TPS7H2140-SEP Evaluation Module (EVM)

TEXAS INSTRUMENTS

Description

The TPS7H2140EVM provides a platform to demonstrate the operation and features of the TPS7H2140-SEP eFuse. The EVM provides test points, jumpers, connection terminals, and labeled easy-to-access components allowing for customized configurations of device features. The board also includes a voltage regulator to enable device functionality without the need for secondary power sources for IO configuration.

Features

1. Operating voltage 4.5 V– 32 V
2. Programmable current limit with external resistor
3. Output channels can be connected in parallel for higher current applications
4. Multiplex current sense output
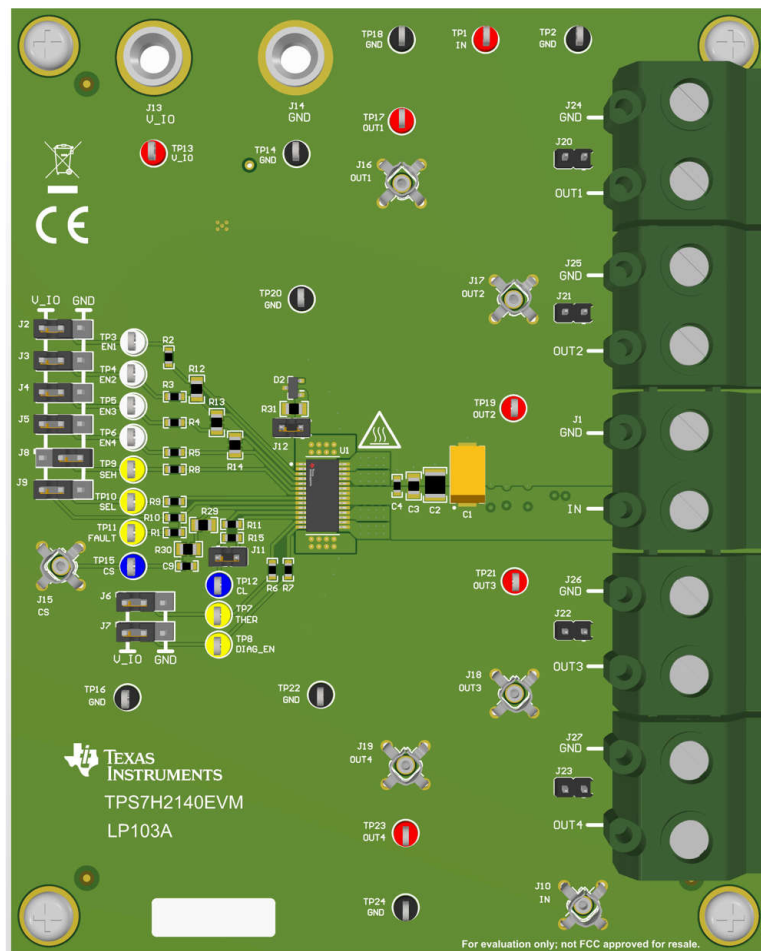
TPS7H2140EVM Board

1 Evaluation Module Overview

1.1 Introduction

The TPS7H2140EVM is the evaluation module (EVM) for the TPS7H2140-SEP and provides a platform to evaluate performance and features. This user's guide provides descriptions for the connectors and test points, the schematic, bill of materials, and board layout of the EVM.

The EVM is designed to be easily configurable for use under different operating conditions or requirements. By default, the EVM is configured as shown in Table 1-1. To change the configuration of the device, please refer to the TPS7H2140-SEP data sheet (SLVSH46) to calculate values of any passive components that need to be changed.

1.2 Kit Contents

*   EVM Board (1)
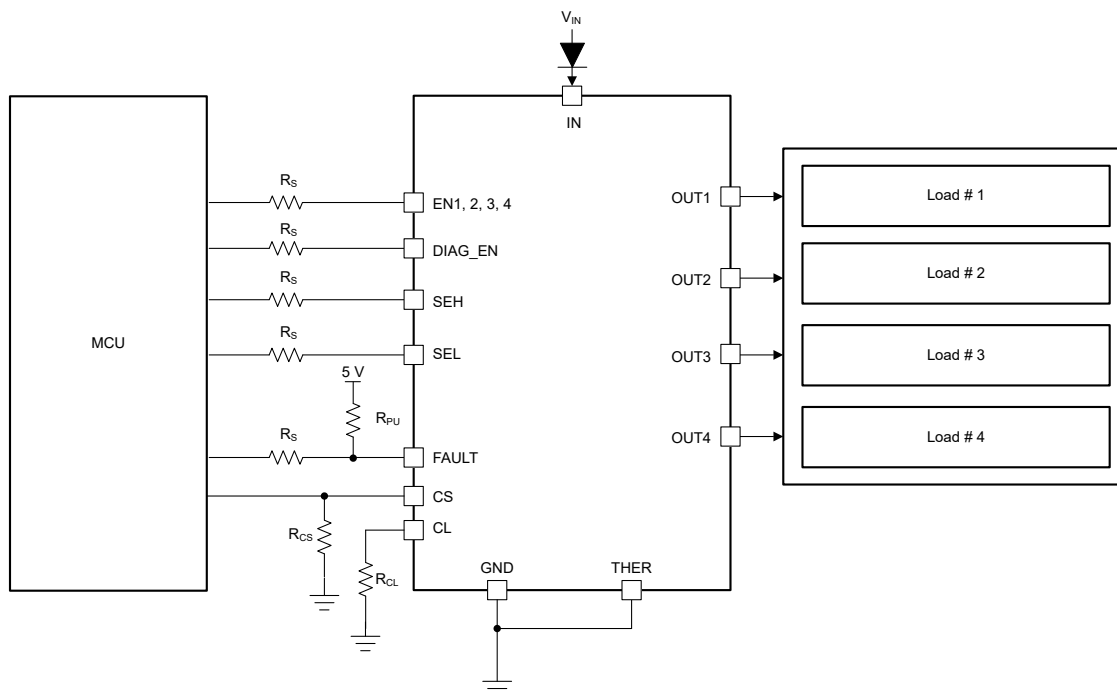*   EVM Kit User's Guide (1)

1.3 Specification

Figure 1-1. Typical Application Diagram

Table 1-1. TPS7H2140EVM Default Configuration

Specification	Value	Description
Input voltage VIN	12 V	Falls within the recommended device input voltage range of 4.5 V to 32 V.
Parallel Output Channels	CH1-CH4	Allows current capacity of all four channels to be shared for higher current applications.
Output current I_{OUT}	0 to 4 A	Allows per-channel output current to remain under the default configured current limit of 1.3 A
Current limit I_L	1.3 A	Does not exceed the maximum recommended output current of 1.35 A per channel. Set by: R11 = 3.01 kΩ R15 = 3.01 kΩ

Table 1-1. TPS7H2140EVM Default Configuration (continued)

Specification	Value	Description
Maximum current sense	2.7 A	Allows for accurate current sense through the default configured current limit. Set by: R29 = 442 Ω

