User's Guide

SLUUC02–February 2019

TPS65295EVM-079, 4.5-V to 18-V_{IN}, complete DDR4 power solution evaluation module

This user's guide contains information for the TPS65295 as well as support documentation for the TPS65295EVM-079 evaluation module. Included are the performance specifications, schematic, and the List of Materials.

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1 Introduction

The TPS65295 device provides a complete power solution for DDR4 memory system with the lowest total cost and minimum space. It meets the JEDEC standard for DDR4 power-up and power-down sequence requirement. The TPS65295 integrates two synchronous buck converters (VPP and VDDQ) and a 1-A sink and source tracking LDO (VTT) and a buffered low noise reference (VTTREF). Table 1 displays detailed input and output information.

The TPS65295 employs D-CAP3™ mode coupled with 600-kHz switching frequency for ease-of-use, fast transient, and support for ceramic output capacitors without an external compensation circuit. The VTTREF tracks ½ VDDQ within excellent 0.8% accuracy. The VTT which provides both 1-A sink and source continual current capabilities requires only 10-µF of ceramic output capacitor.

The TPS65295 provides rich functions as well as excellent power supply performance. It supports flexible power state control, placing VTT at high-Z in S3 and discharging VDDQ, VTT, and VTTREF in S4/S5 state. OVP, UVP, OCP, UVLO and thermal shutdown protections are also available. The part is available in a thermally enhanced 18-pin HotRod™ VQFN package and is designed to operate under the –40°C to 125°C junction temperature range.

The evaluation module is designed to provide access to the features of the TPS65295. Some modifications can be made to this module to test performance at different input and output voltages, current and switching frequency. Please contact TI Field Applications Group for advice on these matters.

Table 1. Input Voltage and Output Current Summary

EVM	INPUT VOLTAGE (V_{IN}) Range	OUTPUT CURRENT (I_{OUT}) RANGE
TPS65295EVM-079	4.5 V to 18 V	I_{VDDQ}= 0 A to 8 A, I_{VPP}= 0 A to 1 A, I_{VTT}= 0 A to 1 A

2 Performance Specification Summary

A summary of the TPS65295EVM-079 performance specifications is provided in Table 2. The TPS65295EVM-079 is designed and tested for VIN = 4.5 V to 18V. The Junction temperature is 25°C for all measurements, unless otherwise noted.

Table 2. TPS65295EVM-079 Performance Specifications Summary

PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT
V_{IN}	Input Voltage Range	4.5		18	V
I_{OUT}	Output Current(VDDQ)	0		8	A
	Output Current(VPP)	0		1	
	Output Current(VTT)	0		1	
	Output Current(VTTREF)	0		0.01	
F_{SW}	Switching Frequency(VDDQ)		600		KHz
	Switching Frequency(VPP)		580		
V_{OUT}	VDDQ	1.188	1.2	1.212	V
	VPP	2.45	2.5	2.55	
	VTT		VTTREF		
	VTTREF		1/2VDDQ		

3 Test Setup and Results

This section describes how to properly connect, set up, and use the TPS65295EVM-079. The section also includes test results typical for the evaluation modules.

