User's Guide
SLVU878–February 2013

4.5-V to 18-V Input, Dual (6.5-A and 3.5-A) Synchronous Step-Down Converter With I²C Controlled VID and Current Sharing Evaluation Module

This document is provided with the TPS65276V PMIC evaluation module (EVM) as a supplement to the TPS65276V datasheet. This user's guide includes the schematic, hardware setup, software installation and bill of materials (BOM).

Contents

List of Figures

List of Tables

1 Introduction

This document presents the information required to operate the TPS65276V PMIC as well as the support documentation including schematic, layout, hardware setup, software installation and bill of materials.

2 Background

The TPS65276V PMIC is designed to provide dual (6.5 A and 3.5 A) continuous currents with an operational range of 4.5 to 18 V. The TPS65276V features I^2C controlled voltage identification (VID) and the output voltage can be set by I^2C from 0.68 V to 1.95 V. Without I^2C, voltage can also be programmed by an external resistor divider. The TPS65276V features externally programmed switching frequency ranging from 200 kHz to 1.6 MHz, external compensation, soft-start and enable.

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

Table 1. Summary of Performance

Test Conditions	Performance
Vin = 4.5 V to 18 V	Buck1 : 1.0 V, up to 6 A, VID control
fsw = 500 kHz (25°C ambient)	Buck2 : 1.1 V, up to 3.5 A, VID control

The EVM is designed to provide access to the features of the TPS65276V. 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 TPS65276V Schematic

Figure 1 shows the TPS65276V PMIC EVM schematic.

