TPS62060EVM-663

This user's guide describes the characteristics, operation, and use of the TPS62060 evaluation module (EVM). The TPS62060EVM-663 is a fully assembled and tested platform for evaluating the performance of the TPS62060 1.6-A step-down converter. This document includes schematic diagrams, printed-circuit board (PCB) layout, bill of materials, and test data. Throughout this document, the abbreviations *EVM*, *TPS62060EVM*, and the term *evaluation module* are synonymous with the TPS62060EVM-663 unless otherwise noted.

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1 Introduction

The TPS62060EVM-663 is a fully assembled and tested PCB for evaluating the TPS62060 1.6-A step-down converter.

1.1 Features

- Input voltage range: 2.7 V to 6 V
- Adjustable output voltage: 0.8 V to VIN
- Up to 1.6-A output current
- Power Save mode/ 3-MHz fixed-PWM mode
- Clock dithering

1.2 TPS62060 Applications

The TPS62060 step-down converters are ideal for these applications:

- POL
- Notebooks, pocket personal computers
- Portable media players
- DSP supply

2 Electrical Performance Specifications

Table 1 summarizes the TPS62060EVM performance specifications.

Table 1. TPS62060EVM Performance Characteristics

Parameter	Symbol	Notes and Conditions	Min	Typ	Max	Units
Input Characteristics						
Input Voltage	VIN		2.7		6	V
Input Undervoltage Lockout (UVLO)	V_{IN_UVLO}	Falling	1.73	1.78	1.83	V
		Rising	1.9	1.95	1.99	V
Output Characteristics						
Line Regulation				0		%/V
Load Regulation				–0.5		%/A
Output Current	I_{OUT}	VIN = 2.7 V to 6 V			1600	mA
Forward Current Limit High-Side and Low Side MOSFET	I_{LIMF}	VIN = 2.7 V to 6 V	1800	2250	2700	mA
Systems Characteristics						
Switching Frequency	f_{SW}	VIN = 2.7 V to 6 V, MODE = High	2600	3000	3400	kHz
Peak Efficiency	η_{pk}	VIN = 3.3 V, MODE = Low			91.0	%
Full Load Efficiency	η	VIN = 5 V, VOUT = 1.8 V, I_{OUT} = 1600 mA		83.3		%

3 TPS62060EVM Schematic

Figure 1 shows the TPS62060EVM schematic.

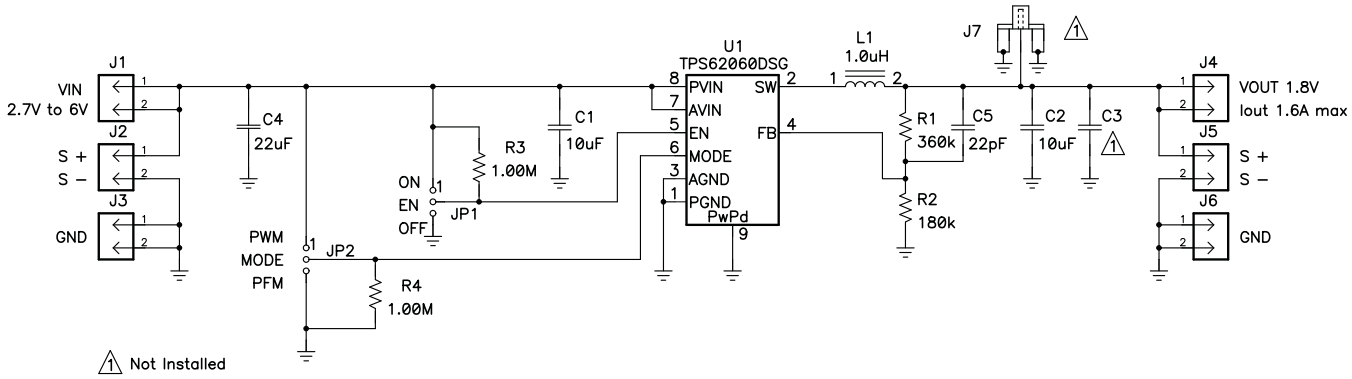


Figure 1. TPS62060EVM Schematic

NOTE: Figure 1 is provided for reference only. See the bill of materials (Table 2) for specific component values.

4 Connector and Test Point Descriptions

4.1 Enable Jumpers/Switches: TPS62060EVM

4.1.1 J1 – VIN

This header is the positive connection to the input power supply. The power supply must be connected between J1 and J3 (GND). Twist the leads to the input supply, and keep them as short as possible. The input voltage must be between 2.7 V and 6 V.

4.1.2 J2 – S+/S–

J2 S+/S– are the sense connections for the input of the converter. Connect a voltmeter, or the sense connection of a power supply or oscilloscope, to this header.

4.1.3 J3 – GND

This header is the return connection to the input power supply. Connect the power supply between J3 and J1 (VIN). Twist the leads to the input supply, and keep them as short as possible. The input voltage must be between 2.7 V and 6 V.

4.1.4 J4 – VOUT

This header is the positive output of the step-down converter. The output voltage of the TPS62060 is adjustable with feedback resistors R1 and R2. On the EVM, the output voltage is set to 1.8 V by default.

NOTE: A feed-forward capacitor C5 is required. Refer to the TPS62060 data sheet (SLVSA95) for detailed information.

4.1.5 J5 – S+/S–

J5 S+/S– are the sense connections for the output of the converter. Connect a voltmeter, or the sense connection of an electronic load or oscilloscope, to this header.

4.1.6 J6 – GND

J6 is the return connection of the converter. A load can be connected between J6 and J4 (V_{OUT}). The converter is capable of carrying a load current up to 1600 mA.

4.1.7 JP1 – EN

This jumper enables/disables the TPS62060 on the EVM. Shorting jumper JP1 between the center pin and *On* turns on the unit. Shorting the jumper between center pin and *Off* turns off the unit. A 1-MΩ pullup resistor is connected between VIN and EN. Removing jumper JP1 turns on the converter.

4.1.8 JP2 – MODE

This jumper enables/disables the power-saving mode under light loads. Shorting jumper JP2 between the center pin and PWM disables the power-saving mode. If the power-save mode is disabled, the converter operates in forced PWM mode over the entire load current range. Shorting the jumper between the center pin and PFM enables the power-saving mode. The device operates in power-saving mode under light load conditions. See the TPS62060 data sheet (SLVSA95) for a detailed description of this configuration. A 1-MΩ pulldown resistor is connected between GND and MODE. By removing JP2, the converter operates in power-saving mode under light-load conditions.

4.1.9 J7 – VOUT (SMA)

This SMA connector is connected to the output voltage of the TPS62060. It can be used to easily analyze the noise spectrum of the output voltage with a spectrum analyzer. By default, J7 is not assembled on the EVM.

5 Test Configuration

5.1 Hardware Setup

Figure 2 illustrates a typical hardware test configuration.

