# TPS65233EVM User's Guide

## Contents



## List of Figures

# 1 INTRODUCTION

This document presents the information required to operate the TPS65233 as well as the support documentation including schematic, layout, hardware setup, software installation, typical waveforms and bill of materials.

# 2 BACKGROUND

The TPS65233 is designed to provide 13-V/18-V output voltage for satellite receiver, with an operational range of 4.5 V to 16 V. For configuration purpose A 22-kHz tone signal is superimposed on the output, this 22-kHz tone also is used to transmit DiSEqC 1.x command signal to satellite receiver and switches from application processor.

TPS65233 features $I^2C$ controlled output voltage from 13 V to 19.8 V with 8 options, output current limit can be programmed via $I^2C$ from 350 mA to 1200 mA with 4 steps; 22-kHz tone can be gated through $I^2C$ also. Diagnostic signal can be retrieved through $I^2C$ to monitor system's operation.

TPS65233 can also run without $I^2C$. A dedicated enable pin to turn on and off the IC. In non-$I^2C$ mode, output current is set by external resistor with ±10% accuracy. EXTM pin for 22-kHz input and VCTRL pin to control 13-V/18-V output are presented to be controlled by GPIO from processor.

As there are many possible options to set the regulator, Table 1 presents the performance specification summary for the EVM.

**Table 1. Summary of Performance**

| TEST CONDITIONS | PERFORMANCE |
|---|---|
| $V_{IN}$ = 5 V to 12 V | Output1: 13 V with 22 kHz |
| $f_{SW}$ = 500 kHz | Output2: 13 V without 22 kHz |
| (25°C ambient) | Output3: 18 V with 22 kHz |
| | Output4: 18 V without 22 kHz |

The evaluation module is designed to provide access to the features of the TPS65233. Some modifications can be made to this module to test performance at different input and output voltages, current and switching frequency. Please contact TI Field Applications Group for advice on these matters.

