

TPS6269xEVM-076 Evaluation Module

This user's guide describes the characteristics, operation, and use of the TPS6269xEVM-076 evaluation module (EVM). The TPS6269xEVM-076 is a fully assembled and tested platform for evaluating the performance of the TPS6269x high-frequency, synchronous, step-down dc-dc converters optimized for battery-powered portable applications. This document includes schematic diagrams, a printed circuit board (PCB) layout, bill of materials, and test data. Throughout this document, the abbreviations *EVM*, *TPS6269xEVM*, and the term *evaluation module* are synonymous with the TPS62690/1/2/3EVM-076 unless otherwise noted.

Contents

1	Introduction	2
1.1	Features	2
1.2	Applications	2
1.3	EVM Ordering Options	2
2	TPS62690/1/2/3EVM Schematic	3
3	Connector and Test Point Descriptions	3
3.1	Input/Output Connectors: TPS6269xEVM	3
3.2	Jumpers and Switches	4
4	Test Configurations	5
4.1	Hardware Setup	5
4.2	Procedure	5
5	TPS62691EVM Test Data	6
5.1	Efficiency	6
5.2	Start-up	7
5.3	Output Voltage Ripple (Power-Save Mode)	8
5.4	Output Voltage Ripple (PWM)	9
6	TPS62690/1/2/3EVM Assembly Drawing and Layout	10
7	TPS62690/1/2/3EVM Bill of Material	13
8	Marking Information for this EVM	13

List of Figures

1	TPS6269xEVM Schematic.....	3
2	JP3 and LP1 Set Up.....	4
3	Hardware Board Connection	5
4	Efficiency vs Load current for the TPS62691	6
5	TPS62691 Start-Up Using EN With No Load, Vin = 3.6 V and Vout = 2.2 V	7
6	TPS62691 Start-up Using EN With 200-mA Load, Vin = 3.6 V and Vout = 2.2 V	7
7	Power-Save Mode Ripple at Vin = 3.6 V and Vout = 2.2 V With Iload = 40 mA	8
8	PWM Mode Ripple at Vin = 3.6 V and Vout = 2.2 V With Iload = 40 mA	9
9	PWM Mode Ripple at Vin = 3.6 V and Vout = 2.2 V With Iload = 200 mA.....	9
10	TPS62690/1/2/3EVM Component Placement (Top View)	10
11	TPS62690/1/2/3EVM Top-Side Copper (Top View)	11
12	TPS62690/1/2/3EVM L2-Side Copper	11
13	TPS62690/1/2/3EVM L3-Side Copper	12
14	TPS62690/1/2/3EVM Bottom-Side Copper (Bottom View)	12

List of Tables

1	Ordering Information for TPS62690/1/2/3EVM.....	2
2	Bill of Material for the TPS62690/1/2/3EVM	13
3	Marking Information	13

1 Introduction

The TPS6269x devices are a series of high-frequency, synchronous, step-down dc-dc converters optimized for battery-powered portable applications. Intended for low-power applications, the TPS6269x can support up to 600-mA load current and allows the use of low-cost chip inductors and capacitors. The TPS62691 and TPS62690 have fixed output voltages of 2.2 V and 2.85 V respectively. The TPS6269x operates at a regulated 4-MHz switching frequency and enters a power-save mode operation under light load currents in order to maintain high efficiency over the entire load-current range. A PFM mode extends the battery life by reducing the quiescent current to 19 μ A (typical) during light load operation.

1.1 Features

- Input voltage range 2.3 V to 4.8 V
- Fixed output voltage
- Up to a 600-mA output current for TPS62691 and 500 mA for the TPS62690
 - 4-MHz regulated frequency operation
- Up to an 800-mA output current for TPS62692 and 500 mA for the TPS62690
 - 3-MHz regulated frequency operation
- Total solution size is less than 12 mm^2
- Very low quiescent current of 19 μ A
- High efficiency

1.2 Applications

- Cell phones, smartphones
- LDO replacement
- Portable audio, portable media
- DC/DC micro-modules

1.3 EVM Ordering Options

Table 1 provides the ordering information for TPS62690/1/2/3EVM-076:

Table 1. Ordering Information for TPS62690/1/2/3EVM

Orderable EVM Number	Device Part Number	Output Voltage	Maximum Output Current
TPS62690EVM-076	TPS62690	2.85 V	500 mA
TPS62691EVM-076	TPS62691	2.2 V	600 mA
TPS62692EVM-076	TPS62692	2.85 V	800 mA
TPS62693EVM-076	TPS62693	2.2 V	800 mA

