

TPS65132S Evaluation Module

This user's guide describes the characteristics, operation, and use of the TPS65132S 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 and Implementation* section for the *High-Current Applications* of the TPS65132 datasheet ([SLVSBM1](#)) were done with this EVM.

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1 Introduction

This EVM uses a TPS65132S 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 TPS65132S, 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 TPS65132S, 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 TPS65132S, 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/toolssoftware> (see also [Section 5.2](#)).

1.2 Applications

The TPS65132S 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 ± 150 mA. Typical applications include:

- Smartphone displays
- Tablet displays
- Split-rail power supply applications

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
- Programmable power-up and power-down sequencing
- Excellent line regulation
- Advanced power-save mode for light-load efficiency
- Thermal shutdown
- Four-layer PCB with all components on top side

2 Electrical Specifications

Table 1 gives an overview of the electrical specifications of the TPS65132S EVM.

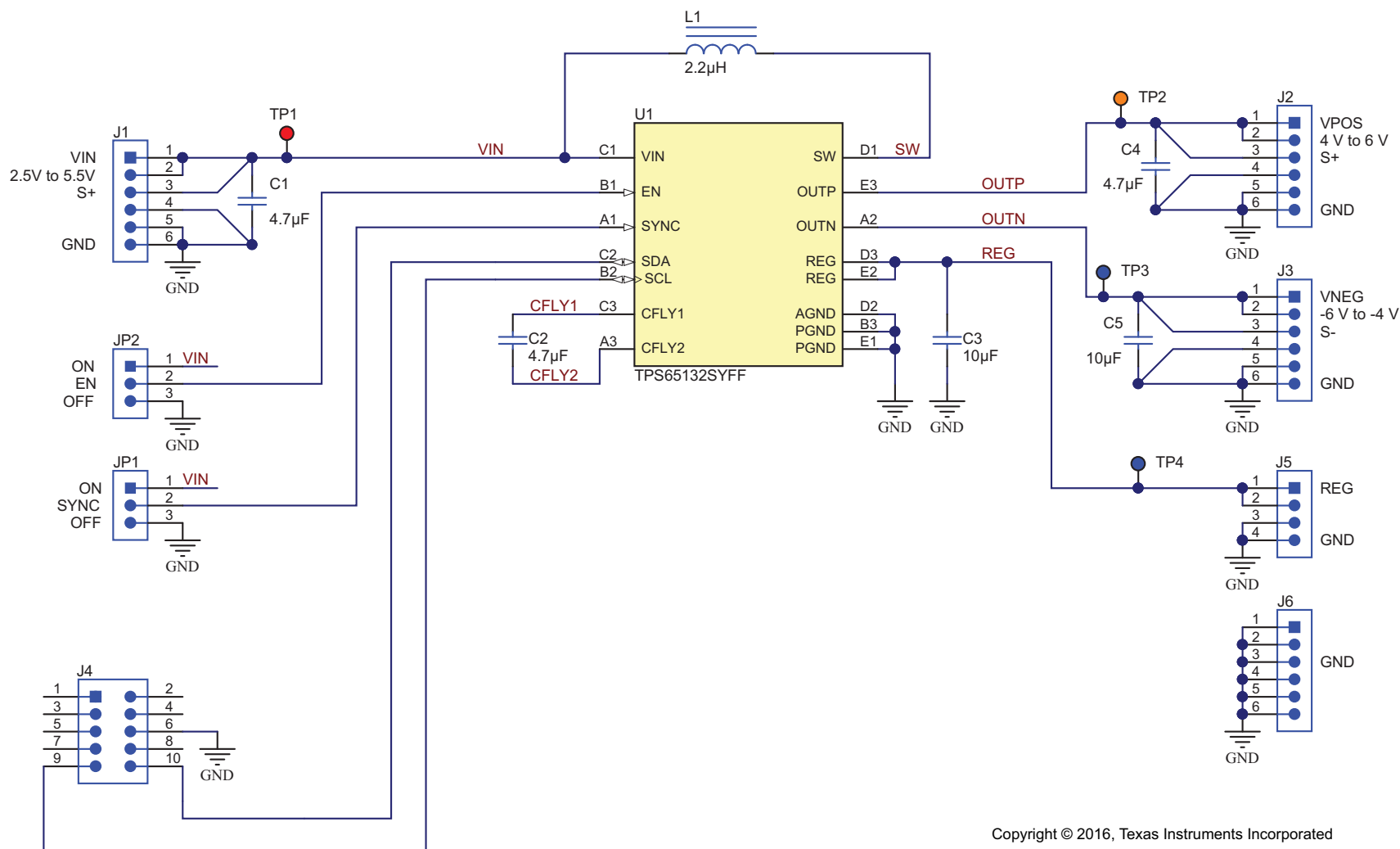
Table 1. Electrical Specifications

Parameter		Notes and Conditions	MIN	TYP	MAX	Unit
Input Characteristics						
V_{IN}	Input voltage		2.5		5.5	V
	Input current	$V_{IN} = 3.7$ V, $I_{POS} = I_{NEG} = 150$ mA		275		mA
		$V_{IN} = 3.7$ V, $I_{POS} = I_{NEG} = 0$ mA		0.1	2	mA
Output Characteristics						
V_{POS}	Default positive output voltage	$V_{IN} = 3.7$ V, $I_{POS} = 150$ mA	5.35	5.4	5.45	V
$\Delta V_{POS(\Delta VIN)}$	Line regulation (V_{POS})	$V_{IN} = 2.5$ V to 5.5 V, $I_{POS} = 150$ mA		5		mV
