This user’s guide describes the characteristics, operation, and use of the TPS65132W evaluation module (EVM) and its software. It includes the EVM specifications, the recommended setup (hardware and software), the schematic diagram, the board layouts, and the bill of materials.

All the measurements in the Application Performance section of the TPS65132W datasheet (SLVSBM1) were done with this EVM.

Contents
1 Introduction ................................................................. 2
2 Electrical Specifications .................................................. 3
3 Schematic ............................................................................. 4
4 Connectors, Jumpers and Test Points .................................. 5
5 Setup ...................................................................................... 6
6 Software Operation ............................................................ 9
7 PCB Layout ................................................................. 14
8 List of Materials .............................................................. 16

List of Figures
1 Schematic ............................................................................. 4
2 Hardware Setup – Full Functionality .................................. 6
3 Hardware Setup – Simplified ............................................... 6
4 Two-Terminal Power Supply Connection .............................. 7
5 Four-Terminal Power Supply Connection ............................ 7
6 Single-Ended Load Connections ........................................ 7
7 Differential Load Connection .............................................. 8
8 Ribbon Cable Connected to the Ten Middle Pins of the USB2ANY Interface Adapter ........................................ 8
9 Device Selection Window .................................................... 9
10 Settings Window .............................................................. 9
11 iC Bus Internal Pullup Connection ....................................... 10
12 iC Bus External Pullup Connection ..................................... 10
13 DAC Registers Window .................................................. 12
14 Demo Mode Prompt with No EVM Connected .................... 13
15 Component Placement (Top View) ..................................... 14
16 PCB Top Layer (Top View) .................................................. 14
17 PCB Bottom Layer (Bottom View) ..................................... 15

List of Tables
1 Electrical Specifications .................................................. 3
2 Connector Overview ....................................................... 5
3 Jumper Overview ............................................................ 5
4 Test Point Overview ......................................................... 5
5 Bill of Materials .............................................................. 16
1 Introduction

This EVM uses a TPS65132W to generate the positive and negative supply voltages needed by LCD panels in smartphones and tablet PCs. It can also be used as a general-purpose power supply in applications that need positive and negative supply rails (for example, op-amp or data acquisition circuits).

For easy performance evaluation of the TPS65132W, this EVM has:
- Software with a Graphical User Interface (GUI) for reading, writing, exporting, and importing the device configuration
- A USB2ANY interface adapter to control the I²C bus
- Test points for measuring the most important voltages
- Jumpers for enabling and disabling the outputs
- Input and output voltage sense terminals for making accurate four-terminal voltage measurements

1.1 Recommended Equipment

In addition to the contents of the EVM box, some or all of the equipment described in the following subsections is required.

1.1.1 Power Supply

To evaluate the full performance of the TPS65132W, a dc power supply capable of delivering 1.2 A from 2.5 V to 5.5 V is required.

1.1.2 Host Computer

To change the output voltages or configuration of the TPS65132W, a personal computer (PC) with the following minimum specifications is needed:
- Microsoft® Windows® 7 operating system
- One free USB port
- A minimum of 280MB of free hard disk space (610MB recommended)
- A minimum of 512MB of RAM

1.1.3 Software

You can download the latest version of the EVM software from the TI website at http://www.ti.com/product/tps65132 (see also Section 5.2).

1.2 Applications

The TPS65132W device is suitable for use in any applications that need positive and negative output voltages in the range ±4 V to ±6 V and output currents less than ±80 mA. Typical applications include:
- Smartphone displays
- Tablet displays
- Split-rail power supply applications

Microsoft, Windows are registered trademarks of Microsoft Corporation.
1.3 Features

- Efficiency greater than 85% at $I_o > 10$ mA
- Input voltage range of 2.5 V to 5.5 V
- Positive output voltage range of 4.0 V to 6.0 V (0.1-V steps)
- Negative output voltage range of –4.0 V to –6.0 V (0.1-V steps)
- Output voltage accuracy of better than 1%
- Programmable active discharge during shutdown
- Excellent line regulation
- Advanced power-save mode for light-load efficiency
- Thermal shutdown
- Two-layer PCB with all components on top side

2 Electrical Specifications

Table 1 gives an overview of the electrical specifications of the TPS65132W EVM.