3.1 Headers Description and Jumper Placement.

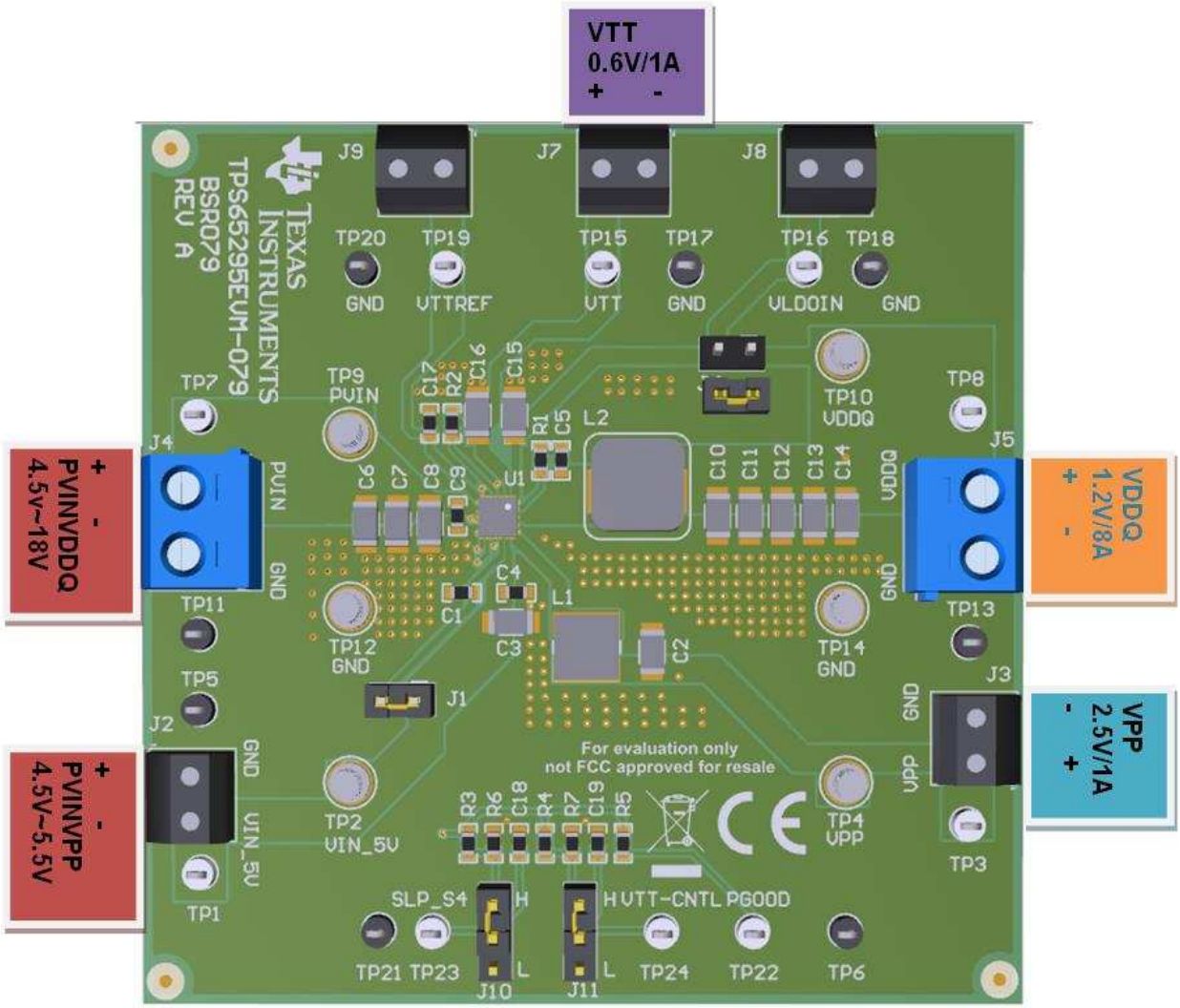

Figure 1. Headers Description and Jumper Placement

3.2 Input/Output Connections

The TPS65295EVM-079 is provided with input/output connectors and test points as shown in Table 4 and Jumpers description shown in Table 3. A power supply capable of supplying greater than 8A must be connected to J1 through a pair of 20-AWG wires or better. The load must be connected to J2 through a pair of 20-AWG wires or better. The maximum load current capability is 8 A. Wire lengths must be minimized to reduce losses in the wires.

Table 3. Jumpers

#	FUNCTIONS	COMMENT
J1	Connects the PVIN_VPP and VCC_5V	Need to jump if share the same power for PVIN_VPP and VCC_5V
J6	Connects the VLDOIN and VDDQ	Need to jump when no external VLDOIN exists on J8
J8	External VLDOIN 1.2V Input for VTT power input	It is for test, leave NA if not use
J10	VPP and VDDQ buck enable	SLP_S4# pin
J11	VTT enable	VTT_CNTL pin

Buck converter outputs are white and have a label for each location. Close to any of these test points there are black ground test points to allow for DVM measurement or to use a metal exposed scope probe to reduce common mode noise measurements. All test points are described in the following Table 4.

Table 4. Connection and Test Points

TP#	NAME	SIGNAL	COLOR
TP1	VIN_5V	VCC_5V input or test point for PVIN_VPP	White
TP2	VIN_5V	VCC_5V input or test point for PVIN_VPP	Silver
TP3	VPP	Output voltage for VPP	White
TP4	VPP	Output voltage for VPP	Silver
TP5	GND	GND	Black
TP6	GND	GND	Black
TP7	PVIN	VDDQ Buck power input test point	White
TP8	VDDQ	Output voltage for VDDQ	White
TP9	PVIN	VDDQ Buck power input test point	Silver
TP10	VDDQ	Output voltage for VDDQ	Silver
TP11	GND	GND	Black
TP12	GND	GND	Silver
TP13	GND	GND	Black
TP14	GND	GND	Silver
TP15	VTT	Output voltage for VTT	White
TP16	VLDOIN	VLDOIN input or test point	White
TP17	GND	GND	Black
TP18	GND	GND	Black
TP19	VTTREF	Output voltage for VTTREF	White
TP20	GND	GND	Black
TP21	GND	GND	Black
TP22	PGOOD	Power good signal	White
TP23	SLP_S4#	VPP and VDDQ buck enable	White
TP24	VTT_CNTL	VTT enable	White

3.3 Start-Up Procedure

1. Jump the J10 and J11 accordingly or connect external drive signals to the TP23 and TP24.
2. Jump J1 and J6 accordingly
3. Connect loadings to the output connectors.
4. Apply proper DC voltage to J2 and J4. If PVIN_VPP and VCC_5V share same power supply, apply the power at J4 first, and then apply J2. If PVIN_VPP and VCC_5V don't share same power supply, apply the power at J4 and J2 first, and then apply the J2-2 for VCC_5V.
5. Check the outputs.

3.4 Load Transient Response

The TPS65295EVM-079 VDDQ and VPP response to load transient is shown in Figure 1 and Figure 3. The current steps and slew rates are indicated in the figures. Total peak-to-peak voltage variation is as shown.