$\Delta V_{POS(\Delta IO)}$	Load regulation (V_{POS})	$I_{POS} = 10$ mA to 150 mA, $V_I = 3.7$ V		–16		mV
$V_{POS(PP)}$	Output voltage ripple (V_{POS})	$V_{IN} = 3.7$ V, $I_O = 150$ mA ⁽¹⁾		5		mV
V_{NEG}	Default negative output voltage	$V_{IN} = 3.7$ V, $I_{NEG} = 150$ mA	–5.45	–5.4	–5.35	V
$\Delta V_{NEG(\Delta VIN)}$	Line regulation (V_{NEG})	$V_{IN} = 2.5$ V to 5.5 V, $I_O = 150$ mA ⁽¹⁾		9		mV
$\Delta V_{NEG(\Delta IO)}$	Load regulation (V_{NEG})	$I_{NEG} = 10$ mA to 150 mA, $V_{IN} = 3.7$ V		–88		mV
$V_{NEG(PP)}$	Output voltage ripple NEG	$V_{IN} = 3.7$ V, $I_O = 150$ mA ⁽¹⁾		50		mV
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} .

3 Schematic

Figure 1 is for reference only; see the bill of materials in Section 8 for specific values.



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Figure 1. Schematic

4 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

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

Table 3. Jumper Overview

Jumper	Signal	Pin	Description	Remarks
JP1	VIN	1	Input Supply	Connect a jumper between pins 1 and 2 to enable the negative output, or between pins 2 and 3 to disable it.
	SYNC	2	High Current Enable	
	GND	3	Ground	
JP2	VIN	1	Input Supply	Connect a jumper between pins 1 and 2 to enable the positive output, or between pins 2 and 3 to disable it.
	EN	2	Enable	
	GND	3	Ground	

Table 4. Test Point Overview

Test Point	Signal	Description
TP1	VIN	Input Supply
TP2	OUTP	Positive Output
TP3	OUTN	Negative Output
TP4	GND	Ground
TP5	GND	Ground
TP6	GND	Ground
TP7	REG	Boost Converter Output

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.

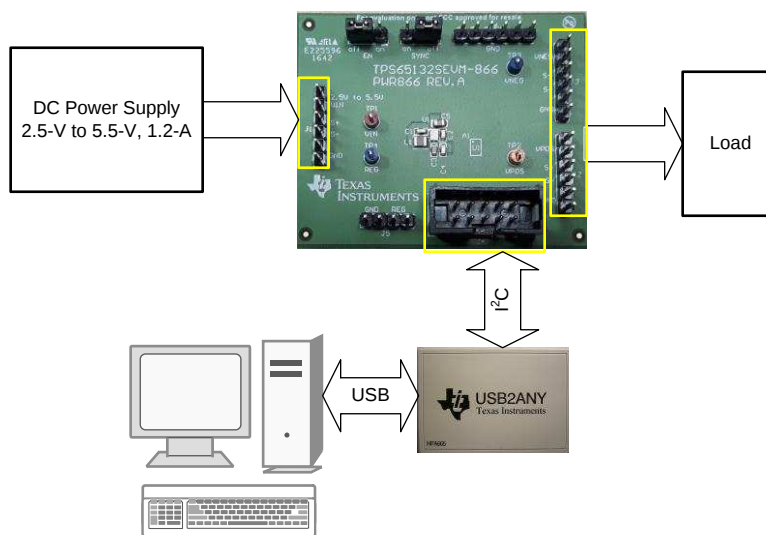


Figure 2. Hardware Setup – Full Functionality

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 TPS65132S device starts up with the register settings stored in its EEPROM the last time it was programmed.