# 3 BOARD LAYOUT

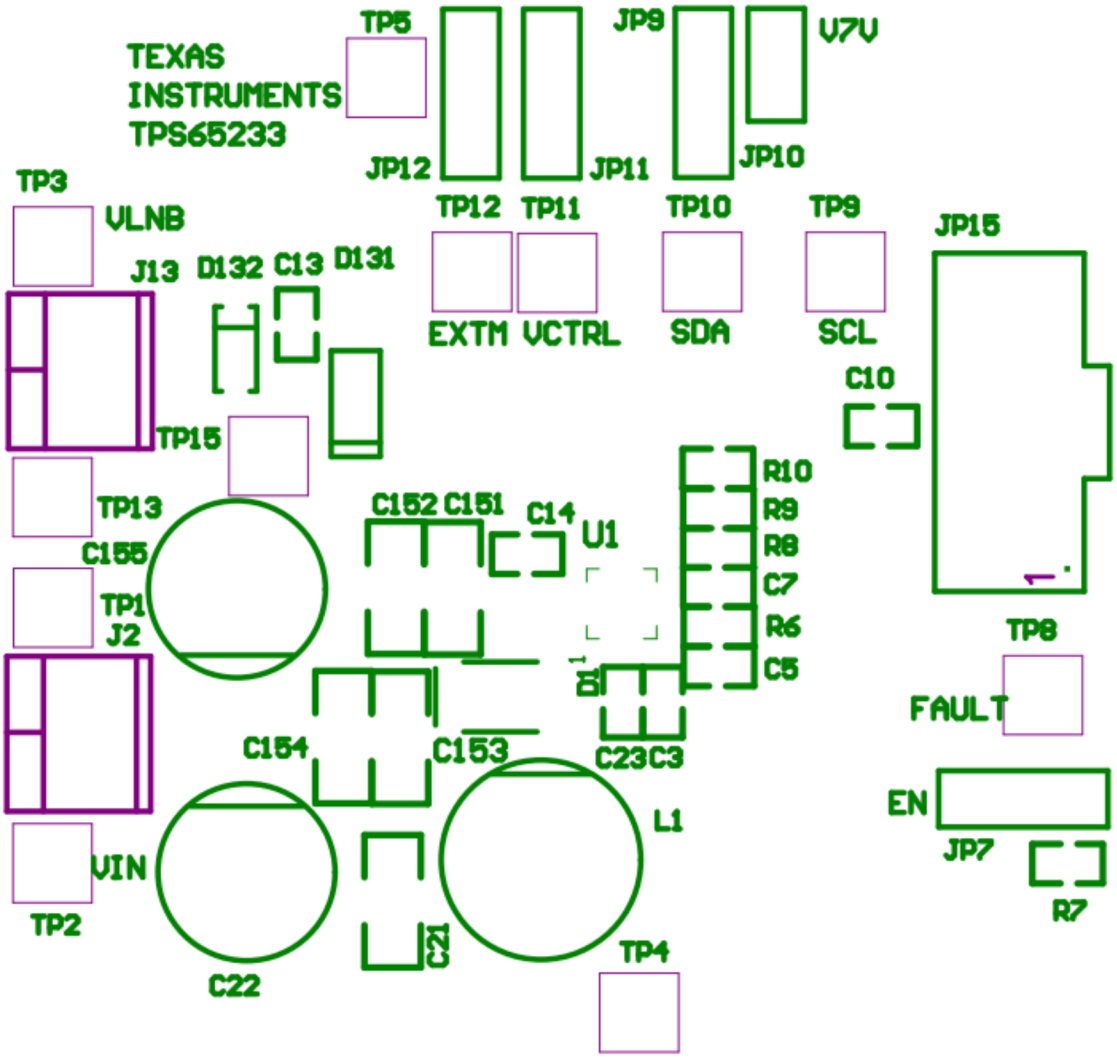


**Figure 1. Placement (Top Layer)**

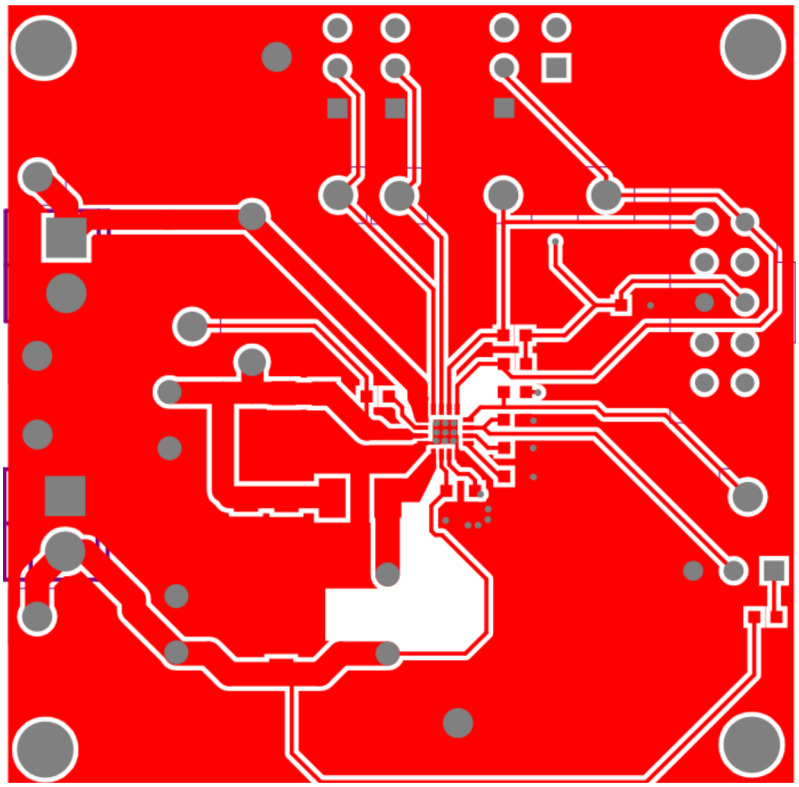

**Figure 2. Board Layout (Top Layer)**

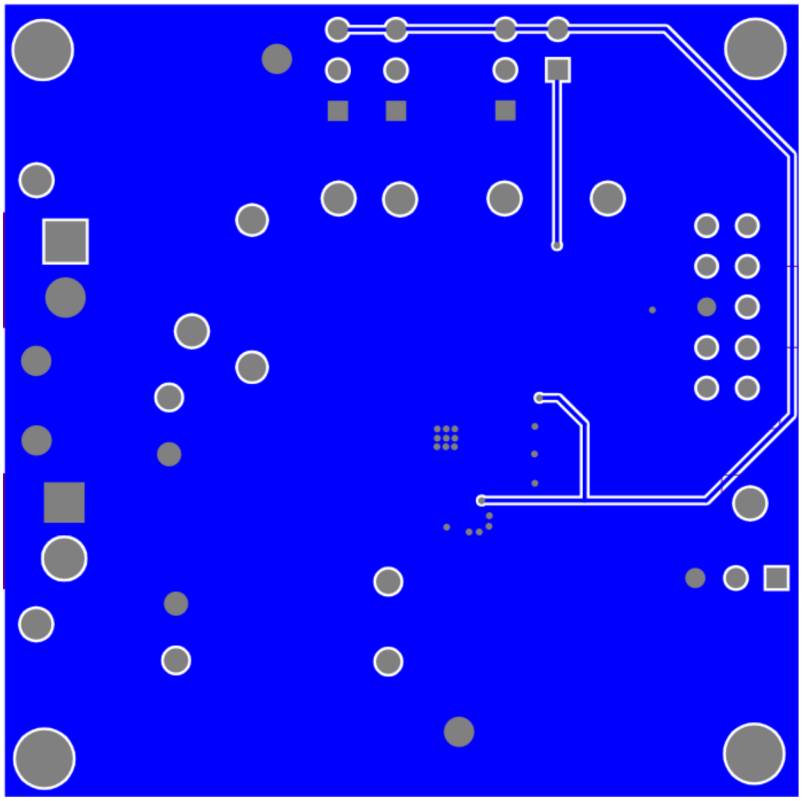

**Figure 3. Board Layout (Bottom Layer)**

# 4 BENCH TEST SETUP CONDITIONS

## 4.1 Headers Description and Jumper Placement

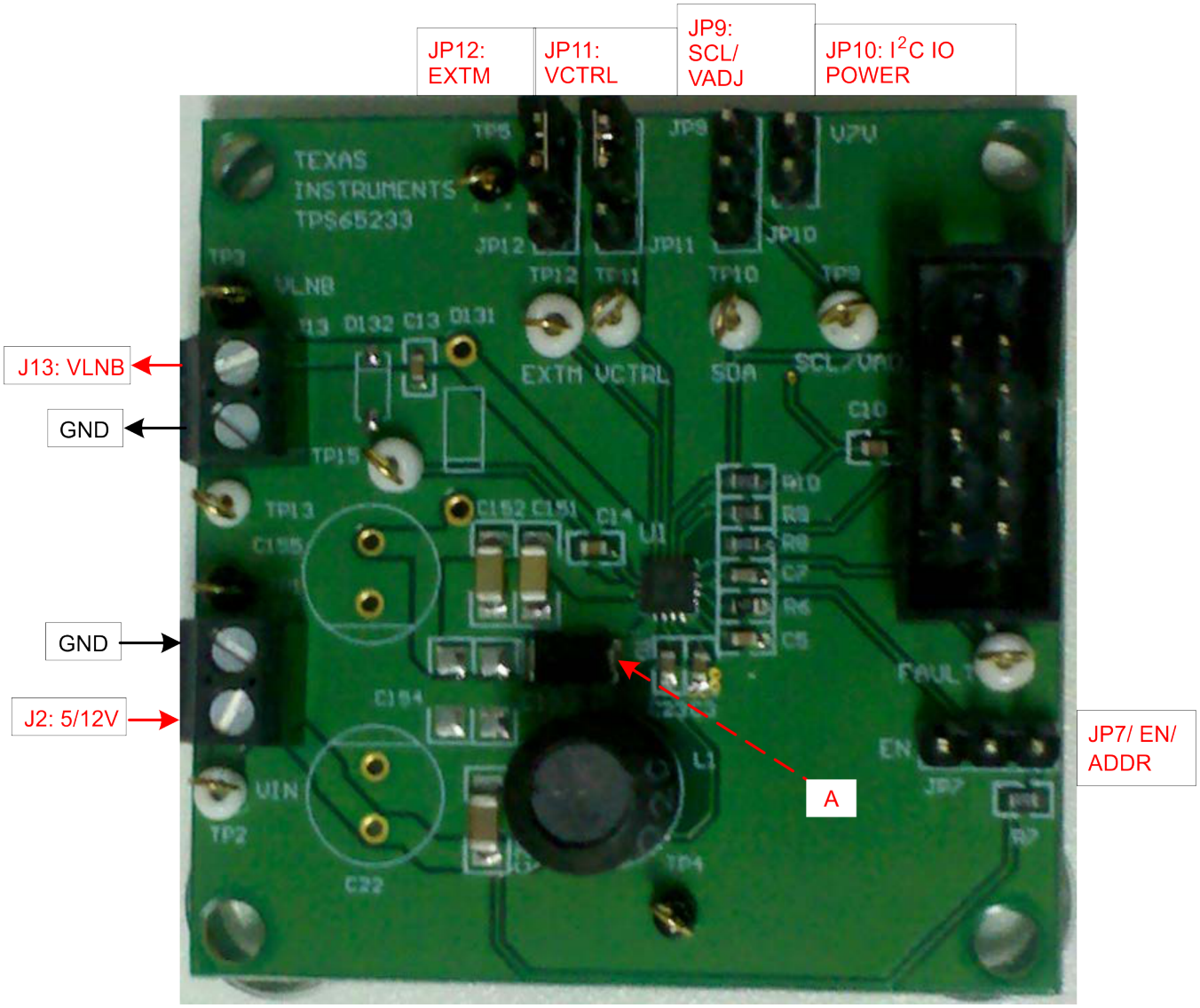


**Figure 4. Headers Description and Jumper Placement**

Test point:
(A) LX of $V_{BOOST}$

## 4.2 Input/Output Connection

**Table 2. Input/Output Connection**

| NO. | FUNCTION | PLACEMENT |
|---|---|---|
| J2 | $V_{IN}$ connector | Apply power supply to this connector. |
| J13 | VLNB connector | Output |

### 4.3 Jumpers and Switches

**Table 3. Jumpers and Switches**

| NO. | FUNCTION | PLACEMENT | COMMENT |
|---|---|---|---|
| JP7 | Regulator enable (EN/ADDR) | Connect EN to GND to disable the output, connect EN to $V_{IN}$ through a 100-kΩ resistor to enable output; leave open to enable output. This pin also acts $I^2C$ address set pin: tie to GND set $I^2C$ address 0x60H, tie to high set $I^2C$ address 0x61H. | |
| JP9 | $I^2C$ clock, output voltage fine adjustment | If the IC is controlled by $I^2C$, this pin receives clock signal; If the IC is controlled by GPIO, connecting this pin to GND and $V_{CC}$ fine tune the output voltage. Tie to GND gives 13 V/18 V, tie to $V_{CC}$ gives 13.4 V/18.6 V. | |