<table>
<thead>
<tr>
<th>Table 1. Electrical Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parameter</strong></td>
</tr>
<tr>
<td><strong>Notes and Conditions</strong></td>
</tr>
<tr>
<td><strong>MIN</strong></td>
</tr>
<tr>
<td>Input Characteristics</td>
</tr>
<tr>
<td>$V_{IN}$ Input voltage</td>
</tr>
<tr>
<td>2.5</td>
</tr>
<tr>
<td>Input current $V_{IN} = 3.7$ V, $I_{POS} = I_{NEG} = 40$ mA</td>
</tr>
<tr>
<td>$V_{IN} = 3.7$ V, $I_{NEG} = 0$ mA</td>
</tr>
<tr>
<td>Output Characteristics</td>
</tr>
<tr>
<td>$V_{POS}$ Positive output voltage</td>
</tr>
<tr>
<td>$V_{IN} = 3.7$ V, $I_{POS} = 40$ mA</td>
</tr>
<tr>
<td>$V_{IN} = 3.7$ V, $I_{NEG} = 0$ mA</td>
</tr>
<tr>
<td>$\Delta V_{POS(VIN)}$ Line regulation ($V_{POS}$)</td>
</tr>
<tr>
<td>$V_{IN} = 2.5$ V to 5.5 V, $I_{POS} = 40$ mA</td>
</tr>
<tr>
<td>$V_{IN} = 3.7$ V, $V_i = 3.7$ V</td>
</tr>
<tr>
<td>$\Delta V_{POS(VO)}$ Load regulation ($V_{POS}$)</td>
</tr>
<tr>
<td>$I_{POS} = 10$ mA to 40 mA, $V_i = 3.7$ V</td>
</tr>
<tr>
<td>$V_{NEG}$ Default negative output voltage</td>
</tr>
<tr>
<td>$V_{IN} = 3.7$ V, $I_{NEG} = 40$ mA</td>
</tr>
<tr>
<td>$V_{IN} = 3.7$ V, $I_{POS} = I_{NEG} = 40$ mA</td>
</tr>
<tr>
<td>$\Delta V_{NEG(VIN)}$ Line regulation ($V_{NEG}$)</td>
</tr>
<tr>
<td>$V_{IN} = 2.5$ V to 5.5 V, $I_{O} = 40$ mA</td>
</tr>
<tr>
<td>$V_{IN} = 3.7$ V, $V_i = 3.7$ V</td>
</tr>
<tr>
<td>$\Delta V_{NEG(VO)}$ Load regulation ($V_{NEG}$)</td>
</tr>
<tr>
<td>$I_{NEG} = 10$ mA to 40 mA, $V_{IN} = 3.7$ V</td>
</tr>
<tr>
<td>$V_{POS(PP)}$ Output voltage ripple ($V_{POS}$)</td>
</tr>
<tr>
<td>$V_{IN} = 3.7$ V, $I_{O} = 40$ mA</td>
</tr>
<tr>
<td>$V_{IN} = 3.7$ V, $V_i = 3.7$ V</td>
</tr>
<tr>
<td>$V_{NEG(PP)}$ Output voltage ripple NEG</td>
</tr>
<tr>
<td>$V_{IN} = 3.7$ V, $I_{O} = 40$ mA</td>
</tr>
<tr>
<td>$V_{IN} = 3.7$ V, $V_i = 3.7$ V</td>
</tr>
</tbody>
</table>

System Characteristics

- Switching frequency 1.6 MHz
- Peak efficiency $V_{IN} = 3.7$ V 89%

---

(1) $I_o$ means that the load is connected from $V_{POS}$ to $V_{NEG}$. 

---

Copyright © 2014–2016, Texas Instruments Incorporated
Figure 1 is for reference only; see the bill of materials in Section 8 for specific values.
Connectors, Jumpers and Test Points

Table 2, Table 3, and Table 4 give an overview of the connector, jumper, and test point connections of the EVM.