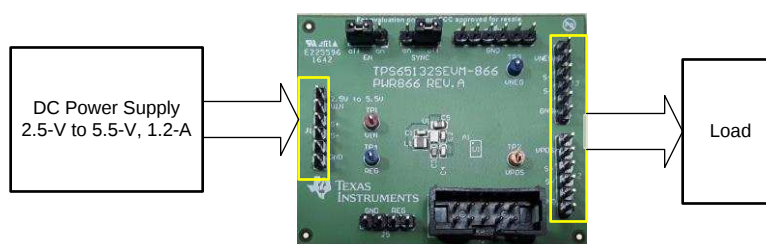


Figure 3. Hardware Setup – Simplified

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.

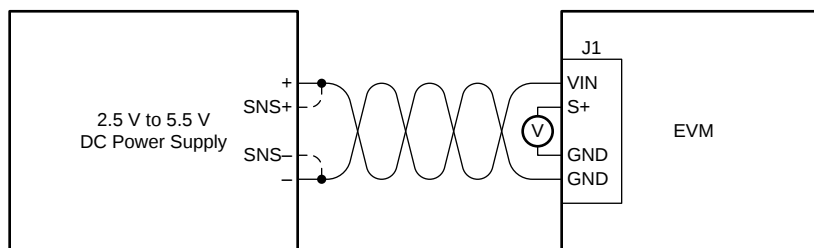


Figure 4. Two-Terminal Power Supply Connection

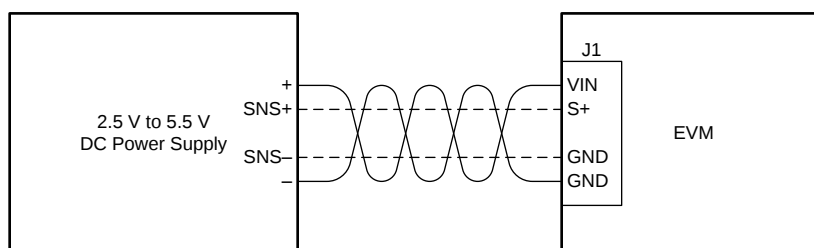


Figure 5. Four-Terminal Power Supply Connection

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).

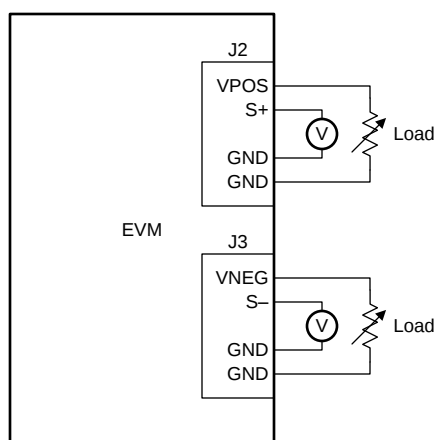


Figure 6. Single-Ended Load Connections

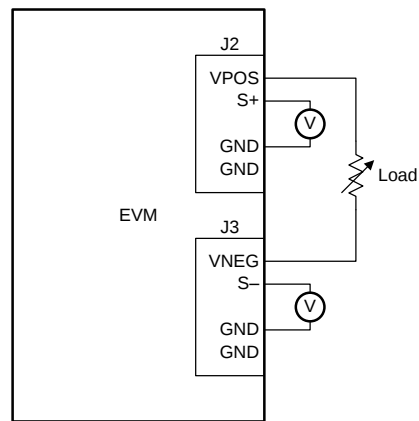


Figure 7. Differential Load Connection

When connecting the USB2ANY interface adapter to the EVM, use the middle ten connections ([Figure 8](#)).