2 TPS62690/1/2/3EVM Schematic

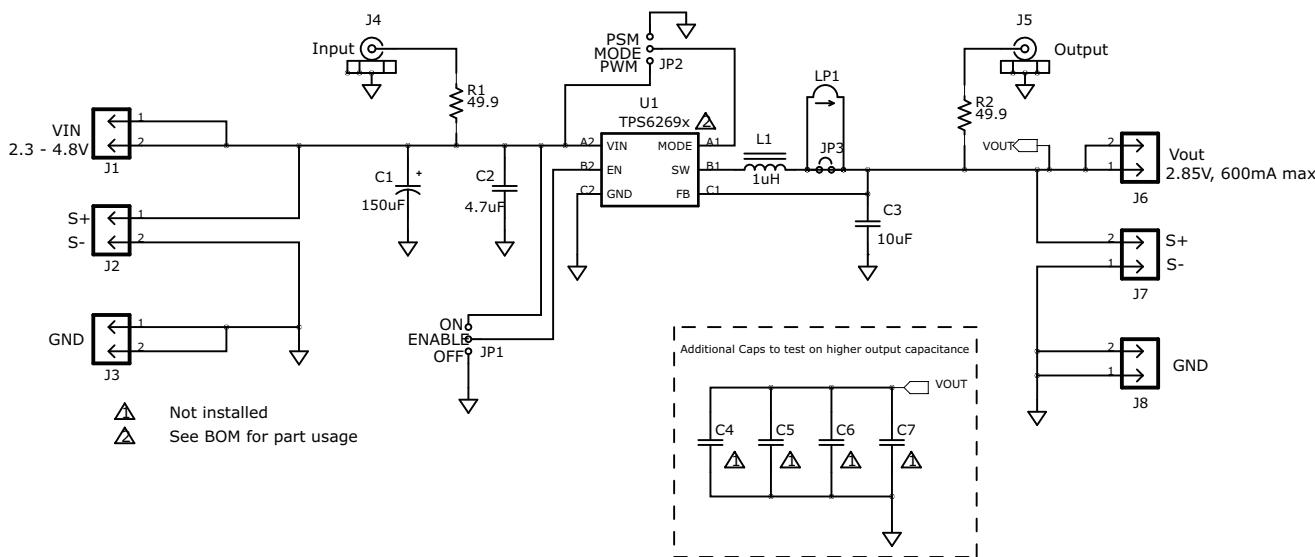


Figure 1. TPS6269xEVM Schematic

3 Connector and Test Point Descriptions

3.1 Input/Output Connectors: TPS6269xEVM

3.1.1 J1 – VIN

This header is the positive connection to the input power supply. The power supply must be connected between J1 (VIN) and J3 (GND). The leads to the input supply must be twisted and kept as short as possible. The input voltage must be between 2.3 V and 4.8 V.

3.1.2 J2 – S+/S-

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

3.1.3 J3 – GND

This header is the return connection to the input power supply. Connect the power supply between J3 (GND) and J1 (VIN). The leads to the input supply must be twisted and kept as short as possible.

3.1.4 J4

This SMA connector is connected to the input voltage of the dc/dc converter. It can be used to easily analyze the noise spectrum of the input voltage with a spectrum analyzer.

3.1.5 J5

This SMA connector is connected to the output voltage of the DC/DC converter. It can be used to easily analyze the noise spectrum of the output voltage with a spectrum analyzer.

3.1.6 J6

This header is the positive output of the step-down converter. The output voltage of the TPS62691 and TPS62690 devices are fixed to 2.2 V and 2.85 V respectively.

3.1.7 J7

J7 S+/S- are the sense connections for the output of the converter. Connect a voltmeter, sense connection of an electronic load, or oscilloscope to this header.

3.1.8 J8

J8 is the return connection of the converter. A load can be connected between J8 and J6 (VOUT).

3.2 Jumpers and Switches

3.2.1 JP1 – ENABLE

This jumper enables/disables the converter on the EVM. Placing a shorting jumper between ENABLE and ON turns on the converter. Placing a shorting jumper between ENABLE and OFF disables the converter.

3.2.2 JP2 – MODE

This jumper enables/disables the power-saving mode under light loads. Placing a shorting jumper between MODE 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.

Placing a shorting jumper between MODE and PSM enables the power-saving mode. This causes the device to operate in power-saving mode under light loads and in PWM mode in heavy loads. See the specific device data sheet for detailed information.

3.2.3 JP3 and LP1

This is the inductor current loop. In order to measure the inductor current, the trace on JP3 needs to be cut and a wire needs to be placed between the two ends of LP1. If the loop is no longer needed, remove the wire on LP1 and shorting JP3.

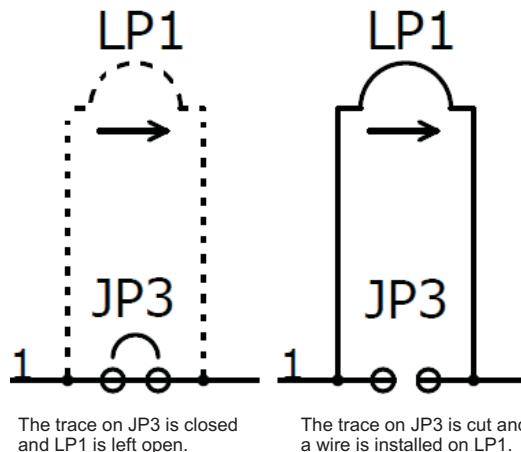


Figure 2. JP3 and LP1 Set Up

4 Test Configurations

4.1 Hardware Setup

Figure 3 illustrates a typical hardware test configuration.