| J10 | $I^2C$ Power | Power connected to the $I^2C$ IO pull-up resistor; leave the two pins unconnected, set the power to be 3.3 V from the $I^2C$ interface adaptor; short the two pins set the power to be $V_{CC}$. | On board $V_{CC}$ is 6.25 V |
| JP11 | Output voltage control | Connect the VCTRL pin to logic high to set output voltage to be 18 V, connect to GND set 13 V. Combined with JP9 to provide different voltage selection. | |
| JP12 | Tone generation | Feed 22-kHz signal to pin EXTM superimpose 22-kHz tone signal at the output voltage; set the pin voltage to logic high also superimposes the 22 kHz; tie the pin to low remove the 22-kHz tone from output voltage. | |

## 5 HARDWARE REQUIREMENT

This EVM requires an external power supply capable of providing 4.5 V to 16 V at 4 A.

The EVM kit includes USB-TO-GPIO interface box which, when installed on a PC and connected to the EVM, allows the user to communicate with the EVM via a GUI interface. The minimum PC requirements are:

- Windows™ 2000, Windows™ XP or Windows™ 7 operating system
- USB port
- Minimum of 30 MB of free hard disk space (100 MB recommended)
- Minimum of 256 MB of RAM

## 6 HARDWARE SETUP

After connecting the power supply to J2, turning on the power supply, and connecting JP7 to $V_{IN}$ through 100-kΩ resistor, connect JP11 to GND and connect JP12 to GND. The EVM will regulate the output voltages to the Output1 in Table 1.