Figure 8. Ribbon Cable Connected to the Ten Middle Pins of the USB2ANY Interface Adapter

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 (see [Figure 2](#)). To download the latest version of the EVM software:

- Go to the TPS65132 product folder on the TI Web site (<http://www.ti.com/product/tps65132/toolssoftware>)
- 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](#)).

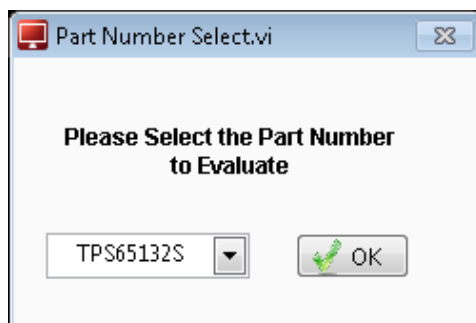


Figure 9. Device Selection Window

After selecting the device variant and clicking the **OK** button, the software shows the Settings window as is in [Figure 10](#).

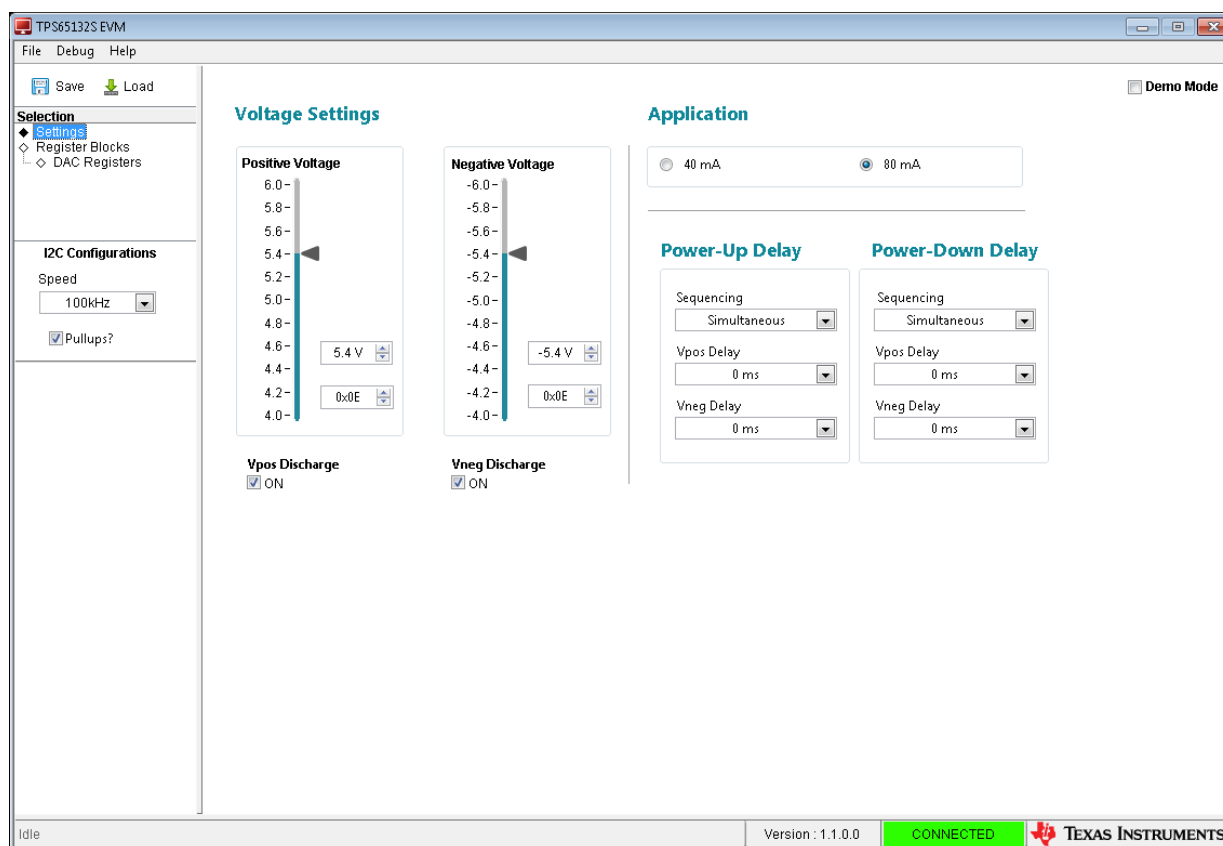


Figure 10. Settings Window

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 I²C Bus Configuration

6.2.1 Slave Address

The EVM software uses the slave address 0x3E to communicate with the TPS65132S device over the I²C bus. This address cannot be changed.