1.4 Device Information

The TPS7H2140-SEP is a quad-channel, 4.5 V to 32 V, 160-mΩ eFuse with an adjustable current limit and high accuracy current sense. Additionally, the TPS7H2140-SEP features short-to-GND protection, loss-of-GND protection, thermal overload protection, and inductive load negative voltage clamp. The device contains four N-channel MOSFETs for independent control of all four channels using a discrete enable signal for each output channel. The device supports diagnostic reporting with both digital status output and analog current sense report. Diagnostics can be disabled for multiplexing the sense pin between different devices. External programmable current limit improves the whole system's reliability by limiting the inrush or overload current. Thermal shutdown behavior can be configured between latch off or auto-retry.
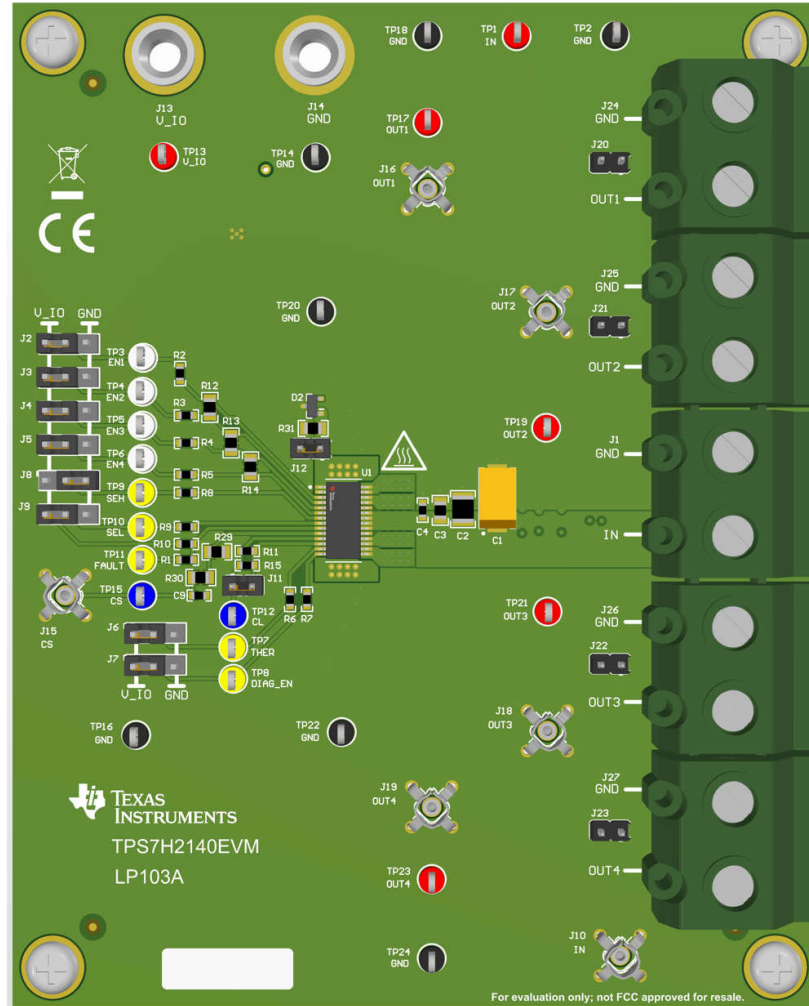
- Data sheet: TPS7H2140-SEP Radiation Tolerant 32-V, 160-mΩ Quad-Channel eFuse

2 Hardware

2.1 Connection Descriptions

This section describes the connectors on the EVM as well and how to properly connect, set up, and use the TPS7H2140EVM.

2.1.1 Connectors

TPS7H2140EVM

Table 2-1. Summary of Connectors and Test Points

Reference Designator	Function	
J1 (pin 1)	IN	Input voltage and current
J1 (pin 2)	GND	
J13	V_IO	Input for IO voltage
J14	GND	
J24 (pin 1)	OUT1	Output voltage and current for channel 1
J24 (pin 2)	GND	
J25 (pin 1)	OUT2	Output voltage and current for channel 2
J25 (pin 2)	GND	
J26 (pin 1)	OUT3	Output voltage and current for channel 3
J26 (pin 2)	GND	
J27 (pin 1)	OUT4	Output voltage and current for channel 4
J27 (pin 2)	GND	
TP1, J10	IN	Test point
TP17, J16	OUT1	
TP19, J17	OUT2	
TP21, J18	OUT3	
TP23, J19	OUT4	
TP2, TP14, TP16, TP18, TP20, TP22, TP24	GND	
TP3	EN1	
TP4	EN2	
TP5	EN3	
TP6	EN4	
TP7	THER	
TP8	DIAG_EN	
TP9	SEH	
TP10	SEL	
TP11	$\overline{\text{FAULT}}$	
TP12	CL	
TP15, J15	CS	
J2	V_IO - EN1 - GND	Shunt for mode selection
J3	V_IO - EN2 - GND	
J4	V_IO - EN3 - GND	
J5	V_IO - EN4 - GND	
J6	V_IO - THER - GND	
J7	V_IO - DIAG_EN - GND	
J8	V_IO - SEH - GND	
J9	V_IO - SEL - GND	
J11	CL - GND	
J12	GND - GND_IC	
J20	Open-load detection pull-up OUT1	
J21	Open-load detection pull-up OUT2	
J22	Open-load detection pull-up OUT3	
J23	Open-load detection pull-up OUT4	

2.2 Variable Resistors for CS and CL

2.2.1 Current Sense Resistor

- For the most accurate and detailed guidance, please refer to the *Accurate Current Sense* section of the TPS7H2140-SEP data sheet.

High-accuracy current sensing allows better real-time monitoring and more accurate diagnostics without further calibration. High-accuracy current sensing provides real-time output current monitoring. A current mirror is used to source $1/K_{CS}$ of the load current, and is reflected as $V_{CS} = I_{CS} \times R_{CS}$. K_{CS} is a constant value (300) across temperature and supply voltage. Verify that the CS voltage is in the linear region (0–4 V) when in normal operation.

When in a fault condition, the CS pin works as a diagnostics report pin. When open load/short to VIN happen in on-state, V_{CS} almost equals to zero. When current limit, thermal shutdown/swing, or open load/short to VIN in disabled-state happen, the voltage is clamped at $V_{CS\_\overline{FAULT}}$. Channel selection for both current and fault reporting is accomplished through the multiplexer digital inputs (SEL and SEH), which can be configured using jumper J8 (SEH) and jumper J9 (SEL).

Equation 1 is the equation for the current-sense resistor, R29.

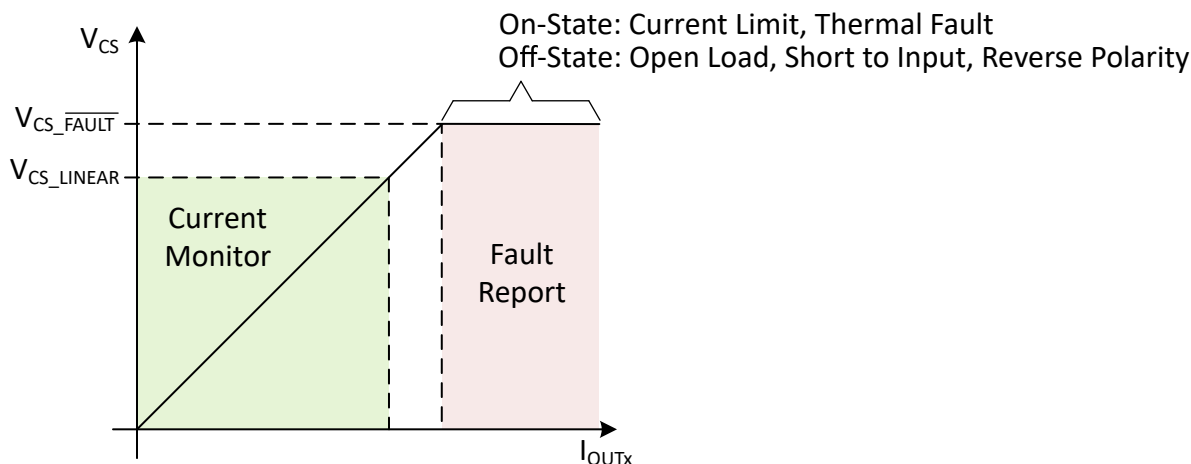$$R_{(CS)} = \frac{V_{CS}}{I_{CS}} = \frac{V_{CS} \times K_{(CS)}}{I_{OUTx}} \tag{1}$$

Figure 2-1. Current-Sense Output-Voltage Curve

Take the following points into consideration when calculating R_{CS}.

- Verify that V_{CS} is within the current-sense linear region (V_{CS_LINEAR}, I_{OUTx_LINEAR}) across the full range of the load current. Check R_{CS} with Equation 2.

$$R_{CS} = \frac{V_{CS}}{I_{CS}} \leq \frac{V_{CS\_LINEAR(MAX)} \times K_{CS}}{I_{OUTx(MAX)}} \tag{2}$$

- In fault mode, verify that I_{CS} is within the source capacity of the CS pin ($I_{CS\_\overline{FAULT}}$). Check R_{CS} with Equation 3.

$$R_{CS} = \frac{V_{CS}}{I_{CS}} \geq \frac{V_{CS\_FAULT(MAX)}}{I_{CS\_FAULT(MIN)}} \tag{3}$$

2.2.2 Current Limit Resistors

- For the most accurate and detailed guidance, please refer to the *Adjustable Current Limit* section of the TPS7H2140-SEP data sheet

External resistors are used to convert a proportional load current into a voltage, which is compared with an internal reference voltage. When the voltage on the CL pin exceeds the reference voltage, the output current is clamped.

The inherent current limit ($I_{CL\_INTERNAL}$) is still present when using an external current limit. The smaller value between the internal or external set value decides the actual nominal current limit. If the user decides to not use an external programmable current, then tie the CL pin to ground.