### Table 2. Connector Overview

<table>
<thead>
<tr>
<th>Connector</th>
<th>Signal</th>
<th>Pin</th>
<th>Description</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>J1</td>
<td>VIN</td>
<td>1, 2</td>
<td>Input Supply</td>
<td>Connect a 2.5-V to 5.5-V dc power supply to J1. Use two-terminal (Figure 4) or four-terminal (Figure 5) connections. To minimize parasitic inductance, use a short (&lt;20 cm) cable and twist the conductors.</td>
</tr>
<tr>
<td></td>
<td>S+</td>
<td>3</td>
<td>Input Supply Sense</td>
<td></td>
</tr>
<tr>
<td></td>
<td>S−</td>
<td>4</td>
<td>Ground Sense</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PGND</td>
<td>5, 6</td>
<td>Ground</td>
<td></td>
</tr>
<tr>
<td>J2</td>
<td>OUTP</td>
<td>1, 2</td>
<td>Positive Output</td>
<td>A load can be connected between the positive output and ground (Figure 6) or between the positive and negative outputs (Figure 7).</td>
</tr>
<tr>
<td></td>
<td>S+</td>
<td>3</td>
<td>Positive Output Sense</td>
<td></td>
</tr>
<tr>
<td></td>
<td>S−</td>
<td>4</td>
<td>Ground Sense</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PGND</td>
<td>5, 6</td>
<td>Ground</td>
<td></td>
</tr>
<tr>
<td>J3</td>
<td>VNEG</td>
<td>1, 2</td>
<td>Negative Output</td>
<td>A load can be connected between the negative output and ground (Figure 7) or between the positive and negative outputs (Figure 7).</td>
</tr>
<tr>
<td></td>
<td>S−</td>
<td>3</td>
<td>Negative Output Sense</td>
<td></td>
</tr>
<tr>
<td></td>
<td>S+</td>
<td>4</td>
<td>Ground</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PGND</td>
<td>5, 6</td>
<td>Ground</td>
<td></td>
</tr>
<tr>
<td>J4</td>
<td>SCL</td>
<td>9</td>
<td>Clock</td>
<td>Use the 10-way ribbon cable supplied with the EVM to connect J4 to the USB2ANY interface adapter (Figure 8).</td>
</tr>
<tr>
<td></td>
<td>SDA</td>
<td>10</td>
<td>Data</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GND</td>
<td>6</td>
<td>Ground</td>
<td></td>
</tr>
<tr>
<td>J5</td>
<td>REG</td>
<td>1, 2</td>
<td>Boost Converter Output</td>
<td>A load can be connected between the boost converter output and ground.</td>
</tr>
<tr>
<td></td>
<td>GND</td>
<td>3, 4</td>
<td>Ground</td>
<td></td>
</tr>
<tr>
<td>J6</td>
<td>GND</td>
<td>1, 2, 3, 4, 5, 6</td>
<td>Ground</td>
<td>Use these pins when you do a measurement and need a ground connection.</td>
</tr>
</tbody>
</table>

### Table 3. Jumper Overview

<table>
<thead>
<tr>
<th>Jumper</th>
<th>Signal</th>
<th>Pin</th>
<th>Description</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>JP1</td>
<td>VIN</td>
<td>1</td>
<td>Input Supply</td>
<td>Connect a jumper between pins 1 and 2 to enable the negative output, or between pins 2 and 3 to disable it.</td>
</tr>
<tr>
<td></td>
<td>ENN</td>
<td>2</td>
<td>Negative Output Enable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GND</td>
<td>3</td>
<td>Ground</td>
<td></td>
</tr>
<tr>
<td>JP2</td>
<td>VIN</td>
<td>1</td>
<td>Input Supply</td>
<td>Connect a jumper between pins 1 and 2 to enable the positive output, or between pins 2 and 3 to disable it.</td>
</tr>
<tr>
<td></td>
<td>ENP</td>
<td>2</td>
<td>Positive Output Enable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GND</td>
<td>3</td>
<td>Ground</td>
<td></td>
</tr>
</tbody>
</table>

