

# **Evaluation Module for TPS62736 Ultra Low Power Buck Converter**

---



---

This user's guide describes the TPS62736 evaluation module (EVM). The TPS62736 device is a high-frequency synchronous stepdown dc-dc converter optimized for ultralow-power energy harvesting applications. The converter can provide up to 50 mA of continuous current to a 1.3 V – 5.3 V output from input voltages up to 5.5 V.

## **Contents**

1	Introduction .....	2
	1.1 TPS62736EVM Schematic .....	3
2	Performance Specification Summary .....	3
3	Test Summary .....	4
	3.1 Recommended Equipment .....	4
	3.2 Equipment and EVM Setup.....	4
	3.3 Tips when Measuring Efficiency .....	5
	3.4 Tips for Taking Scope Plots .....	5
4	PWR205 PCB Layout and Bill of Materials.....	8
	4.1 REV A PCB Layout (FUNCTIONAL) .....	8
	4.2 REV B PCB Layout (BEST) .....	9
	4.3 Bill of Materials .....	11

## **List of Figures**

1	TPS62730 and TPS62733 EVM Board Schematic.....	3
2	EVM Test Setup for Measuring Efficiency .....	5
3	Efficiency Versus Load Current, $V_{OUT} = 1.8\text{ V}$ .....	6
4	Steady State Operation with $RO = 50\ \Omega$ .....	6
5	Load Transient Response .....	6
6	Ship-Mode Startup Behavior .....	7
7	Standby-Mode Startup Behavior.....	7
8	Assembly Layer .....	8
9	Top Layer .....	8
10	Bottom Layer .....	9
11	Assembly Layer .....	9
12	Top Layer.....	10
13	Bottom Layer.....	10

## 1 Introduction

### TPS62736 IC Features

The TPS62736 is a highly integrated ultra low power buck converter solution that is well suited for meeting the special needs of ultra low power applications such as energy harvesting. The TPS62736 provides the system with an externally programmable regulated supply in order to preserve the overall efficiency of the power management stage versus a linear step down converter. Although intended to have input power from an energy storage element such as a Li-Ion battery or super cap, the TPS62736 can accept any input voltage up to 5.5 V, while supplying the rail to low voltage electronics.

The TPS62736 integrates an optimized hysteretic controller for low power applications. The internal circuitry utilizes a time based sampling system in order to reduce the average quiescent current. This allows for the quiescent current consumption to scale with output load levels. The regulated output has been optimized to provide high efficiency across low output currents ( $< 10 \mu\text{A}$ ) to high currents (50 mA).

To further assist users in the strict management of their energy budgets, the TPS62736 toggles the input good (VIN\_OK) flag to signal an attached microprocessor when the voltage on the input supply has dropped below a pre-set critical level. The intent of VIN\_OK is to trigger the reduction of load currents to prevent the system from entering an undervoltage condition. Two separate enable signals allow the user to enable/disable the regulated output or place IC into an ultra-low quiescent sleep state. Two separate enable signals allow the enabling or disabling of the regulated output or allow putting the IC into an ultra-low quiescent sleep state.

The output voltage regulation point and input good threshold are set by external resistors. **In order to maximize efficiency at light load, the use of voltage level setting resistors  $> 1 \text{ M}\Omega$  is recommended. However, during board assembly or modification, contaminants such as solder flux and even some board cleaning agents can leave residue that may form parasitic resistors across the physical resistors and/or from one end of a resistor to ground, especially in humid, fast airflow environments. This can result in the voltage regulation and threshold levels changing significantly from those expected per the installed resistor values. Therefore, the boards must be carefully cleaned then rinsed with de-ionized water until the ionic contamination of that water. If this is not feasible, then it is recommended that the sum of the voltage setting resistors be reduced.**

### TPS62736EVM Features

1. Input voltage range from 2.0 V to 5.5 V
2. Output voltage set to 1.8 V but adjustable from 1.3 V to 5.3 V with external resistors
3. VIN\_OK threshold of 2.9 V but adjustable from VOUT to 5.3 V with external resistors
4. Easily accessible headers for IN, IN-SENSE, OUT, OUT-SENSE, GND, VIN\_OK
5. Jumpers for EN1 and EN2