Use Equation 4 and Equation 5 to calculate the value of R_{CL}. The internal band gap voltage, V_{CL_TH}, has a typical value of 0.8 V. K_{CL} (2500) is the output current and the current-limit set value and is constant across temperature and supply voltage.

$$I_{CL} = \frac{V_{CL\_TH}}{R_{CL}} = \frac{I_{OUT}}{K_{CL}} \tag{4}$$

$$R_{CL} = \frac{V_{CL\_TH} \times K_{CL}}{I_{OUT}} \tag{5}$$

The current-limit resistors, R11 and R15 are both 3.01kΩ resistors connected in parallel. Populate/depopulate R11 and R15 to vary CL. When a shunt is inserted in J11, there is no external current limit function, the internal current limit is active.

2.3 Open-Load Detection Pull-Up Resistors

- For the most accurate and detailed guidance, please refer to the *Open-Load Detection* section of the TPS7H2140-SEP data sheet

The TPS7H2140-SP has the ability to detect an open load on a disabled output channel. For this feature to be functional, a pull-up resistor is required between VIN and the output channel. The TPS7H2140EVM board includes pull-up resistors and jumpers to toggle this functionality. By inserting shunts in J20-J24, each output channel can be pulled up through the included 20 kΩ resistors to enable the open-load detection. When an open load is detected on any disabled channel, the $\overline{\text{FAULT}}$ pin is pulled low. Therefore, when using the TPS7H2140EVM with less than all four channels being loaded, the shunts for each disabled and unloaded channel must be removed for the $\overline{\text{FAULT}}$ pin to report accurately.

2.4 Connecting Channels In Parallel

The TPS7H2140EVM provides the ability to connect output channels in parallel for higher current applications than one channel can allow. Channels can be connected in parallel by soldering 0 Ω resistors to pads on the PCB. Output channels are connected together by soldering 4, 0 Ω resistors on the bottom layer of the PCB. For each channel being connected, TI recommends to solder an additional 0 Ω resistor on the top layer to synchronize the enable signals for each of the bonded channels.

Table 2-2 lists which pads have 0 Ω resistors attached to enable parallel channel operation for each 2-channel combination.

Table 2-2. Output Channel Bonding Connections

Channels To Bond	Reference Designators
CH1 - CH2	R12 (EN), R16, R19, R22, R25
CH2 - CH3	R13 (EN), R18, R21, R24, R27
CH3 - CH4	R14 (EN), R17, R20, R23, R26

Any number of adjacent channels can be connected together and channels combinations are not limited to the pairs shown in Table 2-2.

When a 0 Ω resistor is connected between the enable signals of two or more channels, TI recommends to use only one enable jumper to control the enable status for each bonded channel. Remove the other enable jumpers for the bonded channel set.

3 Implementation Results

3.1 Separated Output Results

The following tests were performed using an EVM which was modified from the default configuration, found in Table 1-1, by removing the parallel connections between all channels.

> **CAUTION**
> When the device is limiting output current, the amount of power dissipated can be large. If left unchecked, then this can cause the board to heat up quickly. If the thermal overload behavior of the device is configured in retry mode, then the board remains hot until overcurrent state is corrected.

3.1.1 Power Up and Power Down
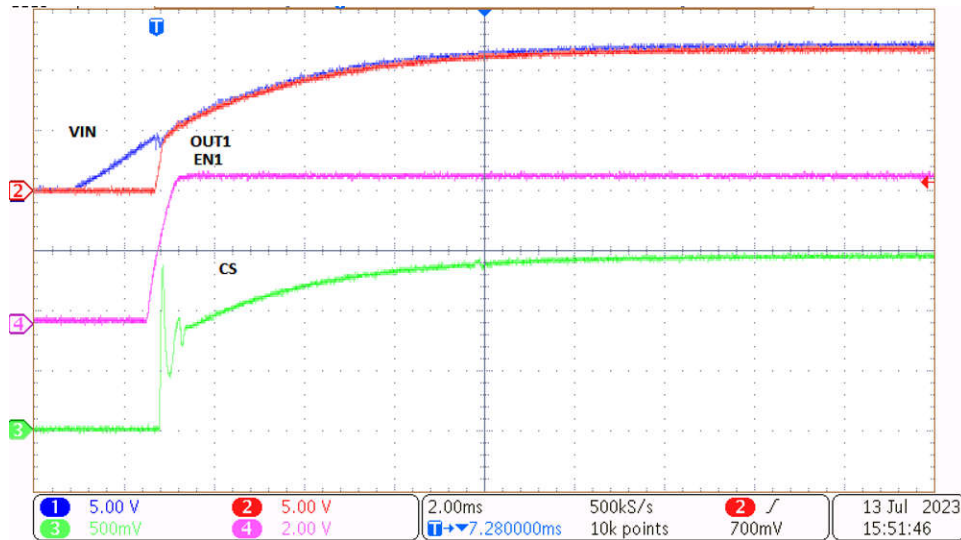
Figure 3-1. Power-up
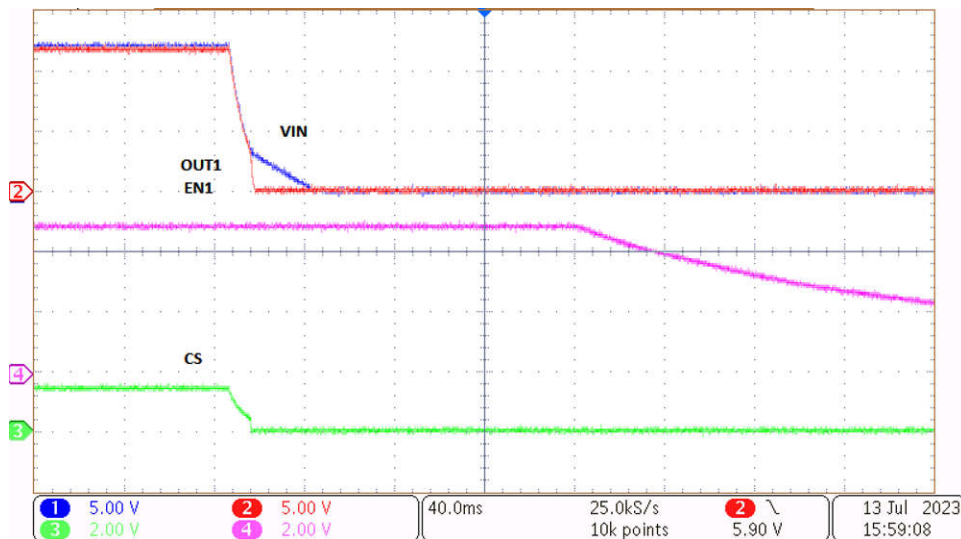
Figure 3-2. Power-down

Both tests were performed using VIN = 12 V and a load of 12 Ω.