6.2.2 Bus Speed

The I²C bus of the EVM can operate in Standard mode (100 kbps) or Fast mode (400 kbps). Select the desired I²C bus speed from the *Speed* drop-down menu.

6.2.3 Pullups

The USB2ANY interface adapter has pullup resistors for the I²C bus. Disable the pullup resistors if they are not needed.

- Check the *Pullups?* checkbox if using the I²C pullup resistors in the USB2ANY interface adapter (refer to [Figure 11](#)). This is the most common setting.
- Uncheck the *Pullups?* checkbox if there are I²C pullup resistors somewhere else in your system (refer to [Figure 12](#)).

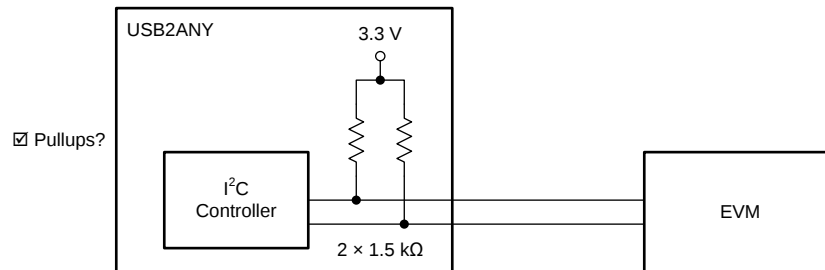


Figure 11. I²C Bus Internal Pullup Connection

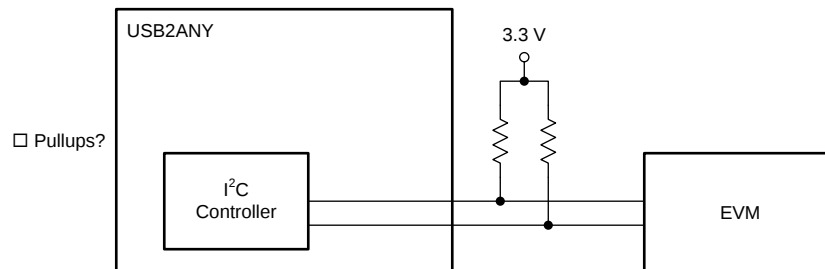


Figure 12. I²C Bus External Pullup Connection

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 I²C bus capacitance (refer to UM10204 – *I²C-bus specification and user manual* from NXP). A higher bus capacitance needs smaller pullup resistors. A value in the range 1.5 kΩ to 10 kΩ 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 TPS65132S operates in Smartphone mode or Tablet mode. The maximum output current in Tablet mode is higher than in Smartphone mode. Refer to the TPS65132 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