### Table 4. Test Point Overview

<table>
<thead>
<tr>
<th>Test Point</th>
<th>Signal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP1</td>
<td>VIN</td>
<td>Input Supply</td>
</tr>
<tr>
<td>TP2</td>
<td>OUTP</td>
<td>Positive Output</td>
</tr>
<tr>
<td>TP3</td>
<td>OUTN</td>
<td>Negative Output</td>
</tr>
<tr>
<td>TP4</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>TP5</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>TP6</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>TP7</td>
<td>REG</td>
<td>Boost Converter Output</td>
</tr>
</tbody>
</table>
Setup

5 Setup

5.1 Hardware Connections

Figure 2 shows how to connect the EVM to a dc power supply, a load, and a host PC.

If no changes to the output voltages or to any other configuration settings are needed, use the simplified set-up shown in Figure 3. If using the simplified setup, the TPS65132W device starts up with the register settings stored in its EEPROM the last time it was programmed.

Use two-terminal (Figure 4) or four-terminal (Figure 5) connections to connect the power supply to the EVM. Two-terminal connections are simpler, but four terminal connections are more accurate.

To minimize parasitic inductance, TI recommends using a short cable (less than 20 cm) and twist the power (VIN) and return (GND) conductors together.
Connect single-ended loads between VPOS and ground and between VNEG and ground (Figure 6) or connect a differential load between VPOS and VNEG (Figure 7).
5.2 Software Installation

To change the register settings, install the EVM software on a host PC and install a USB2ANY interface adapter to connect the host PC to the EVM hardware (Figure 2). To download the latest version of the EVM software:

- Go to the TPS65132W product folder on the TI Web site (http://www.ti.com/product/tp65132)
- Download the software zip file
- Unzip the file
- Run the program setup.exe (TI recommends uninstalling existing versions of the EVM software before installing a new one)

After installing the software, an icon with the name TPS65132 EVM in on the desktop of the host computer. If this icon is not seen, browse the program files in the Start menu for the software. The default location is All Programs → Texas Instruments → TPS65132.

Connect the USB2ANY interface adapter to the host computer and then start the software. If the system asks to update the firmware in the interface adapter, follow the on-screen instructions until the update is complete.
6 Software Operation

The EVM software can be used with all variants of the TPS65132 device. When the software starts, select the device you want to evaluate from the drop-down menu and then click on OK. (refer to Figure 9).

![Figure 9. Device Selection Window](image)

After selecting the device variant and clicking the OK button, the software shows the Settings window as is in Figure 10.

![Figure 10. Settings Window](image)

6.1 Save and Load

Export configurations for reuse later:
- Clicking on the Save icon exports the configuration.
- Clicking on the Load icon imports a saved configuration.
6.2 \( \text{I}^{2}\text{C} \) Bus Configuration

6.2.1 Slave Address
The EVM software uses the slave address 0x3E to communicate with the TPS65132W device over the \( \text{I}^{2}\text{C} \) bus. This address cannot be changed.

6.2.2 Bus Speed
The \( \text{I}^{2}\text{C} \) bus of the EVM can operate in Standard mode (100 kbps) or Fast mode (400 kbps). Select the desired \( \text{I}^{2}\text{C} \) bus speed from the Speed drop-down menu.

6.2.3 Pullups
The USB2ANY interface adapter has pullup resistors for the \( \text{I}^{2}\text{C} \) bus. Disable the pullup resistors if they are not needed.

- Check the Pullups? checkbox if using the \( \text{I}^{2}\text{C} \) pullup resistors in the USB2ANY interface adapter (refer to Figure 11). This is the most common setting.
- Uncheck the Pullups? checkbox if there are \( \text{I}^{2}\text{C} \) pullup resistors somewhere else in your system (refer to Figure 12).

