TPS6126x, Low-Input Voltage, Boost Converter Evaluation Module

This user's guide describes the TPS6126x evaluation module (EVM) and how to perform a stand-alone evaluation to allow the EVM to interface with the system and host. The TPS61260EVM-673 converter is programmed from the factory to deliver a 3.3-Vdc output voltage for a continuous load of up to 100 mA. The boost converter can be enabled or disabled with the JP1 shunt jumper. Other options with a fixed output voltage are available.

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PowerPAD is a trademark of Texas Instruments.

1 Introduction

The TPS6126x devices provide a power supply solution for products powered by either single- or dual-cell alkaline, NiCd, or NiMH batteries. It also is suitable for products powered by high-output impedance battery types, like coin cells. Output currents can go as high as 100 mA while using a single-cell alkaline battery and discharge it down to 1 V or lower. The boost converter is based on a quasi-fixed-frequency, pulse-width-modulation (PWM) controller using synchronous rectification to obtain maximum efficiency. At low-load currents, the converter enters Power Save mode to ensure high efficiency over a wide-load current range. The maximum average current in the switches is limited to a typical value of 300 mA. The output voltage is programmable using an external resistor divider or is fixed internally on the chip. Additionally, the average output current can be programmed. The converter then regulates the programmed output voltage or the programmed output current, whichever demands lower output power. The converter can be disabled to minimize battery drain. During shutdown, the load is disconnected from the battery. The device is packaged in a 6-pin, SON PowerPAD™ package measuring 2 × 2 mm (DRV).

2 Considerations When Evaluating the TPS6126x

The TPS6126x has a voltage loop, current loop, PFM loop, and burst mode. Operations at these transitions are seamless, but one can see the waveforms adjust between modes, and they may appear erratic. If the input voltage rises up close to the output voltage, the duty cycle decreases until the minimum on-time is reached, and then the switching frequency decreases. Further increase in input voltage starts to push the output voltage higher above regulation, and the part goes into burst mode. For low-input voltage, the duty cycle increases and transitions into burst mode. This increases the ripple voltage. Increasing the load can put the IC in average current mode. This typically means dropping out of voltage regulation and going into current mode, which changes the duty cycle and frequency.

At lower input voltage, < 1 V, the maximum delivered output current is less than 100 mA; see the plot in the TPS61260/1 data sheet (SLVSA99).

Consider the impedance of the source; for higher impedances and larger loads, consider putting more input capacitance. The waveforms can look different depending on whether the load is resistive or a constant-current load.

3 Performance Specification Summary

Specification	Test Conditions	MIN	TYP	MAX	UNIT
Input dc voltage, DC	Recommended Vin range	0.8		4	V
Output load current, DC	Maximum load current			50	mA

4 Test Summary

The TPS61260EVM-673 board requires an adjustable laboratory power supply set between 0.8 Vdc and 4 Vdc with an input current limit set to ~450 mA and a load of 100 mA or less (>33 Ω). The test setup connections and jumper-setting selections are configured for a stand-alone evaluation, but can be changed to interface with external hardware such as a system load and microcontroller. As the input voltage drops below 1 V, the 100-mA maximum output current may roll off due to power limitations.

4.1 Equipment

- Adjustable dc power supply between 0.8 V and 4 V with adjustable current limit set to ~450 mA
- Load: system load or resistive load ≥ 33 Ω
- Three Fluke 75 digital multimeters (DMM) (equivalent or better)
- Oscilloscope, model TDS222 (equivalent or better)

4.2 Equipment and EVM Setup

Table 1. Setup I/O Connections and Configuration for Evaluation of TPS61260EVM

Jack/Component (Silk Screen)	Connect or Adjust to:
J1-1/2 (Vin)	Power supply positive lead, preset to 1.5-Vdc, 350-mA current limit
J3-1/2 (GND)	Power supply negative lead (1.5-Vdc supply)
J2-1 (+ SNS); input	Positive lead of DMM #1
J2-2 (– SNS); input	Negative lead of DMM #1
J4-1/2 (Vout)	Positive lead to system load or load resistance
J6-1/2 (GND)	Negative lead to system load or load resistance
J5-1 (+ SNS); output	Positive lead of DMM #2
J5-2 (– SNS); output	Negative lead of DMM #2
JP1-1/2 Vin/EN (On)	Apply shunt to ON for converter operation
JP1-2/3 EN/GND (Off)	See procedure

Connect the meters, scope probes, output load, shunt, and input power supply as listed in Table 1 or shown in Figure 1. Set scope to 200 ns/div, positive trigger, dc-coupled on CH1, 1 V/div; CH2: ac-coupled and 10 mV/div. Additional channels can be added or probes can be moved to view Vin and Ven. The resistive load can be replaced with a system load or decade load box to vary the load between 1 kΩ and 33 Ω.