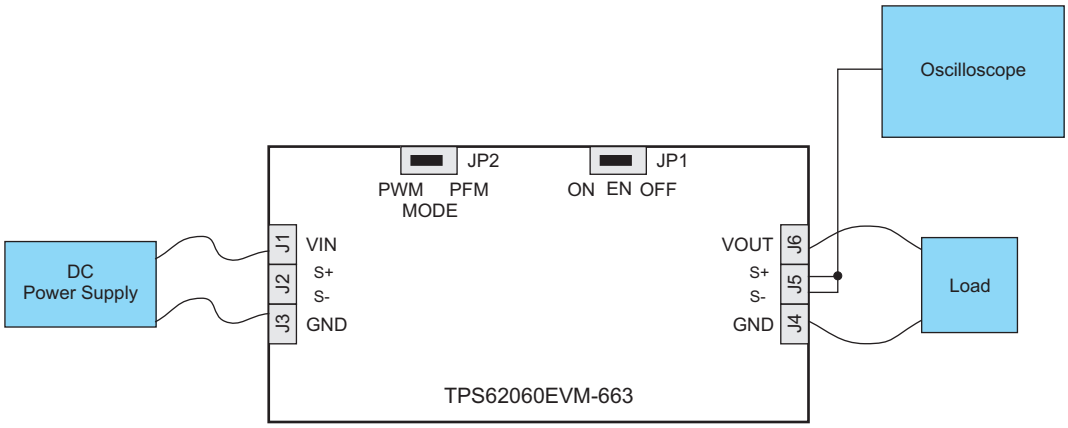


Figure 2. Hardware Board Connection

5.2 Testing Procedure

Follow these procedures when configuring the EVM for testing.

CAUTION

Many of the components on the TPS62060EVM-663 are susceptible to damage by electrostatic discharge (ESD). Customers are advised to observe proper ESD-handling precautions when unpacking and handling the EVM, including the use of a grounded wrist strap, bootstraps, or mats at an approved ESD workstation. An electrostatic smock and safety glasses also are recommended.

1. Connect a dc power supply between J1 and J3 on the TPS62060EVM. Note that the input voltage must be between 2.7 V and 6 V. Keep the wires from the input power supply to the EVM as short as possible and twisted.
2. Connect a dc voltmeter or oscilloscope to J5, the output sense connection of the EVM.
3. A load can be connected between J4 and J6 on the TPS62060EVM.
4. To enable the converter, connect the shorting bar on JP1 between EN and ON located on the TPS62060EVM.
5. The TPS62060EVM has a feature to allow the user to switch between Power-Save mode under light loads and forced PWM mode; this feature is enabled or disabled with jumper JP2.

6 TPS62060EVM Test Data

Figure 3 through Figure 15 present typical performance curves for the TPS62060EVM. Actual performance data can be affected by measurement techniques and environmental variables; therefore, these curves are presented for reference and may differ from actual results obtained by some users.

6.1 Efficiency

Figure 3 and Figure 4 show the typical efficiency performance for the TPS62060EVM.

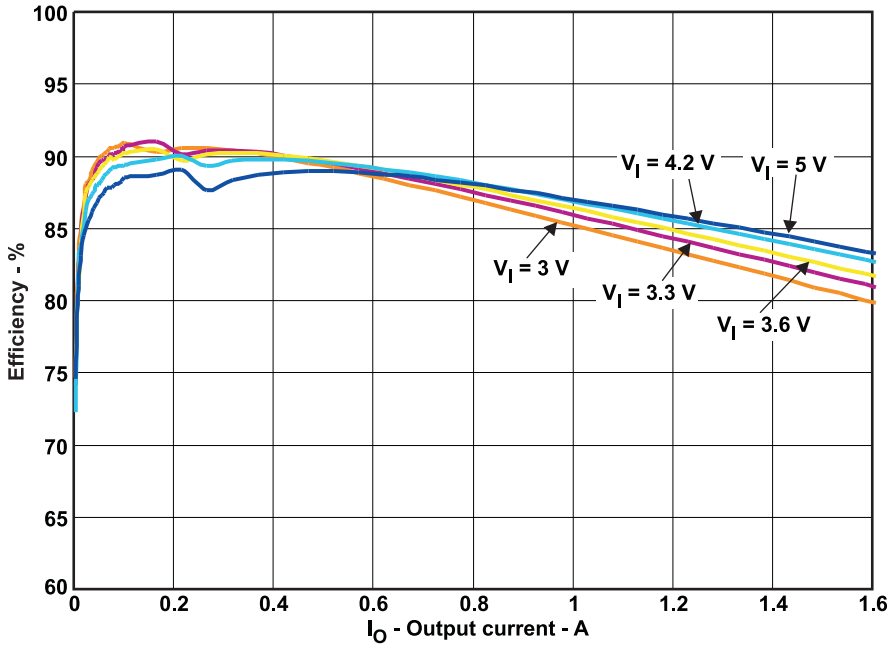


Figure 3. TPS62060 Efficiency vs Load Current, PFM Mode

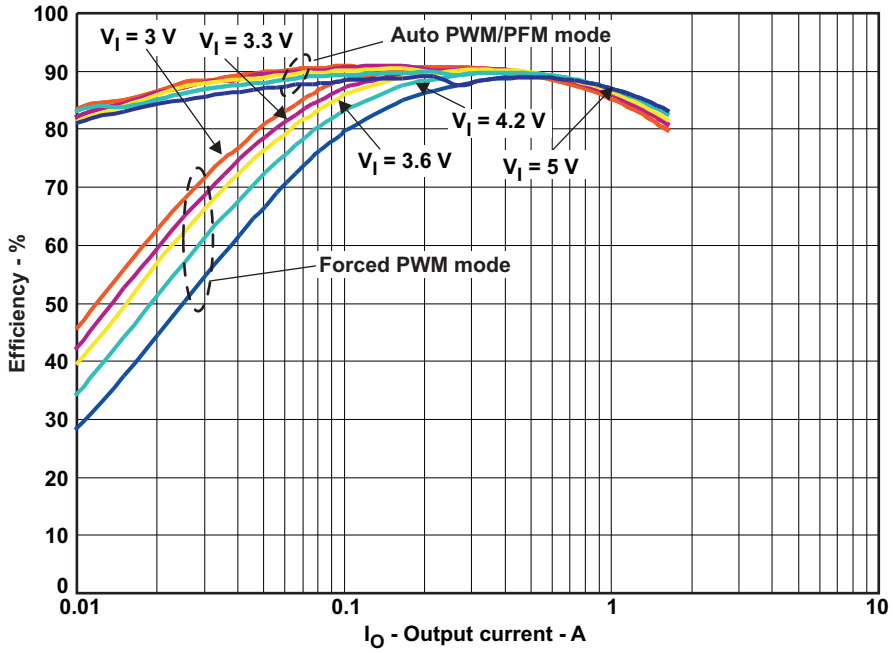
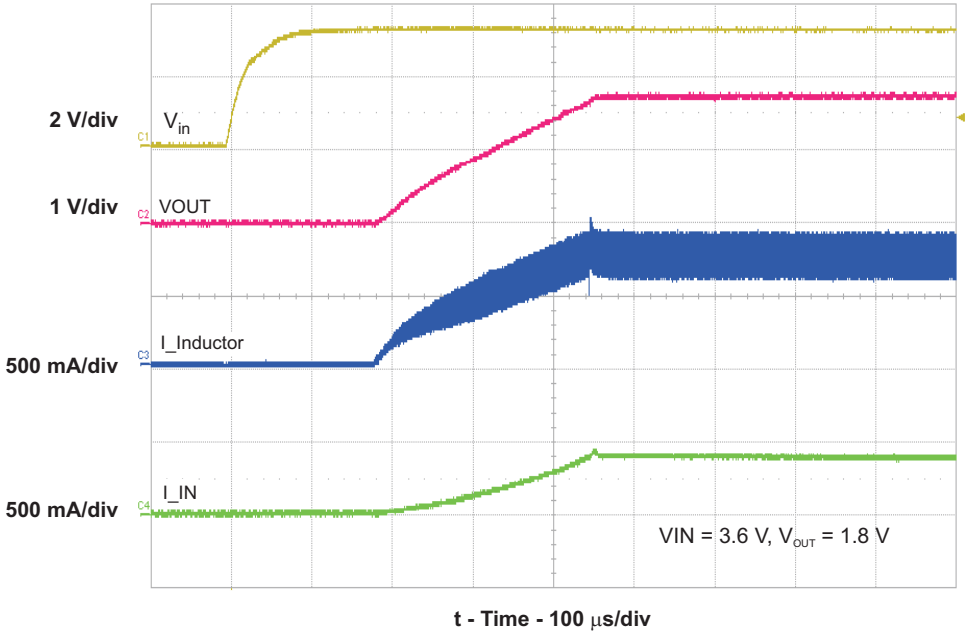


Figure 4. TPS62060 Efficiency vs Load Current

6.2 Start-up

Figure 5 and Figure 6 show the typical start-up performance for the TPS62060EVM.