## 1.1 TPS62736EVM Schematic

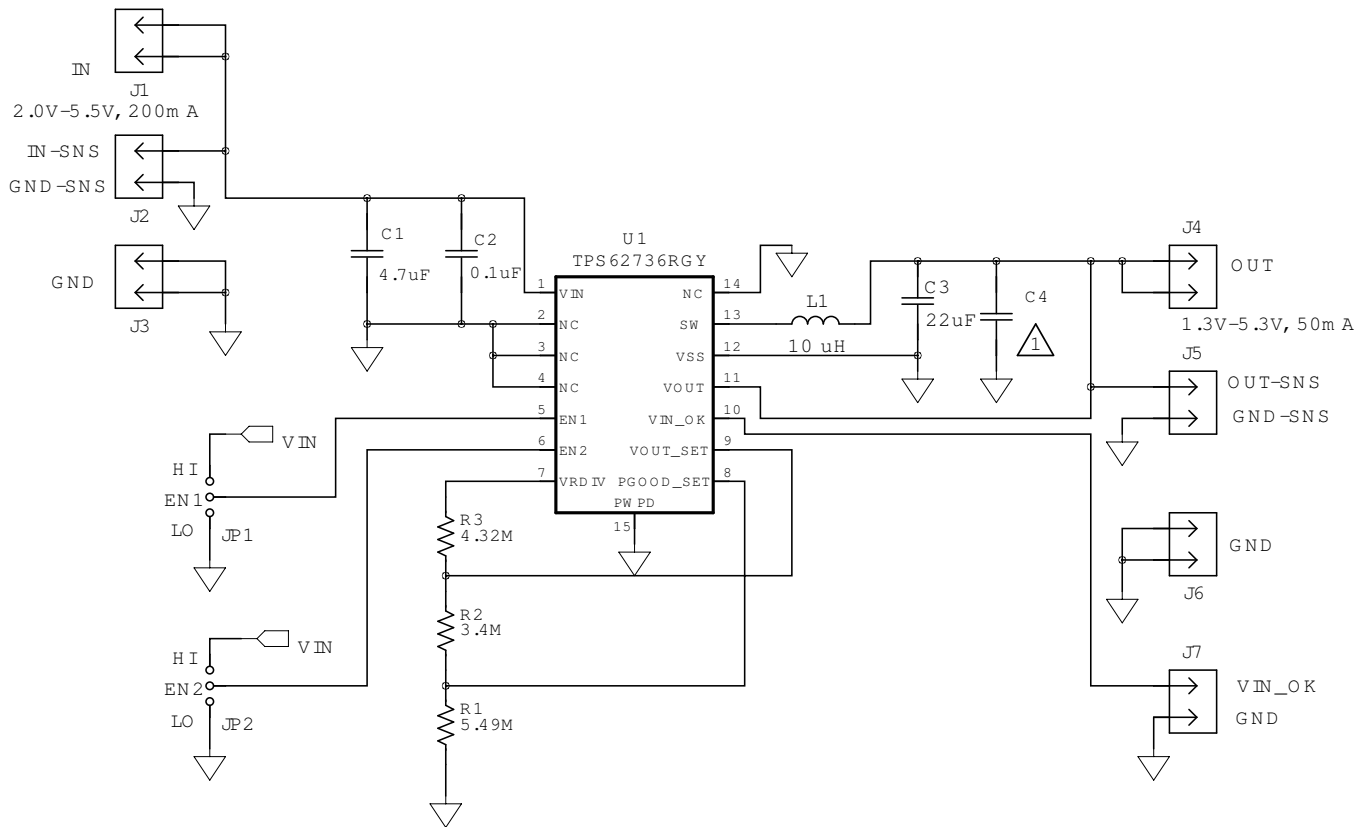


Figure 1. TPS62730 and TPS62733 EVM Board Schematic

## 2 Performance Specification Summary

Specification	Conditions	MIN	TYP	MAX	UNIT
Input dc voltage, IN		2.0		5.5	V
Output dc voltage, OUT	Adjustable by changing external resistors from 1.3 V to 5.3 V		1.8		V
VBAT_OK threshold	Adjustable by changing external resistors from OUT to 5.3 V		2.9		V
Output current		0		50	mA

### 3 Test Summary

#### 3.1 Recommended Equipment

- Adjustable dc power supply between 2.0 V and 5.5 V with the adjustable current limit set to approximately 100 mA
- Load: system load or resistive load  $\geq 300 \Omega$
- Two digital multimeters configured to measure voltage (equivalent or better)
- Two digital multimeters configured to measure current (equivalent or better). **NOTE:** Due to the input current pulses inherent to a hysteretically-controlled converter, the input current meter must be capable of filtering and/or averaging in order to measure the correct value. Adding a large ( $> 100 \mu\text{F}$ ) capacitor between IN and GND may be necessary to assist with filtering. Use of a sourcemeter, configured to regulate voltage and measure current, or power, or both current and power is also recommended.
- Oscilloscope with up to four voltage probes

#### 3.2 Equipment and EVM Setup

**Table 1. Setup I/O Connections and Configuration for Measuring Efficiency of TPS62736 EVM**

Jack and Component (Silk Screen)	Description	Connect or Adjustment To:
J1 (IN)		Negative lead of current meter (CM#1)
J2-1 (+ IN SNS)	Kelvin connection to capacitance	Positive lead of voltmeter (VM#1)
J2-2 (- GND SNS)	Kelvin connection to capacitance	Negative lead of voltmeter (VM#1)
J3 (GND)		Power supply negative lead
J4 (OUT)		Positive lead of current meter (CM#2)
J5-1 (+ OUT SNS)	Kelvin connection to capacitance	Positive lead of voltmeter (VM#2)
J5-2 (- GND SNS)	Kelvin connection to capacitance	Negative lead of voltmeter (VM#2)
J6 (GND)		Negative lead to load resistance
J7-1 (VIN_OK)	Push-pull output of comparator that indicates the status of the input voltage	n/a
J7-2 (GND)		n/a
JP1 (EN1)	EN1 = HI and EN2 = x implements full standby mode. Switching converter and VIN_OK indication is off (ship mode).	EN1 = LO
JP2 (EN2)	EN1 = LO and EN2 = HI implements full buck converter mode. EN1 = LO and EN2 = LO implements partial standby mode. Switching converter is off, but VIN_OK indication is on.	EN2 = HI

Table 1 and Figure 2 show the test setup for measuring efficiency.