3.1.2 Enable and Disable
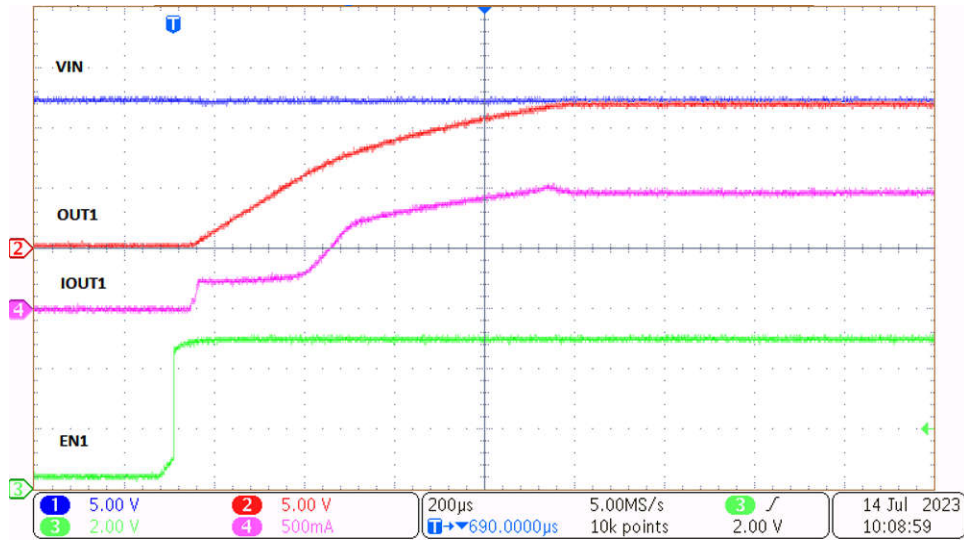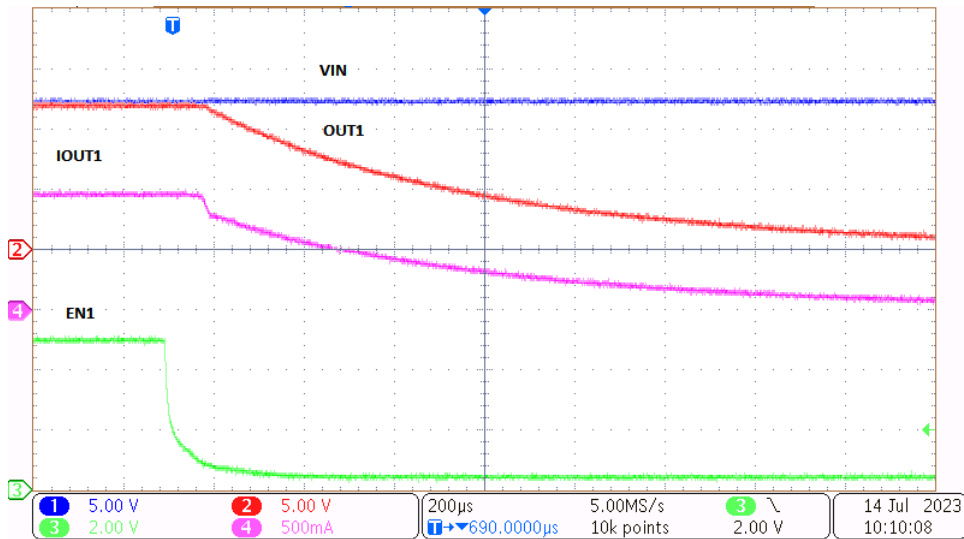

Figure 3-3. Channel Enable

Figure 3-4. Channel Disable

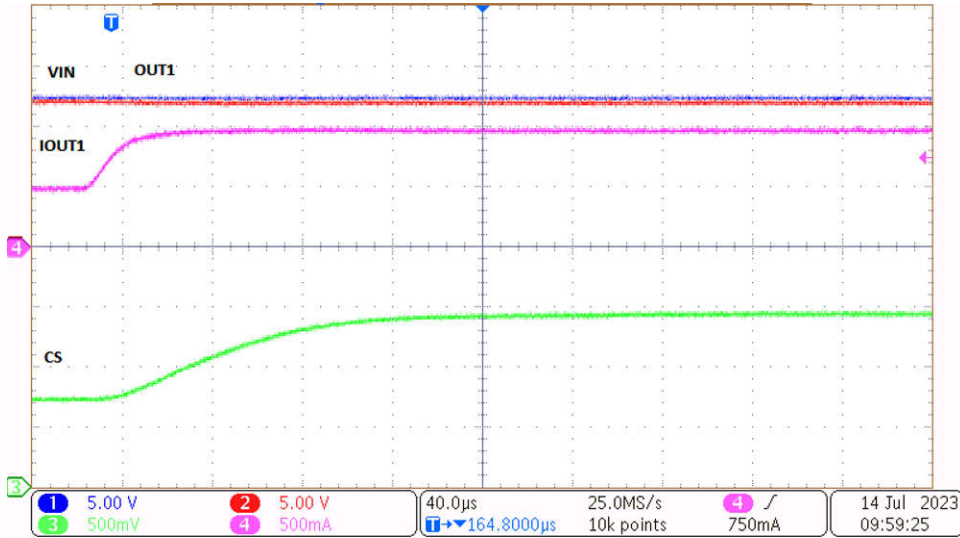Both tests were performed using VIN = 12 V and a load of 12 Ω.

3.1.3 Current Sensing

Figure 3-5. Current Sense Load Step

The current sense load step test was performed using VIN = 12 V, and a load step from 24 Ω to 12 Ω.
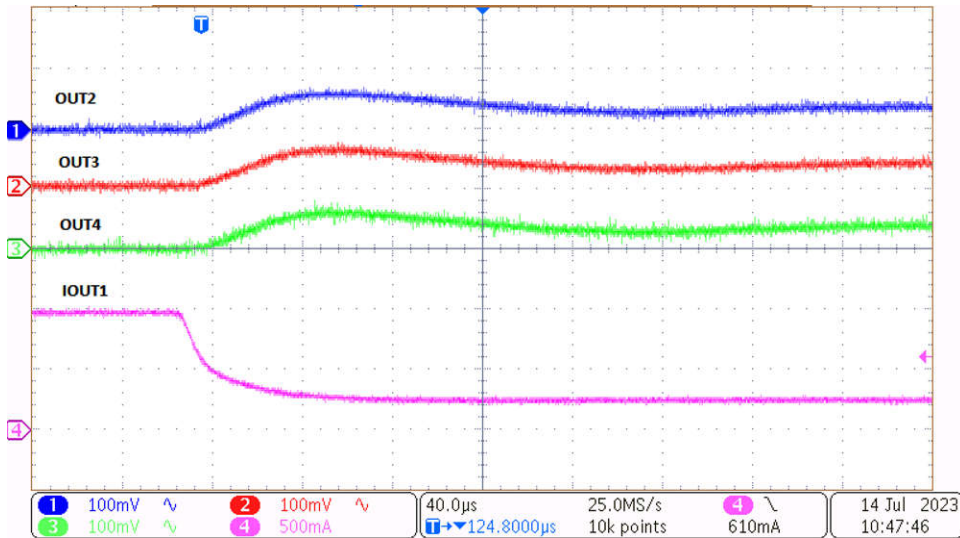
3.1.4 Load Step Effects Across Output Channels

Figure 3-6. Load Step Effects Across Channels (AC Coupling)

The cross-channel load step test was performed using VIN = 12 V, and a load step from 48 Ω to 12 Ω on CH1. Voltage measurements for CH2-CH4 were made using AC coupling mode.
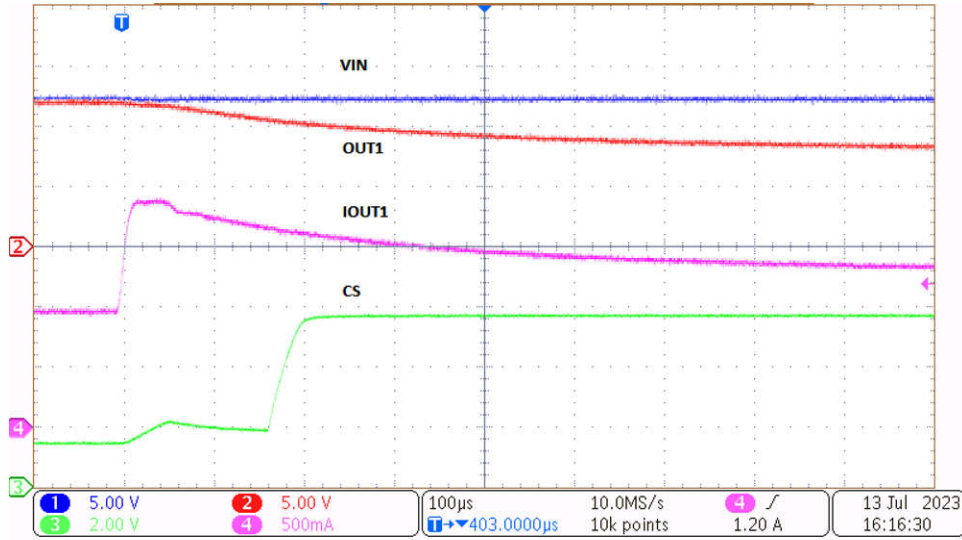
3.1.5 Overcurrent Protection

Figure 3-7. OCP Assertion at R$_{Load}$ = 6 Ω
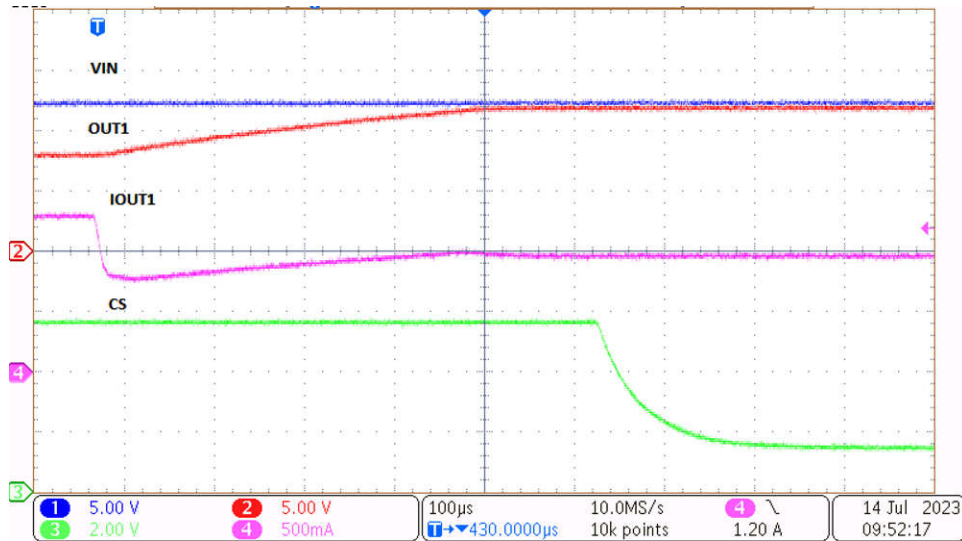

Figure 3-8. OCP Deassertion by returning R$_{Load}$ = 12 Ω

Both tests were performed using VIN = 12 V, and a load between 6 Ω and 12 Ω.