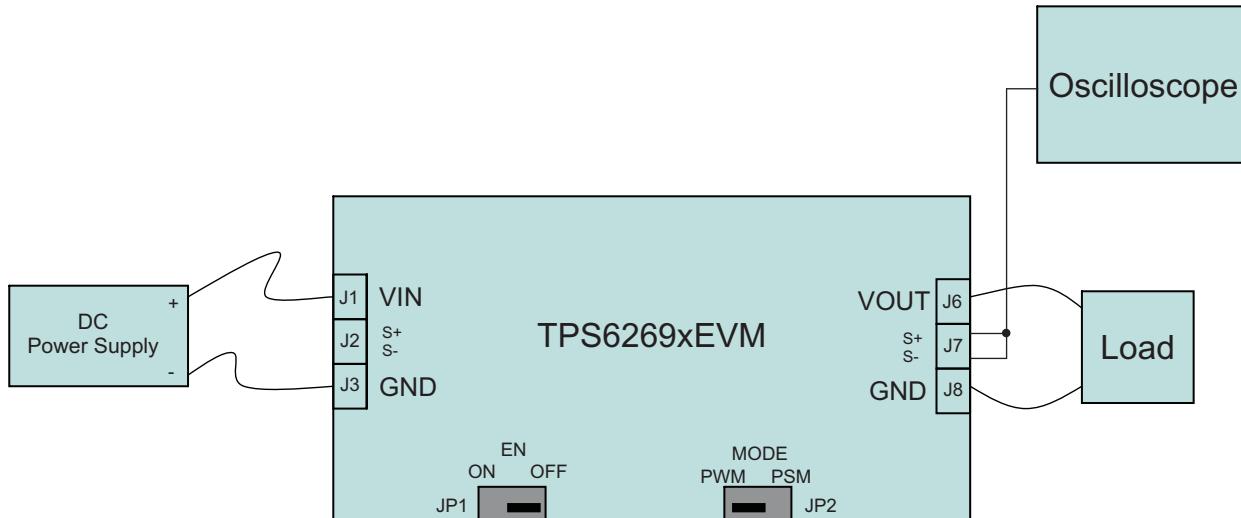


Figure 3. Hardware Board Connection

4.2 Procedure

Follow these procedures when configuring the EVM for testing.

CAUTION

Many of the components on the TPS62690EVM-076 and TPS62691EVM-076 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 should also be worn.

1. Work at an ESD workstation. Make sure that any wrist straps, bootstraps, or mats are connected and secure the user to earth ground before power is applied to the EVM. Electrostatic smock and safety glasses should also be worn.
2. Connect a dc power supply between J1 and J3 on the TPS62690/1/2/3EVM. Note that the input voltage must range from 2.3 V to 4.8 V. Keep the wires from the input power supply to the EVM twisted and as short as possible.
3. Connect a dc voltmeter or oscilloscope to the output sense connection of the EVM.
4. A load can be connected between J6 and J8 on the TPS62690/1/2/3EVM.
5. To enable the converter, connect the shorting jumper on JP1 between ENABLE and ON located on the TPS62690/1/2/3EVM.
6. Use jumper JP2 to switch the TPS62690/1/2/3EVM between power-save mode under light loads and forced PWM mode.

5 TPS62691EVM Test Data

Figure 4 through Figure 9 present typical performance graphs for the TPS62690/1/2/3EVM. 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.

5.1 Efficiency

Figure 4 shows the typical efficiency performance for the TPS62691EVM.

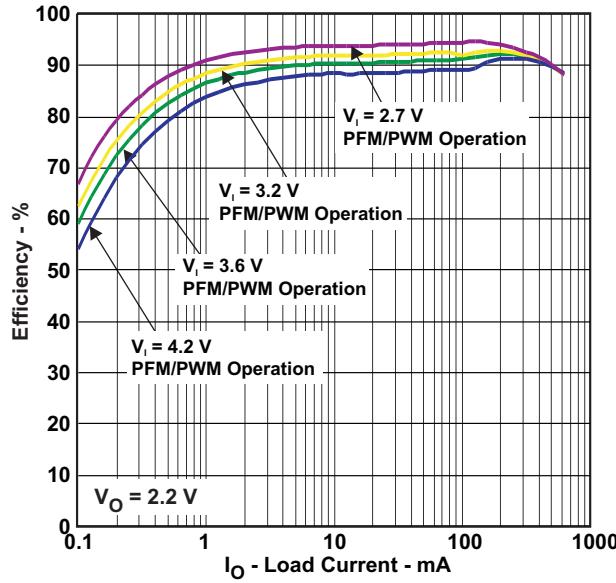


Figure 4. Efficiency vs Load current for the TPS62691

5.2 Start-up

Figure 5 and Figure 6 show the typical start-up performance for different loads for the TPS62691EVM board.