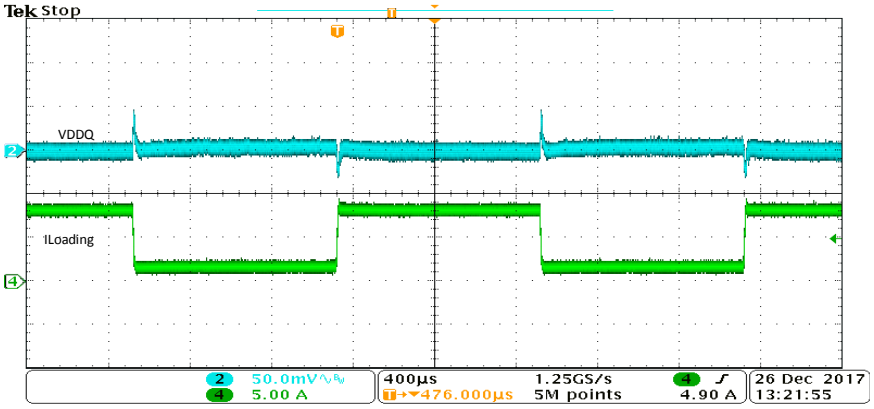

Figure 2. TPS65295EVM-079 VDDQ transient response with 1.6-8A loading, 2.5A/us

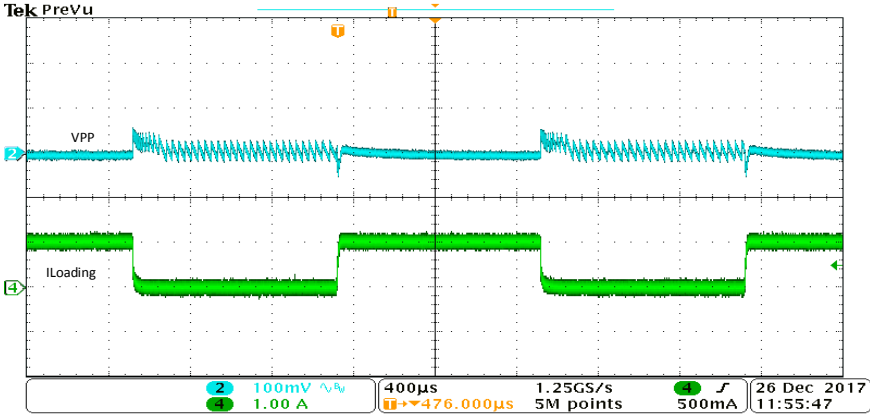

Figure 3. TPS65295EVM-079 VPP transient response with 0.01-1A loading, 2.5A/us

3.5 Output Voltage Ripple

The TPS65295EVM-079 output voltage ripple is shown in Figure 4, and Figure 5. The output currents are as indicated.

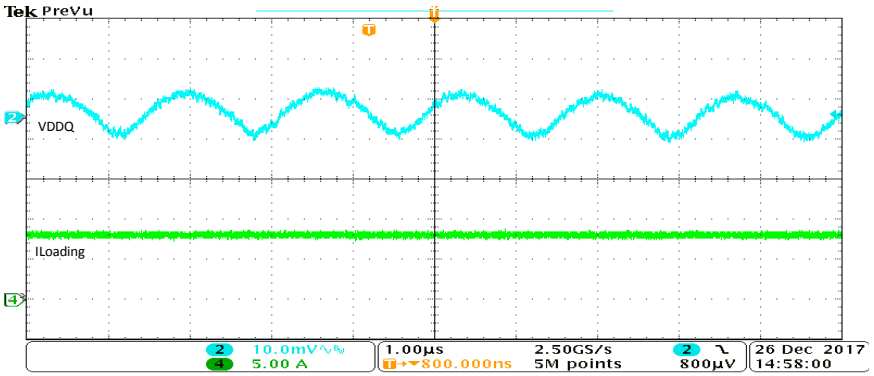

Figure 4. TPS65295EVM-079 VDDQ Ripple, I_{OUT} = 8 A

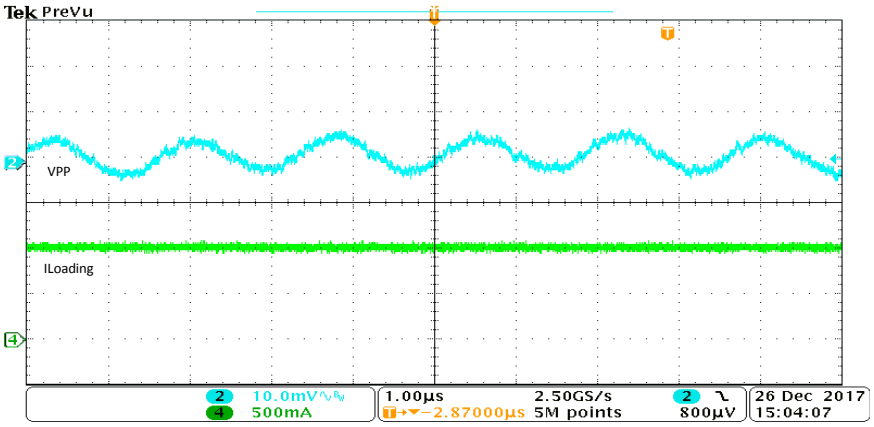

Figure 5. TPS65295EVM-079 VPP Ripple, I_{OUT} = 1 A

3.6 Power-Up

The TPS65295EVM-079 power up waveform relative to SLP_S4 is shown in Figure 6.

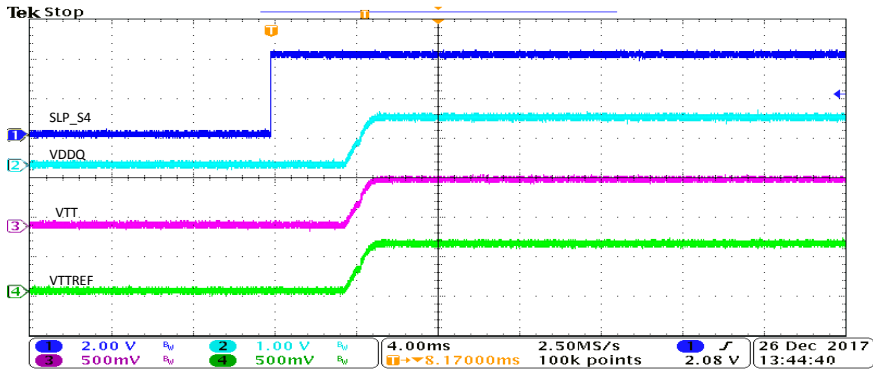

Figure 6. TPS65295EVM-079 Power Up Relative to SLP_S4

3.7 Power-Down

The TPS65295EVM-079 power down waveform relative to SLP_S4 is shown in Figure 7.