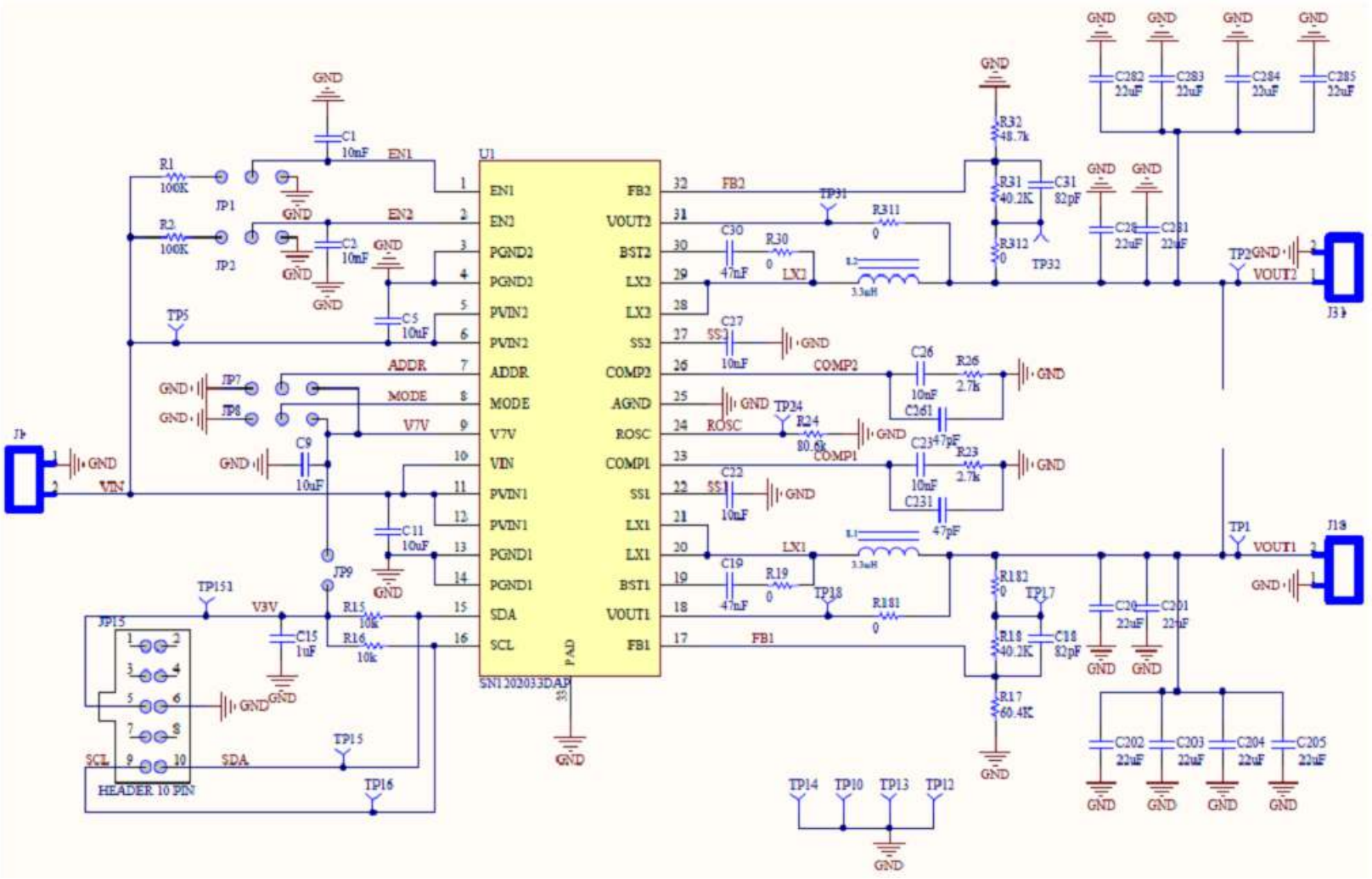


Figure 1. TPS65276V Schematic

4 Board Layout

Figure 2 through Figure 6 illustrate the printed-circuit boards for this EVM.

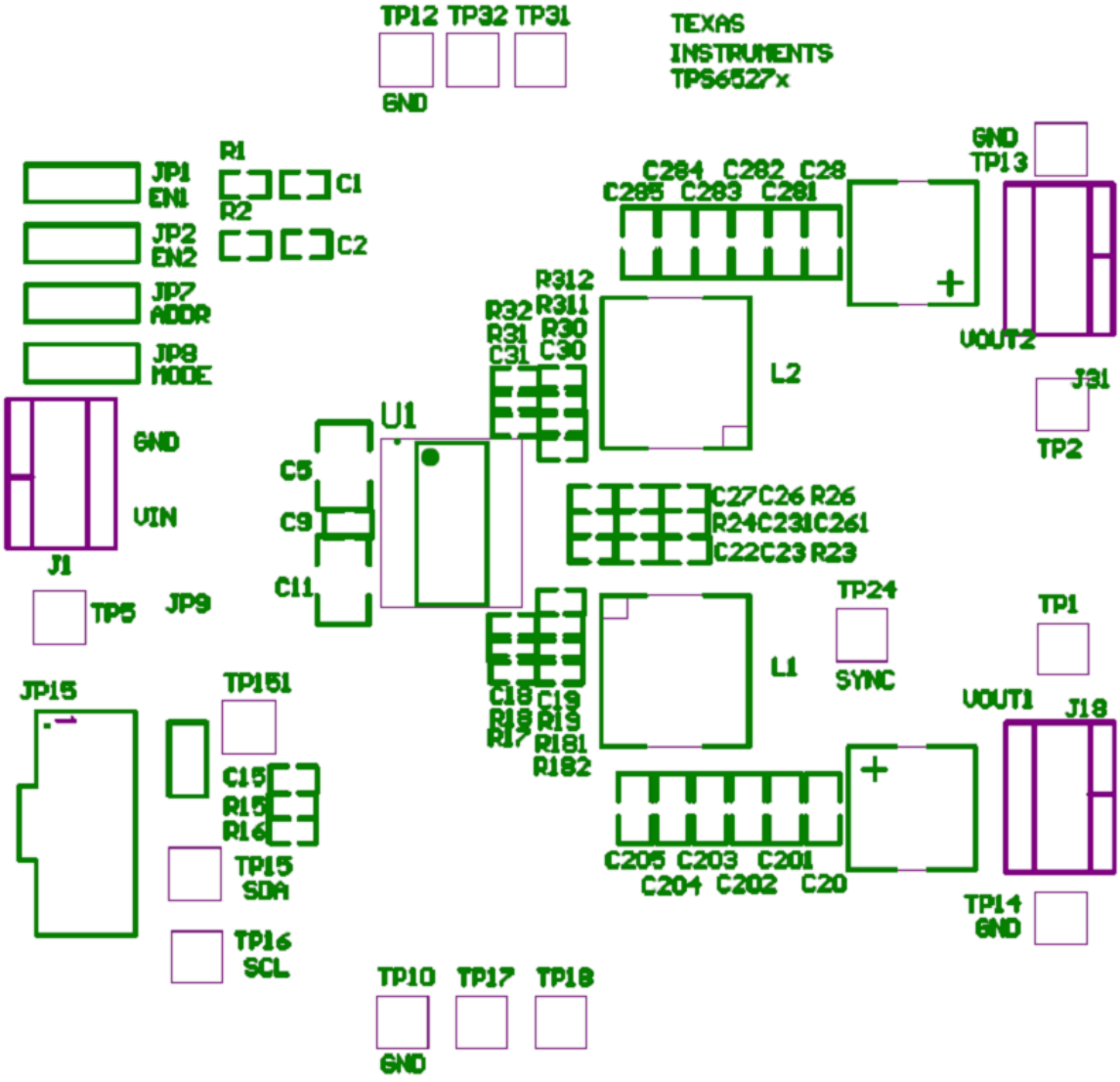


Figure 2. Component Placement (Top Layer)