In order to change the output voltage by sending the digital control signal via a PC running the TPS65233 Controller software and USB-TO-GPIO interface box, perform the following steps:

- Connect one end of the USB-TO-GPIO box to the PC using the USB cable and the other end to JP15 of the TPS65233 using the supplied 10-pin ribbon cable per Figure 5. The connectors on the ribbon cable are keyed to prevent incorrect installation.
- Connect the power supply on J1 and turn on the power supply.
- Run the software as explained in the next section.

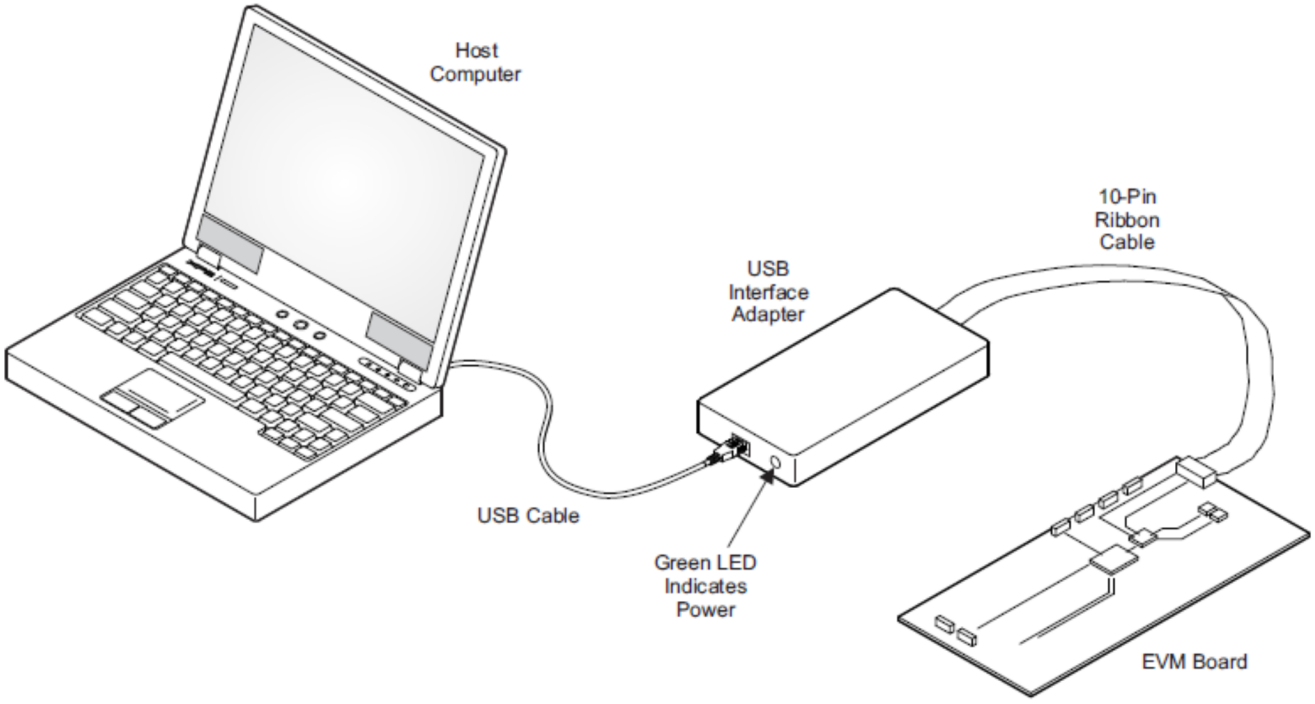


**Figure 5. USB Interface Adapter Quick Connection Diagram**

## 7 SOFTWARE INSTALL

If installing from the TI Web site, go to the URL, www.ti.com.

**NOTE:** This installation page is best viewed with Microsoft Internet Explorer browser (it may not work correctly with other browsers).

Click on the install button; your PC should give you a security warning and ask if you want to install this application. Select Install to proceed. If a pre-release or Beta version is currently installed on your PC, you must uninstall this version of the software before installing the final version.

The software attempts to install the Microsoft Dot Net Framework 2.0 (if it is not already installed). This framework is required for the software to run.

To run the software after installation, go to Start → All programs → Texas Instruments. → TPS65233 EVM Software.

At start-up, the software first checks the firmware version of the USB-TO-GPIO adapter box. If an incorrect firmware version is installed, the software automatically searches on the Internet (if connected) for updates. If a new update is available, the software notifies the user of the update, and downloads and installs the software. Note that after the firmware is updated, the user must disconnect and then reconnect the USB cable between the adapter and PC, as instructed during the install process. The host PC software also automatically searches on the Internet (if connected) for updates. If a new update is available, the software notifies the user of the update and downloads and installs it. During future use of the software, it may prompt you to install a new version if one becomes available on the Web.

**NOTE:** VeriSign™ Code Signing is used to prevent any malicious code from changing this application. If at any time in the future the binaries are modified, the code will no longer attempt to run.

# 8 SOFTWARE OPERATION

This section provides descriptions of the EVM software.

The supplied software is used to communicate with the TPS65233EVM. Click on the icon on the host computer to start the software. The software displays the main control panel for the user interface.