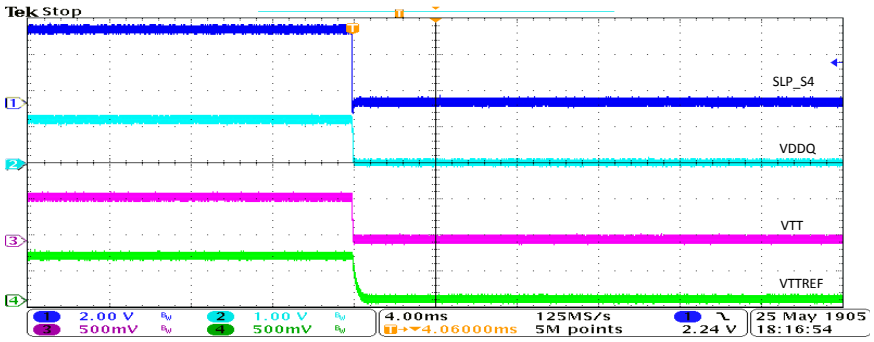

Figure 7. TPS65295EVM-079 Power Down Relative to SLP_S4

4 Board Layout

This section provides a description of the TPS65295EVM-079 board layout and layer illustrations.

This section provides a description of the TPS65295EVM-079 board layout and layer illustrations. The board layout for the TPS65295EVM-079 is shown in Figure 9 ~ Figure 12. The top and bottom are 2-oz. copper and internal layers are 1-oz. copper.

- Place the decoupling capacitors right across PVIN, PVIN_VPP, and VLDOIN as close as possible.
- Place output inductors and capacitors with IC at the same layer, SW routing should be as short as possible to minimize EMI, and should be a width plane to carry big current, enough vias should be added to the PGND connection of output capacitor and also as close to the output pin as possible. Reserve some space between VDDQ choke and VPP choke, just minimize radiation crosstalk.
- Place BST resistor and capacitor with IC at the same layer, close to BST and SW plane, >15mil width trace is recommended to reduce line parasitic inductance.
- VPPSNS/VDDQSNS/VTTSNS could be 10mil and must be routed away from the switching node, BST node or other high efficiency signal.
- PVIN and PVIN_VPP trace must be wide to reduce the trace impedance and provide enough current capability.
- Output capacitors for VTT and VTTREF should be put as close as output pin.
- For the TPS65295, an additional input bulk capacitor may be required, depending on the EVM connection to the input supply.