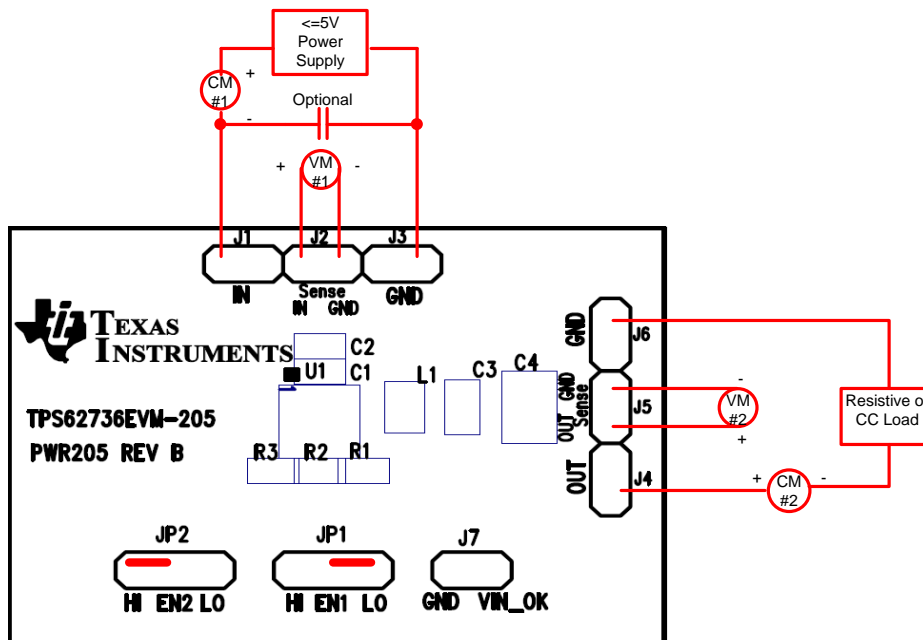


Figure 2. EVM Test Setup for Measuring Efficiency

### 3.3 Tips when Measuring Efficiency

1. Ensure that the EVM setup is according to Table 1 and Figure 2, and preset the power supply to a voltage less than 5.5 V at a current limit of approximately 100 mA.
2. Slowly increase the system load current until 50 mA is reached.

### 3.4 Tips for Taking Scope Plots

1. If measuring DC waveforms similar to those shown in Figure 3 – Figure 7, set the timebase as shown in the plot and connect the probes to the applicable headers (IN, OUT, VBAT\_OK) or SW pin and the closest GND header.
2. If measuring AC waveforms such as output voltage ripple, set the timebase as shown in the plot, remove the voltage probe hat, connect the probe tip to the top of capacitor C3 and a short ground lead to capacitor C3's ground.
3. Please note that when measuring switching waveforms, the timebase may need to be adjusted as the output load current adjusts due to the hysteretic control methodology.