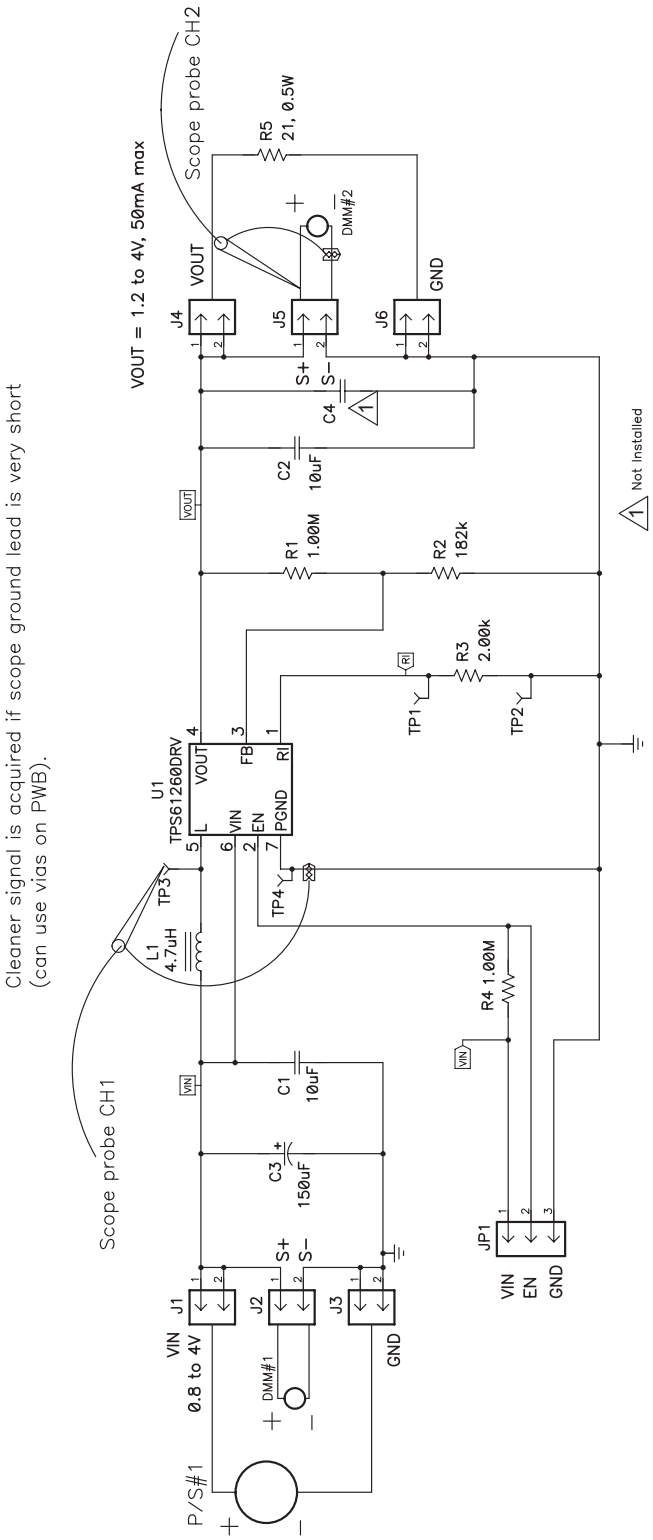

Figure 1. EVM Schematic and Evaluation Setup

4.3 Test Procedure – Input: One Alkaline Battery Cell (1.5 V) or Equivalent Power Source

1. Make sure that the EVM is set up according to Table 1 and Figure 1, and that the power supply is preset to 1.5 Vdc at ~350 mA current limit.
2. Turn on the input supply, and verify the input voltage is ~1.5 Vdc (DMM#1), and the output voltage is between 3.15 Vdc and 3.4 Vdc (DMM#2).
3. Look at CH1 and CH2, and verify that the duty cycle is between 54% and 60%, and the ripple is less than 10 mV. Note that the duty cycle is the on-time (low) divided by the period (Figure 2).