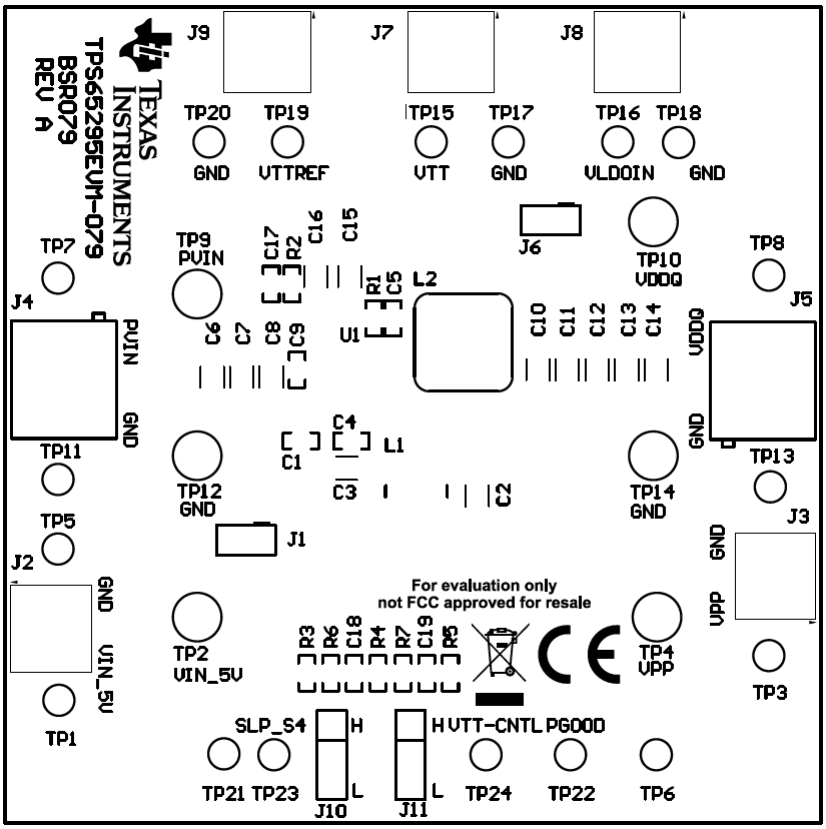

Figure 8. Top Assembly

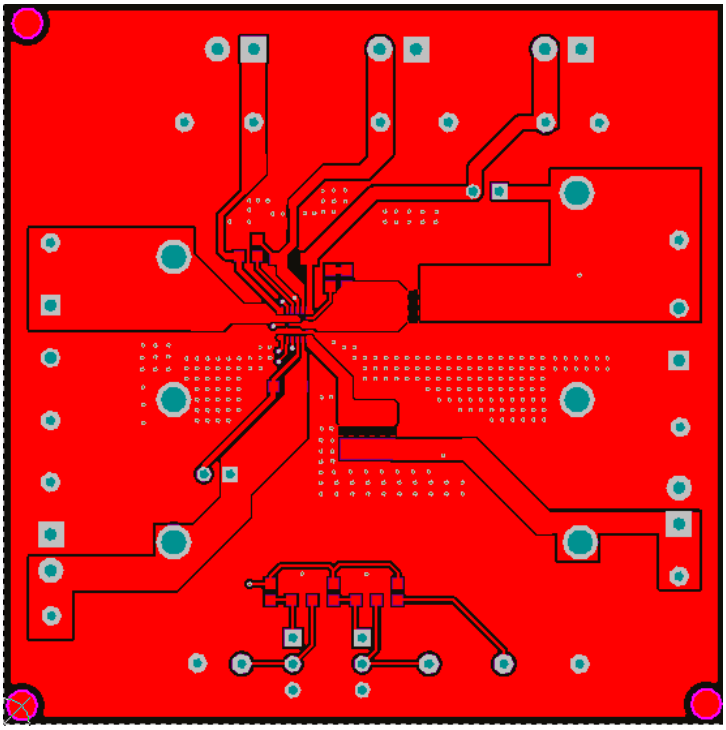

Figure 9. Top Layer

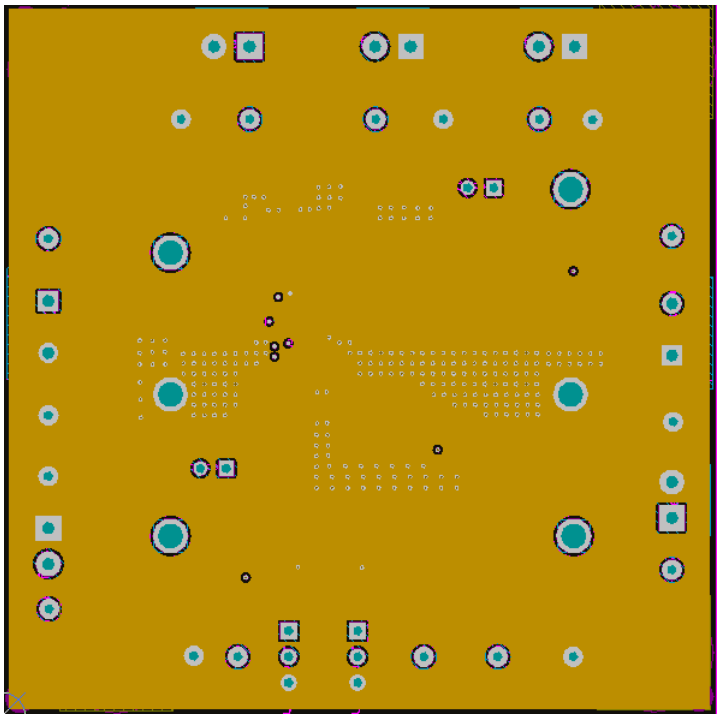

Figure 10. Inner1 Layer

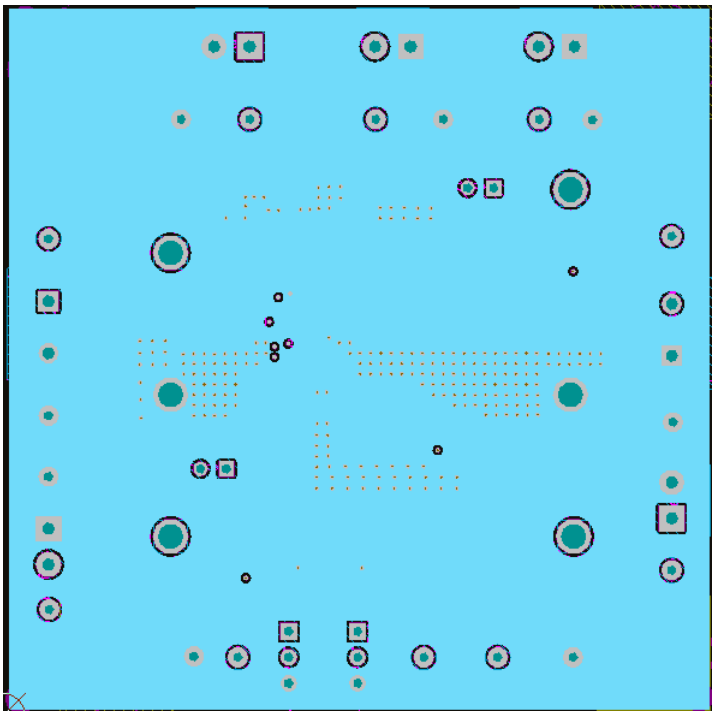

Figure 11. Inner2 Layer

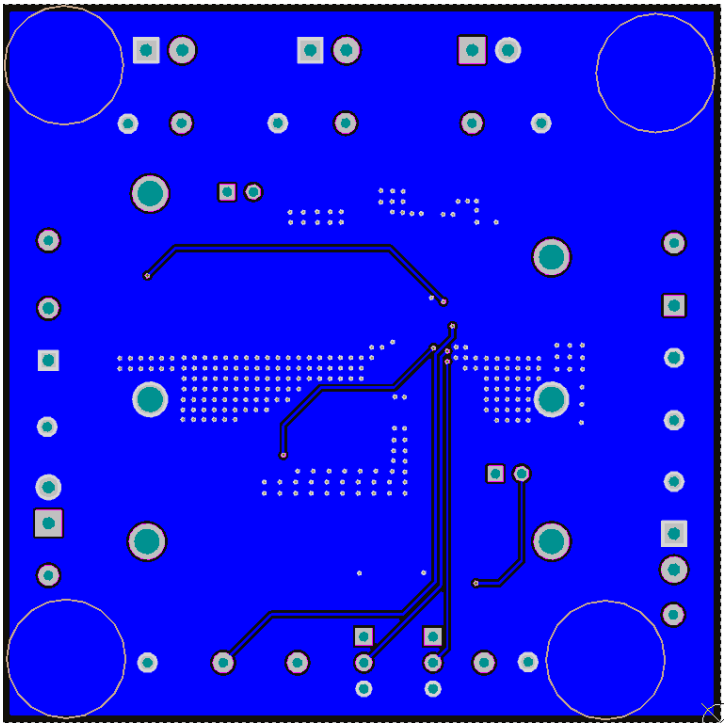

