This user's guide describes the characteristics, operation, and use of the Texas Instruments TPS62740 evaluation module (EVM). This EVM is designed to help the user easily evaluate and test the operation and functionality of the TPS62740. The EVM converts a 2.2-V to 5.5-V input voltage to a regulated output voltage that is set between 1.8 V and 3.3 V at up to 300 mA. The TPS62740 also includes a load switch and power good output, while having an ultra-low quiescent current of 360 nA. This user's guide includes setup instructions for the hardware, a printed-circuit board layout for the EVM, a schematic diagram, a bill of materials, and test results for the EVM.

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1 Introduction
The TPS62740 is a 300-mA, synchronous, step-down converter in a 2 x 3-mm, 10-pin SON package. The output voltage is fixed inside the device by the connection of the four VSELx pins.

1.1 Background
The TPS62740EVM-186 (PWR186-001) uses the TPS62740 device. The EVM operates with full-rated performance with an input voltage between 2.2 V and 5.5 V.
1.2 Performance Specification

Table 1 provides a summary of the TPS62740EVM-186 performance specifications. All specifications are given for an ambient temperature of 25°C and an input voltage of 3.6 V.

Table 1. Performance Specification Summary

<table>
<thead>
<tr>
<th>Specification</th>
<th>Test Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Voltage</td>
<td></td>
<td>2.2</td>
<td>3.6</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>Output Voltage Setpoint</td>
<td>Programmable through the VSELx pins in 100 mV steps</td>
<td>1.8</td>
<td>3.3</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Output Current</td>
<td>( V_{IN} &gt; 0.7 , V + V_{OUT} )</td>
<td>0</td>
<td>300</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Output Current</td>
<td>( V_{IN} &lt; 0.7 , V + V_{OUT} )</td>
<td>0</td>
<td>100</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Peak Efficiency</td>
<td>( V_{IN} = 2.2 , V; , V_{OUT} = 1.8 , V )</td>
<td></td>
<td></td>
<td>92.5%</td>
<td></td>
</tr>
<tr>
<td>Soft-Start Delay Time</td>
<td>Time from high EN to Start of ( V_{OUT} ) Ramp</td>
<td>10</td>
<td></td>
<td></td>
<td>ms</td>
</tr>
</tbody>
</table>

1.3 Modifications

The printed-circuit board (PCB) for this EVM is designed to accommodate some modifications by the user. Additional input and output capacitors can be added. Finally, the loop response of the IC can be measured.

1.3.1 Input and Output Capacitors

C3 is provided for an additional input capacitor. This capacitor is not required for proper operation but can be used to reduce the input voltage ripple.

C4 and C6 are provided for additional output capacitors. These capacitors are not required for proper operation but can be used to reduce the output voltage ripple and to improve the load transient response. The total output capacitance must remain within the recommended range in the data sheet for proper operation.

1.3.2 Loop Response Measurement

The loop response of the TPS62740EVM-186 can be measured with two simple changes to the circuitry. First, install a 10-Ω resistor across the pads in the middle of the back of the PCB. The pads are spaced to allow installation of an 0402-sized resistor. Second, cut the short section of trace between the via on the VOS pin and the output capacitor C2. This change is shown in Figure 1. With these changes, an ac signal (10-mV, peak-to-peak amplitude recommended) can be injected into the control loop across the added resistor. Details of measuring the control loop of DCS-Control devices are found in SLVA465.
2 Setup

This section describes how to properly use the TPS62740EVM-186.

2.1 Input/Output Connector Descriptions

- **J1 – VIN**: Positive input connection from the input supply for the EVM.
- **J2 – S+/S-**: Input voltage sense connections. Measure the input voltage at this point.
- **J3 – GND**: Return connection from the input supply for the EVM.
- **J4 – VOUT**: Output voltage connection.
- **J5 – S+/S-**: Output voltage sense connections. Measure the output voltage at this point.
- **J6 – GND**: Output return connection.
- **J7 – PG/GND**: The PG output appears on pin 1 of this header with a convenient ground on pin 2.
- **J8 – LOAD**: Load switch output connection.
- **J9 – S+/S-**: Load switch output voltage sense connections. Measure the load switch output voltage at this point.
- **J10 – GND**: Load switch output return connection.
- **JP1 – EN**: EN pin input jumper. Place the supplied jumper across ON and EN to turn on the IC. Place the jumper across OFF and EN to turn off the IC.
- **JP2 – CTRL**: CTRL pin input jumper. Place the supplied jumper across LOAD_ON and CTRL to activate (close) the internal load switch. Place the jumper across LOAD_OFF and CTRL to de-activate (open) the internal load switch.
- **JP3 through JP6 – VSELx**: These four inputs set the output voltage. By connecting each pin high or low, the output voltage is programmed per Table 2. Do not leave any jumper open for proper operation.
Table 2 provides the output voltage settings for the TPS62740EVM-186. A 0 refers to logic low, while 1 refers to logic high.