3.2 Modified Configuration Results

The following test was performed with an EVM board that was modified by removing the output capacitors, and is meant to demonstrate the fast-trip overcurrent protection of the TPS7H2140-SEP. For the purposes of demonstrating the fast-trip feature, the output of the device was short-circuited to collect Figure 3-9. Purposefully short-circuiting any output of the EVM is not recommended and rapidly causes the device to overheat.

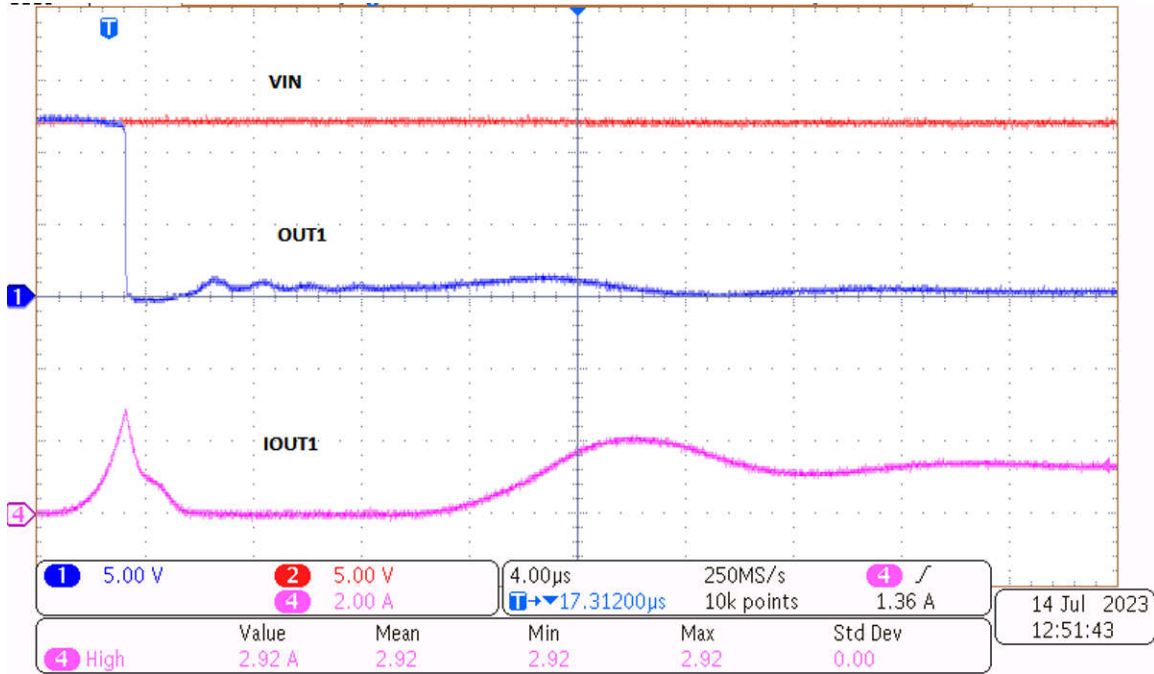### 3.2.1 Short-to-GND (Fast-Trip) Overcurrent

Figure 3-9. Fast Trip Current Protection - Short to GND

The short to GND test was performed using VIN = 12 V, and a load step from 2.56 kΩ to 0 Ω.