4. Move shunt on JP1-ON to JP1-OFF, and verify that the boost converter is disabled (see Figure 3).
5. Remove the shunt on JP1-OFF and place on JP1-ON. Verify that the converter starts back up (see Figure 4).
6. Vary input voltage and load to understand performance of EVM. The EVM's output cuts off when the input drops to ~0.8 V, and the circuit goes into a PFM mode when the input approaches 3.3 V.

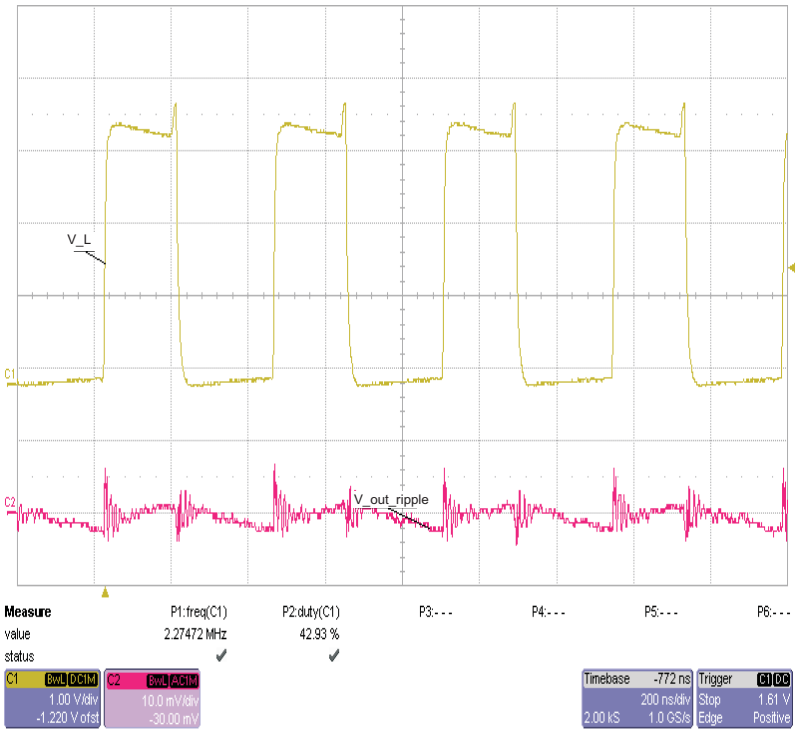

Figure 2. Boost Switch Node, V_L and Output Ripple; Vin = 1.5 V, Vout = 3.3 Vdc With 49.9-Ω Load