<table>
<thead>
<tr>
<th>VOUT</th>
<th>VSEL 4</th>
<th>VSEL 3</th>
<th>VSEL 2</th>
<th>VSEL 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1.9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2.0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2.1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2.2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2.3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2.4</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2.5</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2.6</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2.7</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2.8</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
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<tr>
<td>2.9</td>
<td>1</td>
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<td>1</td>
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<td>3.0</td>
<td>1</td>
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<td>0</td>
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<td>3.1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>3.2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>3.3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

2.2 Setup

To operate the EVM, set jumpers JP1 through JP6 to the desired positions per Section 2.1. Connect the input supply to J1 and J3 and connect the load to J4 and J6.

3 Common Efficiency Measurement Errors with Ultra-Low Iq Devices

Efficiency is a common measurement for a power supply. With an ultra-low quiescent current device, such as the TPS62740, measurement errors can have a large impact on the measured efficiency, especially at very low load currents (< 100 µA).

3.1 Efficiency Measurement Setup

To accurately measure the efficiency of the TPS62740EVM-186, use the setup described in SLVA236 Figure 6. The 'Additional Input Capacitor' referred to in that app note is not needed as C5 is already included on the TPS62740EVM-186. Any additional input capacitance is not recommended as it incurs increased leakage on the input which lowers the measured efficiency.

When measuring efficiency through the setup in SLVA236, special care must be taken to remove the current consumed by the measurement instruments from the efficiency calculations. Such measurement instruments typically include the input voltage and output voltage multimeters as well as the input power supply's remote sense lines (if it has this capability). The current into these points affects the measured efficiency at very light loads. Two possible methods to overcome this are: measuring the current into these points (measure the current into the multimeters and/or remote sense lines) and then subtracting this current from the efficiency calculation or simply removing these instruments from the test setup. At very light load currents, it is typically best to remove the remote sense lines of the input power supply and then measure the current into the input and output voltage multimeters to get the most accurate efficiency measurement.
3.2 **Pull-Up and Pull-Down Resistors**

In addition to the input capacitor and remote sense lines noted in Section 3.1, any pull-up or pull-down resistors can draw significant current and affect the measured efficiency. For example, if the VSEL2 pin were pulled up to the input voltage with a 1-MΩ resistor and the pin were tied low through JP4, this would draw an extra 3.6 µA from the input source at a 3.6-V input voltage. This would greatly affect the efficiency at very light loads. For this reason, no pull-up or pull-down resistors have been used on the TPS62740EVM-186. The final application circuit should ensure that all digital inputs to the TPS62740 are terminated either high or low and not left floating, per the device data sheet.

4 **TPS62740EVM-186 Test Results**

The TPS62740EVM-186 was used to take most of the data in the TPS62740 data sheet, SLVSB02. The only difference is the inductor used. This EVM was designed for the smallest solution size and uses a 0805-size inductor. The data sheet inductor achieves best efficiency but is 3 x 3 mm in size.
5 Board Layout

This section provides the TPS62740EVM-186 board layout and illustrations. The gerbers are available on the EVM product page: TPS62740EVM-186.

Figure 2. Assembly Layer

Figure 3. Top Silk Layer
Figure 4. Top Layer

Figure 5. Bottom Layer
6 Schematic and Bill of Materials

This section provides the TPS62740EVM-186 schematic and bill of materials.

6.1 Schematic

Figure 6. TPS62740EVM-186 Schematic
### 6.2 Bill of Materials

Table 3. TPS62740EVM-186 Bill of Materials

<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>3</td>
<td>C1, C2, C7</td>
<td>10uF</td>
<td>Capacitor, Ceramic, X5R, 6.3V, 20%</td>
<td>0603</td>
<td>GRM188R60J106</td>
<td>Murata</td>
</tr>
<tr>
<td>1</td>
<td>C5</td>
<td>100uF</td>
<td>Capacitor, Ceramic, X5R, 6.3V, 20%</td>
<td>1210</td>
<td>GRM32ER60J107</td>
<td>Murata</td>
</tr>
<tr>
<td>1</td>
<td>L1</td>
<td>2.2uH</td>
<td>Inductor, SMT, 0.7A, 230-mΩ</td>
<td>0805</td>
<td>MIPSZ2012D2R2</td>
<td>FDK</td>
</tr>
<tr>
<td>1</td>
<td>R1</td>
<td>1.00M</td>
<td>Resistor, Chip, 1/16W, 1%</td>
<td>0603</td>
<td>RC0603FR-071ML</td>
<td>Yageo</td>
</tr>
<tr>
<td>1</td>
<td>U1</td>
<td>TPS62740</td>
<td>IC, 360 nA I&lt;sub&gt;Q&lt;/sub&gt; Step Down Converter</td>
<td>2 mm x 3 mm</td>
<td>TPS62740DSS</td>
<td>TI</td>
</tr>
</tbody>
</table>
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General Statement for EVMs including a radio

User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. 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 Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

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

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.
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- 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.

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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.

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 for RF Products in Japan】

This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product 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 this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

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3. Since the EVM is not a completed product, it may not meet all applicable regulatory and safety compliance standards (such as UL, CSA, VDE, CE, RoHS and WEEE) which may normally be associated with similar items. You assume full responsibility to determine and/or assure compliance with any such standards and related certifications as may be applicable. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.

4. You will take care of proper disposal and recycling of the EVM’s electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI’s recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please 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 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 the EVM schematic located in the EVM User’s Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

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