Conditions: VIN = 3.6 V, V_{OUT} = 1.8 V

Figure 5. TPS62060 Start-up Into 2.2-Ω Load

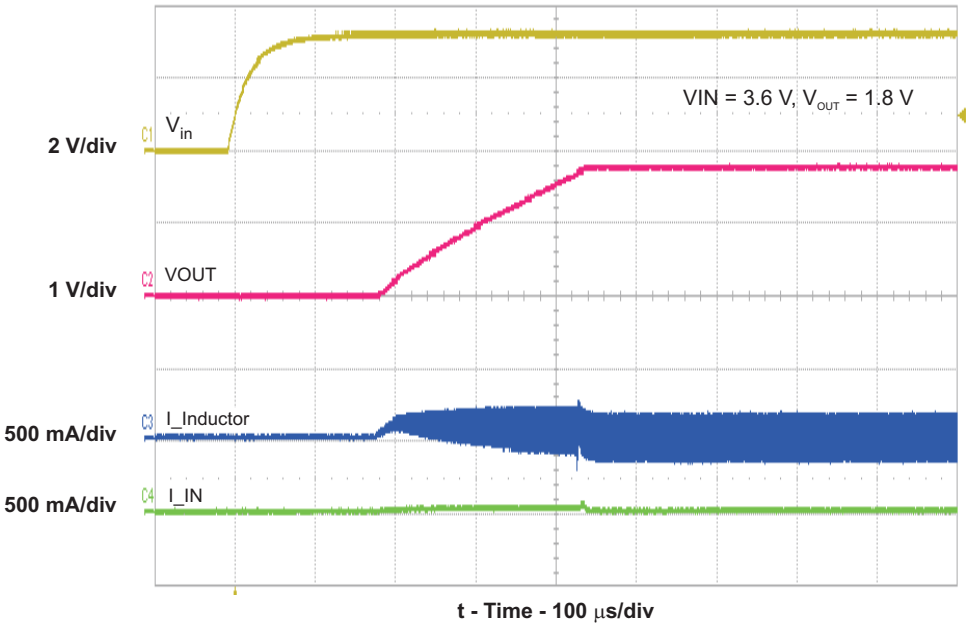
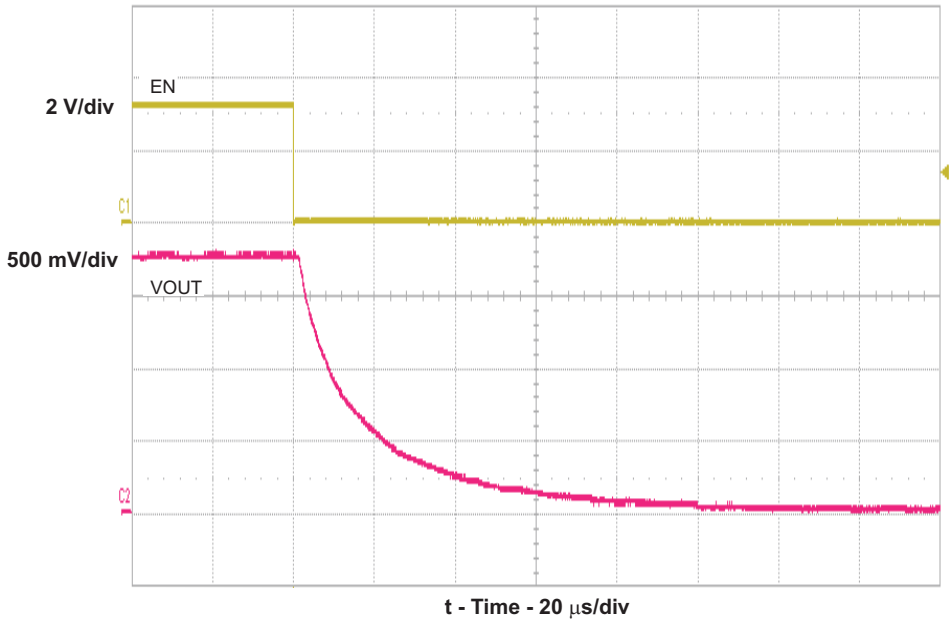


Figure 6. TPS62060 Start-up With No Load

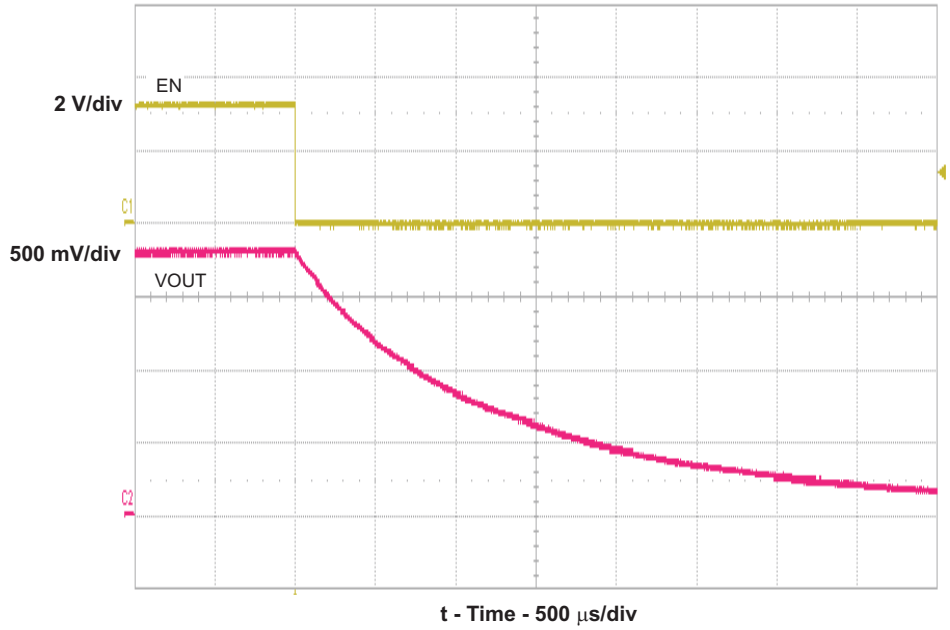
6.3 Shutdown

Figure 7 and Figure 8 illustrate the typical shutdown behavior for the TPS62060EVM.



Conditions: VIN = 3.6 V, V_{OUT} = 1.8 V

Figure 7. TPS62060 Shutdown Into 2.2-Ω Load



Conditions: VIN = 3.6 V, V_{OUT} = 1.8 V

Figure 8. TPS62060 Shutdown With No Load

6.4 Output Voltage Ripple

Figure 9 and Figure 10 show the typical output voltage ripple for the TPS62060EVM in PFM and PWM modes, respectively.