**NOTE:** The external pullup resistors (if used) must be connected to 3.3 V (Figure 12). Pullup voltages lower than 3.3 V can cause incorrect operation. Pullup voltages higher than 3.3 V can damage the USB2ANY interface adapter.

The maximum value of the external pullup resistors depends on the \( \text{I}^{2}\text{C} \) bus capacitance (refer to UM10204 – \( \text{I}^{2}\text{C} \)-bus specification and user manual from NXP). A higher bus capacitance needs smaller pullup resistors. A value in the range 1.5 k\( \Omega \) to 10 k\( \Omega \) works well in most applications.
6.3 **Settings Window**

The Settings window is shown in Figure 10.

6.3.1 **Output Voltage**

The positive and negative output voltages are adjustable in the following ways:

- Drag the voltage sliders
- Click on the up- and down-arrows of the voltage entry boxes
- Enter a voltage in the voltage entry boxes
- Click on the up- and down-arrows of the hexadecimal entry boxes
- Enter a hexadecimal number in the hexadecimal entry boxes

**NOTE:** If an incorrect value is entered into the voltage or hexadecimal entry boxes, the software rounds that entry down to the nearest correct value. If a value below the minimum output voltage is entered, the software uses the minimum value.

Use the Vpos Discharge and Vneg Discharge checkboxes to enable and disable the output discharge resistors.

- Check the Vpos Discharge check box to enable the Vpos discharge resistor. Uncheck this checkbox to disable the discharge resistor.
- Check the Vneg Discharge check box to enable the Vneg discharge resistor. Uncheck this checkbox to disable the discharge resistor.

6.3.2 **Application**

Use the Smartphone and Tablet radio buttons to select if the TPS65132W operates in Smartphone mode or Tablet mode. The maximum output current in Tablet mode is higher than in Smartphone mode. Refer to the TPS65132W data sheet (SLVSBM1) for more information.
6.4 **DAC Registers Window**

The *DAC Registers* window shows the contents of the EEPROM and DAC registers the last time they were read. The register contents are shown in hexadecimal and binary. The *Field View* decodes the register settings into a more user-friendly format.

Change the content of the registers in the following ways:

- Enter hexadecimal values in the EEPROM and Reg Data columns
- Click on the individual bits to toggle them
- Select values from the drop-down lists in the Field View

Use the icons at the top of the window to select which data the window shows.

- Click on **Write** to program the registers in the TPS65132W device with the contents shown in the GUI window.
- Click on **Write Modified** to program only the selected register in the TPS65132W device with the contents shown in the GUI window.
- Click on **Read** to refresh only the value of the selected register shown in the GUI window.
- Click on **Read All** to refresh the value of all registers.
- Click on **Copy to EEPROM** to copy the current register settings to the EEPROM in the TPS65132W device. The values in the EEPROM are the ones used by the TPS65132W device during start-up.
- If **Read From** = EEPROM, the values are read out of the EEPROM when **Read** or **Read All** is clicked.
- If **Read From** = Register, the values are read out of the (volatile) registers.
- If **Mode** = Immediate, any changes made to the register bits or in the Field View have an immediate effect. If **Mode** = Manual, changes have no effect until **Write Register** is clicked.

*Figure 13. DAC Registers Window*
6.5 Demo Mode

The EVM software can be used on its own, that is:

- Without a USB2ANY interface adapter connected to the host PC
- Without an EVM connected to the USB2ANY interface adapter

If starting the EVM software when one of the previous conditions is true, an error message like the one shown in Figure 14 displays. Clicking on Continue in Demo Mode operates the software as if an EVM were connected, but it shows simulated data. Clicking Stop shuts the software down.

If starting in Demo Mode and then connecting to an EVM, uncheck the Demo Mode checkbox in the top right of the window to exit Demo Mode. If this box is unchecked when there is no EVM connected, an error message like the one shown in Figure 14 displays.