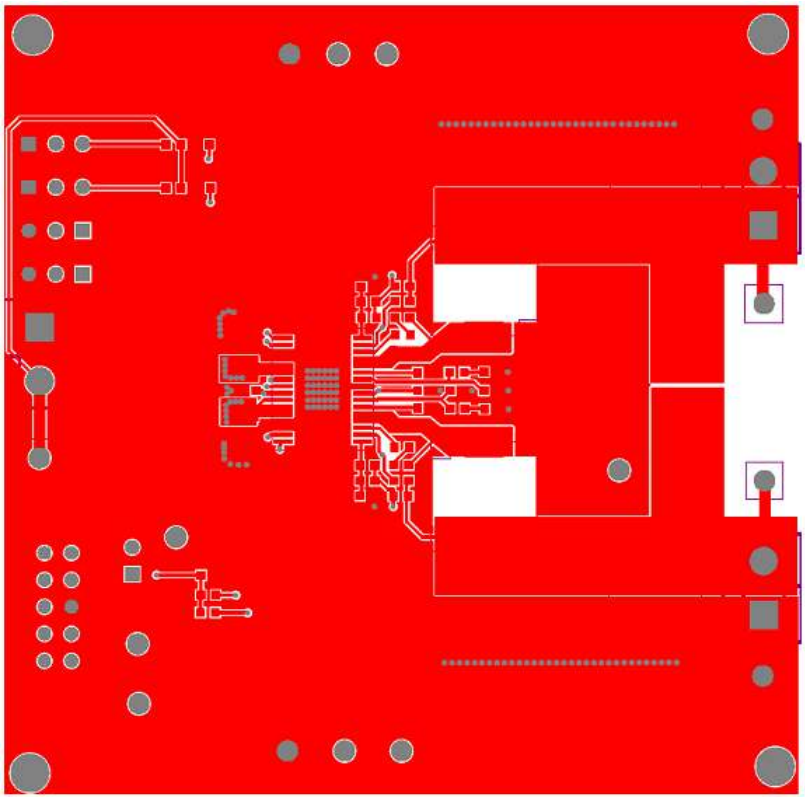


Figure 3. Board Layout (Top Layer)

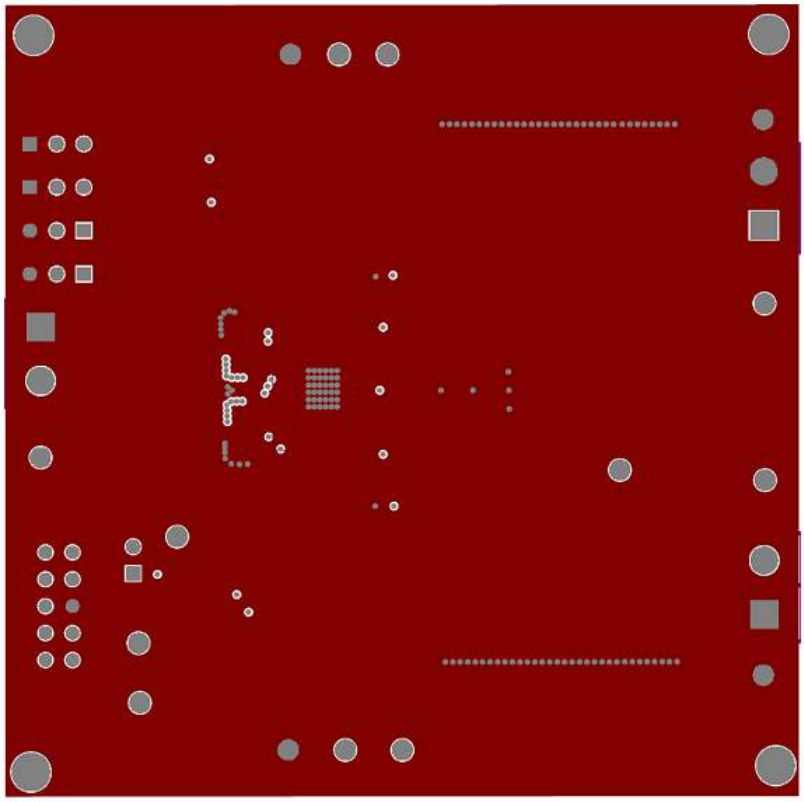


Figure 4. Board Layout (Second Layer)