### Test Results (Taken on the TPS62730EVM-205)

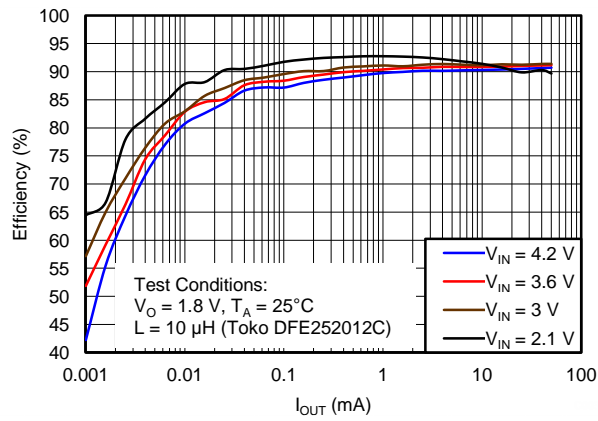


Figure 3. Efficiency Versus Load Current,  $V_{OUT} = 1.8\text{ V}$

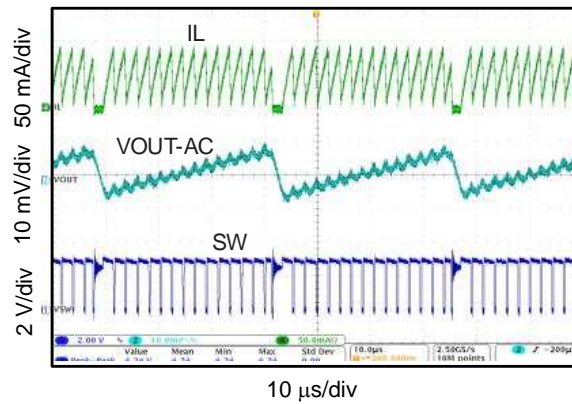


Figure 4. Steady State Operation with  $R_O = 50\ \Omega$

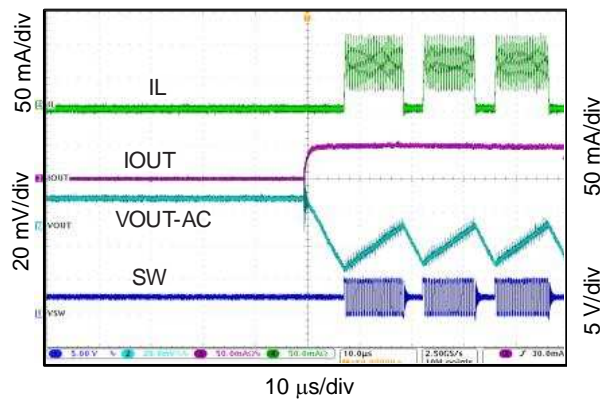


Figure 5. Load Transient Response

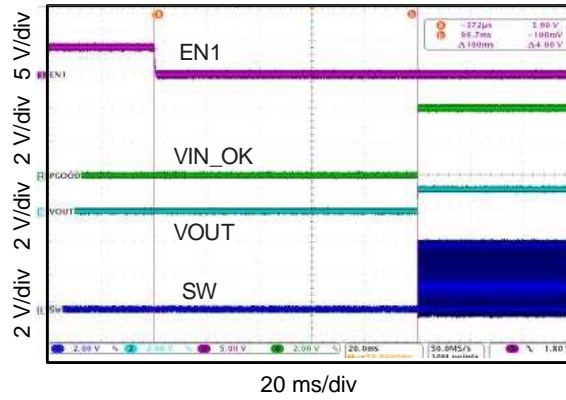


Figure 6. Ship-Mode Startup Behavior

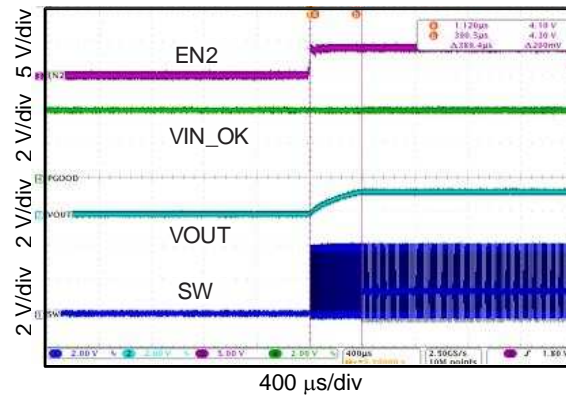


Figure 7. Standby-Mode Startup Behavior

4 PWR205 PCB Layout and Bill of Materials

4.1 REV A PCB Layout (FUNCTIONAL)

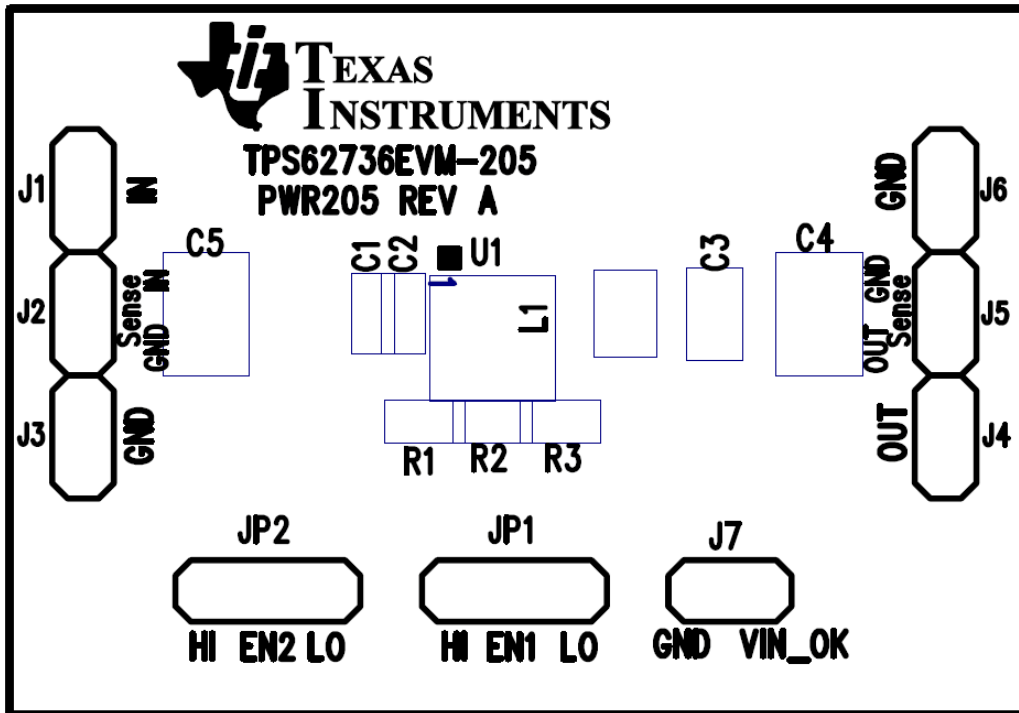


Figure 8. Assembly Layer

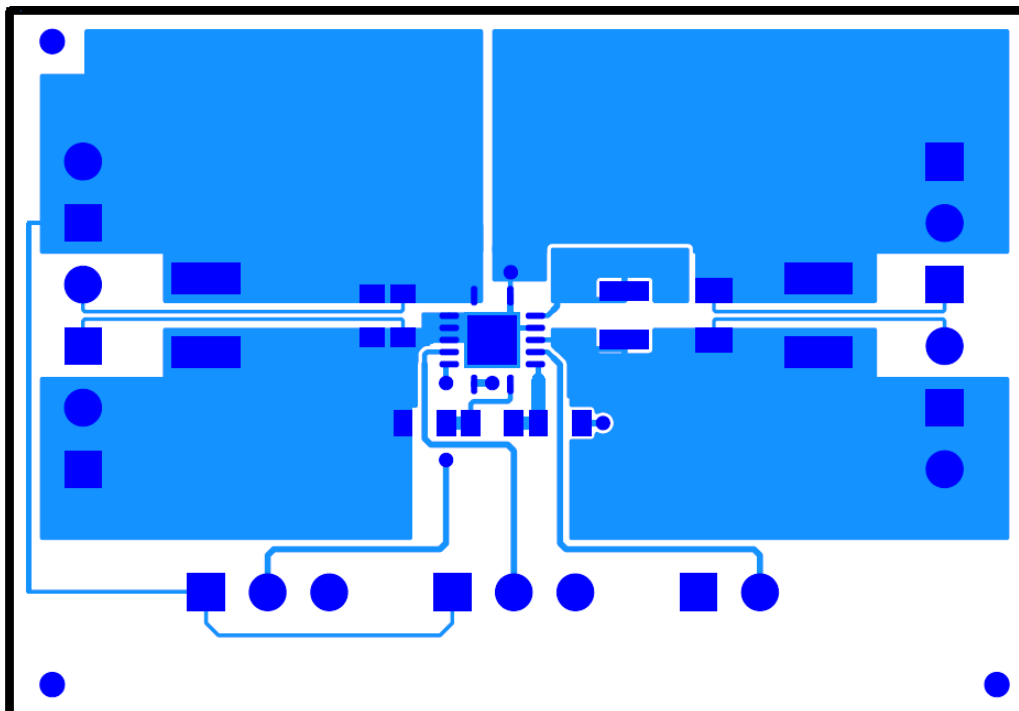