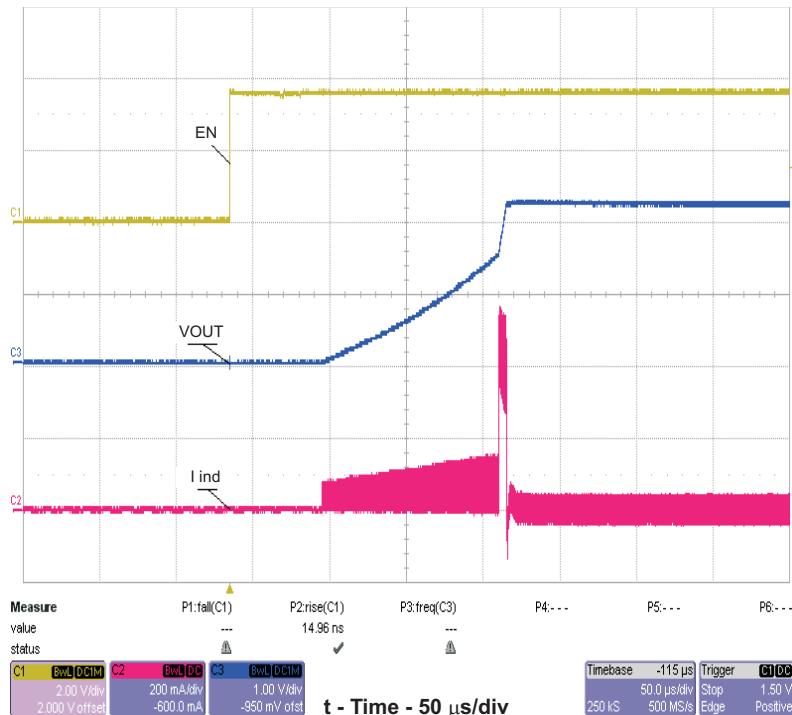


Figure 5. TPS62691 Start-Up Using EN With No Load, Vin = 3.6 V and Vout = 2.2 V

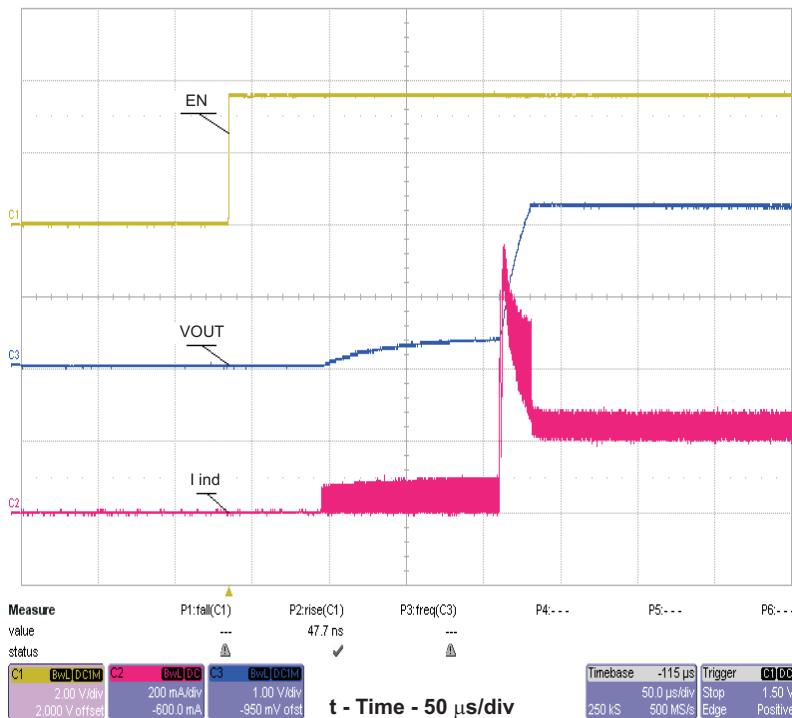


Figure 6. TPS62691 Start-up Using EN With 200-mA Load, Vin = 3.6 V and Vout = 2.2 V

5.3 Output Voltage Ripple (Power-Save Mode)

Figure 7 illustrates the typical output voltage ripple for the TPS62691EVM in power-save mode.

