.2uF, 250V, +/- 20%, X7R, AEC-Q200 Grade 1, 6x5x5mm	6x5x5mm	CKG57NX7R2E225M500JH			TDK
C12, C13, C15	3	1uF	CAP, CERM, 1µF, 50V,+/- 10%, X7R, AEC-Q200 Grade 1, 0805	0805	08055C105K4Z2A			AVX
C14	1	0.1uF	CAP, CERM, 0.1µF, 50V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	C0603C104K5RACAUTO			Kemet
D1, D3	2	200V	Diode, Schottky, 200V, 1A, SMA	SMA	SS1200-LTP			Micro Commercial Components
D2	1	12V	Diode, Zener, 12V, 500mW, AEC-Q101, SOD-123	SOD-123	BZT52B12-E3-08			Vishay-Semiconductor
D4	1	200V	Diode, Schottky, 200V, 10A, TH	TO-220AB	MBR20200CTTU			Fairchild Semiconductor
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH			B&F Fastener Supply
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C			Keystone
J1, J2, J13, J16	4		Standard Banana Jack, Uninsulated, 8.9mm	Keystone575-8	575-8			Keystone
J3, J4, J8, J10, J12, J14	6		Header, 2.54mm, 2x1, Gold, TH	Header, 2.54mm, 2x1, TH	GBC02SAAN			Sullins Connector Solutions
J5	1		Terminal Block, 2.54mm, 2x1, Brass, TH	Terminal Block, 2.54mm, 2-pole, Brass, TH	OSTVN02A150			On-Shore Technology
J6, J15	2		Connector, SMA, TH	SMA	142-0701-201			Cinch Connectivity
J7, J11	2		Compact Probe Tip Circuit Board Test Points, TH, 25 per	TH Scope Probe	131-5031-00			Tektronix
J9	1		Header, 100mil, 4x1, Tin, TH	Header, 4x1, 100mil, TH	5-146278-4			TE Connectivity
Q1, Q2	2		N-Channel 200V 48A (Ta) Surface Mount 7-QFN (3x5)	QFN7	EPC2307ENGRT	EPC2206	EPC2066	EPC
R1, R7	2	100	RES, 100, 1%, 0.1 W, 0603	0603	RC0603FR-07100RL			Yageo

Table 4-1. Bill of Materials (BOM) (continued)

Designator	Qty	Value	Description	Package Reference	Part Number TPS7H6003EVM-CVAL	TPS7H6013EVM-CVAL Alternate Part	TPS7H6023EVM-CVAL Alternate Part	Manufacturer
R2, R3, R10, R11	4	2	RES, 2.00, 1%, 0.125 W, 0603	0603	MCT06030C2008FP500			Vishay/Beyschlag
R4, R8, R9	3	10.0k	RES, 10.0 k, 0.1%, 0.1 W, 0603	0603	RG1608P-103-B-T5			Susumu Co Ltd
TP1, TP2, TP3, TP4, TP5, TP6	6		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000			Keystone Electronics
TP9, TP10, TP11	3		Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001			Keystone
U1	1		Radiation-Hardness-Assured 200V, 1.5A 3A, Half Bridge GaN FET Gate Driver	CFP48	TPS7H6003/EM	TPS7H6013/EM	TPS7H6023/EM	Texas Instruments
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A			N/A
R5, R6	0	0	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RMCF0603ZT0R00			Stackpole Electronics Inc

