EVM User's Guide: TLA431EVM

TLA431 Evaluation Module

Description

The TLA431 evaluation module (EVM) is an adjustable voltage reference evaluation module that demonstrates the performance of the TLA431 from Texas Instruments.

Get Started

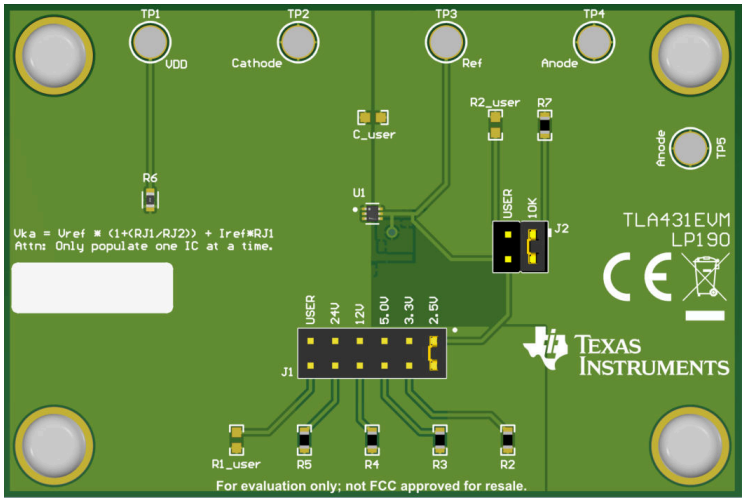
1. Order the EVM from the TLA431 tool page.
2. Configure EVM jumpers to select desired reference voltage method.
3. Connect VDD and Anode to power supply power and ground respectively.
4. Test the cathode voltage output.

Features

- Multiple resistor options for cathode voltage settings
- Open 0603 footprints for user resistor settings
- Open 0603 footprints for user output capacitor settings
- Test points for voltage measurement
- Open SOT23-3 footprints to allow EVM to be compatible with SOT23-3 variants of TLA431, TLA432, and all other pin-to-pin shunt voltage references

Applications

- Rack and server power
- Industrial AC/DC
- AC inverter and VF drives
- Servo drive control module
- Non-USB AC/DC adapter



TLA431EVM

1 Evaluation Module Overview

1.1 Introduction

The TLA431EVM is an adjustable voltage reference evaluation module that demonstrates the TLA431 performance in a six pin SOT-563 package. The TLA431 is an adjustable shunt voltage reference that is stable with all capacitor loads, improved performance across temperature, and a lower minimum cathode current requirement. This device is also available in pin-to-pin compatible packages with the TL431 which can help systems easily adopt TLA431.

This user's guide describes the characteristics, operation, and recommended use cases of the TLA431EVM. This document provides examples and instructions on how to use the TLA431EVM board. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the TLA431EVM. This document also includes a schematic, reference printed circuit board (PCB) layouts, and a complete bill of materials (BOM).

1.2 Kit Contents

Table 1-1 details the contents of the EVM kit. Contact the TI Product Information Center at (972) 644-5580 if any component is missing.

Table 1-1. Kit List

Item	Quantity
TLA431EVM	1

1.3 Specification

TLA431EVM primary function is to evaluate the TLA431 adjustable shunt voltage reference. Alligator clips and mini hook leads enable connection to the TLA431 device while jumpers simplify common device configuration. For specific configurations, empty component footprints allow users to implement customized test setups. TLA431EVM can be configured to be powered directly from the lab power supply.

1.4 Device Information

TLA431 is a three-terminal adjustable shunt voltage reference which comes as an upgrade to industry standard TL431. The device is designed to have all output capacitor stability, and also features improved temperature performance and a wider operating current range compared to TL431. Active output circuitry provides a very sharp turn-on characteristic, making TLA431 an excellent replacement for Zener diodes in several applications such as onboard regulation, adjustable power supplies, and switching power supplies. The internal amplifier and reference of the TLA431 is also used as an error amplifier in isolated optocoupler flyback power supplies.

2 Hardware

2.1 EVM Connection

Table 2-1 describes the purpose of each test point on the TLA431EVM.