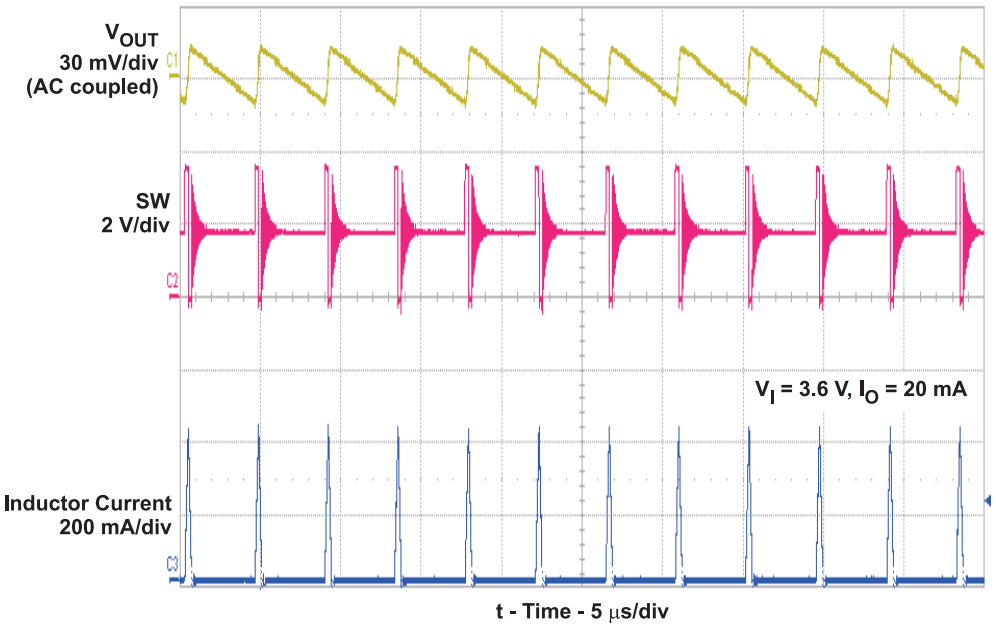


Figure 9. TPS62060 Output Voltage Ripple, PFM Mode

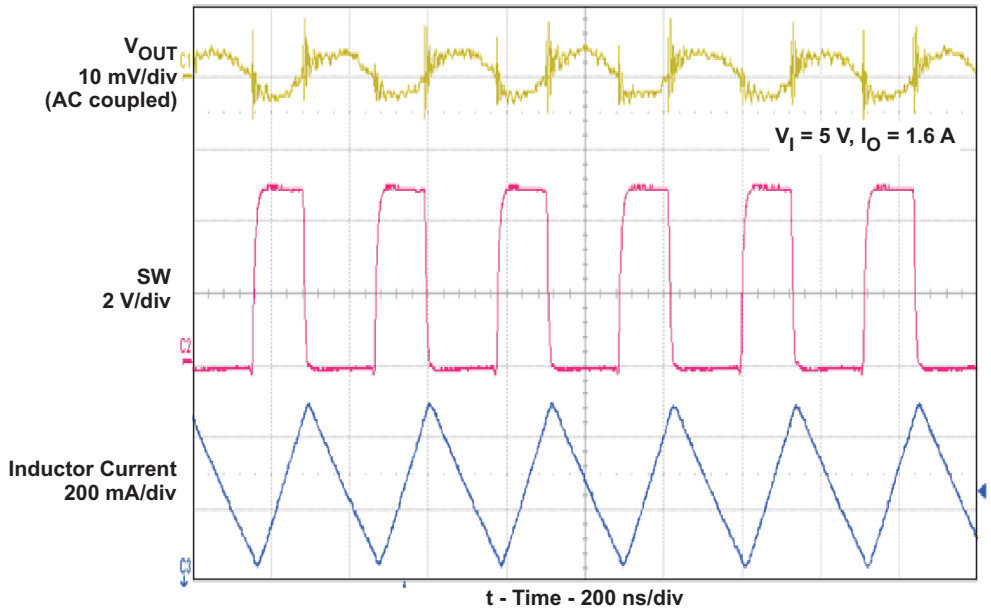


Figure 10. TPS62060 Output Voltage Ripple, PWM Mode

6.5 Input Voltage Ripple

Figure 11 shows the typical input voltage ripple for the TPS62060EVM at 3.6 V in and 1.6 A load.

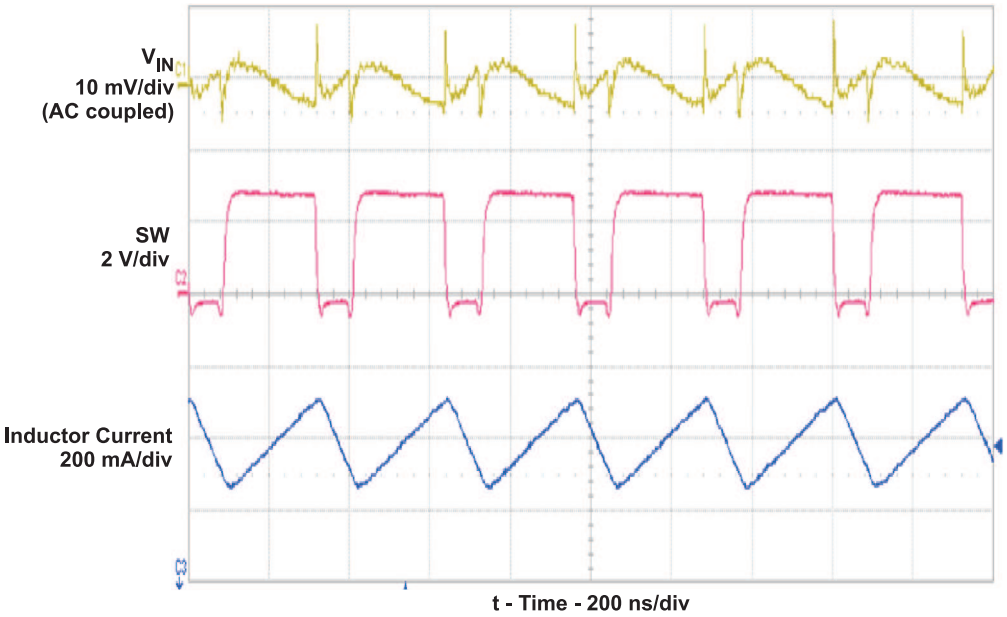
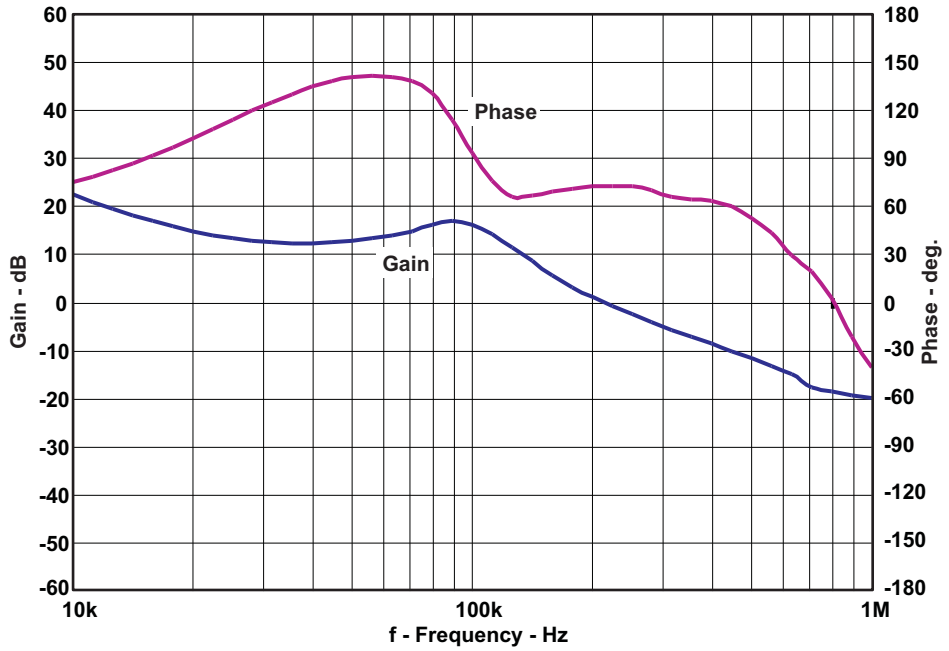