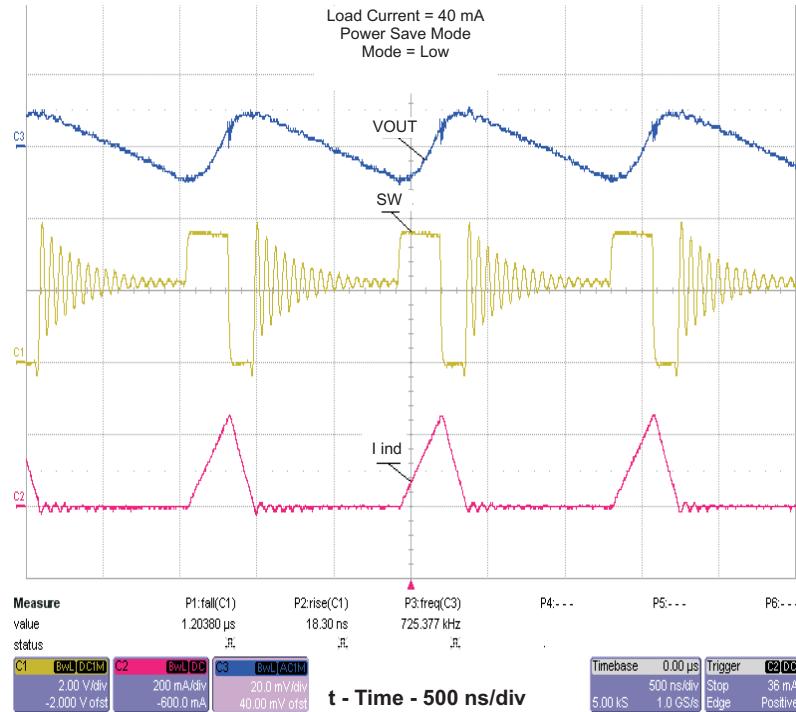


Figure 7. Power-Save Mode Ripple at $V_{in} = 3.6$ V and $V_{out} = 2.2$ V With $I_{load} = 40$ mA

5.4 Output Voltage Ripple (PWM)

Figure 8 and Figure 9 illustrate a typical output voltage ripple for the TPS62691 in PWM mode

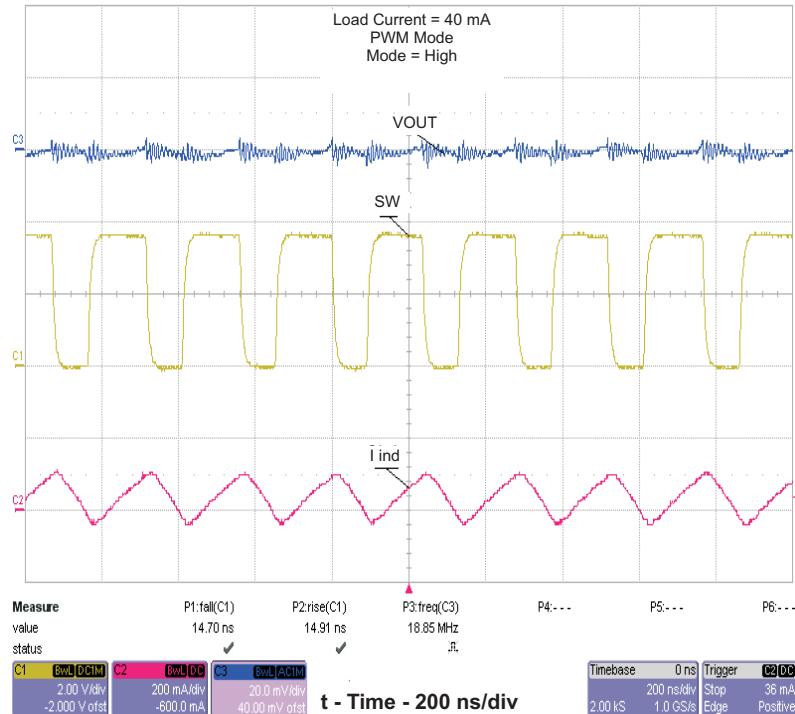


Figure 8. PWM Mode Ripple at $V_{in} = 3.6\text{ V}$ and $V_{out} = 2.2\text{ V}$ With $I_{load} = 40\text{ mA}$