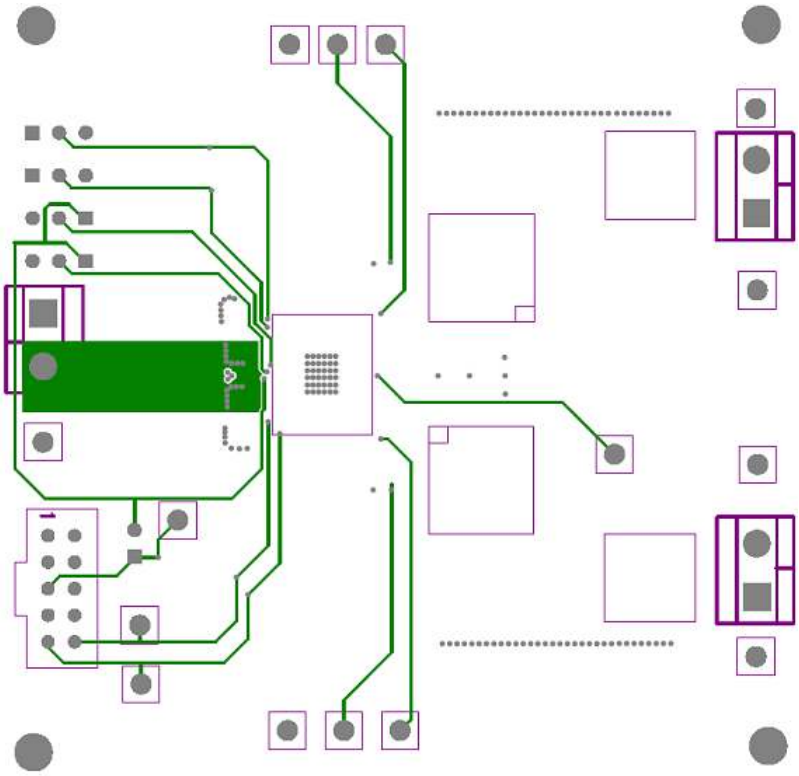


Figure 5. Board Layout (Third Layer)

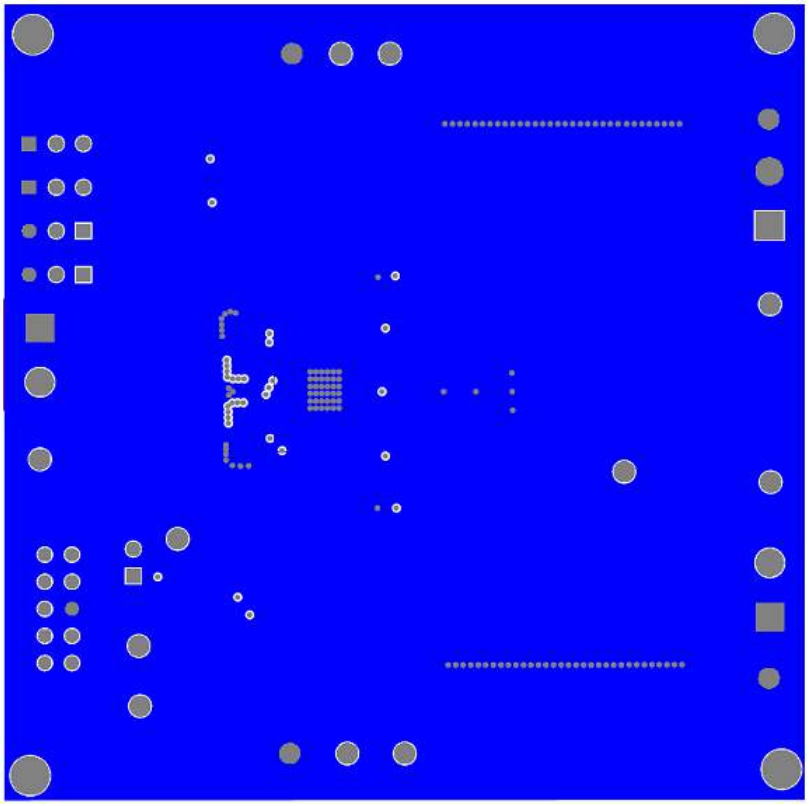
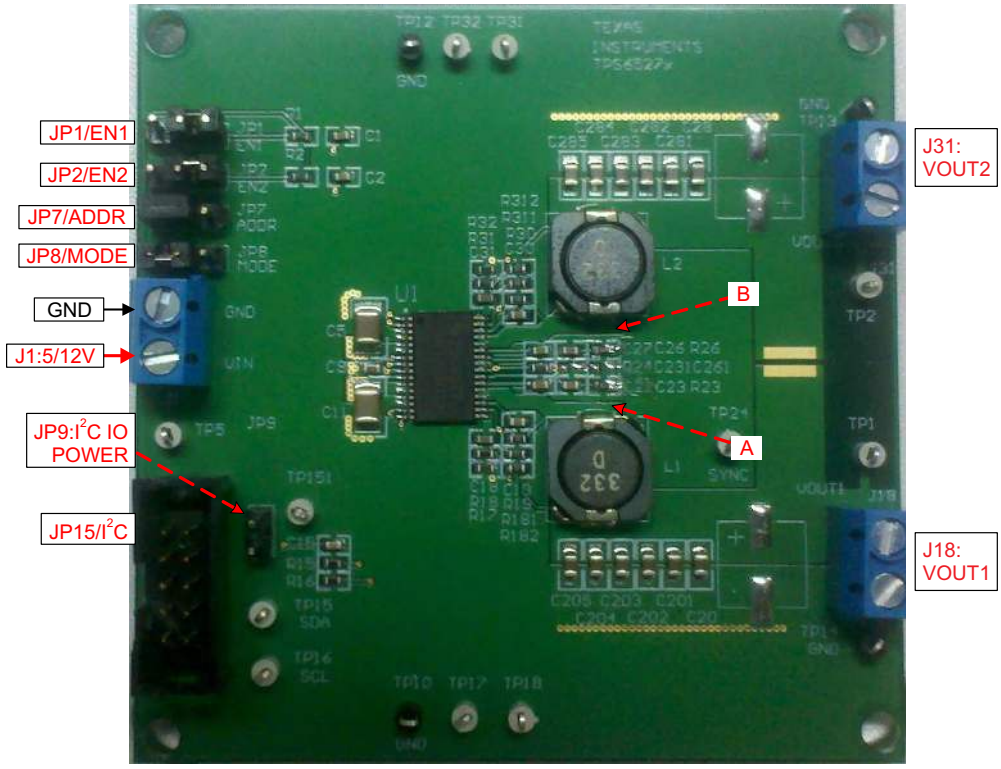