Figure 12. Bottom Layer

5 Board Profile, Schematic, List of Materials and Reference

5.1 Board Profile

Figure 13 is the top view for the TPS65295EVM-079.

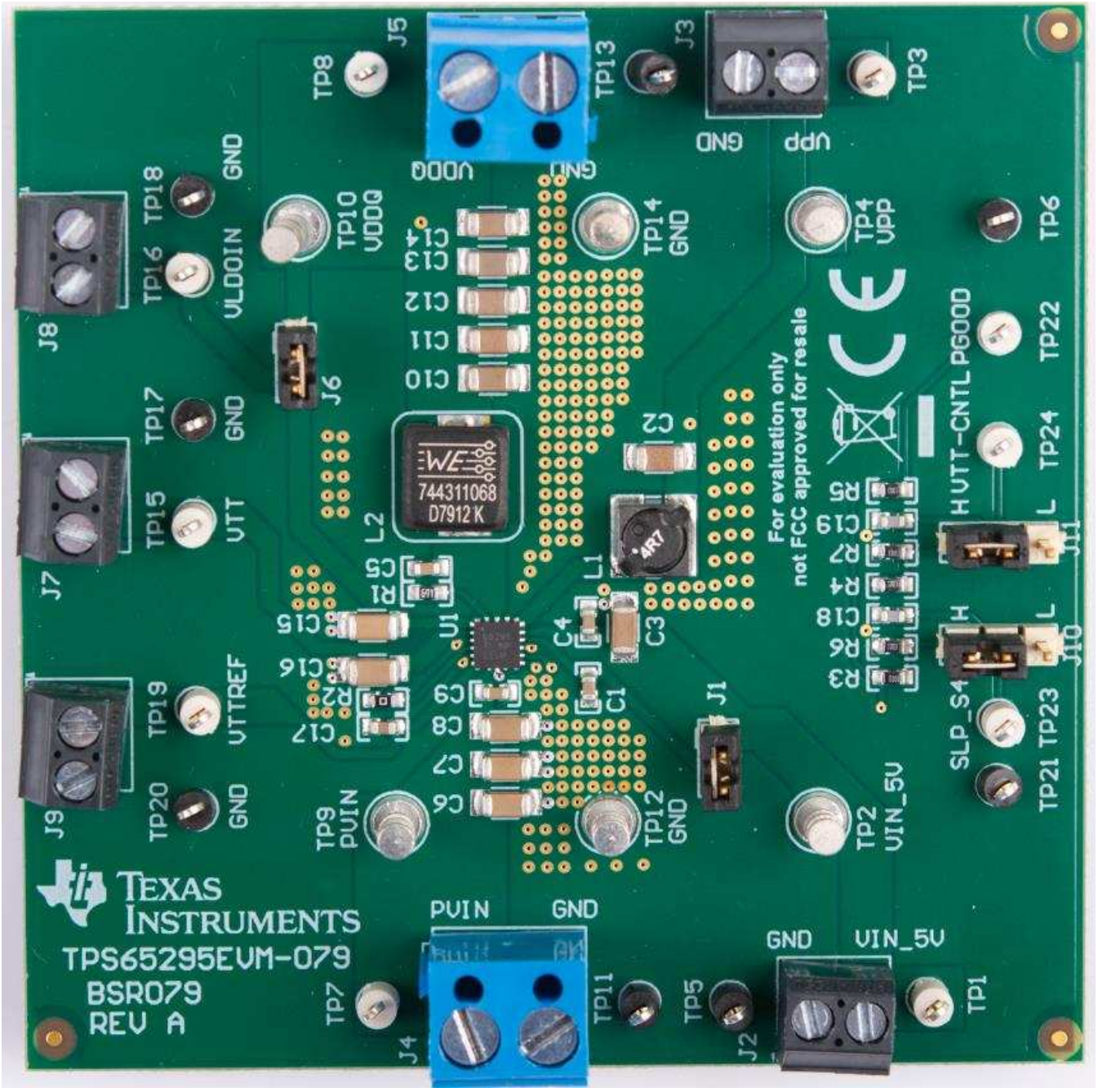

Figure 13. Top View of TPS65295EVM-079

Figure 14 is the bottom view for the TPS65295EVM-079.