Figure 11. TPS62060 Input Voltage Ripple

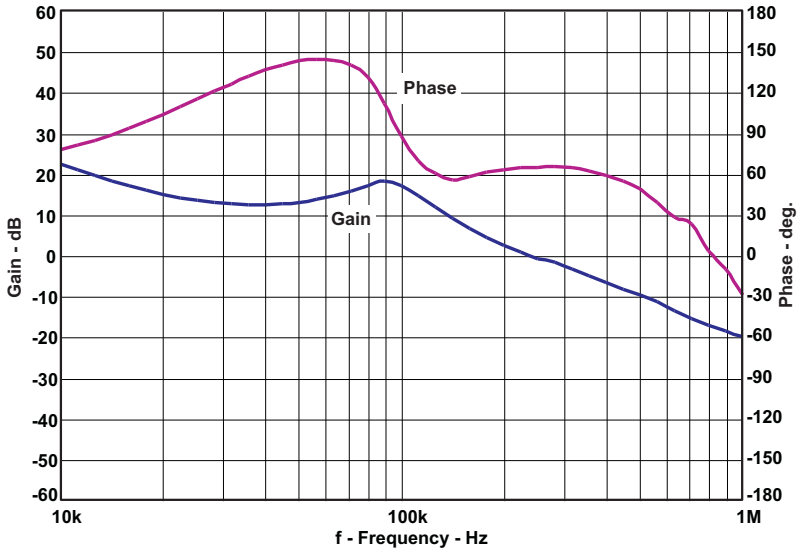
6.6 Control Loop Bode Diagrams

Figure 12 and Figure 13 illustrate typical TPS62060EVM gain and phase performance versus frequency at VIN = 3.6 V and 5 V, respectively.



Conditions: VIN = 3.6 V, VOUT = 1.8 V, I_{OUT} = 1.6 A; bandwidth: 213 kHz, phase margin: 73°

Figure 12. TPS62060 Gain and Phase vs Frequency



Conditions: VIN = 5 V, VOUT = 1.8 V, I_{OUT} = 1.6 A; bandwidth: 241 kHz, phase margin: 66°

Figure 13. TPS62060 Gain and Phase vs Frequency

6.7 Transient Performance

Figure 14 and Figure 15 show the load transient response of the TPS62060EVM in PFM and PWM modes, respectively.

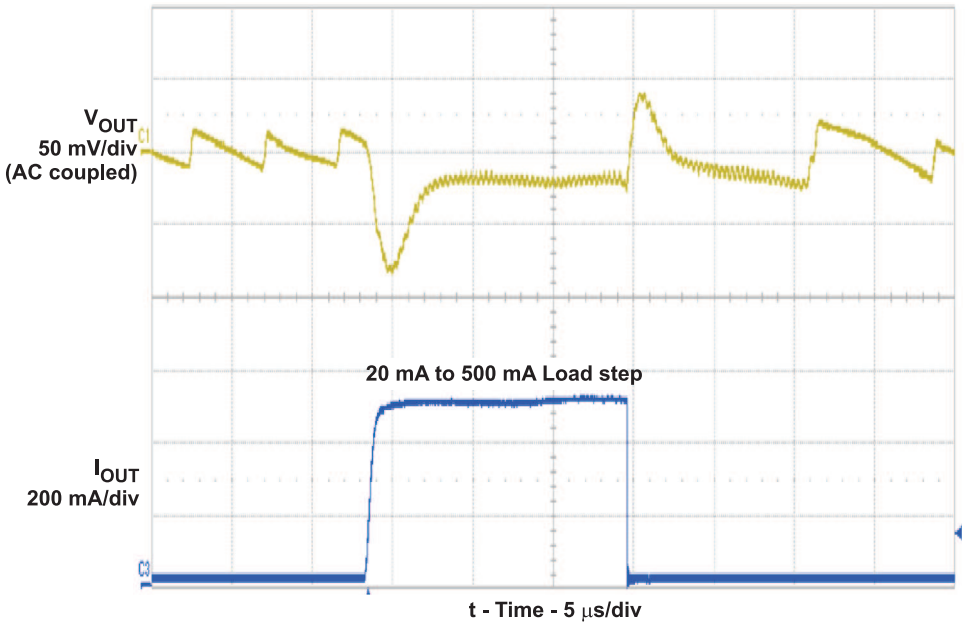


Figure 14. TPS62060 Transient Response, PFM Mode

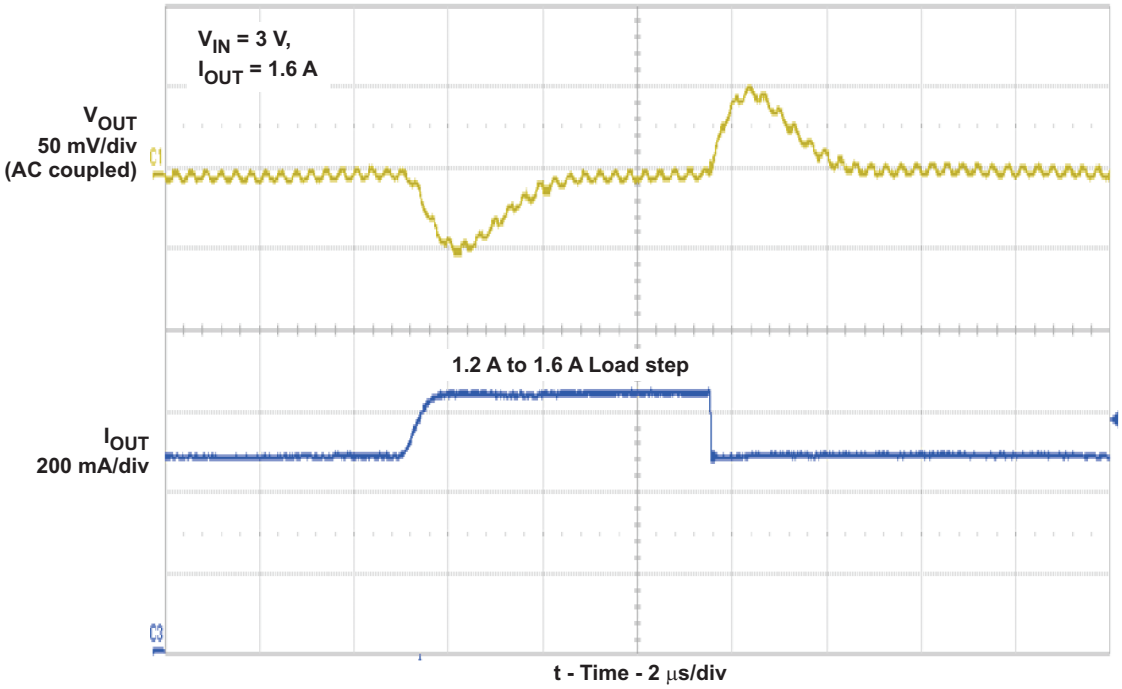


Figure 15. TPS62060 Transient Response, PWM Mode

7 TPS62060EVM Thermal Performance

Figure 16 shows a thermal picture of the TPS62060EVM operating at the full rated load of 1.6 A at an input voltage of 3 V.