Figure 6. Board Layout (Bottom Layer)

5 Bench Test Setup Conditions

5.1 Header Description and Jumper Placement

Figure 7 illustrates the header description and jumper placement for the EVM.



Test points:

A: LX of Vout1

B: LX of Vout2

Vout1, Vout2

Figure 7. Header Description and Jumper Placement

Table 2 shows the I/O connections for the EVM.

Table 2. Input/Output Connection

Jumper Number	Function	Description
J1	Vin Connector	Apply power supply to this connector
J18	Buck1 Connector	Output of Buck1
J31	Buck2 Connector	Output of Buck2

Table 3 shows the jumpers and switches for the EVM.

Table 3. Jumpers and Switches

Jumper Number	Function	Placement	Comment
JP1	Buck1 enable (EN1)	Connect EN1 to GND to disable Vout1, connect EN1 to Vin through a 100-kΩ resistor to enable Vout1; Leave open to enable Vout1	
JP2	Buck2 enable (EN2)	Connect EN2 to GND to disable Vout2, connect EN2 to Vin through a 100-kΩ resistor to enable Vout2; Leave open to enable Vout2	
JP7	I^2C address	I^2C address configuration pin. Connect this pin to GND to set address 0x60H; connect it to Vcc to set address 0x61H; leave it open to set address 0x62H	On board Vcc is 6.25 V
JP8	Mode	Operation mode control pin. Connect this pin to GND to set forced PWM mode; leave the pin open to set auto PSM-PWM; connect this pin to Vcc, set the IC to run in current share mode.	
JP9	I^2C Power	Power connected to the I^2C IO pull-up resistor; Leave the two pins un-connected set the power to be 3.3V from the I^2C interface adaptor; short the two pins set the power to be Vcc.	On board Vcc is 6.25 V
JP15	I^2C interface connector	Pin 5 is 3.3 V from adaptor; pin 6 is Ground; pin 9 is SCL, pin 10 is SDA.	

5.2 Hardware Requirement

This EVM requires an external power supply capable of providing 4.5 V to 18 V at 7 A.

A function generator capable of driving the SYNC pin with 0.4- to 3.3-V amplitude and a 200-kHz to 1.6-MHz square wave signal is required for synchronization. The EVM kit includes a USB-TO-GPIO interface box which, when installed on a PC and connected to the EVM, allows communication with the EVM via a GUI interface. The minimum PC requirements are:

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

5.3 Hardware Setup

After connecting the power supply to J1, turn on the power supply, and connect JP1 to Vin through a 100-kΩ resistor, connect JP2 to Vin through a 100-kΩ resistor, connect JP7 to GND, connect JP8 to GND, the EVM will regulate the output voltages to the values shown in Table 1. Additional input capacitance may be required in order to mitigate the inductive voltage droop that may occur during a load transient event.