4 Hardware Design Files
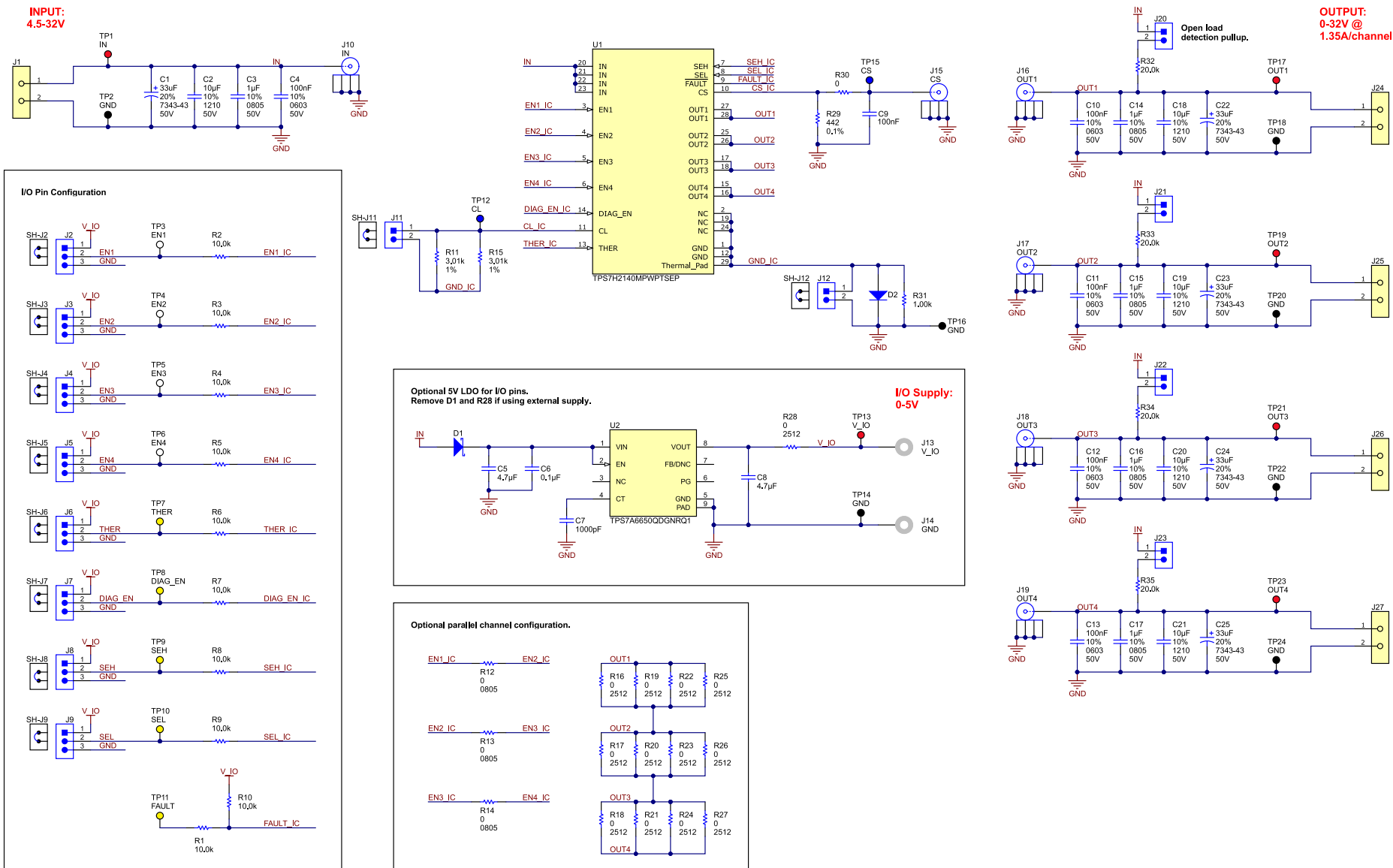
4.1 Schematic

Figure 4-1. TPS7H2140EVM Schematic

4.2 PCB Layouts

Figure 4-2 to Figure 4-9 show the design of the TPS7H2140EVM printed-circuit board (PCB). The EVM has main power input and output connectors on the right side of the board, with auxiliary IO power inputs on the top. Jumpers for device configuration are located on the left side of the board, around the IC, and directly behind the output terminals. Vias under the TPS7H2140 allow a thermal path from the top layer all the way to the bottom layer. The EVM board utilizes a GND network to allow for testing of applications that can require one. However, if a GND network is not required for the application of the TPS7H2140-SEP, the thermal pad can also be connected directly to a GND plane to improve thermal performance. Additional information can be found in the *Layout Examples* section of the TPS7H2140-SEP data sheet. Pads are provided on the bottom of the EVM that can be populated with 0 Ω resistors to connect the output channels together in parallel, as well as pads on the top layer to synchronize the enable signals of the output channels.
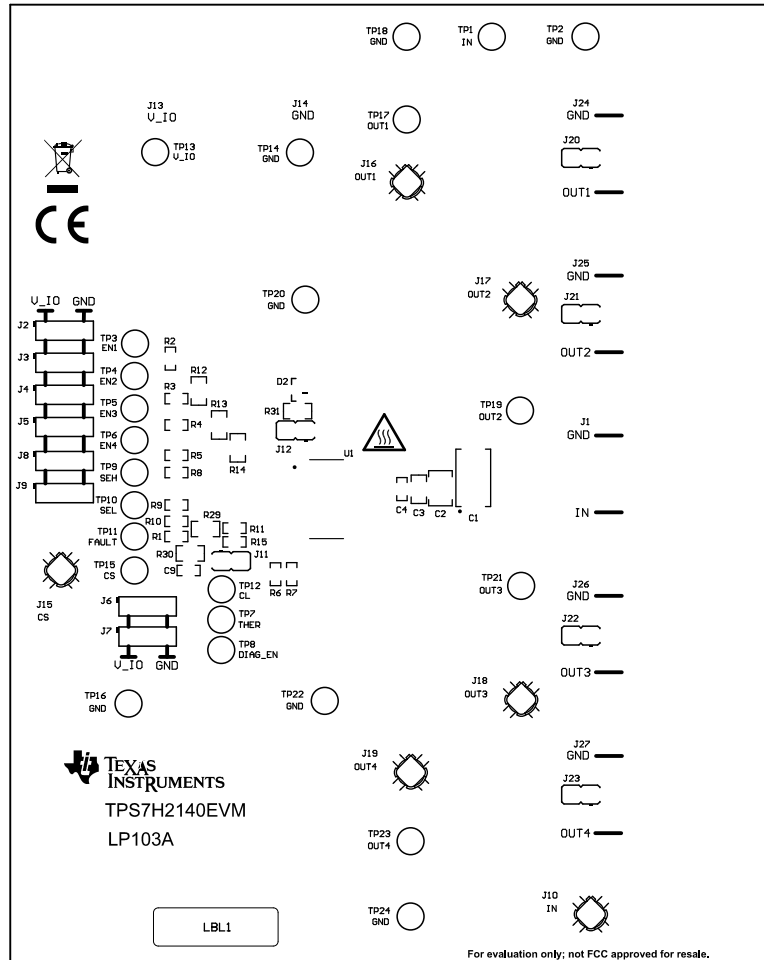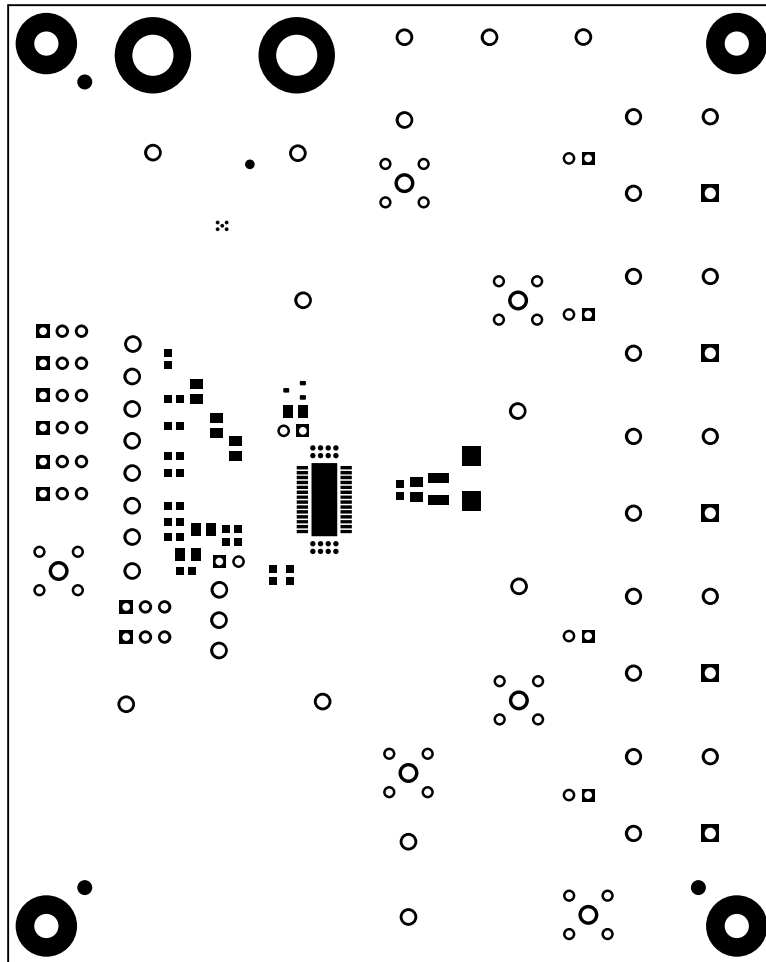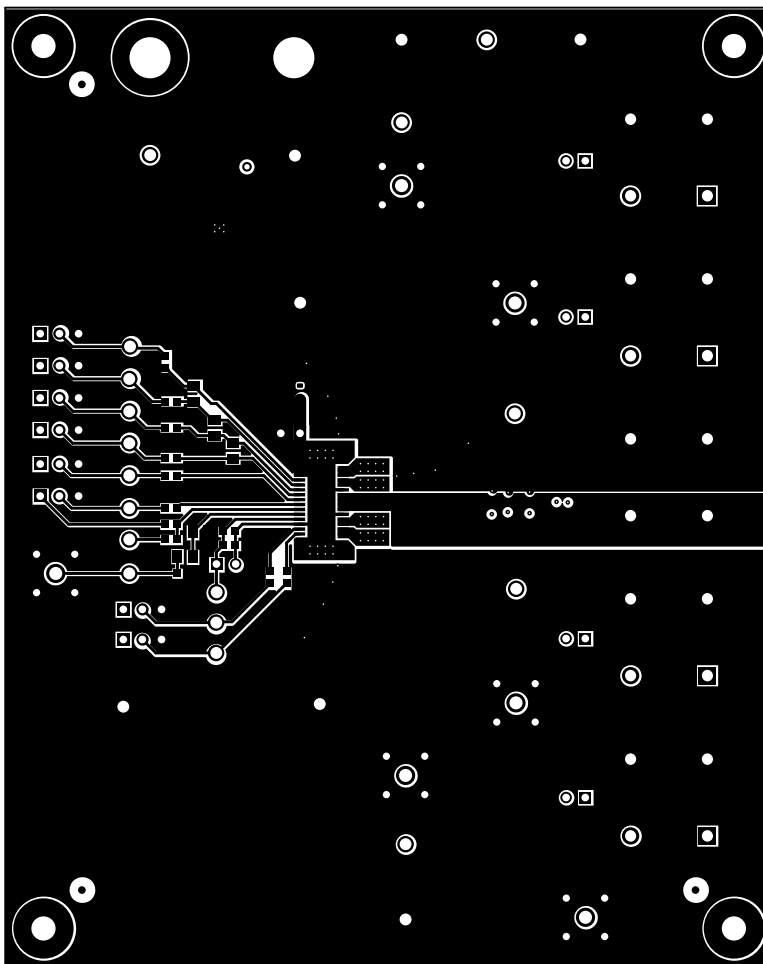
Figure 4-2. Top Overlay