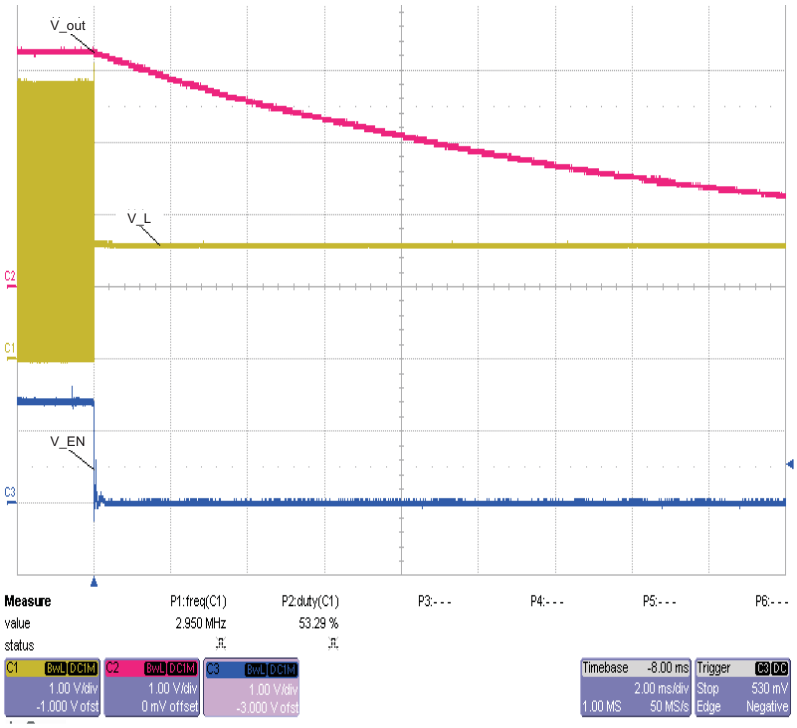

Figure 3. Power Down With Enable: Boost Switch Node, V_L, Output, Enable; Vin = 1.5 V, Vout = 3.3 Vdc With 49.9-Ω Load

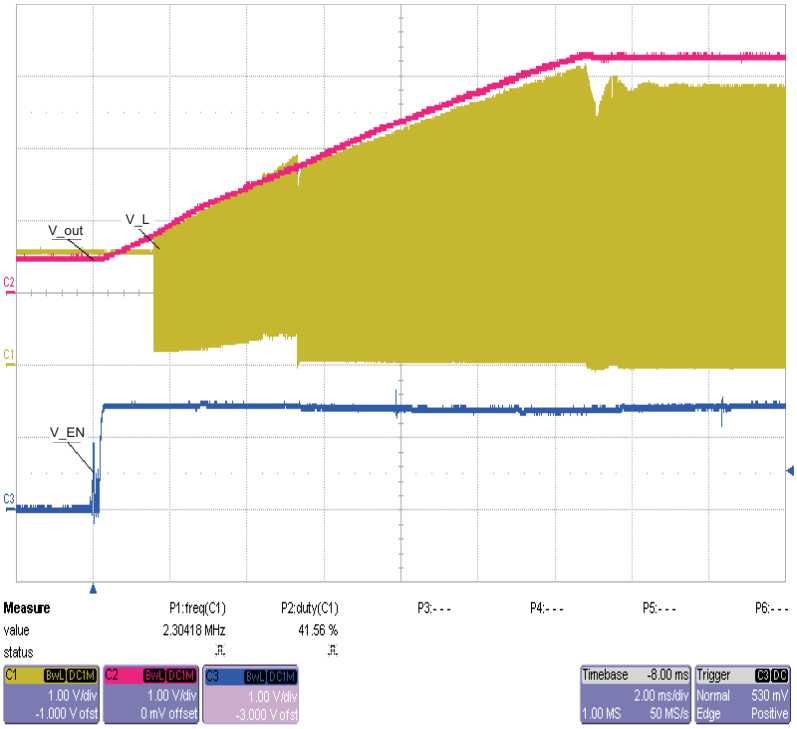

Figure 4. Power-Up With Enable: Boost Switch Node, V_L, Output, Enable; Vin = 1.5 V, Vout = 3.3 Vdc With 49.9-Ω Load