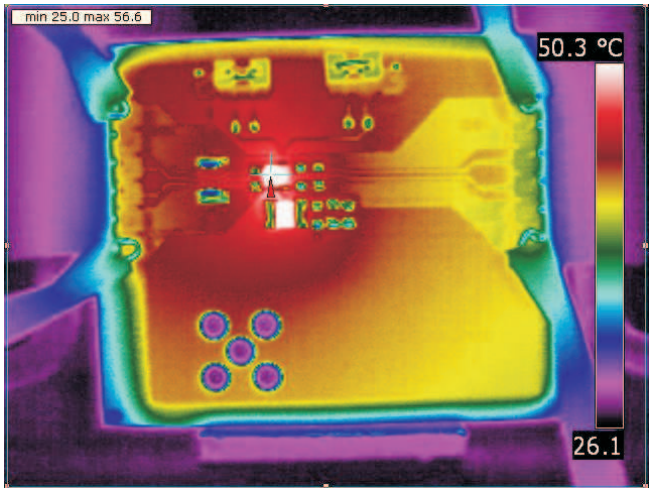


Figure 16. TPS62060EVM Thermal Performance

8 TPS62060EVM Assembly Drawings and Layout

Figure 17 through Figure 21 show the design of the TPS62060EVM-663 printed-circuit board. This EVM has been designed using a four-layer, 1-ounce, copper-clad PCB (1.8 in.by 1.5 in.) with all components in an active area on the top side of the board. All active traces are routed on the top and bottom layers to allow the user to easily view, probe, and evaluate the TPS62060 control integrated circuit (IC) in a practical, double-sided application environment. Moving components to both sides of the PCB or using additional internal layers can offer additional size reduction for space-constrained systems.

NOTE: Board layouts are not to scale. These figures are intended to show how the board is laid out; they are not intended to be used for manufacturing TPS62060EVM-663 PCBs.