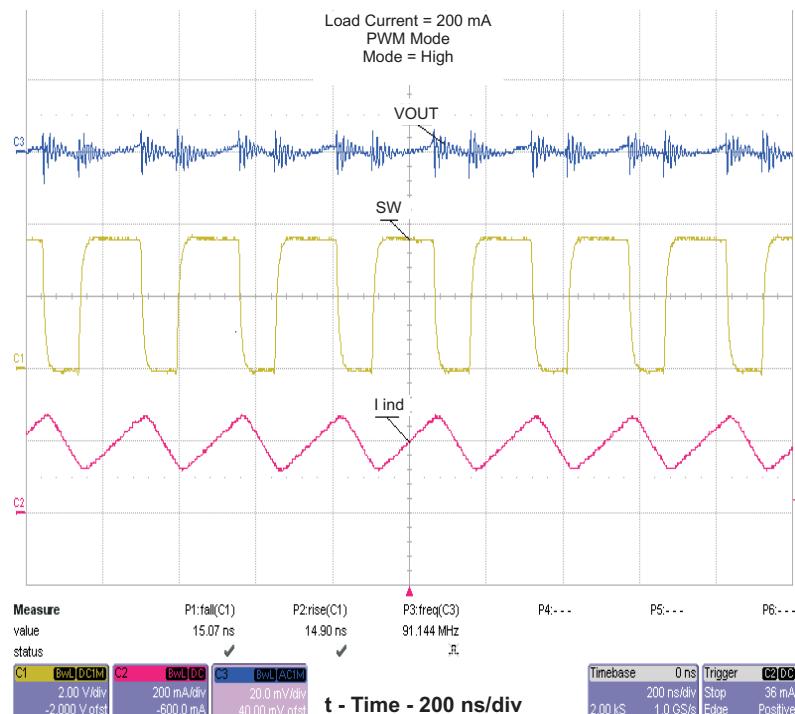


Figure 9. PWM Mode Ripple at $V_{in} = 3.6\text{ V}$ and $V_{out} = 2.2\text{ V}$ With $I_{load} = 200\text{ mA}$

6 TPS62690/1/2/3EVM Assembly Drawing and Layout

Figure 10 through Figure 14 show the design of the TPS62690/1/2/3EVM-076 printed-circuit boards (PCB). The EVM has been designed using a two-layer, 1-ounce copper-clad PCB with all components in an active area on the top side of the board. 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 show how the board is laid out; they are not intended to be used for manufacturing TPS62690/1/2/3EVM-076 PCBs. Note the connection of the TPS6269x feedback (FB) pin. It is recommended that the FB pin be connected directly to the inductor, not directly on the VOUT connection of the output capacitor. The connection to the inductor provides better transient response performance.

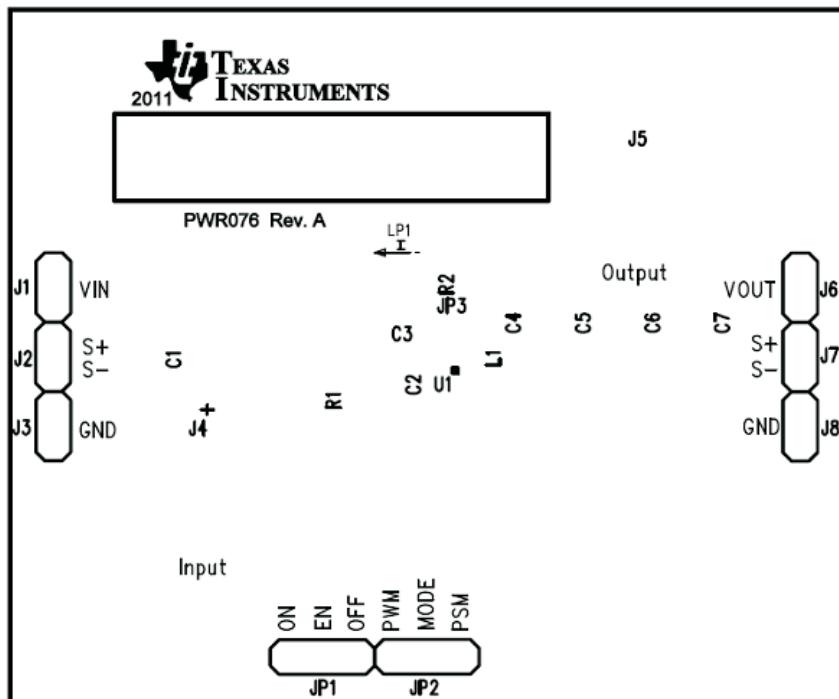


Figure 10. TPS62690/1/2/3EVM Component Placement (Top View)