The output voltage is changed by sending the digital control signal via a PC running the TPS65276V controller software and USB-TO-GPIO interface box. Change the output voltage with 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 TPS65276V using the supplied 10-pin ribbon cable as shown in Figure 8. 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.

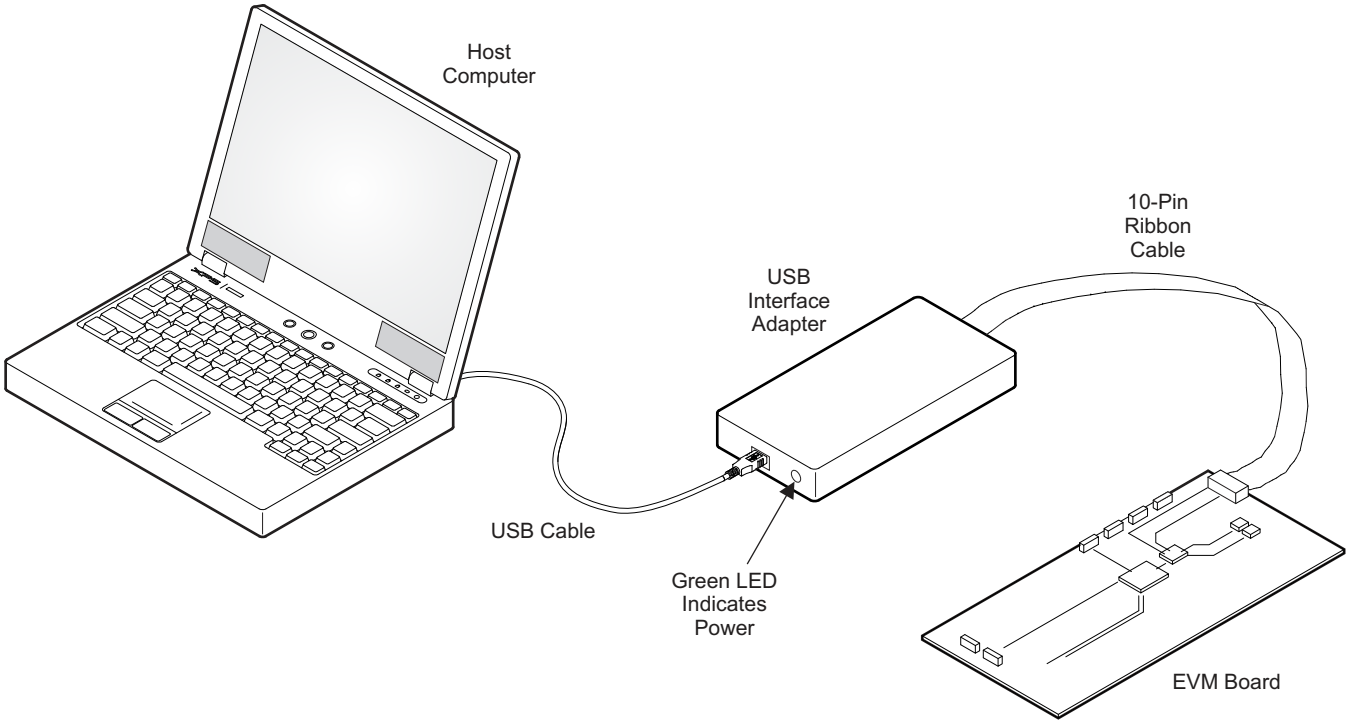


Figure 8. USB Interface Adapter Quick Connection Diagram

5.4 Installing Software

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

Note: This installation page is best viewed with the 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.

To run the software after installation, go to Start → All programs → Texas Instruments → TPS65276V 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 gives notification of the update, and downloads and installs the software. Note that after the firmware is updated the USB cable between the adapter and PC must be disconnected and then reconnected, 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 gives notification of the update and downloads and installs it. During future use of the software, a prompt may be given to install a new version, if one becomes available.

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.

5.5 Software Operation

This section provides descriptions of the EVM software.

The supplied software is used to communicate with the TPS65276V EVM. Click on the icon on the host computer to start the software. The software displays the main control panel for the user interface (Figure 9).