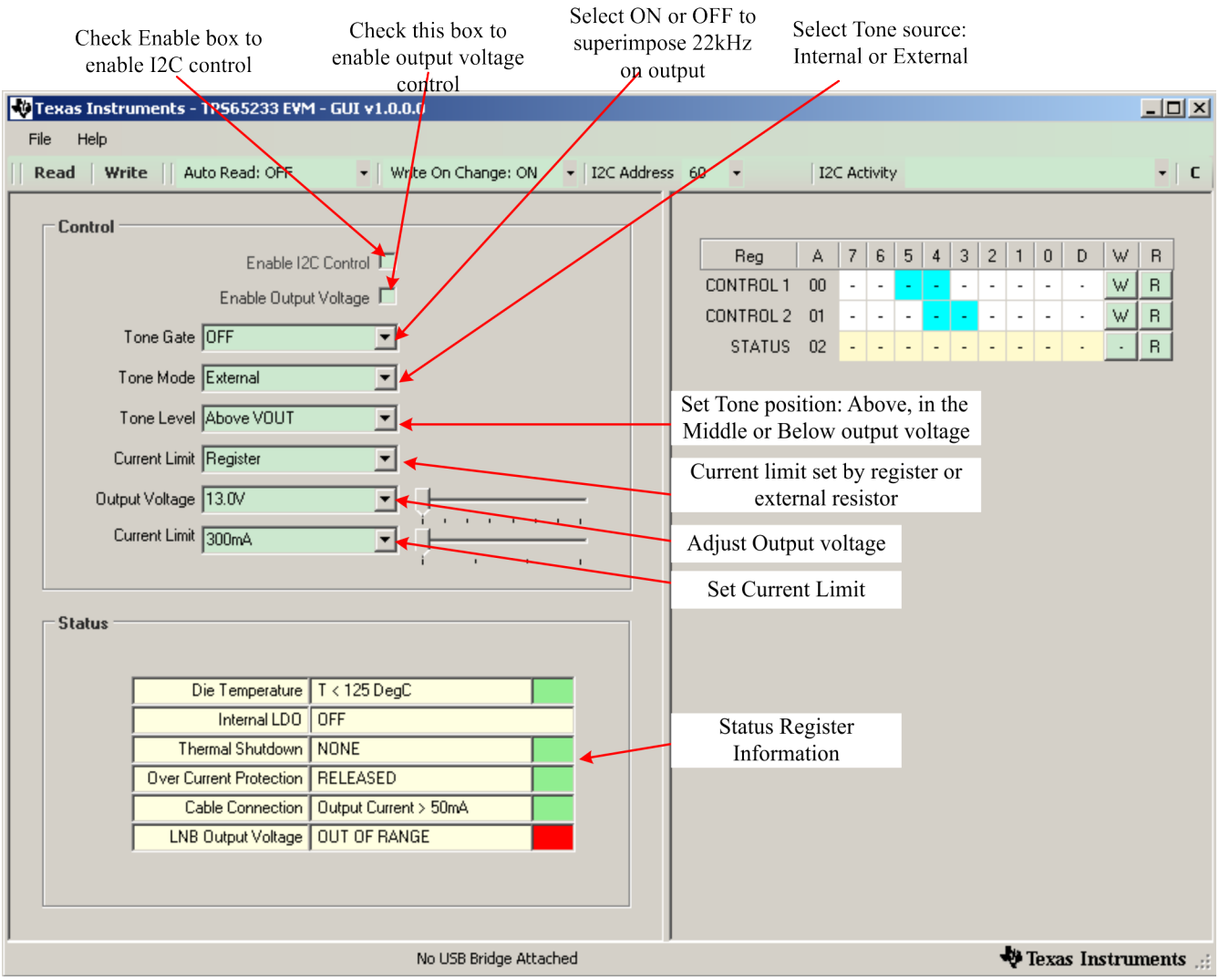


**Figure 6. Screen Capture of TPS65233 Software GUI Interface**

Figure 6 shows the control GUI interface. There are three 8-bit register embedded in TPS65233, two to control the output voltage characteristics, and one for status feedback. Change can be made by selecting and checking the components in the GUI on the left hand side, it can also be make by directly clicking the bits of each register. $I^2C$ address is set to 0x60H if EN is set to logic high, If EN is set to logic high, address is 0x61H. Changing the $I^2C$ address need configure the EVM accordingly.

An option is to “write on change”, if this option is set to ON, any change of will send to the EVM immediately; if this option is set to OFF, “Write” button or “W” button for each register must be clicked to send the control signal.

Register values can be read back from the EVM by clicking “Read” or “R” for each register.

## 9 POWER-UP PROCEDURE

1. Connect $I^2C$ adaptor to JP15.
2. Apply 12 V to J2.
3. Toggle JP7 to enable and disable converter.
4. Apply loads to the output connector J13.