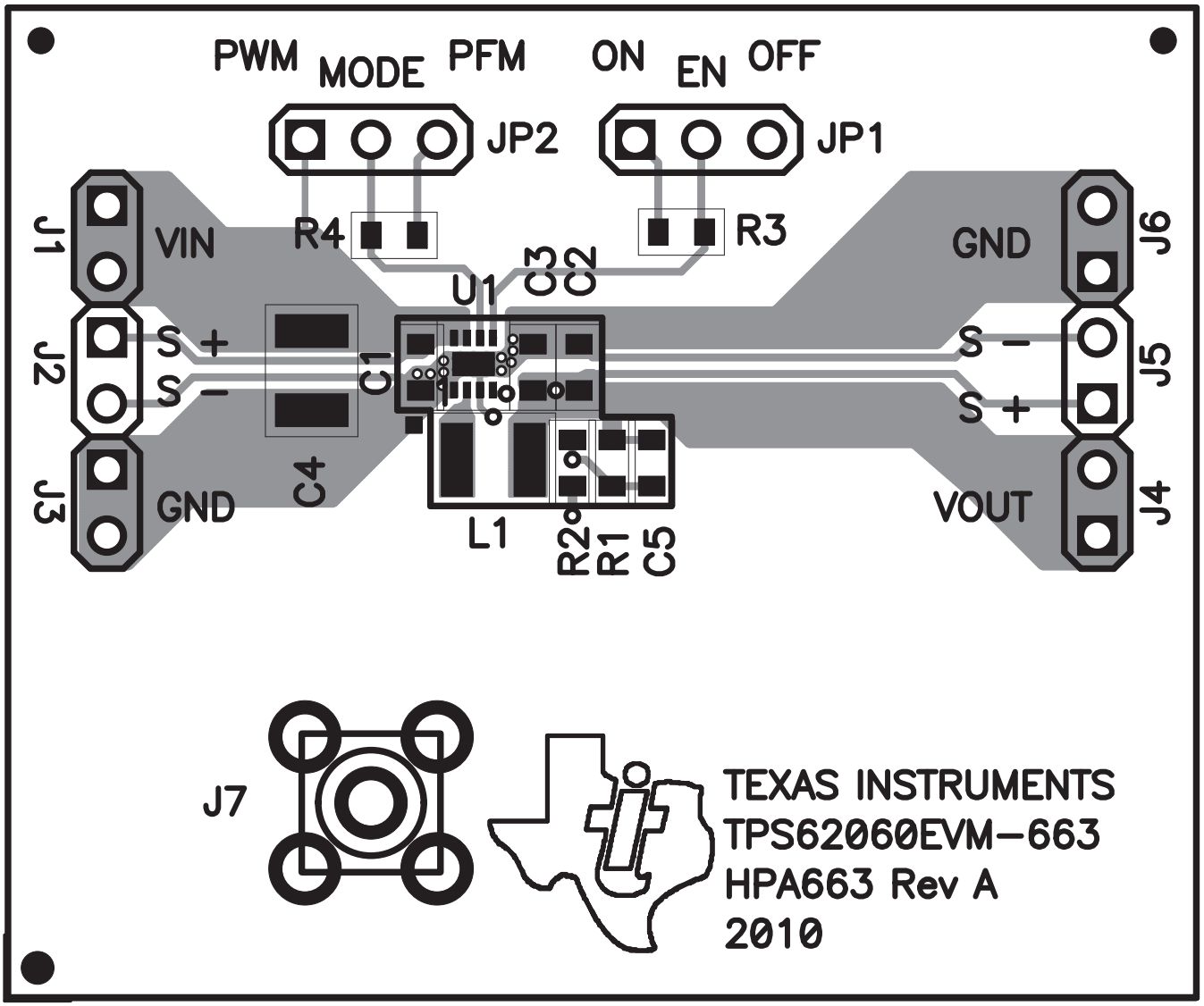


Figure 17. TPS62060EVM Component Placement, Top View

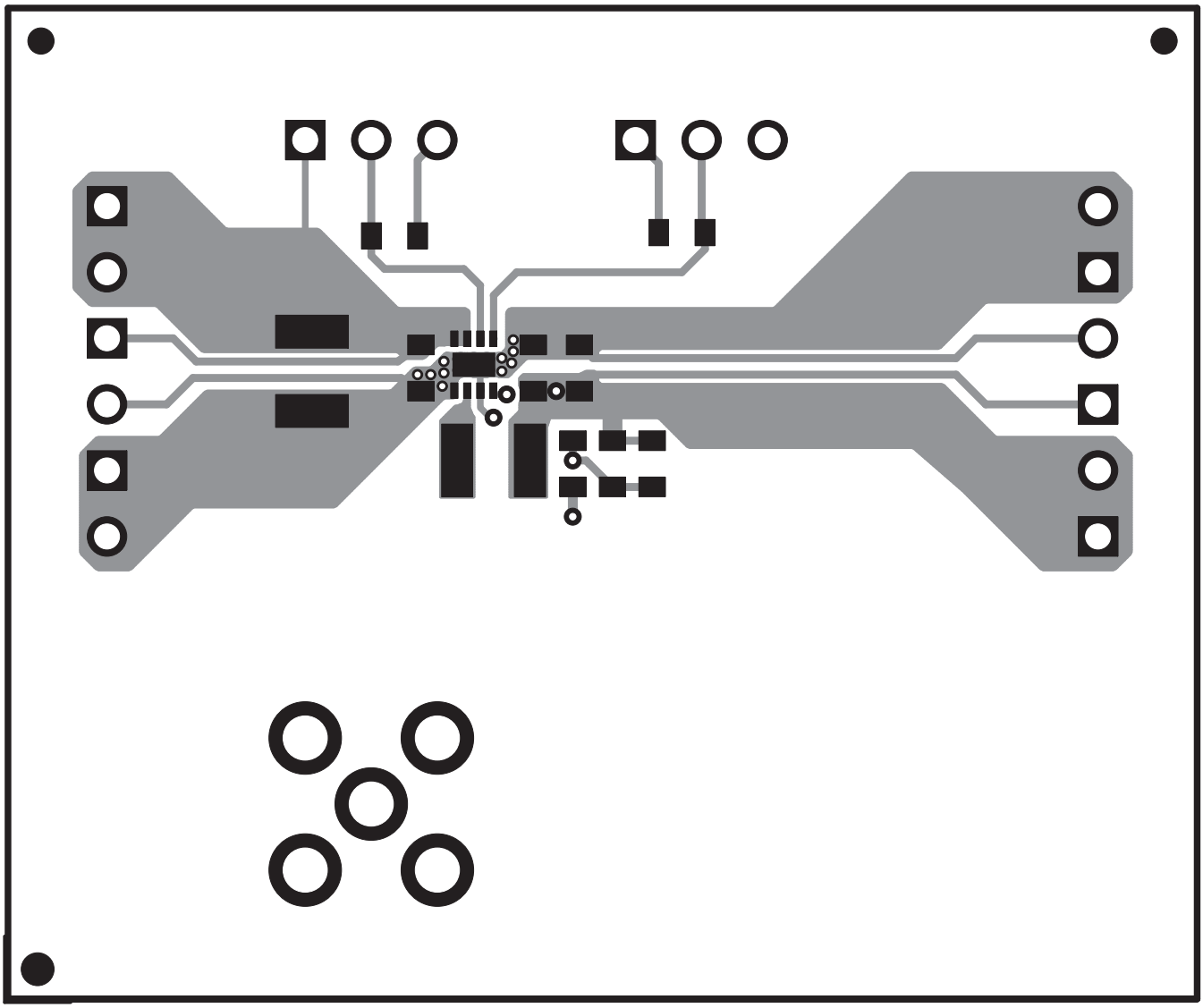


Figure 18. TPS62060EVM Top-Side Copper, Top View

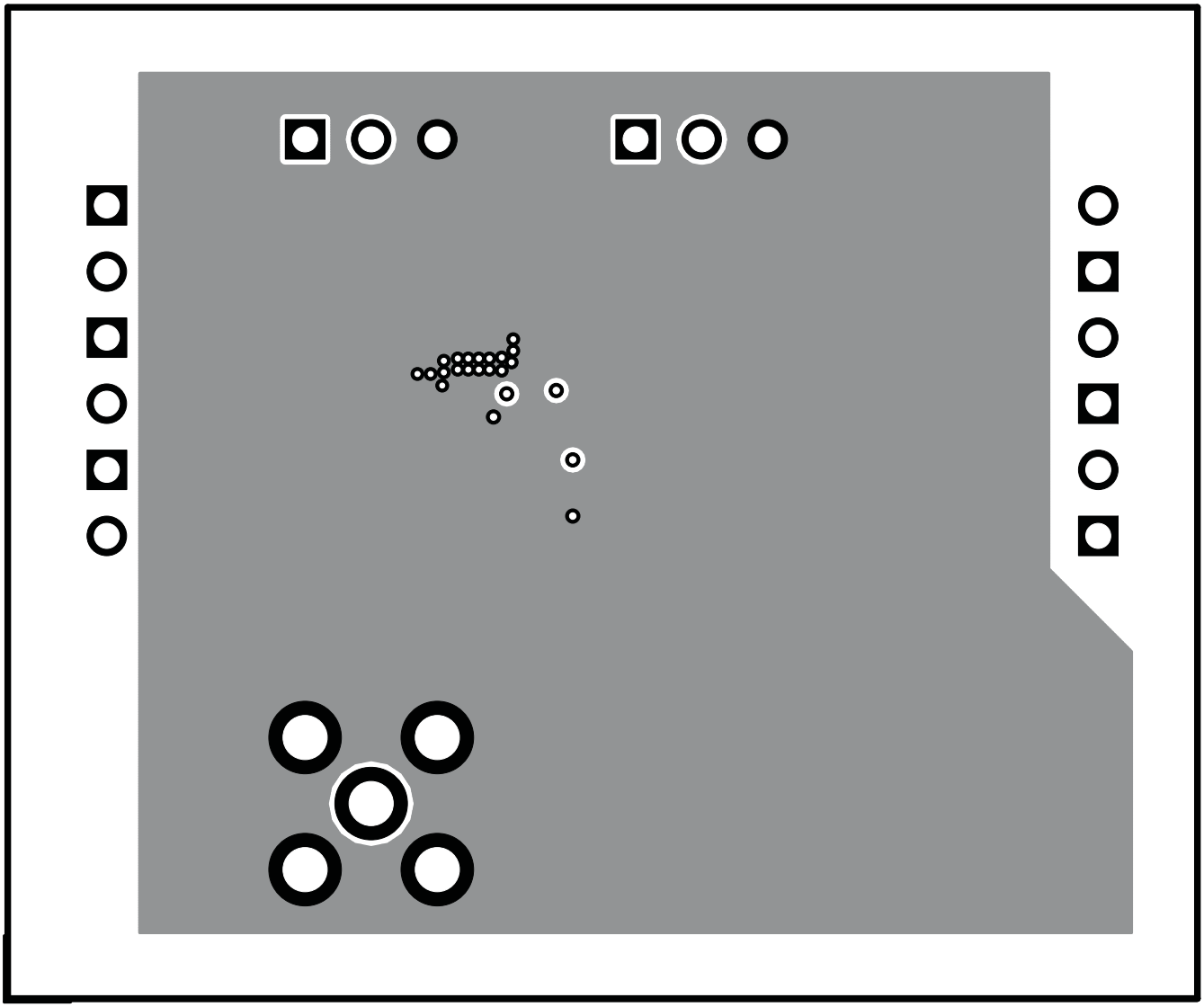


Figure 19. TPS62060EVM Internal Layer 1, X-Ray View From Top

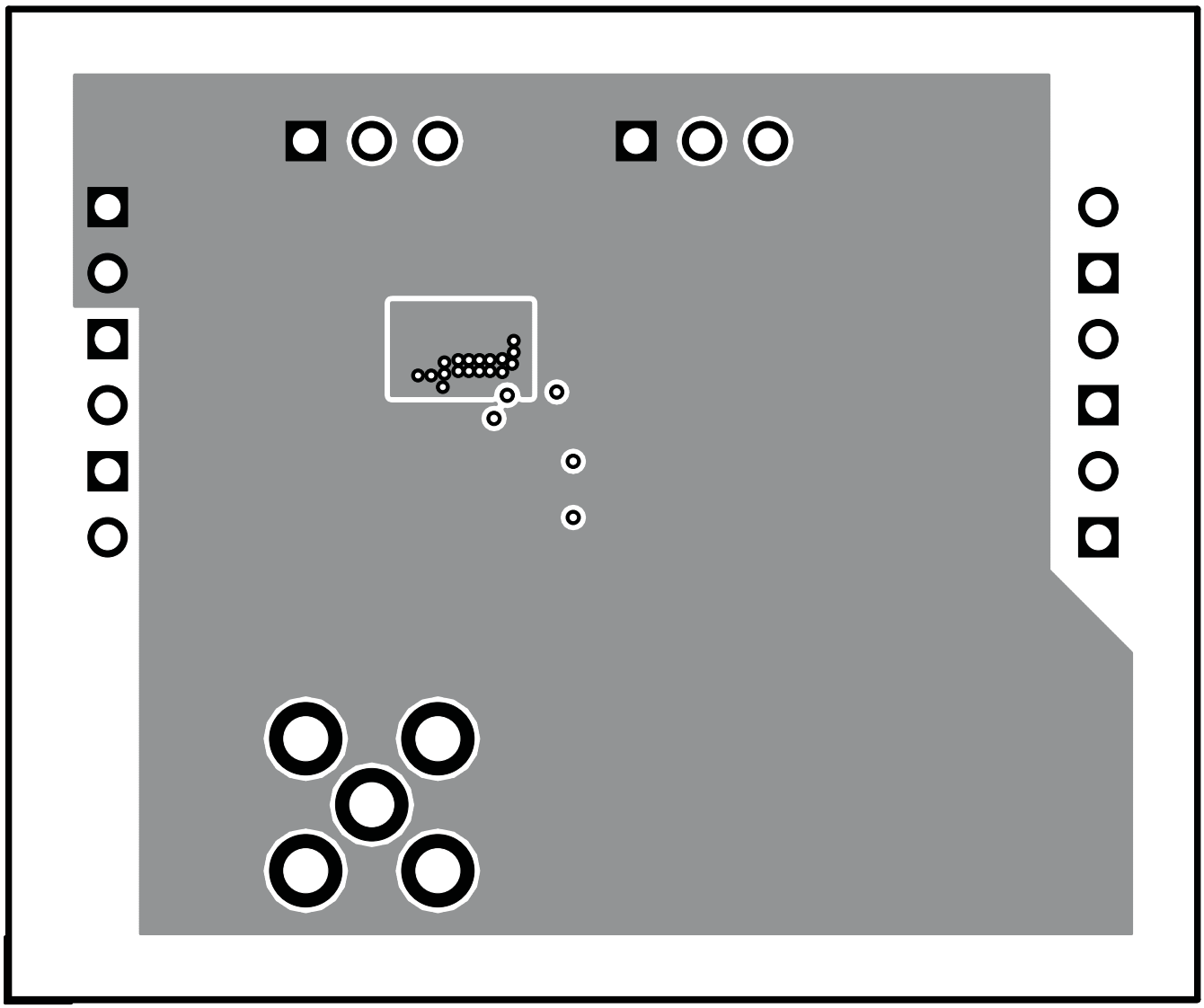


Figure 20. TPS62060EVM Internal Layer 2, X-Ray View From Top

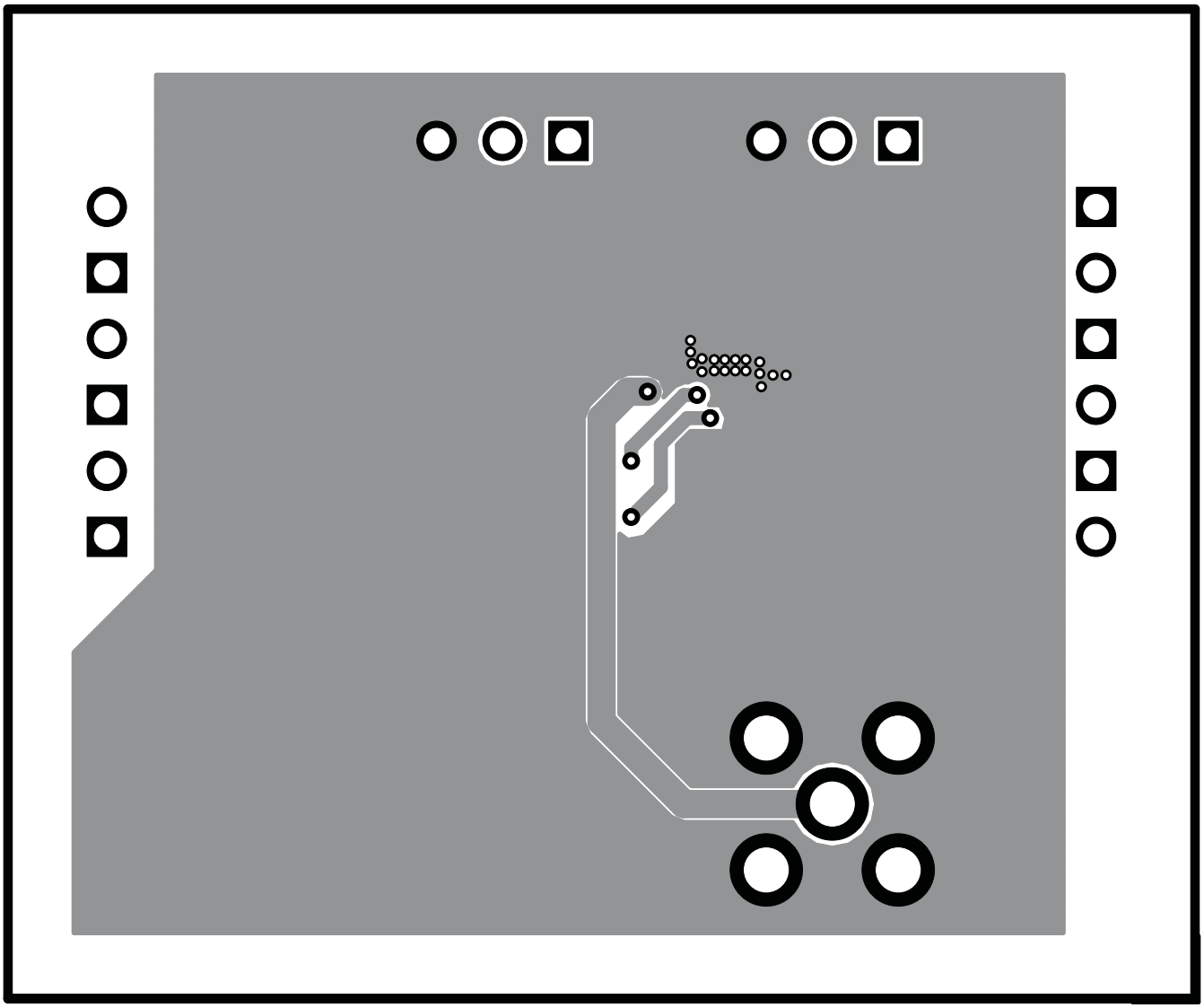


Figure 21. TPS62060EVM Bottom-Side Copper, Bottom View

9 Bill of Materials

Table 2 lists the bill of materials for the TPS62060EVM.

Table 2. TPS62060EVM Bill of Materials

Count	RefDes	Value	Description	Size	Part Number	MFR
2	C1, C2	10uF	Capacitor, Ceramic, 6.3V, X5R, 20%	0603	Std	Std
1	C4	22uF	Capacitor, Ceramic, 10V, X5R, 20%	1210	Std	Std
1	C5	22pF	Capacitor, Ceramic, 50V, NPO, 5%	0603	Std	Std
1	L1	1.0 uH	Inductor, SMT Multi-layer, 1.8A, 40 milliohm	3225	MIPS3225D1R0	FDK
1	R1	360k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R2	180k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	R3, R4	1.00M	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	U1	TPS62060DSG	IC, Step-Down Converter, 3MHz, 1.6A	SON-8	TPS62060DSG	TI

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EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 2.7 V to 6 V and the output voltage range of 0.8 V to 6 V .

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 60° C. The EVM is designed to operate properly with certain components above 60° C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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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:

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CAUTION

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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.

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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