Table 2-1. TLA431EVM Test Point Summary

Test Point	Test Point Name	Type	Functionality
TP1	Vdd	Input	Provide power to the TLA431EVM through input resistor R6.
TP2	Cathode	Output	Constant voltage output set by configuring jumpers J1 and J2.
TP3	Ref	Output	Reference voltage of the TLA431.
TP4/5	Anode	Input	Provide path for shunt current to flow. This test point is commonly connected to GND.

The underside of the TLA431EVM includes two footprints which can also accommodate testing for shunt voltage references which are pin-to-pin compatible with the TLA431 and TLA432 in SOT23-3 package. The cathode, reference, and anode pins for these footprints are also connected to each test point as shown in Figure 3-1 and described in Table 2-1. The plastic standoffs at each corner of the board can be unscrewed and turned around to access these footprints when soldering.

2.2 Jumper Information

TLA431EVM can be configured to preset voltage output options or set based on specific system requirements. Table 2-2 details jumper connection characteristics.

Table 2-2. TLA431EVM Jumper Connection

J1 Pin Connection	J2 Pin Connection	Cathode Voltage (V)
1 and 2	1 and 2	2.5
3 and 4	1 and 2	3.3
5 and 6	1 and 2	5.0
7 and 8	1 and 2	12.0
9 and 10	1 and 2	24.0
11 and 12	3 and 4	User Defined

2.3 EVM Theory and Operation

The following single channel schematic is representative of the TLA431EVM with each passive bank selection.

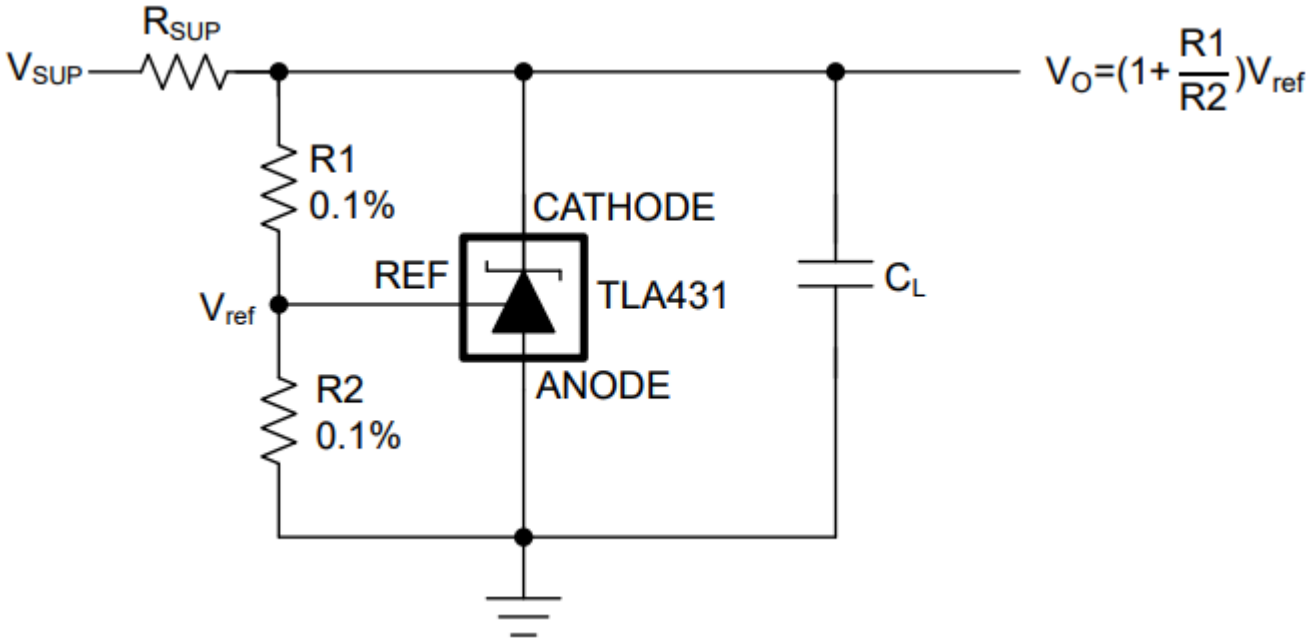


Figure 2-1. Base Shunt Reference Schematic

The TLA431EVM is designed to allow users to setup the configuration shown in Figure 2-1 with multiple options for each passive component and open footprints to test multiple use-cases. Table 2-3 shows a mapping of EVM components to board base components.