## 10 TYPICAL APPLICATION WAVEFORMS

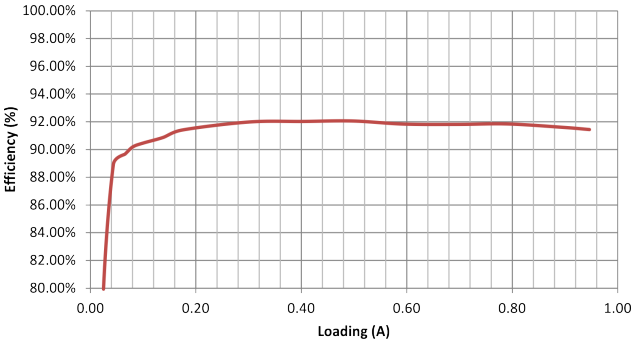


**Figure 7. Efficiency, $V_{IN}$ = 12 V, VLNB = 13.5 V**

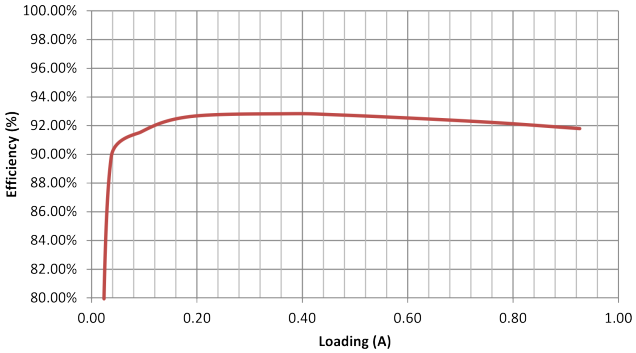


**Figure 8. Efficiency, $V_{IN}$ = 12 V, VLNB = 18.6 V**

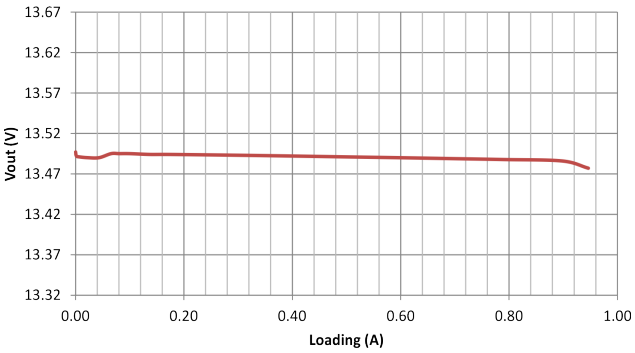


**Figure 9. Load Regulation, $V_{IN}$ = 12 V, VLNB = 13.5 V**

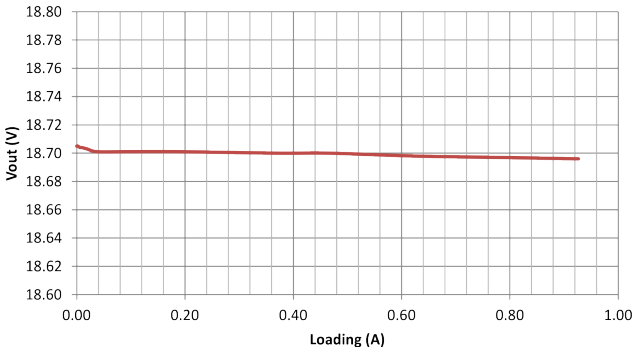


**Figure 10. Load Regulation, $V_{IN}$ = 12 V, VLNB = 18.6 V**

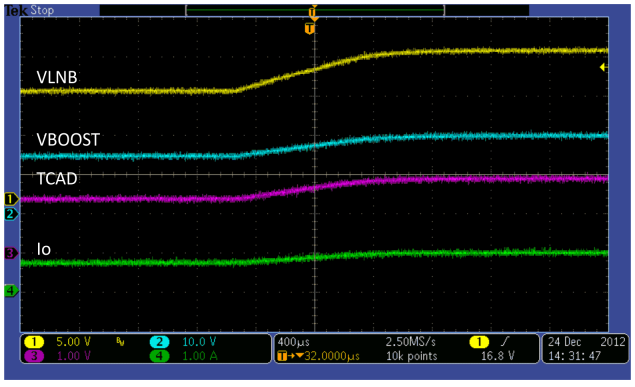


**Figure 11. Voltage Transition, $V_{IN}$ = 12 V, VLNB = 13.4 V to 18.6, $I_O$ = 1 A**

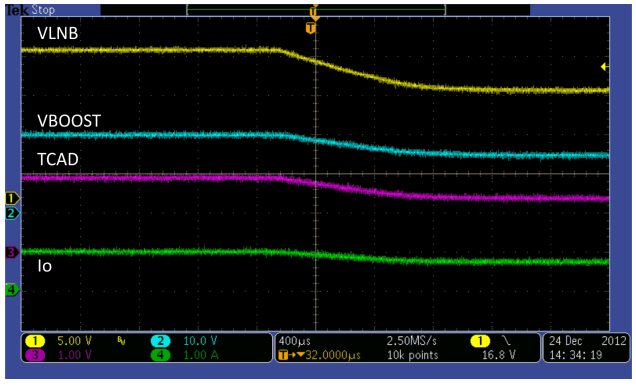


**Figure 12. Voltage Transition, $V_{IN}$ = 12 V, VLNB = 18.64 V to 13.4, $I_O$ = 1 A**

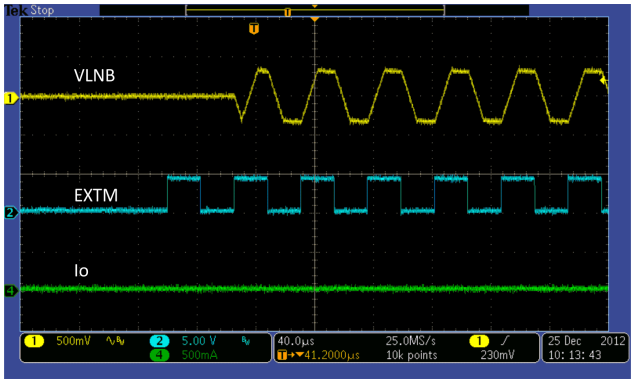


**Figure 13. 22-kHz Tone Sync to External Clock, $V_{IN}$ = 12 V, VLNB = 13.4 V, $I_O$ = 0 A**

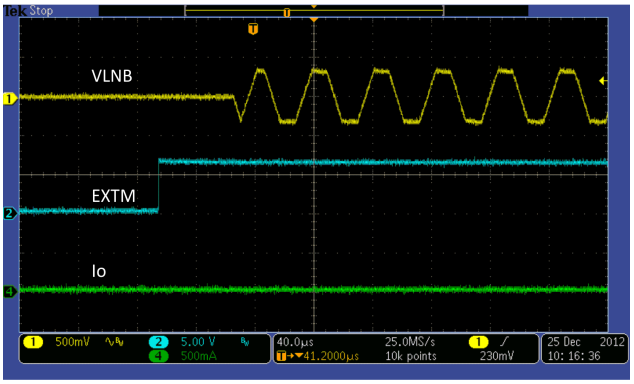


**Figure 14. 22-kHz Tone Controlled by EXTM Logic Level, $V_{IN}$ = 12 V, VLNB = 13.4 V, $I_O$ = 0 A**

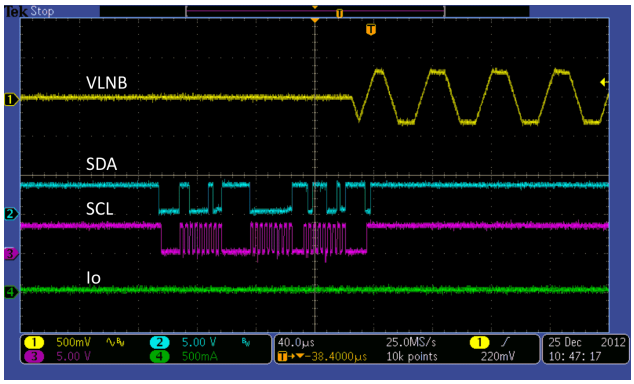


**Figure 15. 22-kHz Tone Controlled by $I^2C$, $V_{IN}$ = 12 V, VLNB = 13.4 V, $I_O$ = 0 A**

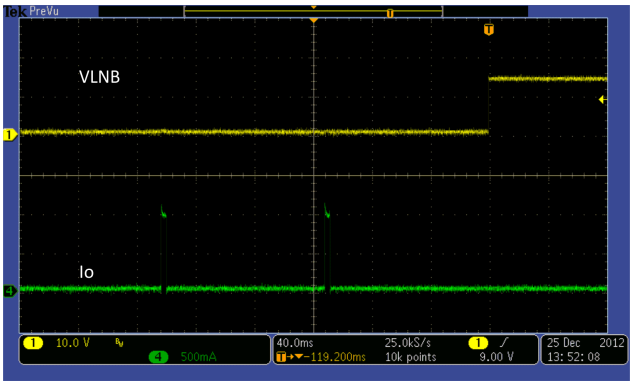


**Figure 16. Output Hard Short and Recovery, $V_{IN}$ = 12 V, VLNB = 13.4 V**

## 11 SCHEMATIC AND BILL OF MATERIALS

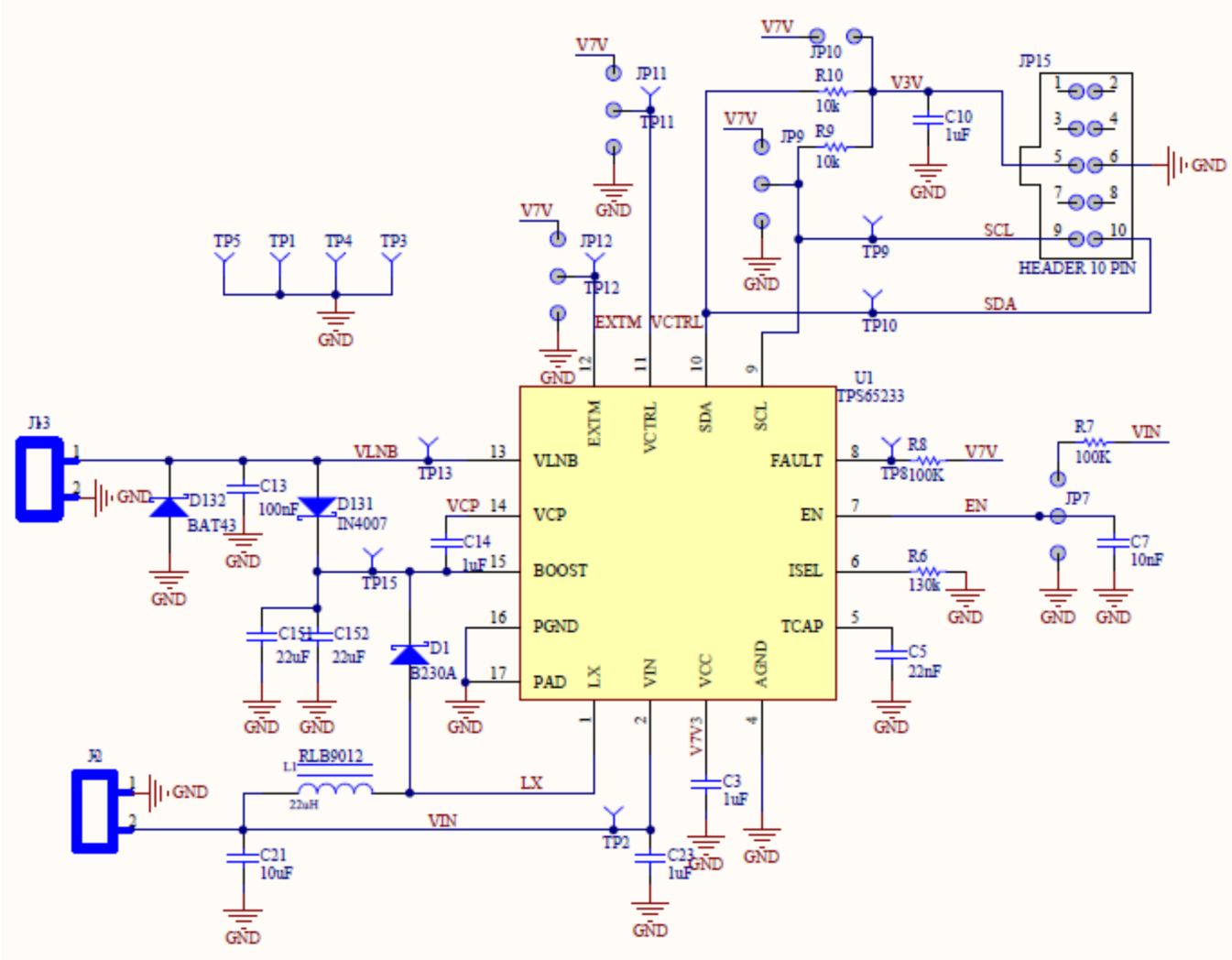


**Figure 17. TPS65233EVM Schematic**

TPS65233 is stable with all ceramic capacitor solution where C153 and C154 are 25-V ceramic capacitors. Because large, high voltage ceramic capacitors are usually costly, in applications that do not require ceramic capacitors, these two capacitors can be replaced by a 100-µF electrolytic capacitor and 1-µF 25-V ceramic capacitor to reduce cost.

## Table 4. TPS65233EVM Bill of Materials

| Item No. | Qty | Designator | Value | Footprint | Manufacturer | Part No. | Description |