5 Schematic, Physical Layouts, and Bill of Materials

5.1 Schematic

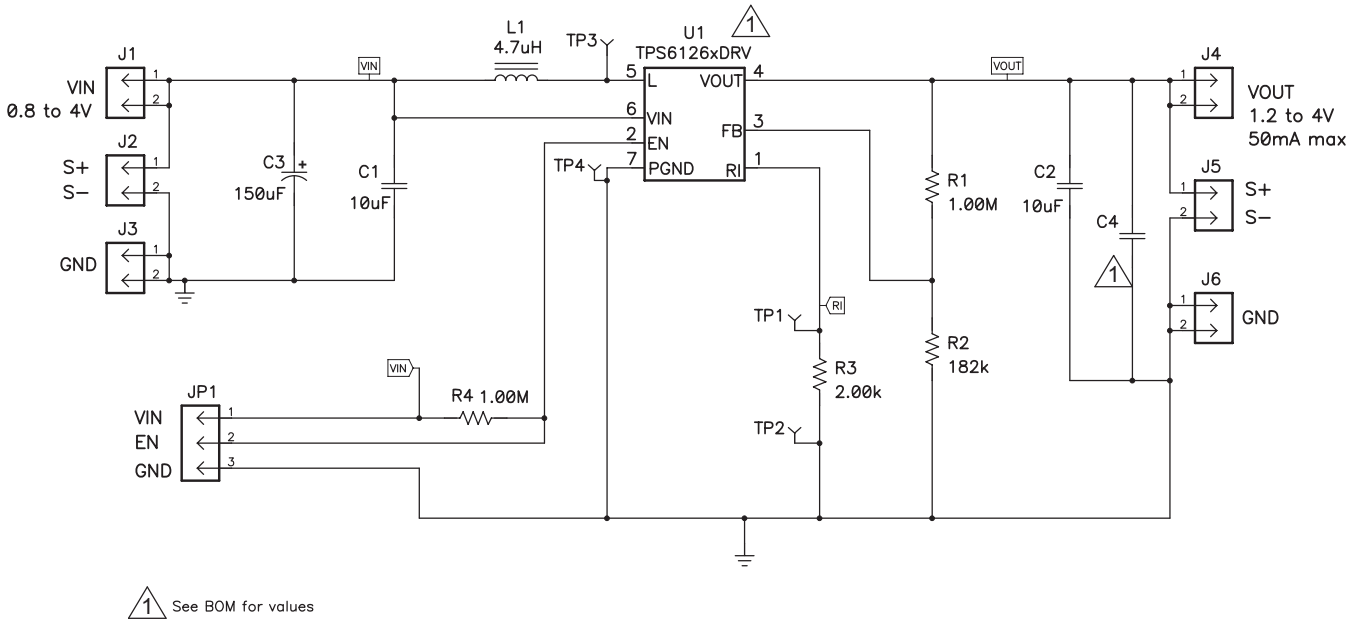

Figure 5. Schematic

5.2 Physical Layouts

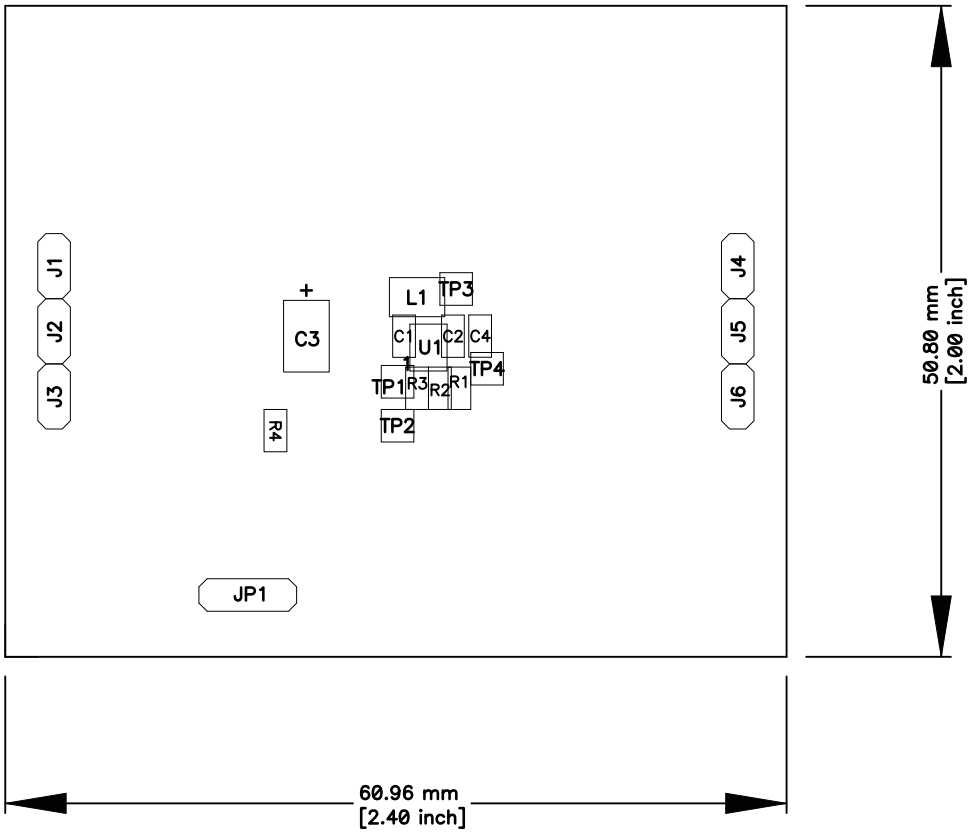

Figure 6. Assembly Layer

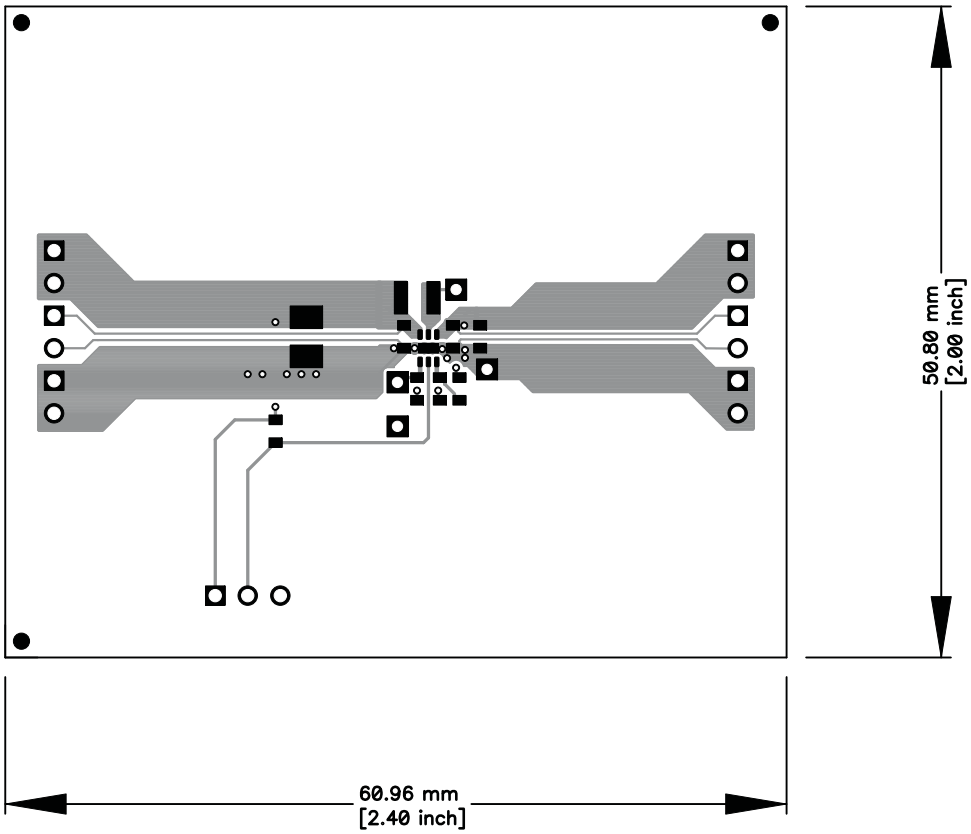

Figure 7. Top Layer

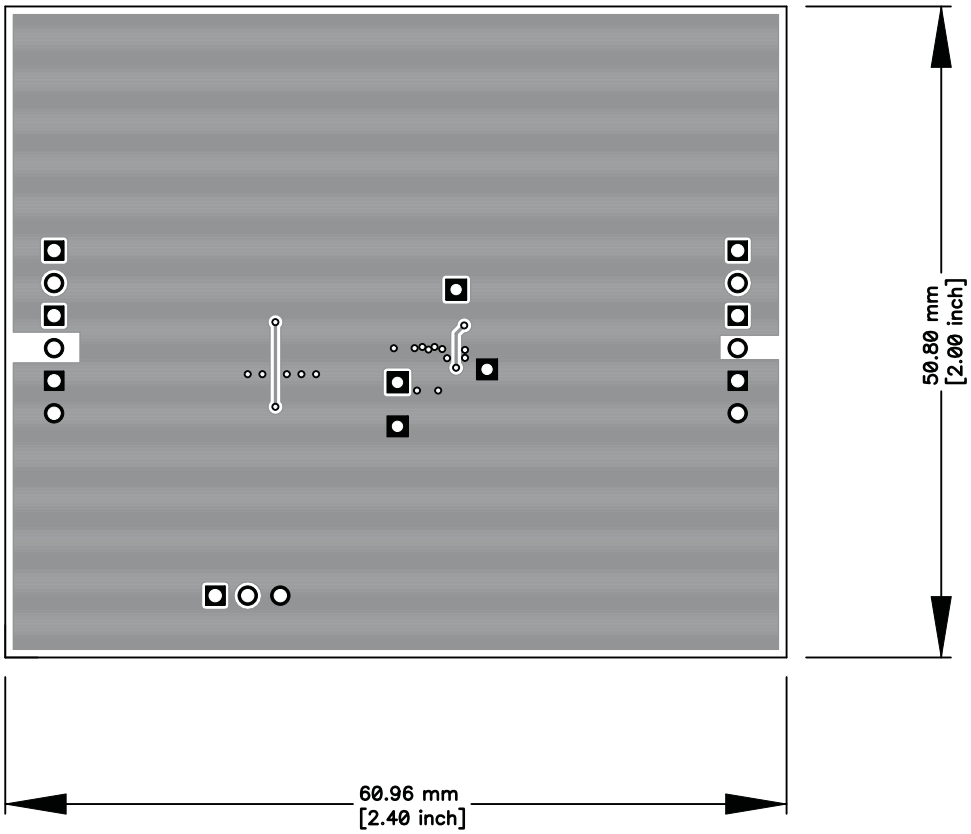

Figure 8. Bottom Layer

5.3 Bill of Materials

Table 2. HPA673A Bill of Materials

~001						
Count	**RefDes**	**Value**	**Description**	**Size**	**Part Number**	**MFR**
2	C1, C2	10uF	Capacitor, Ceramic, Low Inductance, 6.3V, X5R, 20%	0603	GRM188R60J106ME47D	Murata
1	C3	150uF	Capacitor, Tantalum, 6.3V, 25milliohm, 20%	3528(B)	T520B157M006ATE025	Kemet
0	C4		Capacitor, Ceramic, Low Inductance, 6.3V, X5R, 20%	0603		Murata
6	J1, J2, J3, J4, J5, J6	PEC02SAAN	Header, Male 2-pin, 100mil spacing	0.100 inch x 2	PEC02SAAN	Sullins
1	JP1	PEC03SAAN	Header, Male 3-pin, 100mil spacing,	0.100 inch x 3	PEC03SAAN	Sullins
1	L1	4.7uH	Inductor, Power, 1.1 A, 138 milliohms	2.5 x 2.0 mm	LQM2HPN4R7MG0	Murata
2	R1, R4	1.00M	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R2	182k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R3	2.00k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	U1	TPS61260DRV	IC, Tiny Low Input Voltage Boost Converter	SON	TPS61260DRV	TI
1	--		PCB, 2.4 In x 2 In x 0.031 In		HPA673	Any
1			Label - See note 5	1.25 x 0.25 inch	THT-13-457-10	Brady
1	Apply on: JP1-ON		Shunt, 100-mil, Black	0.1	929950-00	3M

Evaluation Board/Kit Important Notice