Table 2-3. EVM Component Mapping

Base Component	EVM Components
Rsup	R6
R1	R2 – R5, R1_user
R2	R7, R2_user
CL	C_user

As shown in Figure 3-1, the EVM is designed to allow users to visually map out each jumper connection to the respective passive component by the labeling of the configuration value next to J1.

2.3.1 Setting the Cathode Current (I_{KA})

Set R_{SUP} in conjunction with Vdd and the desired cathode voltage (V_{KA}) to provide enough current for operation. The TLA431 needs > 0.2mA to operate in the proper gain region for accurate regulation. Use Equation 1 to determine the cathode current.

$$I_{KA} = \frac{V_{SUP} - V_{KA}}{R_{SUP}} \quad (1)$$

When setting I_{KA}, be sure not to exceed the absolute maximum rating of 100mA for TLA431. For evaluation above 50mA, remove resistor R6 and replace with a resistor of a higher power rating. The TLA431EVM default R6 has a power rating of 0.5W.

2.3.2 Setting the Cathode Voltage (V_{KA})

Once the desired cathode current is determined, R_1 and R_2 must be selected to determine the cathode voltage. Use Equation 2 to determine V_{KA}. As I_{REF} is 4µA maximum, the I_{REF} * R_1 portion of the equation is almost negligible.

$$V_{KA} = \left(1 + \frac{R_1}{R_2}\right) * V_{REF} \quad + I_{REF} * R_1 \tag{2}$$

Jumpers J1 and J2 can be used to select the desired V_{KA} and each jumper selection in J1 is denoted with the respective V_{KA} value. Consider that these values are only valid with R_2 = 10kΩ which can be set by connecting pins 1 and 2 of jumper J2. If R_2 is disconnected or tied to a user setting, then use Equation 2 to determine the cathode voltage values.

When setting V_{KA}, be sure not to exceed the absolute maximum voltage rating of 37V for the TLA431.

2.3.3 Checking Stability and Transient Response

Although TLA431 is all-capacitor stable, capacitor footprint denoted C_user on the schematic in Figure 3-1 can still be used to evaluate TLA431 performance under conditions with a load capacitance.

2.4 Test Modes

The TLA431EVM can be configured to measure every parameter shown in the typical characters of the TLA431 data sheet. Figure 2-2 through Figure 2-5 show the configurations that can be used to take these measurements.