|---|---|---|---|---|---|---|---|
| 1 | 4 | C3, C10, C14, C23 | 1uF | 603 | Generic | | CAP CER 1uF 50V 10% X7R 0603 |
| 2 | 1 | C5 | 22nF | 603 | Generic | | CAP CER 22nF 50V 10% X7R 0603 |
| 3 | 1 | C7 | 10nF | 603 | Generic | | CAP CER 10nF 50V 10% X7R 0603 |
| 4 | 1 | C13 | 100nF | 603 | Generic | | CAP CER 100nF 50V 10% X7R 0603 |
| 5 | 1 | C151, C152 | 22uF | 1206 | Murata | C3216X5R1V226M | CAP CER 22UF 35V 10% X5R 1206 |
| 6 | 1 | C21 | 10uF | 1206 | Murata | GRM31CR6YA106 KA12L | CAP CER 10UF 35V 10% X5R 1206 |
| 7 | 1 | JP15 | | HEADER10 | 3M | N2510-6002-RB | Ten Pin Header |
| 8 | 1 | D1 | | SMD | Diodes Inc | B230A-13-F | DIODE SCHOTTKY 30V 2A SMA |
| 9 | 2 | J2, J13 | ED555/2DS | TB_2X3.5MM | OnShore Technology Inc | ED555/2DS | Terminal Block, 2-pin, 6-A, 3.5mm |
| 10 (1) | 3 | JP7, JP11, JP12 | JUMPER 3 PIN | JMP0.3 | Mil-Max | 800-10-064-10-001000 | Three Pin Jumper, |
| 11 (2) | 1 | JP9 | JUMPER 2 PIN | JMP0.2 | Mil-Max | 800-10-064-10-001000 | Two Pin Jumper, |
| 12 | 1 | L1 | 22uH | Radial | Bourns Inc. | RLB9012-220KL | Magnetic-Core Inductor, 9 mm Dia. x 12.2 mm H |
| 13 | 1 | R6 | 130k | 603 | Generic | | RES 130K OHM 1/10W 1% 0603 SMD |
| 14 | 2 | R7, R8 | 100K | 603 | Generic | | RES 100K OHM 1/10W 1% 0603 SMD |
| 15 | 2 | R9, R10 | 10k | 603 | Generic | | RES 10K OHM 1/10W 1% 0603 SMD |
| 16 | 4 | TP1, TP3, TP4, TP5 | | TP | Keystone | 5001 | Test Point Black |
| 17 | 8 | TP2, TP8, TP9, TP10, TP11, TP12, TP13, TP15 | | TP | Keystone | 5002 | Test Point White |
| 18 | 1 | U1 | | QFN 3x3 | | | TPS65233RTER |

(1) Item 10: split into 3 pins
(2) Item 11: split into 2 pins

## EVALUATION BOARD/KIT/MODULE (EVM) ADDITIONAL TERMS

Texas Instruments (TI) provides the enclosed Evaluation Board/Kit/Module (EVM) under the following conditions:

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING LIMITED WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

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As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

**General Statement for EVMs including a radio**

*User Power/Frequency Use Obligations*: 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.

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

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

**For EVMs annotated as IC – INDUSTRY CANADA Compliant**

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

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

**Concerning EVMs including radio transmitters**

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

**Concerning EVMs including detachable antennas**

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

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.

**Texas Instruments Japan Limited**
**(address) 24-1, Nishi-Shinjuku 6 chome, Shinjuku-ku, Tokyo, Japan**

http://www.tij.co.jp

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## EVALUATION BOARD/KIT/MODULE (EVM)
## WARNINGS, RESTRICTIONS AND DISCLAIMERS

**For Feasibility Evaluation Only, in Laboratory/Development Environments.** Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure 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.
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.

**Agreement to Defend, Indemnify and Hold Harmless.** You agree to 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 use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

**Safety-Critical or Life-Critical Applications.** If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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