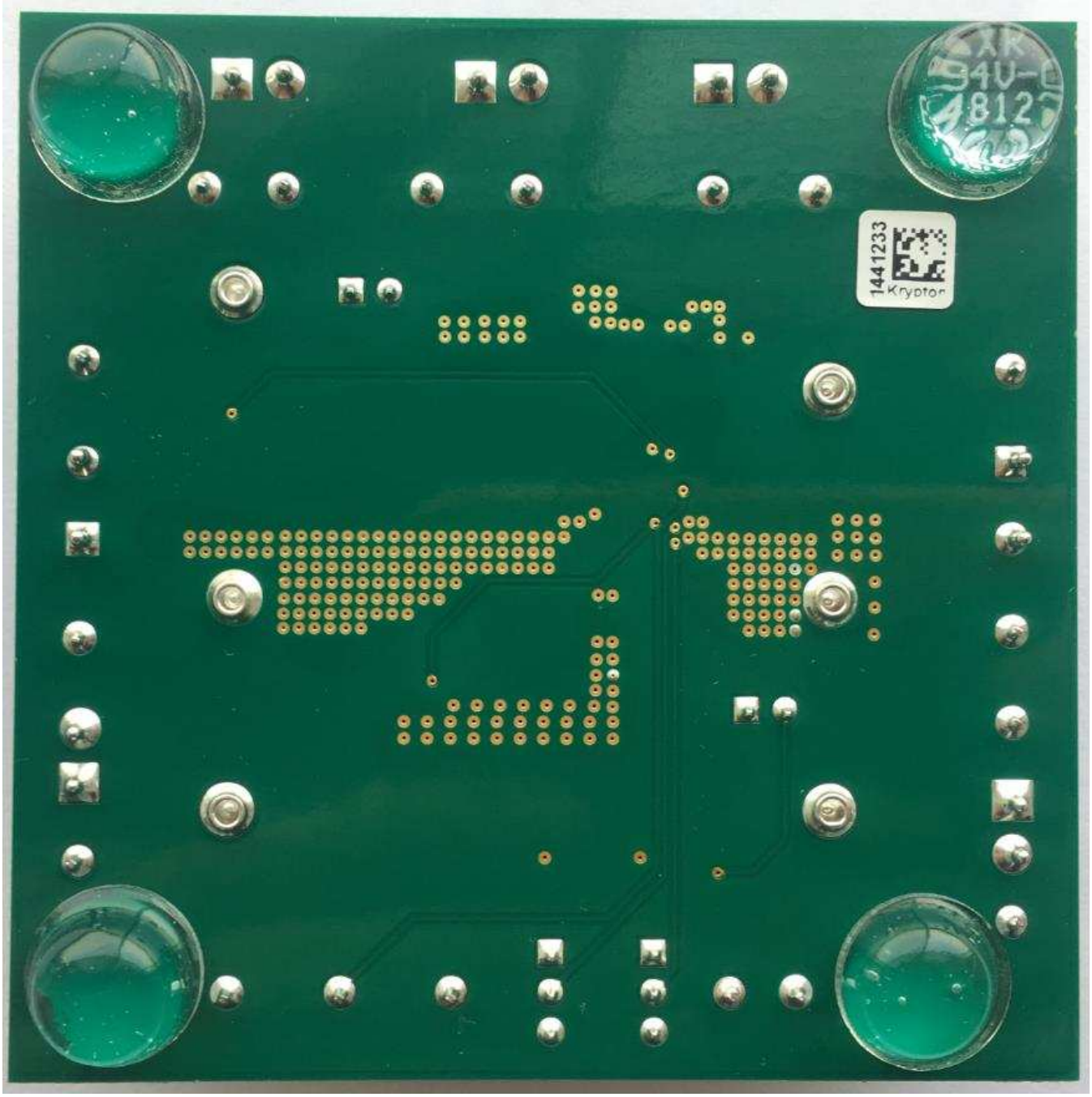

Figure 14. Bottom View of TPS65295EVM-079

5.2 Schematic

Figure 15 is the schematic for the TPS65295EVM-079.