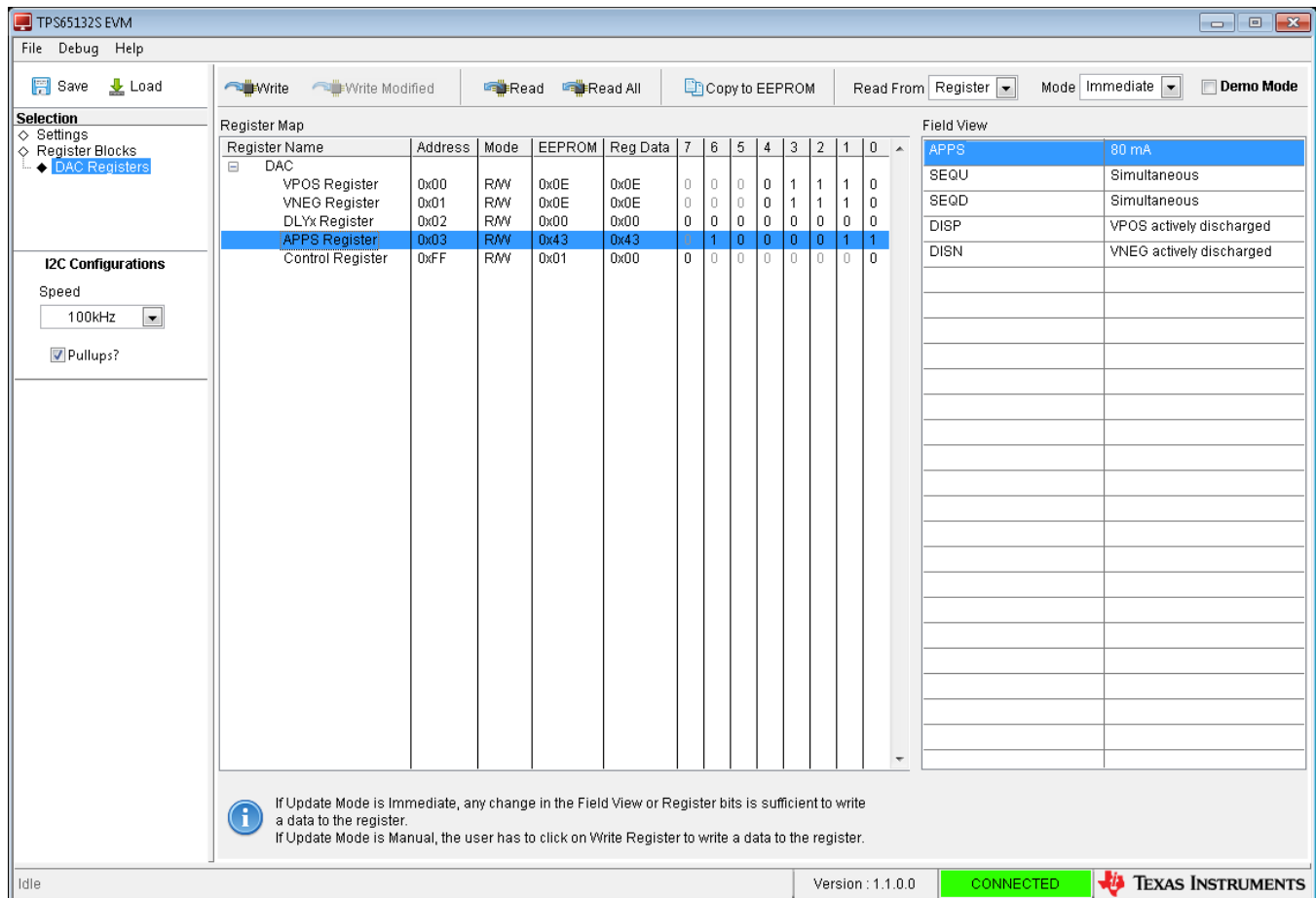


Figure 13. DAC Registers Window

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 TPS65132S device with the contents shown in the GUI window.
- Click on *Write Modified* to program only the selected register in the TPS65132S 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 TPS65132S device. The values in the EEPROM are the ones used by the TPS65132S 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.

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

7 PCB Layout

Figure 15 through Figure 19 show the design of the TPS65132S 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 TPS65132S control IC. Moving components to both sides of the PCB can offer additional size reduction for space-constrained systems.

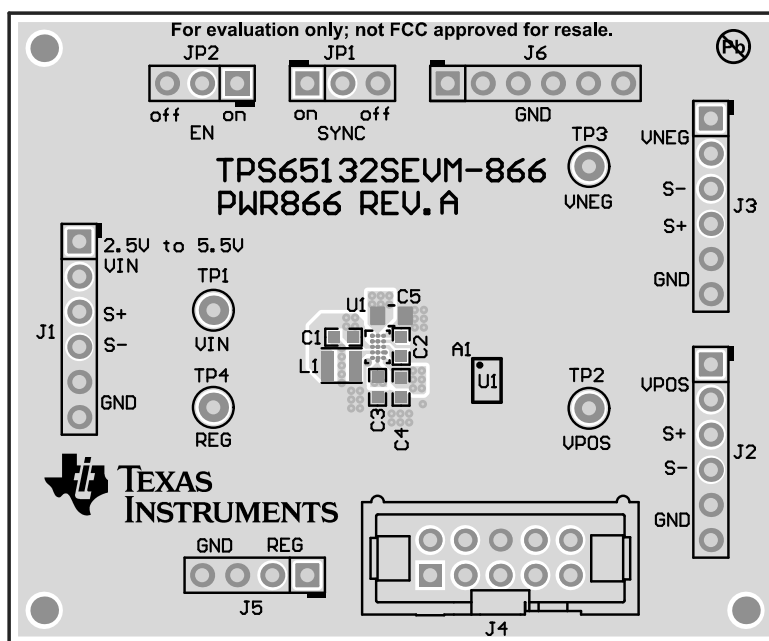


Figure 15. Component Placement (Top View)