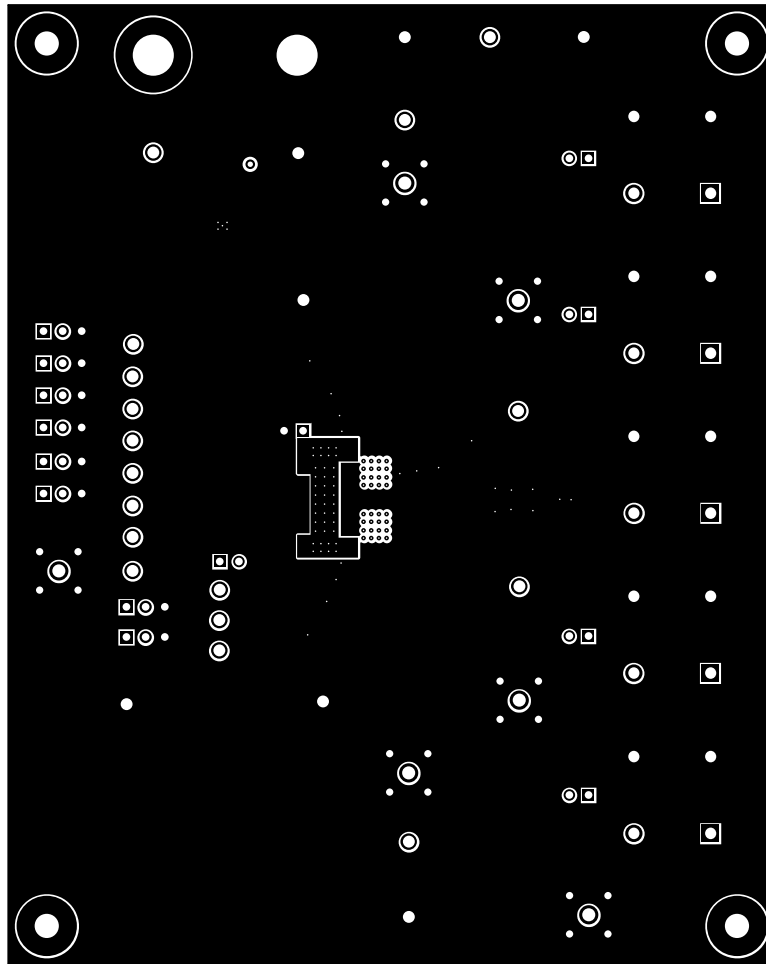**Figure 4-3. Top Solder Mask**

Figure 4-4. Layer 1 (Top)
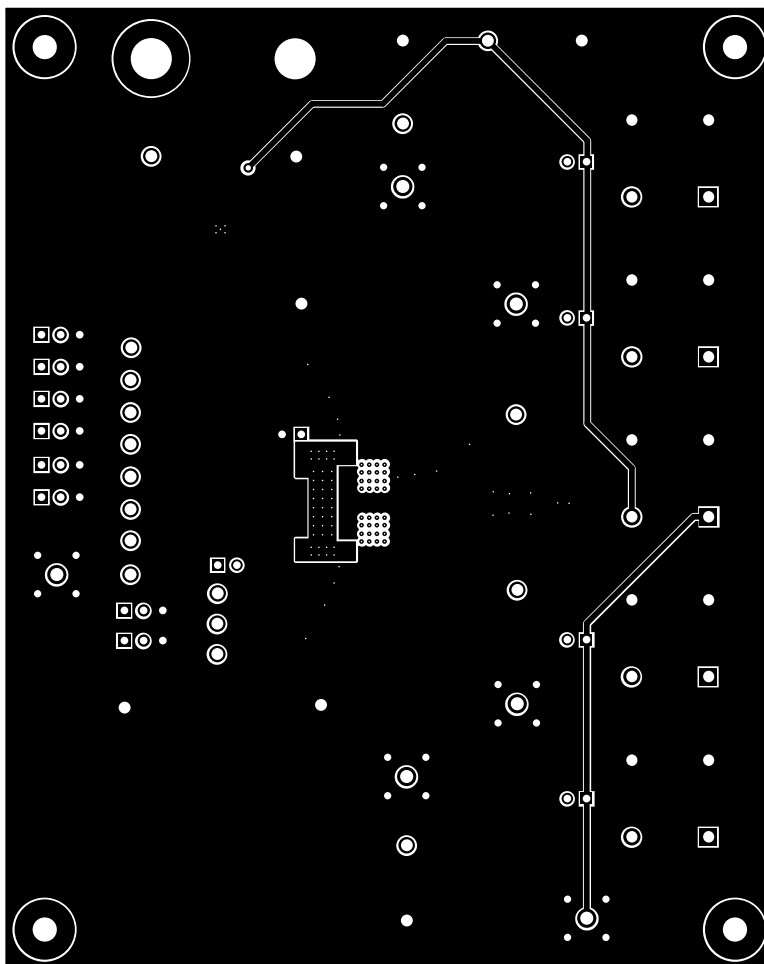
Figure 4-5. Layer 2
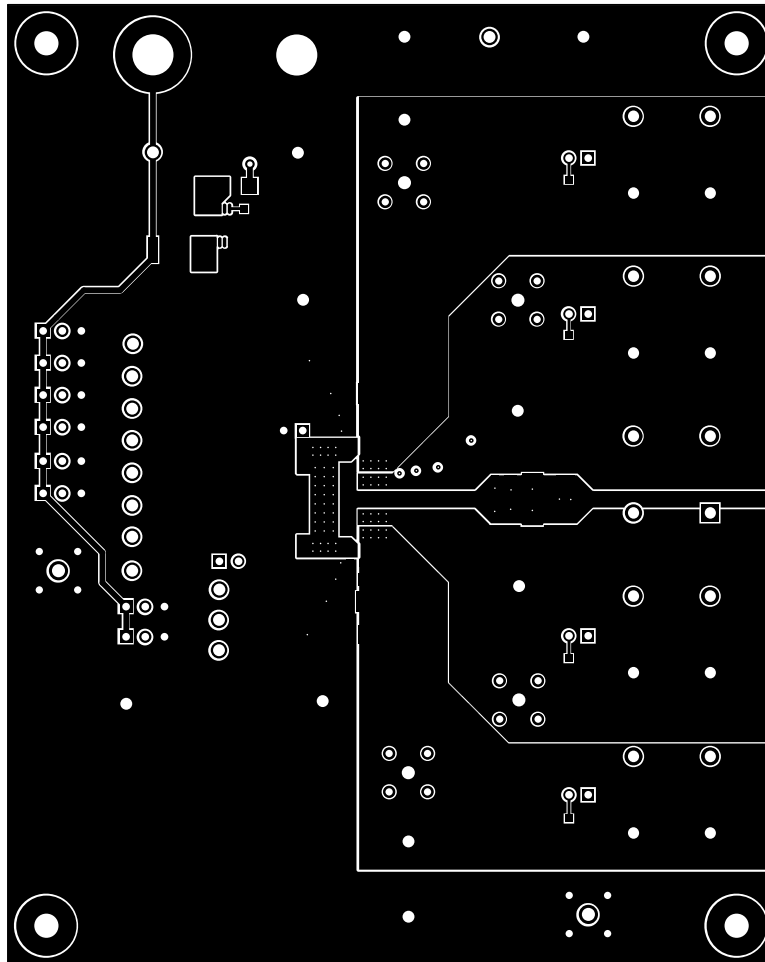
Figure 4-6. Layer 2