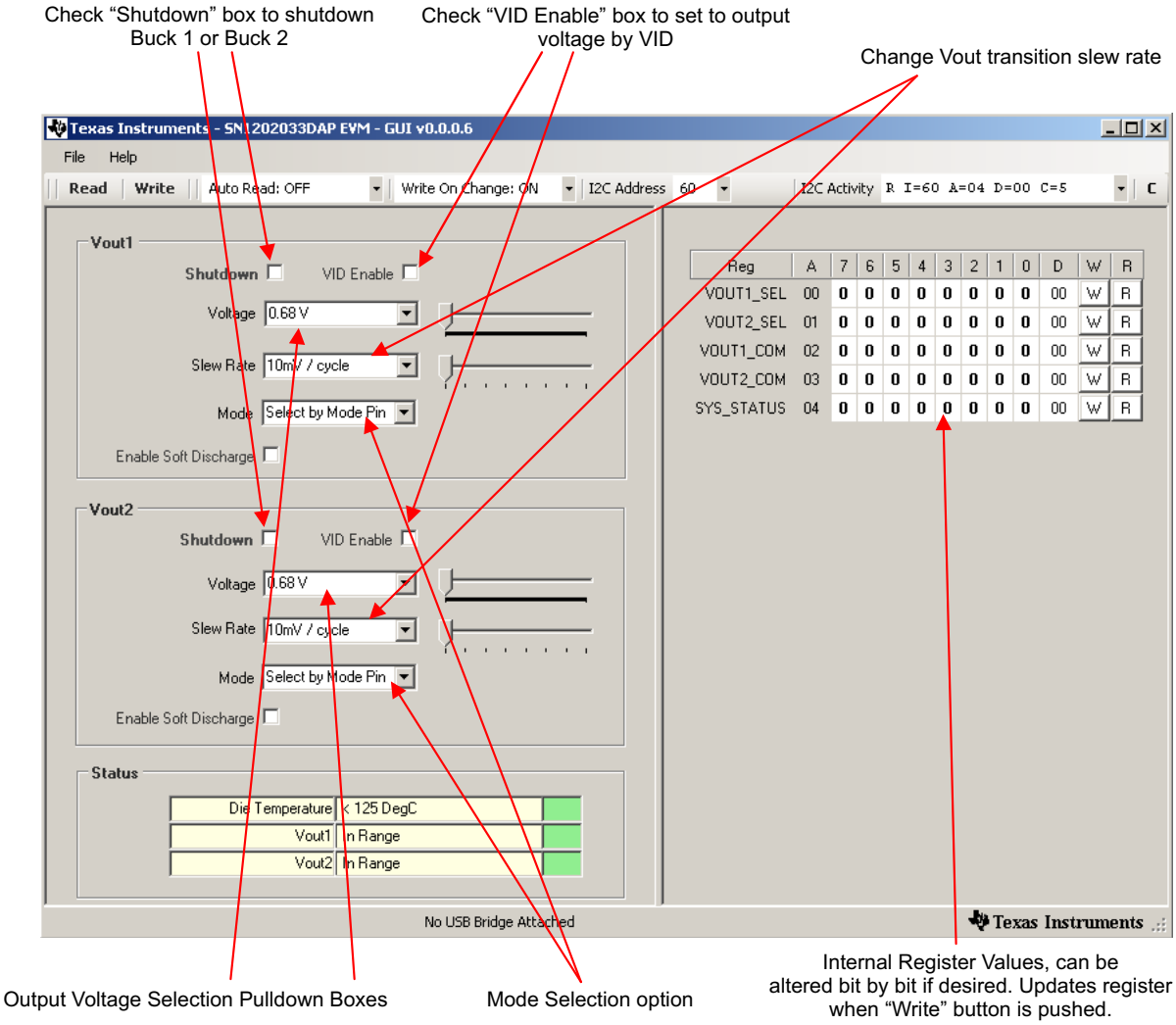


Figure 9. Screen Capture of TPS65276V Software GUI Interface

Figure 9 shows the GUI control interface. There are five 8-bit registers embedded in TPS65276V, two to select the output voltage, two to configure the buck converter’s operation, and one for status feedback. Changes are made by selecting and checking the components in the GUI on the left hand side and can also be made by directly clicking the bits of each register. I^2C address is set to default 0x60H, this address is corresponding to the EVM jumper JP7 to connect to GND. Changing the I^2C address requires that the EVM be configured accordingly.

An option is to “write on change”, if this option is set to ON, any change is sent 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.

6 Power-Up Procedure

Use the following steps to power-up the EVM:

1. Connect I^2C adaptor to JP15
2. Apply 4.5 V to J1
3. Toggle JP1 or JP2 to enable Vout1 and Vout2, respectively
4. Apply loads to the output connectors.