![Figure 14. Demo Mode Prompt with No EVM Connected](imageURL)
7 PCB Layout

Figure 15 through Figure 17 show the design of the TPS65132W EVM printed-circuit board (PCB). The EVM has been designed using a four-layer, 35-μm (1 oz), copper-clad circuit board. All components are on the top side, and all signal traces on the top and bottom layers allow the user to easily view, probe, and evaluate the TPS65132W control IC. Moving components to both sides of the PCB can offer additional size reduction for space-constrained systems.

Figure 15. Component Placement (Top View)

Figure 16. PCB Top Layer (Top View)
Figure 17. PCB Bottom Layer (Bottom View)
8 List of Materials

Table 5 contains the EVM 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>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>C1, C2, C4</td>
<td>4.7 µF</td>
<td>Capacitor, Ceramic, X5R, 16-V, ±10%</td>
<td>0603</td>
<td>GRM188R61C475KAAJ</td>
<td>Murata</td>
</tr>
<tr>
<td>2</td>
<td>C3, C5</td>
<td>10 µF</td>
<td>Capacitor, Ceramic, X5R, 25-V, ±10%</td>
<td>0603</td>
<td>GRM188R61E106MA73</td>
<td>Murata</td>
</tr>
<tr>
<td>4</td>
<td>J1, J2, J3, J6</td>
<td>—</td>
<td>Header, Male 6-pin, 100-mil Spacing, 0.100&quot; × 6</td>
<td></td>
<td>TSW-106-07-G-S</td>
<td>Samtec</td>
</tr>
<tr>
<td>1</td>
<td>J4</td>
<td>—</td>
<td>Connector, Male, Straight 2×5-pin, 100-mil Spacing, 4-Wall</td>
<td>0.338&quot; × 0.788&quot;</td>
<td>N2510-6002RB</td>
<td>3M</td>
</tr>
<tr>
<td>1</td>
<td>J5</td>
<td>—</td>
<td>Header, Male, 4-pin, 100-mil Spacing, 0.100&quot; × 4</td>
<td></td>
<td>TSW-104-07-G-S</td>
<td>Samtec</td>
</tr>
<tr>
<td>2</td>
<td>JP1, JP2</td>
<td>—</td>
<td>Header, Male, 3-pin, 100-mil Spacing, 0.100&quot; × 3</td>
<td></td>
<td>TSW-103-07-G-S</td>
<td>Samtec</td>
</tr>
<tr>
<td>1</td>
<td>L1</td>
<td>2.2 µH</td>
<td>Inductor, Shielded, SMT, ±30%, 0.156 Ω</td>
<td>2520</td>
<td>1269AS-H-2R2</td>
<td>Toko</td>
</tr>
<tr>
<td>3</td>
<td>TP1, TP2, TP3</td>
<td>—</td>
<td>Test Point, Red, Thru-Hole</td>
<td>0.125&quot; × 0.125&quot;</td>
<td>5000</td>
<td>Keystone</td>
</tr>
<tr>
<td>3</td>
<td>TP4, TP5, TP6</td>
<td>—</td>
<td>Test Point, Black, Thru-Hole</td>
<td>0.125&quot; × 0.125&quot;</td>
<td>5001</td>
<td>Keystone</td>
</tr>
<tr>
<td>3</td>
<td>TP7, TP8, TP9</td>
<td>—</td>
<td>Test Point, White, Thru-Hole</td>
<td>0.125&quot; × 0.125&quot;</td>
<td>5002</td>
<td>Keystone</td>
</tr>
<tr>
<td>1</td>
<td>U1</td>
<td>—</td>
<td>IC, Single-Inductor, Dual-Output Power Supply, ±5.4-V</td>
<td>QFN</td>
<td>TPS65132WRVC</td>
<td>Ti</td>
</tr>
</tbody>
</table>

Revision History

Changes from Original (October 2014) to A Revision

- The SLVUAB3A is almost entirely rewritten from the original release of the TPS65132W EVM user's guide. ............... 1

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.
STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. **Delivery:** TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.

   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 and conditions 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 and conditions 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 any defects that are 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. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.

   2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, 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.

3 **Regulatory Notices:**

   3.1 **United States**

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

      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

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-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.