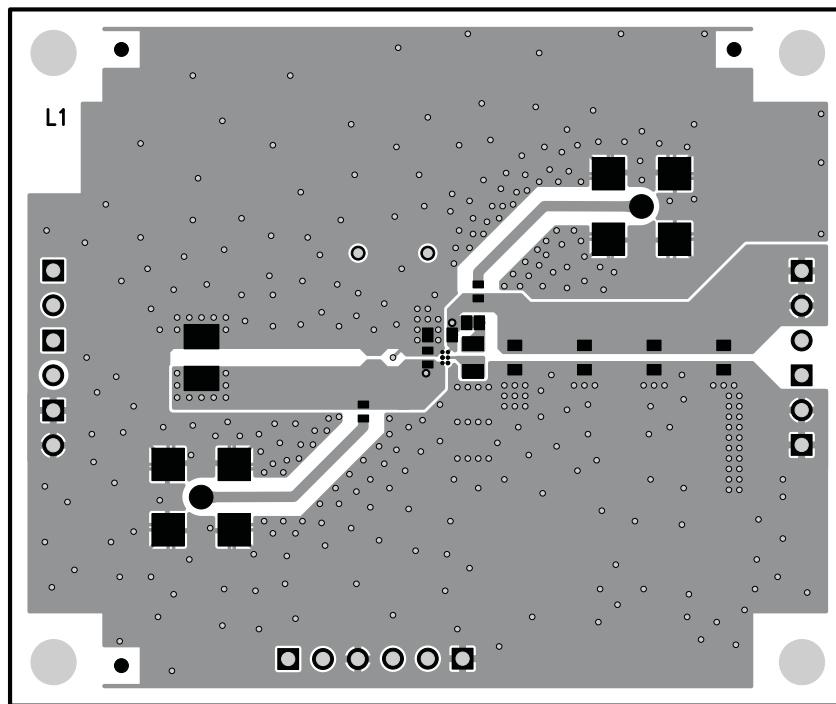


Figure 11. TPS62690/1/2/3EVM Top-Side Copper (Top View)