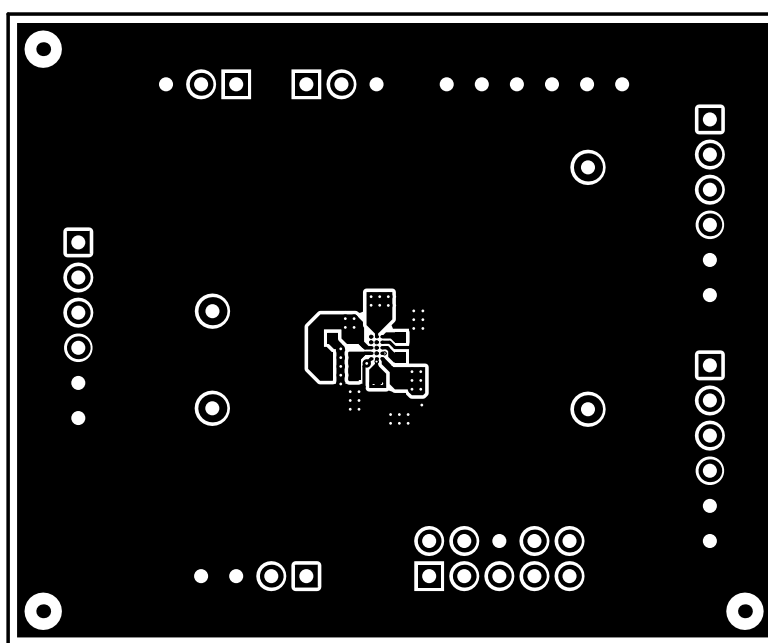


Figure 16. PCB Top Layer (Top View)

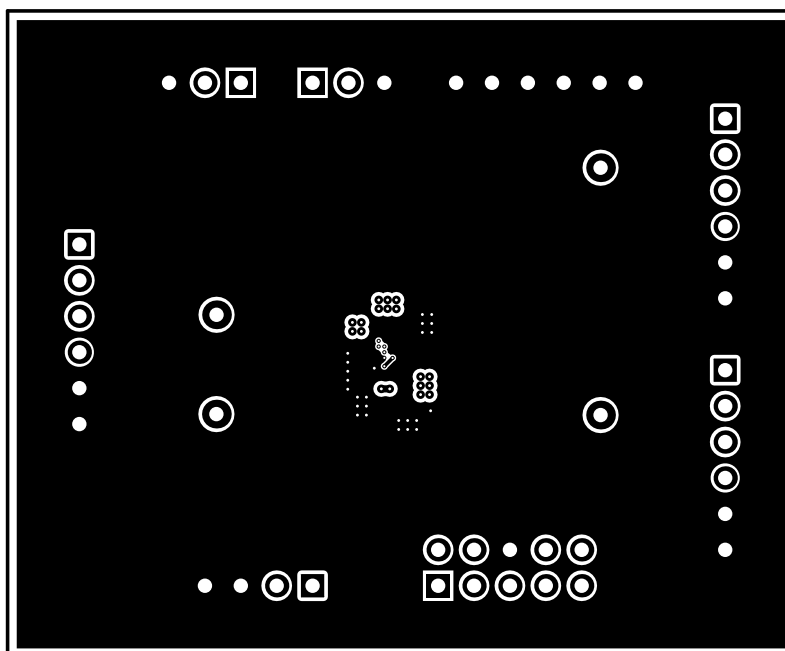


Figure 17. PCB Inner Layer 1 (Top View)