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/lads/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、次のとところをご覧ください。http://www.tij.co.jp/lads/ti_ja/general/eStore/notice_01.page

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 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.
【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】開発キットの中には技術基準適合証明を持っていないものがあります。技術基準適合証明を持っていないも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

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。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

4. EVM Use Restrictions and Warnings:

4.1 EVMs are not for use in functional safety and/or safety critical evaluations, including but not limited to evaluations of life support applications.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 Safety-Related Warnings and Restrictions:

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. Accuracy of Information: To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.
6. **Disclaimers:**

   6.1 **EXCEPT AS SET FORTH ABOVE, EVMS AND ANY WRITTEN DESIGN MATERIALS PROVIDED WITH THE EVM (AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED “AS IS” AND “WITH ALL FAULTS.” TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

   6.2 **EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS AND CONDITIONS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT MADE, CONCEIVED OR ACQUIRED PRIOR TO OR AFTER DELIVERY OF THE EVM.

7. **User's Indemnity Obligations and Representations.** User will defend, indemnify and hold TI, its 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 or use of the EVM that is not in accordance with these terms and conditions. This obligation shall apply whether claims arise under statute, regulation, or the law of tort, contract or any other legal theory, and even if the EVM fails to perform as described or expected.

8. **Limitations on Damages and Liability:**

   8.1 **General Limitations.** In no event shall TI be liable for any special, collateral, indirect, punitive, incidental, consequential, or exemplary damages in connection with or arising out of these terms and conditions or the use of the EVMS provided hereunder. Regardless of whether TI has been advised of the possibility of such damages, excluded damages include, but are not limited to, cost of removal or reinstallation, ancillary costs to the procurement of substitute goods or services, retesting, outside computer time, labor costs, loss of goodwill, loss of profits, loss of savings, loss of use, loss of data, or business interruption. No claim, suit or action shall be brought against TI more than one year after the related cause of action has occurred.

   8.2 **Specific Limitations.** In no event shall TI's aggregate liability from any warranty or other obligation arising out of or in connection with these terms and conditions, or any use of any TI EVM provided hereunder, exceed the total amount paid to TI for the particular units sold under these terms and conditions with respect to which losses or damages are claimed. The existence of more than one claim against the particular units sold to user under these terms and conditions shall not enlarge or extend this limit.

9. **Return Policy.** Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the component(s), excluding any postage or packaging costs.

10. **Governing Law:** These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2015, Texas Instruments Incorporated
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 TI 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: [www.ti.com/audio](http://www.ti.com/audio)
- Amplifiers: [amplifier.ti.com](http://amplifier.ti.com)
- Data Converters: [dataconverter.ti.com](http://dataconverter.ti.com)
- DLP® Products: [www.dlp.com](http://www.dlp.com)
- DSP: [dsp.ti.com](http://dsp.ti.com)
- Clocks and Timers: [www.ti.com/clocks](http://www.ti.com/clocks)
- Interface: [interface.ti.com](http://interface.ti.com)
- Logic: [logic.ti.com](http://logic.ti.com)
- Power Mgmt: [power.ti.com](http://power.ti.com)
- Microcontrollers: [microcontroller.ti.com](http://microcontroller.ti.com)
- RFID: [www.ti-rfid.com](http://www.ti-rfid.com)
- OMAP Applications Processors: [www.ti.com/omap](http://www.ti.com/omap)
- Wireless Connectivity: [www.ti.com/wirelessconnectivity](http://www.ti.com/wirelessconnectivity)

**Applications**

- Automotive and Transportation: [www.ti.com/automotive](http://www.ti.com/automotive)
- Communications and Telecom: [www.ti.com/communications](http://www.ti.com/communications)
- Energy and Lighting: [www.ti.com/energy](http://www.ti.com/energy)
- Industrial: [www.ti.com/industrial](http://www.ti.com/industrial)
- Medical: [www.ti.com/medical](http://www.ti.com/medical)
- Video and Imaging: [www.ti.com/video](http://www.ti.com/video)

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2016, Texas Instruments Incorporated