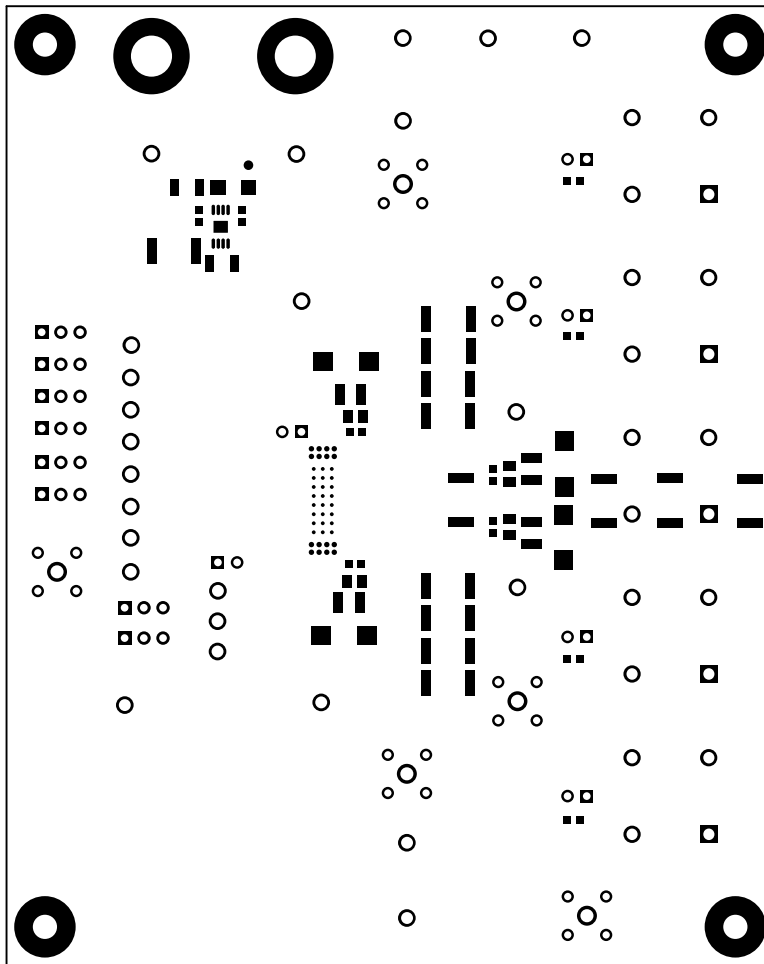**Figure 4-7. Layer 3 (Bottom)**
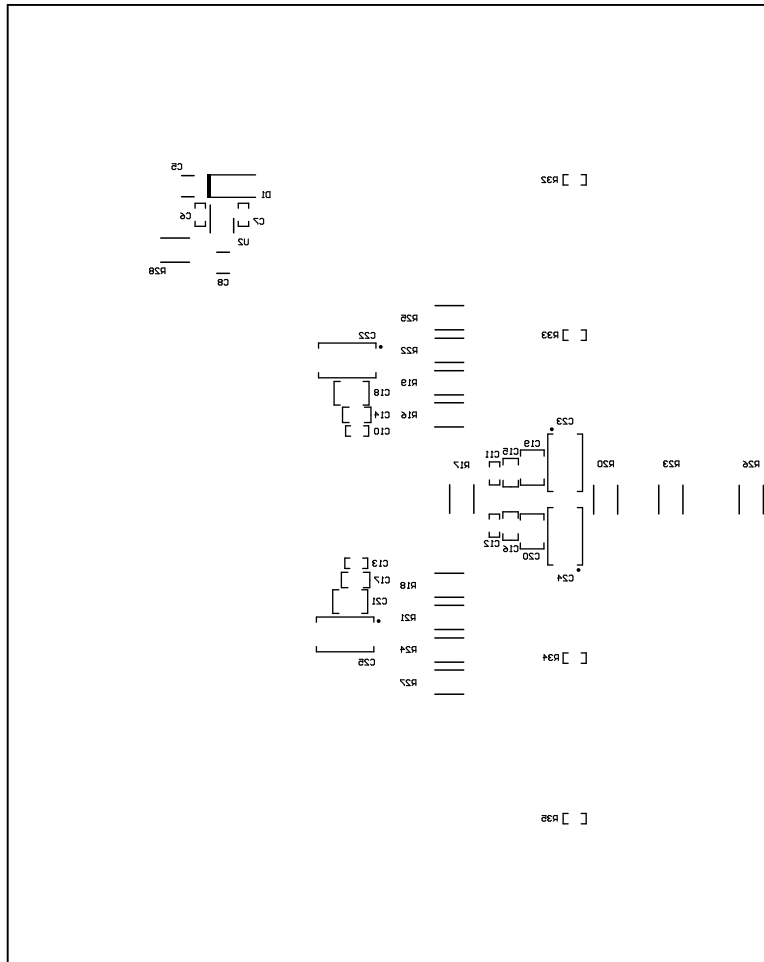
Figure 4-8. Bottom Solder Mask

Figure 4-9. Bottom Overlay

4.3 Bill of Materials

[Table 4-1](#) lists the bill of materials for an EVM in the default configuration.

Table 4-1. Bill of Materials

Designator	Qty	Value	Description	Package Reference	PartNumber	Manufacturer
C1, C22, C23, C24, C25	5	33uF	CAP, Tantalum Polymer, 33 uF, 50 V, +/- 20%, 0.05 ohm, 7343-43 SMD	7343-43	T521X336M050ATE050	Kemet
C2, C18, C19, C20, C21	5	10uF	CAP, CERM, 10 µF, 50 V,+/- 10%, X7R, 1210	1210	CL32B106KBJNNWE	Samsung Electro-Mechanics
C3, C14, C15, C16, C17	5	1uF	CAP, CERM, 1 µF, 50 V,+/- 10%, X7R, 0805	0805	CL21B105KBFNFNE	Samsung
C4, C6, C10, C11, C12, C13	6	0.1uF	CAP, CERM, 0.1 µF, 50 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	06035C104KAZ2A	AVX
C5, C8	2	4.7uF	CAP, CERM, 4.7 µF, 50 V,+/- 10%, X7R, AEC-Q200 Grade 1, 1210	1210	C1210C475K5RACAUTO	Kemet
C7	1	1000 pF	CAP, CERM, 1000 pF, 50 V, +/- 10%, C0G/NP0, 0603	0603	06035A102KAT2A	AVX
C9	1	0.1uF	CAP, CERM, 0.1 µF, 50 V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	C0603C104K5RACAUTO	Kemet
D1	1	50 V	Diode, Schottky, 50 V, 1 A, SMA	SMA	B150-13-F	Diodes Inc.
D2	1	200 V	Diode, Switching, 200 V, 0.2 A, SOT-23	SOT-23	BAS21-7-F	Diodes Inc.
H1, H3, H5, H7	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone
H2, H4, H6, H8	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply
J1, J24, J25, J26, J27	5		Fixed Terminal Blocks MKDSP 10 HV/ 2-10	HDR2	1929517	Phoenix Contact
J2, J3, J4, J5, J6, J7, J8, J9	8		Header, 100mil, 3x1, Tin, TH	Header, 3x1, 100mil, TH	5-146278-3	TE Connectivity
J10, J15, J16, J17, J18, J19	6		Compact Probe Tip Circuit Board Test Points, TH, 25 per	TH Scope Probe	131-5031-00	Tektronix
J11, J12, J20, J21, J22, J23	6		Header, 2.54mm, 2x1, Tin, TH	Header, 2.54mm, 2x1, TH	22284023	Molex
J13, J14	2		Standard Banana Jack, Uninsulated, 5.5mm	Keystone_575-4	575-4	Keystone
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650 x 0.200 inch	THT-14-423-10	Brady
R1, R2, R3, R4, R5, R6, R7, R8, R9, R10	10	10.0k	RES, 10.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310K0FKEA	Vishay-Dale
R11, R15	2	3.01k	RES, 3.01 k, 1%, 0.2 W, 0603	0603	ERJ-P03F3011V	Panasonic
R12, R13, R14, R30	4	0	RES, 0, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	CRCW08050000Z0EA	Vishay-Dale
R16, R17, R18, R19, R20, R21, R22, R23, R24, R25, R26, R27, R28	13	0	RES, 0, 5%, 1 W, 2512	2512	RC6432J000CS	Samsung
R29	1	442	RES, 442, 0.1%, 0.125 W, 0805	0805	RT0805BRD07442RL	Yageo America
R31	1	1.00k	RES, 1.00 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	CRCW08051K00FKEA	Vishay-Dale

Table 4-1. Bill of Materials (continued)

Designator	Qty	Value	Description	Package Reference	PartNumber	Manufacturer
R32, R33, R34, R35	4	20.0k	RES, 20.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0720KL	Yageo
SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8, SH-J9, SH-J11, SH-J12	10		Shunt, 100mil, Gold plated, Black	JUMPER	QPC02SXGN-RC	Sullins
TP1, TP13, TP17, TP19, TP21, TP23	6		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone Electronics
TP2, TP14, TP16, TP18, TP20, TP22, TP24	7		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone Electronics
TP3, TP4, TP5, TP6	4		Test Point, Multipurpose, White, TH	White Multipurpose Testpoint	5012	Keystone Electronics
TP7, TP8, TP9, TP10, TP11	5		Test Point, Multipurpose, Yellow, TH	Yellow Multipurpose Testpoint	5014	Keystone
TP12, TP15	2		Test Point, Multipurpose, Blue, TH	Blue Multipurpose Testpoint	5127	Keystone Electronics
U1	1		Radiation Tolerant 32-V, 160-mΩ Quad-Channel eFuse	HTSSOP28	TPS7H2140MPWPTSEP	Texas Instruments
U2	1		High-Voltage Ultralow-I(q) Low-Dropout Regulator, DGN0008D (HVSSOP-8)	DGN0008D	TPS7A6650QDGNRQ1	Texas Instruments

5 Additional Information

Trademarks
All trademarks are the property of their respective owners.

6 Related Documentation

- Texas Instruments, Standard Terms for Evaluation Modules

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

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.

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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２４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.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations.* IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

IMPORTANT NOTICE AND DISCLAIMER