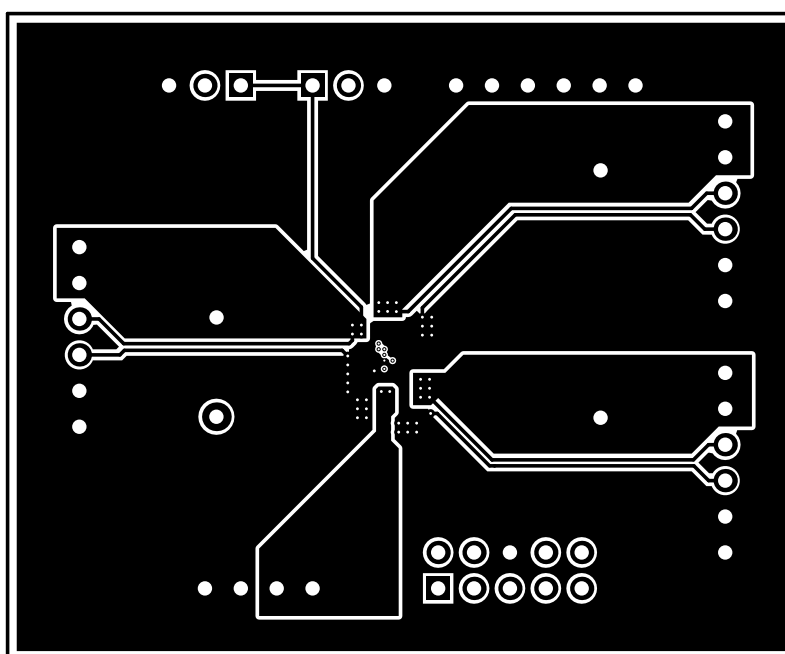


Figure 18. PCB Inner Layer 2 (Top View)

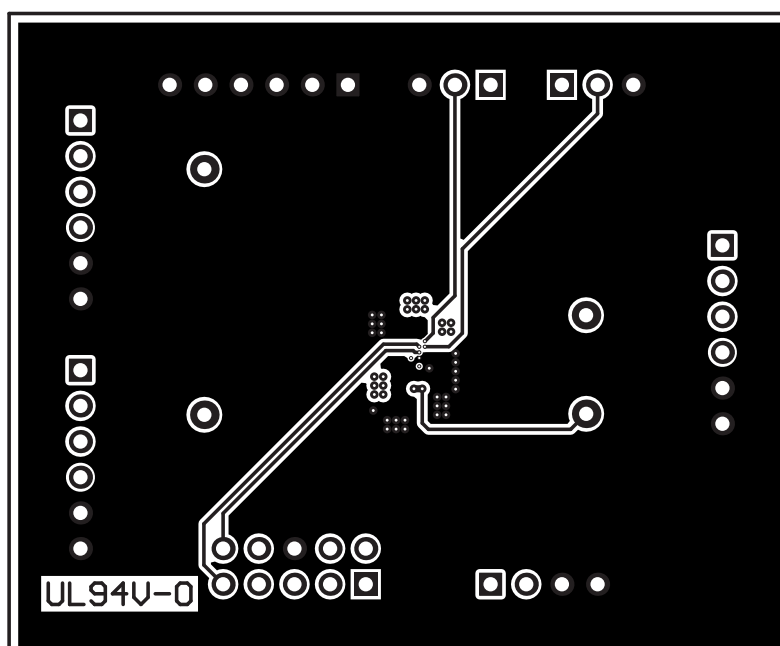


Figure 19. PCB Bottom Layer (Bottom View)

8 List of Materials

[Table 5](#) contains the EVM bill of materials.

Table 5. Bill of Materials

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
C1, C2, C4	3	4.7uF	CAP, CERM, 4.7 μ F, 16 V, +/- 10%, X5R, 0603	0603	GRM188R61C475KAAJ	Murata
C3	1	10uF	CAP, CERM, 10 μ F, 25 V, +/- 20%, X5R, 0603	0603	GRM188R61E106MA73D	Murata
C5	1	10uF	CAP, CERM, 10 μ F, 10 V, +/- 10%, X5R, 0805	0805	GRM219R61A106KE44D	Murata
L1	1	2.2uH	Inductor, Multilayer, Metal Composite, 2.2 μ H, 1.5 A, 0.156 ohm, SMD	2.5x1x2mm	1269AS-H-2R2M=P2	Murata Toko
U1	1		Single Inductor - Dual Output Power Supply, YFF0015ARAG (DSBGA-15)	YFF0015ARAG	TPS65132SYFF	Texas Instruments

STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including demonstration software, components, and/or documentation which may be provided together or separately (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms 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/llds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/llds/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.

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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.

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