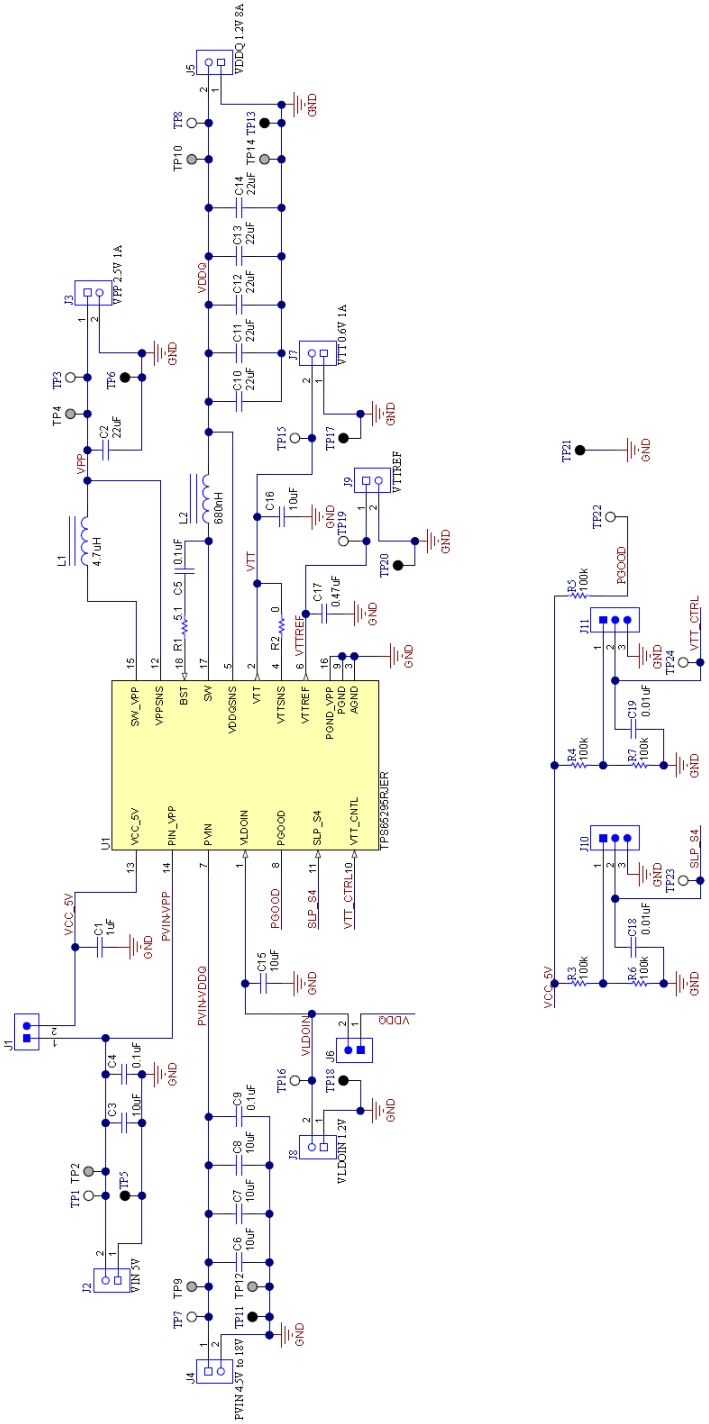

Figure 15. TPS65295EVM-079 Schematic

5.3 List of Materials

Table 5 displays the TPS65295EVM-079 bill of materials.

Table 5. List of Materials

DESIGNATOR	QUANTITY	DESCRIPTION	PART NUMBER	MANUFACTURER
PCB	1	Printed Circuit Board	BSR079	
C1	1	Capacitor, ceramic, 1 µF, 25 V, ±10%, X7R, 0603	C1608X7R1E105K080AB	TDK
C2, C10, C11, C12, C13, C14	6	Capacitor, ceramic, 22 µF, 10 V, ±10%, X7R, 1206	GRM31CR71A226KE15L	MuRata
C3, C15, C16	3	Capacitor, ceramic, 10 µF, 10 V, ±10%, X7R, 1206	GRM31CR71A106KA01L	MuRata
C4, C5, C9	3	Capacitor, ceramic, 0.1 µF, 50 V, ±10%, X7R, 0603	C1608X7R1H104K080AA	TDK
C6, C7, C8	3	Capacitor, ceramic, 10 µF, 35 V, ±20%, X5R, 1206	C3216X5R1V106M160AB	TDK
C17	1	Capacitor, ceramic, 0.47 µF, 50 V, ±10%, X7R, 0603	C1608X7R1H474K080AC	TDK
C18, C19	2	Capacitor, ceramic, 0.01 µF, 50 V, ±5%, X7R, 0603	C0603C103J5RACTU	Kemet
H1, H2, H3, H4	4	Bumpon, hemisphere, 0.44 X 0.20, Clear	SJ-5303 (CLEAR)	3M
J1, J6	2	Header, 100mil, 2x1, tin, TH, 2 PIN	PEC02SAAN	Sullins Connector Solutions
J2, J3, J7, J8, J9	5	Terminal block, 3.5 mm pitch, 2x1, TH	ED555/2DS	On-Shore Technology
J4, J5	2	Terminal block, 5.08 mm, 2x1, Brass, TH	ED120/2DS	On-Shore Technology
J10, J11	2	Header, 100 mil, 3x1, Gold, TH	PBC03SAAN	Sullins Connector Solutions
L1	1	Inductor, shielded drum core, ferrite, 4.7 µH, 2.2 A, 0.045 Ω, SMD	74408943047	Wurth Elektronik
L2	1	Inductor, shielded drum core, Superflux, 680 nH, 17 A, 0.0035 ohm, SMD	744311068	Wurth Elektronik
R1	1	Resistor, 5.1 Ω, 5%, 0.1 W, 0603	CRCW06035R10JNEA	Vishay-Dale
R2	1	Resistor, 0 Ω, 5%, 0.1 W, 0603	RC0603JR-070RL	Yageo
R3, R4, R5, R6, R7	5	Resistor, 100 k Ω, 5%, 0.1 W, 0603	CRCW0603100KJNEA	Vishay-Dale
SH-J1, SH-J2, SH-J3, SH-J4	4	Shunt, 100 mil, gold plated, black, 1x2	SNT-100-BK-G	Samtec
TP1, TP3, TP7, TP8, TP15, TP16, TP19, TP22, TP23, TP24	10	Test point, miniature, white, TH	5002	Keystone
TP2, TP4, TP9, TP10, TP12, TP14	6	Terminal, turret, TH, triple	1598-2	Keystone
TP5, TP6, TP11, TP13, TP17, TP18, TP20, TP21	8	Test point, miniature, black, TH	5001	Keystone
U1	1	Complete DDR4 memory power solution, RJE0018B (VQFN-HR-18)	TPS65295RJER	Texas Instruments
FID1, FID2, FID3	0	Fiducial mark. There is nothing to buy or mount		
Notes: Unless otherwise noted in the Alternate PartNumber and/or Alternate Manufacturer columns, all parts may be substituted with equivalents.				

5.4 Reference

1. *TPS65295, 4.5-18Vin, Complete DDR4 Synchronous Step-Down Voltage Regulator* Datasheet (SLUSDK5)

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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   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。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

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。http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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.

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