7 TPS65276V EVM Bill of Materials

Table 4 is the BOM for the EVM.

Table 4. TPS65276V EVM Bill of Materials

#	Value	Qty	Designator	Footprint	MFG	MFG Part Number	Description
1	10nF	2	C1, C2	0603	Generic		CAP 10nF 50V CERAMIC X7R 0603
2	10nF	4	C22, C23, C26, C27	0603	Generic		CAP 10nF 50V CERAMIC X7R 0603
3	10uF	2	C5, C11	1210	Panasonic -ECG	ECJ-4YB1E106M	CAP 10UF 25V CERAMIC X5R 1210
4	10uF	1	C9	0603	Panasonic -ECG	ECJ-1VB1A106M	CAP 10UF 10V CERAMIC X5R 0603
5	1uF	1	C15	0603	Generic		CAP 1UF 10V CERAMIC X5R 0603
6	82pF	2	C18, C31	0603	Generic		CAP 82pF 50V CERAMIC X7R 0603
7	47nF	2	C19, C30	0603	Generic		CAP 47nF 50V CERAMIC X7R 0603
8	22uF	12	C20, C28, C201, C202, C203, C204, C205, C281, C282, C283, C284, C285	0805	TDK	C2012X6S0J226M	CAP CER 22UF 6.3V 20% X6S 0805
9(1)	470uF	DNI	C204, C284	E_CAP_D8_L6.7	Nichicon	RHA0J471MCN1GS	CAP ALUM 470UF 6.3V 20% SMD
10	47pF	DNI	C231, C261	0603	Generic		CAP 47pF 50V CERAMIC X7R 0603
11(1)	ED500/2DS	3	J1, J18, J31	TB_2X5.0MM	OnShore Technology Inc	ED500/2DS	Terminal Block, 2-pin, 15-A, 5.0mm
12	HEADER 3 PIN	4	JP1, JP2, JP7, JP8	JMP0.3	Mil-Max	800-10-064-10-001000	Three Pin Header
13	HEADER 2 PIN(2)	1	JP9	JMP0.2	Mil-Max	800-10-064-10-001000	Two Pin Header
14	HEADER 10 PIN(3)	1	JP15,	HEADER10	3M	N2510-6002-RB	Ten Pin Header
15	3.3uH	2	L1, L2	IND3	Coilcraft	MSS1048-332NLB	SMT power inductor
16	100K	2	R1, R2	0603	Generic		RES 100k OHM 1/10W 1% 0603 SMD
17	100K	1	R24	0603	Generic		RES 100k OHM 1/10W 1% 0603 SMD
18	10k	2	R15, R16	0603	Generic		RES 10k OHM 1/10W 1% 0603 SMD
19	60.4K	1	R17	0603	Generic		RES 60.4k OHM 1/10W 1% 0603 SMD
20	40.2K	2	R18, R31	0603	Generic		RES 40.2k OHM 1/10W 1% 0603 SMD
21	0	6	R19, R30, R181, R182, R311, R312	0603	Generic		RES 0 OHM 1/10W 1% 0603 SMD
22	3.74k	2	R23, R26	0603	Generic		RES 3.7k OHM 1/10W 1% =0603 SMD
23	48.7k	1	R32	0603	Generic		RES 48.7k OHM 1/10W 1% 0603 SMD
24	Test Point White	11	TP1, TP2, TP5, TP15, TP16, TP17, TP18, TP24, TP31, TP32, TP151	TP	Keystone	5002	TEST POINT PC MINI .040"D WHITE
25	Test Point Black	4	TP10, TP12, TP13, TP14	TP	Keystone	5001	TEST POINT PC MINI .040"D BLACK
26(4)		4					Jumper, 2.54mm, applied on item 13
27(5)		4			3M	SJ-5303 (CLEAR)	BUMPON HEMISPHERE .44X.20 CLEAR
28		1	U1		Texas Instruments	TPS65276V	

(1) Item 9, 11: optional
(2) Item 13: split into 3 pins
(3) Item 14: split into 2 pins
(4) Install item 26 on item 13 no order - be consistent
(5) Install item 27 on bottom at corners

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.

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit www.ti.com/esh or contact TI.

No license is granted under any patent right or other intellectual property right of TI covering or relating to any machine, process, or combination in which such TI products or services might be or are used. TI currently deals with a variety of customers for products, and therefore our arrangement with the user is not exclusive. TI assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein.

REGULATORY COMPLIANCE INFORMATION

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 this Product 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

【ご使用にあたっての注】

本開発キットは技術基準適合証明を受けておりません。

本製品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
http://www.tij.co.jp

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. 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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

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 it 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		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265