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This evaluation board/kit is intended for use for **ENGINEERING DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY** and is not considered by TI to be a finished end-product fit for general consumer use. Persons handling the product(s) must have electronics training and observe good engineering practice standards. As such, the goods being provided are not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety and environmental measures typically found in end products that incorporate such semiconductor components or circuit boards. This evaluation board/kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and therefore may not meet the technical requirements of these directives or other related directives.

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 0.8 V to 4 V and the output voltage range of 1.8 V to 4 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 50°C. The EVM is designed to operate properly with certain components above 50°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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

STANDARD TERMS FOR EVALUATION MODULES

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

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

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

2 *Limited Warranty and Related Remedies/Disclaimers*:

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

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

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

WARNING

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

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

NOTE:

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

3 *Regulatory Notices:*

3.1 *United States*

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

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

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

CAUTION

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

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

FCC Interference Statement for Class A EVM devices

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

FCC Interference Statement for Class B EVM devices

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

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

3.2 *Canada*

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

Concerning EVMs Including Radio Transmitters:

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

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

Concernant les EVMs avec appareils radio:

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

Concerning EVMs Including Detachable Antennas:

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

Concernant les EVMs avec antennes détachables

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

3.3 *Japan*

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

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

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

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

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

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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。
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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.

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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.

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Last updated 10/2025