Table 4-2. TPS7H6005EVM Bill of Materials

Designator	Qty	Value	Description	Package Reference	Part Number	TPS7H6015EVM Alternate Part	TPS7H6025EVM Alternate Part	Manufacturer
!PCB1	1		Printed Circuit Board		LP128			Any
C1, C2, C3, C4, C5, C6, C7, C8, C9	9	0.1uF	CAP, CERM, 0.1uF, 250V, +/- 10%, X7R, 1206	1206	GRM31CR72E104KW03L			MuRata
C10	1	1uF	CAP, CERM, 1uF, 250V, +/- 10%, X7R, 1825	1825	1825PC105KAT1A			AVX
C11	1	2.2uF	CAP, CERM, 2.2uF, 250V, +/- 20%, X7R, AEC-Q200 Grade 1, 6x5x5mm	6x5x5mm	CKG57NX7R2E225M500JH			TDK
C12, C13, C15	3	1uF	CAP, CERM, 1µF, 50V,+/- 10%, X7R, AEC-Q200 Grade 1, 0805	0805	08055C105K4Z2A			AVX
C14	1	0.1uF	CAP, CERM, 0.1µF, 50V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	C0603C104K5RACAUTO			Kemet
D1, D3	2	200V	Diode, Schottky, 200V, 1A, SMA	SMA	SS1200-LTP			Micro Commercial Components
D2	1	12V	Diode, Zener, 12V, 500mW, AEC-Q101, SOD-123	SOD-123	BZT52B12-E3-08			Vishay-Semiconductor
D4	1	200V	Diode, Schottky, 200V, 10A, TH	TO-220AB	MBR20200CTTU			Fairchild Semiconductor
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH			B&F Fastener Supply
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C			Keystone
J1, J2, J13, J16	4		Standard Banana Jack, Uninsulated, 8.9mm	Keystone575-8	575-8			Keystone
J3, J4, J8, J10, J12, J14	6		Header, 2.54mm, 2x1, Gold, TH	Header, 2.54mm, 2x1, TH	GBC02SAAN			Sullins Connector Solutions
J5	1		Terminal Block, 2.54mm, 2x1, Brass, TH	Terminal Block, 2.54mm, 2-pole, Brass, TH	OSTVN02A150			On-Shore Technology
J6, J15	2		Connector, SMA, TH	SMA	142-0701-201			Cinch Connectivity
J7, J11	2		Compact Probe Tip Circuit Board Test Points, TH, 25 per	TH Scope Probe	131-5031-00			Tektronix
J9	1		Header, 100mil, 4x1, Tin, TH	Header, 4x1, 100mil, TH	5-146278-4			TE Connectivity
Q1, Q2	2		N-Channel 200V 48A (Ta) Surface Mount 7-QFN (3x5)	QFN7	EPC2307ENGRT	EPC2206	EPC2066	EPC
R1, R7	2	100	RES, 100, 1%, 0.1 W, 0603	0603	RC0603FR-07100RL			Yageo
R2, R3, R10, R11	4	2	RES, 2.00, 1%, 0.125 W, 0603	0603	MCT06030C2008FP500			Vishay/Beyschlag
R4	1	10.0k	RES, 10.0 k, 0.1%, 0.1 W, 0603	0603	RG1608P-103-B-T5			Susumu Co Ltd

Table 4-2. TPS7H6005EVM Bill of Materials (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	TPS7H6015EVM Alternate Part	TPS7H6025EVM Alternate Part	Manufacturer
R8, R9	2	30.0k	RES, 30.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ-3EKF3002V			Panasonic
R12, R13	2	10.0k	RES, 10.0 k, 1%, 0.1 W, 0603	0603	M55342K12B10E0T			TT Electronics/IRC
TP1, TP2, TP3, TP4, TP5, TP6	6		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000			Keystone Electronics
TP9, TP10, TP11	3		Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001			Keystone
U1	1		TPS7H6005/EM	TSSOP56	TPS7H6005/EM	TPS7H6015/EM	TPS7H6025/EM	Texas Instruments
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A			N/A
R5, R6	0	0	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RMCF0603ZT0R00			Stackpole Electronics Inc

5 References

- Texas Instruments, TPS7H60x3-SP Radiation-Hardness-Assured 1.3A, 2.5A, Half Bridge GaN FET Gate Drivers data sheet
- Texas Instruments, TPS7H60x5-SP and TPS7H60x5-SEP Radiation-Hardness-Assured Half Bridge GaN FET Gate Drivers data sheet

6 Revision History

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

Changes from Revision A (February 2024) to Revision B (July 2024)	Page
• Added the TPS7H60X5EVM information throughout document	1

Changes from Revision * (July 2023) to Revision A (February 2024)	Page
• Added TPS7H6005EVM, TPS7H6015EVM, and TPS7H6025EVM throughout document	1
• Added TPS7H6013-SP and TPS7H6023-SP throughout document	1

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

3.1.1 *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社

東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user 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, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

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