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.

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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 µA) 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 MΩ 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

![Schematic Diagram]

**Figure 1.** TPS62730 and TPS62733 EVM Board Schematic

2 Performance Specification Summary

<table>
<thead>
<tr>
<th>Specification</th>
<th>Conditions</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input dc voltage, IN</td>
<td>2.0V–5.5V, 200mA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output dc voltage, OUT</td>
<td>Adjustable by changing external resistors from 1.3 V to 5.3 V</td>
<td></td>
<td></td>
<td>1.8</td>
<td>V</td>
</tr>
<tr>
<td>VBAT_OK threshold</td>
<td>Adjustable by changing external resistors from OUT to 5.3 V</td>
<td></td>
<td></td>
<td>2.9</td>
<td>V</td>
</tr>
<tr>
<td>Output current</td>
<td></td>
<td>0</td>
<td>50</td>
<td></td>
<td>mA</td>
</tr>
</tbody>
</table>
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 ≥ 300 Ω
• 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 μF) 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>
<thead>
<tr>
<th>Jack and Component (Silk Screen)</th>
<th>Description</th>
<th>Connect or Adjustment To:</th>
</tr>
</thead>
<tbody>
<tr>
<td>J1 (IN)</td>
<td>Negative lead of current meter (CM#1)</td>
<td></td>
</tr>
<tr>
<td>J2-1 (+ IN SNS)</td>
<td>Kelvin connection to capacitance</td>
<td>Positive lead of voltmeter (VM#1)</td>
</tr>
<tr>
<td>J2-2 (- GND SNS)</td>
<td>Kelvin connection to capacitance</td>
<td>Negative lead of voltmeter (VM#1)</td>
</tr>
<tr>
<td>J3 (GND)</td>
<td>Power supply negative lead</td>
<td></td>
</tr>
<tr>
<td>J4 (OUT)</td>
<td>Positive lead of current meter (CM#2)</td>
<td></td>
</tr>
<tr>
<td>J5-1 (+ OUT SNS)</td>
<td>Kelvin connection to capacitance</td>
<td>Positive lead of voltmeter (VM#2)</td>
</tr>
<tr>
<td>J5-2 (- GND SNS)</td>
<td>Kelvin connection to capacitance</td>
<td>Negative lead of voltmeter (VM#2)</td>
</tr>
<tr>
<td>J6 (GND)</td>
<td>Negative lead to load resistance</td>
<td></td>
</tr>
<tr>
<td>J7-1 (VIN_OK)</td>
<td>Push-pull output of comparator that indicates the status of the input voltage</td>
<td>n/a</td>
</tr>
<tr>
<td>J7-2 (GND)</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>JP1 (EN1)</td>
<td>EN1 = HI and EN2 = x implements full standby mode. Switching converter and VIN_OK indication is off (ship mode).</td>
<td>EN1 = LO</td>
</tr>
<tr>
<td>JP2 (EN2)</td>
<td>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.</td>
<td>EN2 = HI</td>
</tr>
</tbody>
</table>
Table 1 and Figure 2 show the test setup for measuring efficiency.

![EVM Test Setup for Measuring Efficiency](image)

### 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, $V_{\text{out}} = 1.8$ V

Figure 4. Steady State Operation with $R_O = 50$ Ω

Figure 5. Load Transient Response
Figure 6. Ship-Mode Startup Behavior

Figure 7. Standby-Mode Startup Behavior
4.1  REV A PCB Layout (FUNCTIONAL)

Figure 8. Assembly Layer

Figure 9. Top 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>
<thead>
<tr>
<th>Count</th>
<th>RefDes</th>
<th>Value</th>
<th>Description</th>
<th>Size</th>
<th>Part Number</th>
<th>MFR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C2</td>
<td>0.1uF</td>
<td>Capacitor, Ceramic Chip, 10V, X5R, +10%</td>
<td>603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>C1</td>
<td>4.7uF</td>
<td>Capacitor, Ceramic Chip, 10V, X5R, ±10%</td>
<td>603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>C3</td>
<td>22uF</td>
<td>Capacitor, Ceramic Chip, 6.3V, X5R, ±10%</td>
<td>805</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>0</td>
<td>C4</td>
<td>DNP</td>
<td>Capacitor, Ceramic Chip, xxV, ±10%</td>
<td>1210</td>
<td>Std</td>
<td>STD</td>
</tr>
<tr>
<td>7</td>
<td>J1-7</td>
<td>PEC02SAAN</td>
<td>Header, Male 2-pin, 100mil spacing,</td>
<td>0.100 inch x 2</td>
<td>PEC02SAAN</td>
<td>Sullins</td>
</tr>
<tr>
<td>1</td>
<td>L1</td>
<td>10uH</td>
<td>Inductor, SMT, 1.4A, 216mΩ</td>
<td>2.5mm x 2.0mm x 1.20mm</td>
<td>DFE252012C-1239AS-H-100N</td>
<td>TOKO</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Inductor SMT, 500mA, 500mΩ</td>
<td>2.5mm x 2.0mm x 1.20mm</td>
<td>74479889310</td>
<td>Wurth Elektronik</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Inductor SMT, 250mA, 500mΩ</td>
<td>2.5mm x 2.0mm x 1.00mm</td>
<td>74479888310</td>
<td>Wurth Elektronik</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Inductor SMT, 500mA, 390mΩ</td>
<td>2.8mm x 2.8mm x 1.35mm</td>
<td>744029100</td>
<td>Wurth Elektronik</td>
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<tr>
<td>2</td>
<td>JP1-2</td>
<td>PEC03SAAN</td>
<td>Header, Male 3-pin, 100mil spacing,</td>
<td>0.100 inch x 3</td>
<td>PEC03SAAN</td>
<td>Sullins</td>
</tr>
<tr>
<td>1</td>
<td>R3</td>
<td>4.32M</td>
<td>Resistor, Chip, 1/16W, 1%</td>
<td>603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>R2</td>
<td>3.4M</td>
<td>Resistor, Chip, 1/16W, 1%</td>
<td>603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>R1</td>
<td>5.49M</td>
<td>Resistor, Chip, 1/16W, 1%</td>
<td>603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>U1</td>
<td>TPS62736RGY</td>
<td>IC, Ultra Low Power Harvester Power Management Core</td>
<td>VQFN</td>
<td>TPS62736RGY</td>
<td>TI</td>
</tr>
<tr>
<td>2</td>
<td>--</td>
<td>--</td>
<td>Shunt, 100-mil, Black</td>
<td>0.100</td>
<td>929950-00</td>
<td>3M</td>
</tr>
</tbody>
</table>
## Revision History

### Changes from A Revision (May 2013) to B Revision

- Changed content in the bill of materials ................................................................. 11

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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 about 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.
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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. 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.

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.

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