Figure 9. Top Layer



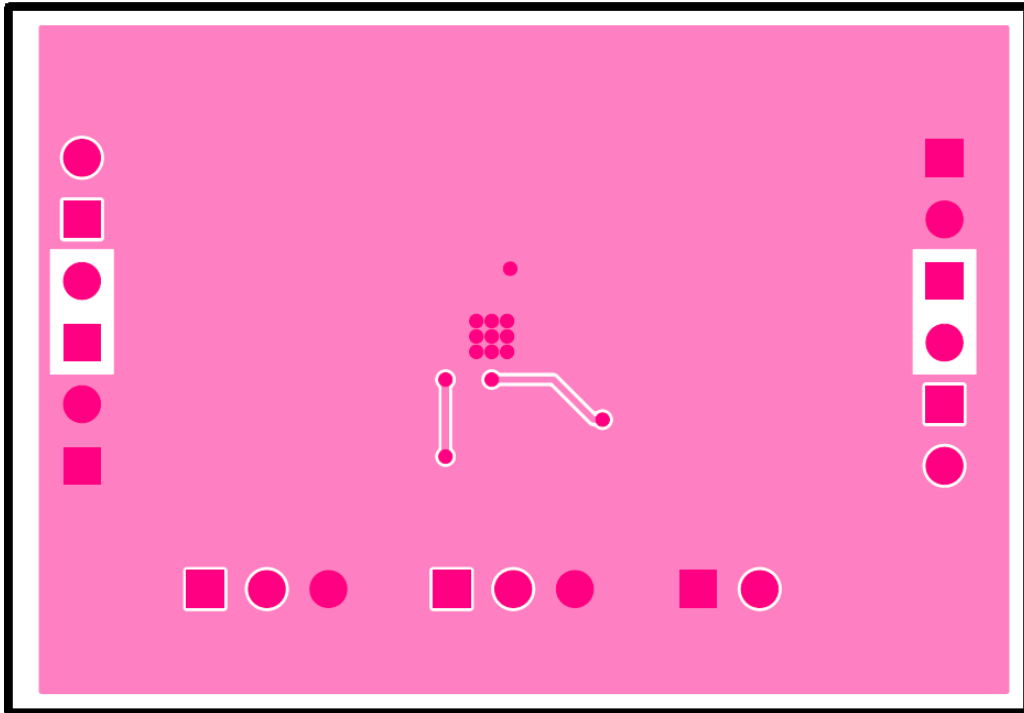


Figure 10. Bottom Layer

4.2 REV B PCB Layout (BEST)

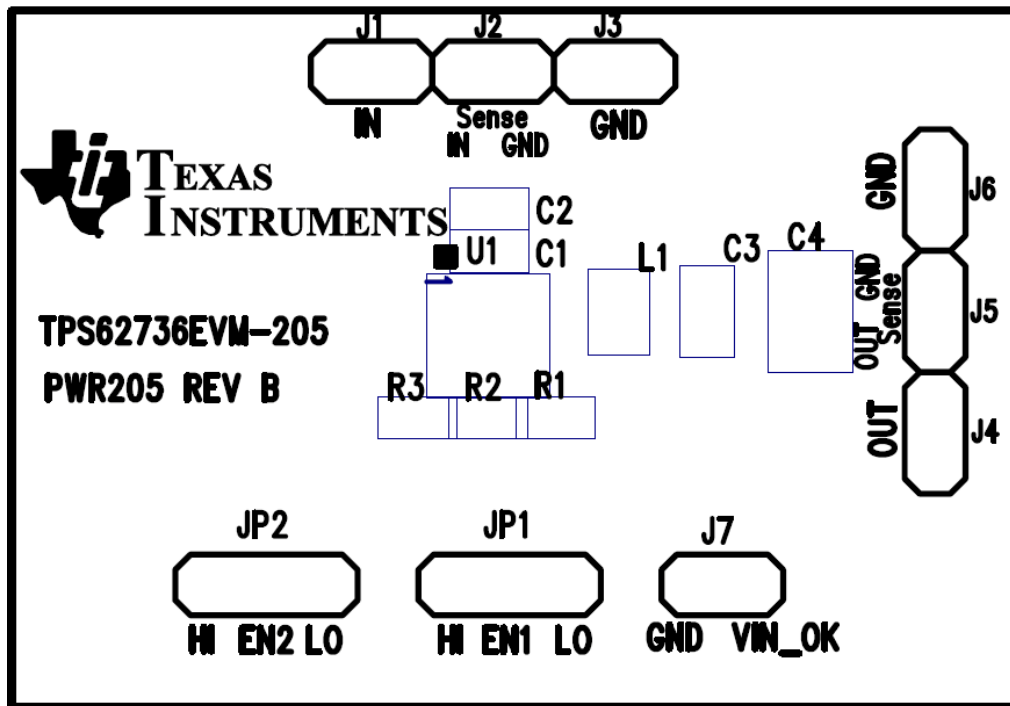


Figure 11. Assembly Layer

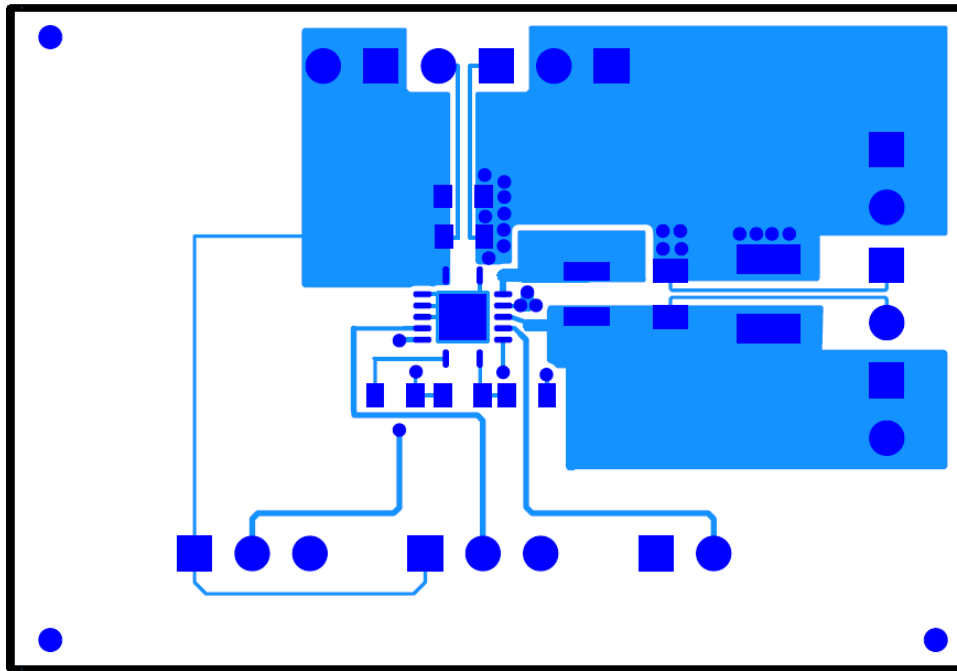


Figure 12. Top Layer

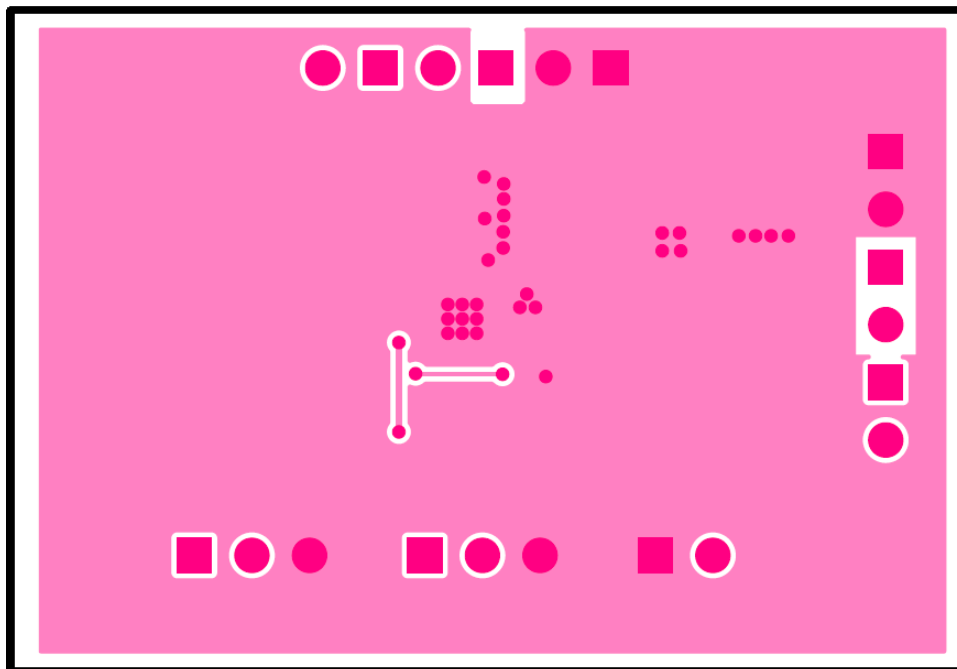


Figure 13. Bottom Layer

### 4.3 Bill of Materials

Table 2 lists the TPS62736EVM BOM.

**Table 2. PWR205 Bill of Materials**

Count	RefDes	Value	Description	Size	Part Number	MFR
1	C2	0.1uF	Capacitor, Ceramic Chip, 10V, X5R, +10%	603	STD	STD
1	C1	4.7uF	Capacitor, Ceramic Chip, 10V, X5R, ±10%	603	STD	STD
1	C3	22uF	Capacitor, Ceramic Chip, 6.3V, X5R, +20%	805	STD	STD