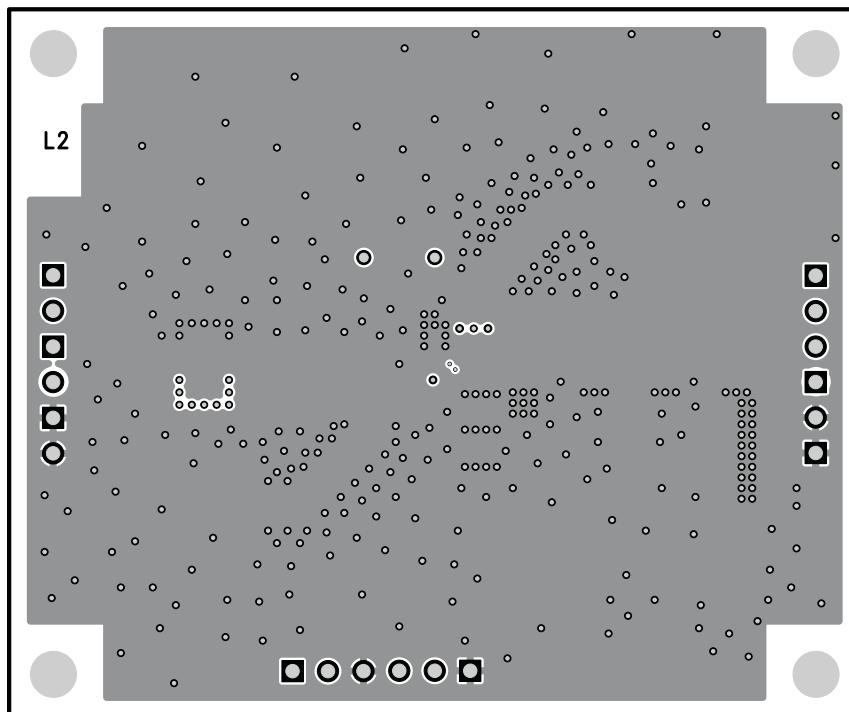


Figure 12. TPS62690/1/2/3EVM L2-Side Copper

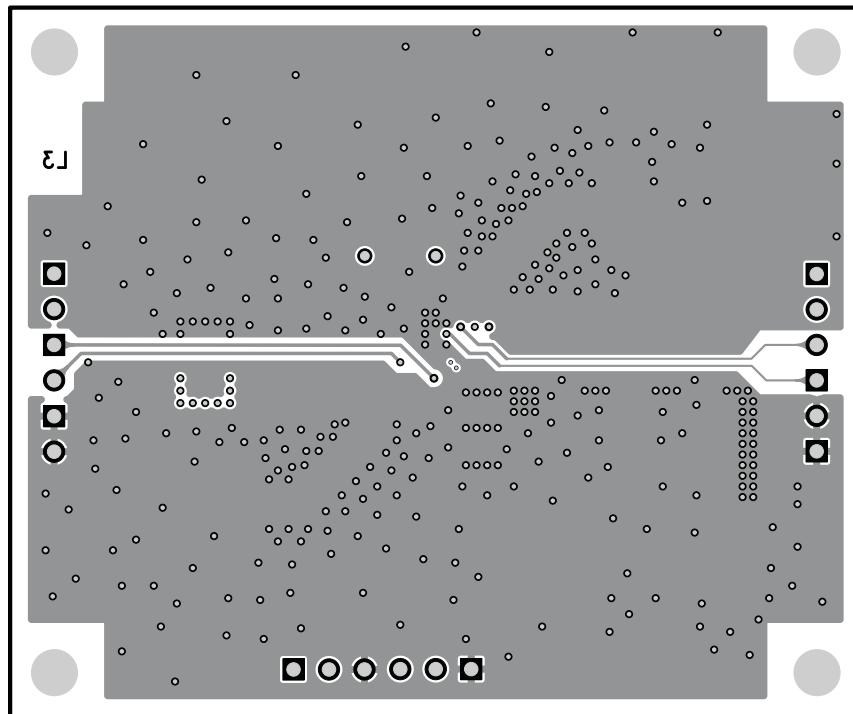


Figure 13. TPS62690/1/2/3EVM L3-Side Copper

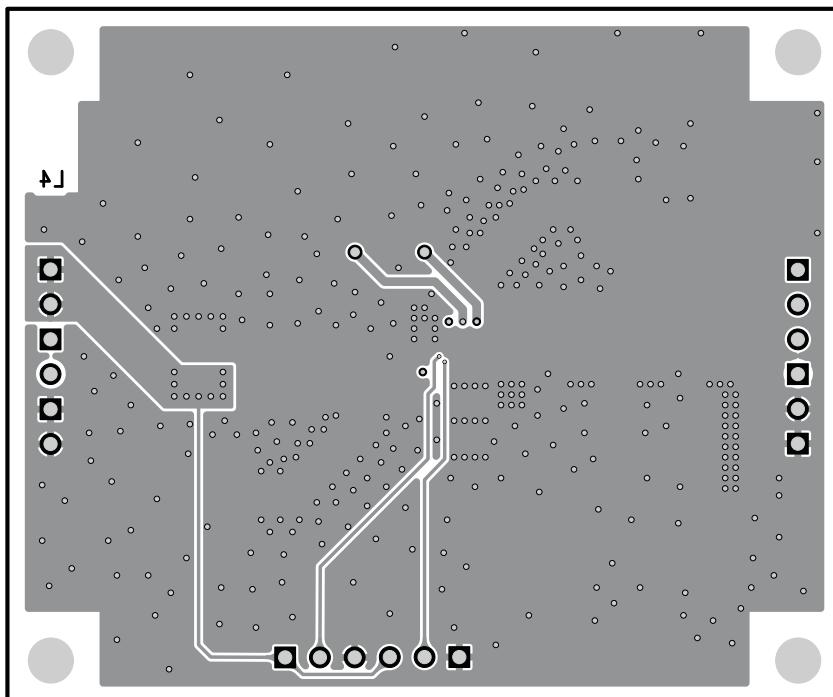


Figure 14. TPS62690/1/2/3EVM Bottom-Side Copper (Bottom View)

7 TPS62690/1/2/3EVM Bill of Material

Table 2 lists the bill of materials for the TPS6269xEVM.

Table 2. Bill of Material for the TPS62690/1/2/3EVM

TPS62690	TPS62691	TPS62692	TPS62693	RefDes	Value	Size	Description	Part Number
Qty	Qty	Qty	Qty					
1	1	1	1	C2 ⁽¹⁾	4.7 μ F	402	Capacitor, Ceramic, 6.3 V, X5R, 20%	GRM155R60J475M
1	1	1	1	C3 ⁽¹⁾	10 μ F	603	Capacitor, Ceramic, 6.3 V, X5R, 20%	GRM188R60J106ME84
4	4	4	4	C4, C5, C7, C8	Open	603	Capacitor, Ceramic	STD
1	1	1	1	C1	150 μ F	0.110 x 0.215 in	Capacitor, Tantalum Poly, 6.3 V, 70 m Ω , 20%	T520B157M006ATE070
1	1	1	1	L1 ⁽¹⁾	1 μ H	2012	Inductor, SMT, 0.9 A, 180 m Ω	MDT2012-CH1R0A
2	2	2	2	R1, R2	49.9 Ω	402	Resistor, Chip, 1/16 W, 1%	STD
1	0	0	0	U1	TPS62690YFF	WCSP-6	IC, 2.85-V, 500-mA, 4-MHz Synchronous Step-Down Converter	TPS62690YFF
0	1	0	0	U1	TPS62691YFF	WCSP-6	IC, 2.2-V, 600-mA, 4-MHz Synchronous Step-Down Converter	TPS62691YFF
0	0	1	0	U1	TPS62692YFF	WCSP-6	IC, 2.85-V, 800-mA, 3-MHz Synchronous Step-Down Converter	TPS62692YFF
0	0	0	1	U1	TPS62693YFF	WCSP-6	IC, 2.2-V, 800-mA, 3-MHz Synchronous Step-Down Converter	TPS62693YFF

⁽¹⁾ These are recommended but can be replaced with specified parts listed in the datasheet.

8 Marking Information for this EVM

Table 3. Marking Information

Assembly Number	Marking Text
PWR076-001	TPS62690EVM-076
PWR076-002	TPS62691EVM-076
PWR076-003	TPS62692EVM-076
PWR076-004	TPS62693EVM-076

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Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. **THE FOREGOING WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.**

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EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 2.3 V to 4.8 V and the output voltage range of fixed 2.2 V ('691) to fixed 2.85 V ('690).

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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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.
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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.

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NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGRADATION 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 isotope 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/lsts/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.

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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。

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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsts/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:*

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