0	C4	DNP	Capacitor, Ceramic Chip, xxV, ±10%	1210	Std	STD
7	J1-7	PEC02SAAN	Header, Male 2-pin, 100mil spacing,	0.100 inch x 2	PEC02SAAN	Sullins
1	L1	10uH	Inductor, SMT, 1.4A, 216mΩ Inductor SMT, 500mA, 500mΩ Inductor SMT, 250mA, 500mΩ Inductor SMT, 500mA, 390mΩ	2.5mm x 2.0mm x 1.20mm 2.5mm x 2.0mm x 1.20mm 2.5mm x 2.0mm x 1.00mm 2.8mm x 2.8mm x 1.35mm	DFE252012C-1239AS-H-100N 74479889310 74479888310 744029100	TOKO Würth Elektronik Würth Elektronik Würth Elektronik
2	JP1-2	PEC03SAAN	Header, Male 3-pin, 100mil spacing,	0.100 inch x 3	PEC03SAAN	Sullins
1	R3	4.32M	Resistor, Chip, 1/16W, 1%	603	STD	STD
1	R2	3.4M	Resistor, Chip, 1/16W, 1%	603	STD	STD
1	R1	5.49M	Resistor, Chip, 1/16W, 1%	603	STD	STD
1	U1	TPS62736RGY	IC, Ultra Low Power Harvester Power Management Core	VQFN	TPS62736RGY	TI
2	--		Shunt, 100-mil, Black	0.100	929950-00	3M

---

## Revision History

<b>Changes from A Revision (May 2013) to B Revision</b>	<b>Page</b>
• Changed content in the bill of materials .....	11

---

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

## ADDITIONAL TERMS AND CONDITIONS, WARNINGS, RESTRICTIONS, AND DISCLAIMERS FOR EVALUATION MODULES

Texas Instruments Incorporated (TI) markets, sells, and loans all evaluation boards, kits, and/or modules (EVMs) pursuant to, and user expressly acknowledges, represents, and agrees, and takes sole responsibility and risk with respect to, the following:

1. User agrees and acknowledges that EVMs are intended to be handled and used for feasibility evaluation only in laboratory and/or development environments. Notwithstanding the foregoing, in certain instances, TI makes certain EVMs available to users that do not handle and use EVMs solely for feasibility evaluation only in laboratory and/or development environments, but may use EVMs in a hobbyist environment. All EVMs made available to hobbyist users are FCC certified, as applicable. Hobbyist users acknowledge, agree, and shall comply with all applicable terms, conditions, warnings, and restrictions in this document and are subject to the disclaimer and indemnity provisions included in this document.
2. Unless otherwise indicated, EVMs are not finished products and not intended for consumer use. EVMs are intended solely for use by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.
3. User agrees that EVMs shall not be used as, or incorporated into, all or any part of a finished product.
4. User agrees and acknowledges that certain EVMs may not be designed or manufactured by TI.
5. User must read the user's guide and all other documentation accompanying EVMs, including without limitation any warning or restriction notices, prior to handling and/or using EVMs. Such notices contain important safety information related to, for example, temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit [www.ti.com/esh](http://www.ti.com/esh) or contact TI.
6. User assumes all responsibility, obligation, and any corresponding liability for proper and safe handling and use of EVMs.
7. Should any EVM not meet the specifications indicated in the user's guide or other documentation accompanying such EVM, the EVM may be returned to TI within 30 days from the date of delivery for a full refund. THE FOREGOING LIMITED WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY TI TO USER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. TI SHALL NOT BE LIABLE TO USER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES RELATED TO THE HANDLING OR USE OF ANY EVM.
8. No license is granted under any patent right or other intellectual property right of TI covering or relating to any machine, process, or combination in which EVMs might be or are used. TI currently deals with a variety of customers, and therefore TI's arrangement with the user is not exclusive. TI assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or services with respect to the handling or use of EVMs.
9. User assumes sole responsibility to determine whether EVMs may be subject to any applicable federal, state, or local laws and regulatory requirements (including but not limited to U.S. Food and Drug Administration regulations, if applicable) related to its handling and use of EVMs and, if applicable, compliance in all respects with such laws and regulations.
10. User has sole responsibility to ensure the safety of any activities to be conducted by it and its employees, affiliates, contractors or designees, with respect to handling and using EVMs. Further, user is responsible to ensure that any interfaces (electronic and/or mechanical) between EVMs 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.
11. User shall employ reasonable safeguards to ensure that user's use of EVMs will not result in any property damage, injury or death, even if EVMs should fail to perform as described or expected.
12. User shall be solely responsible for proper disposal and recycling of EVMs consistent with all applicable federal, state, and local requirements.

**Certain Instructions.** User shall operate EVMs within TI's recommended specifications and environmental considerations per the user's guide, accompanying documentation, and any other applicable requirements. Exceeding the specified ratings (including but not limited to input and output voltage, current, power, and environmental ranges) for EVMs may cause property damage, personal injury or death. If there are questions concerning these ratings, 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the applicable 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 as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using EVMs' schematics located in the applicable EVM user's guide. When placing measurement probes near EVMs during normal operation, please be aware that EVMs may become very warm. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use EVMs.

**Agreement to Defend, Indemnify and Hold Harmless.** User agrees to defend, indemnify, and hold TI, its directors, officers, employees, agents, representatives, affiliates, 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 and/or use of EVMs. User's indemnity shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if EVMs fail to perform as described or expected.

**Safety-Critical or Life-Critical Applications.** If user intends to use EVMs in evaluations of safety critical applications (such as life support), and a failure of a TI product considered for purchase by user for use in user's product would reasonably be expected to cause severe personal injury or death such as devices which are classified as FDA Class III or similar classification, then user must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

## **RADIO FREQUENCY REGULATORY COMPLIANCE INFORMATION FOR EVALUATION MODULES**

Texas Instruments Incorporated (TI) evaluation boards, kits, and/or modules (EVMs) and/or accompanying hardware that is marketed, sold, or loaned to users may or may not be subject to radio frequency regulations in specific countries.

### **General Statement for EVMs Not Including a Radio**

For EVMs not including a radio and not subject to the U.S. Federal Communications Commission (FCC) or Industry Canada (IC) regulations, TI intends EVMs to be used only for engineering development, demonstration, or evaluation purposes. EVMs are not finished products typically fit for general consumer use. EVMs may nonetheless generate, use, or radiate radio frequency energy, but have not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or the ICES-003 rules. Operation of such EVMs may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

### **General Statement for EVMs including a radio**

*User Power/Frequency Use Obligations:* For EVMs including a radio, the radio included in such EVMs is intended for development and/or professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability in such EVMs and their development application(s) must comply with local laws governing radio spectrum allocation and power limits for such EVMs. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by TI unless user has obtained appropriate experimental and/or development licenses from local regulatory authorities, which is the sole responsibility of the user, including its acceptable authorization.

### **U.S. Federal Communications Commission Compliance**

#### **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 could void the user's authority to operate the equipment.

##### **FCC Interference Statement for Class A EVM devices**

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 its own expense.

##### **FCC Interference Statement for Class B EVM devices**

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.

##### **Industry Canada Compliance (English)**

#### **For EVMs Annotated as IC – INDUSTRY CANADA Compliant:**

This Class A or B digital apparatus complies with Canadian ICES-003.

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

##### **Concerning EVMs Including Radio Transmitters**

This device complies with Industry Canada licence-exempt RSS standard(s). 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.

##### **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.

## Canada Industry Canada Compliance (French)

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

### 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.

### 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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2014, Texas Instruments Incorporated

## Important Notice for Users of EVMs Considered “Radio Frequency Products” in Japan

### EVMs entering Japan are NOT certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If user uses EVMs in Japan, user is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

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.

<http://www.tij.co.jp>

【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】本開発キットは技術基準適合証明を受けておりません。本製品のご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。

日本テキサス・インスツルメンツ株式会社

東京都新宿区西新宿6丁目24番1号

西新宿三井ビル

<http://www.tij.co.jp>

Texas Instruments Japan Limited

(address) 24-1, Nishi-Shinjuku 6 chome, Shinjuku-ku, Tokyo, Japan

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

### Products

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
OMAP Applications Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>

### Applications

Automotive and Transportation	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>

### TI E2E Community

[e2e.ti.com](http://e2e.ti.com)