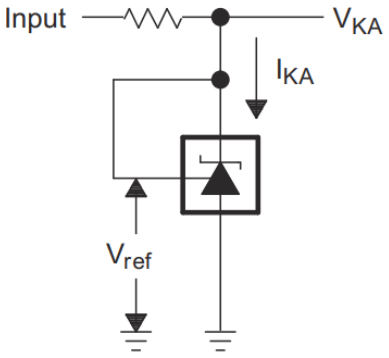


Figure 2-2. Test Circuit for VKA = Vref

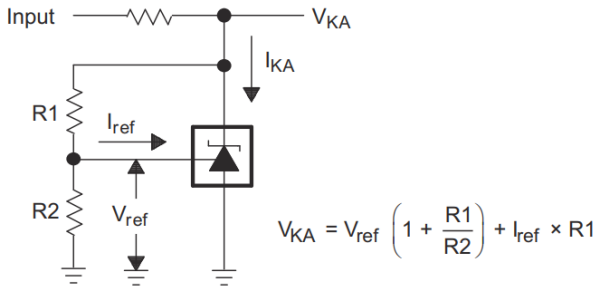


Figure 2-3. Test Circuit for VKA > Vref

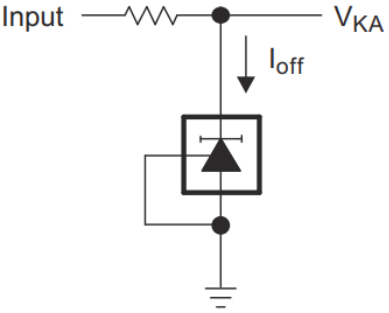


Figure 2-4. Test Circuit for Ioff

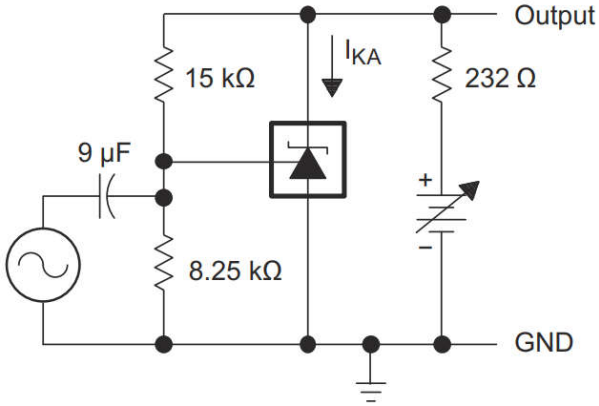


Figure 2-5. Test Circuit for Phase and Gain Measurement

3 Hardware Design Files

3.1 Schematic

The schematic shown in Figure 3-1 is representative of the TLA431EVM.

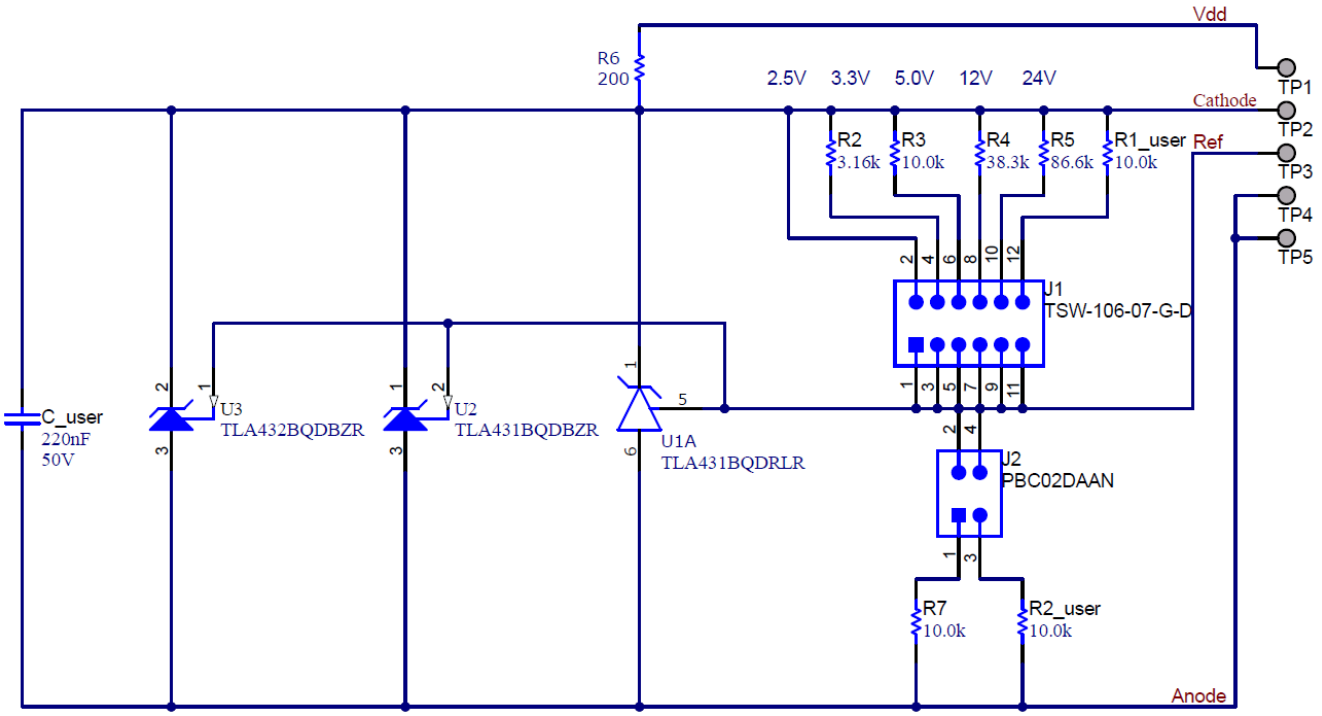


Figure 3-1. TLA431EVM Schematic

The TLA431EVM is designed to allow users to evaluate the configuration shown in Figure 3-1. Multiple test points and jumpers are provided to quickly setup and evaluate common configurations while components labeled with the suffix *user* are empty footprints intended to allow users to implement custom setups. Although the TLA431 is all-capacitor stable, capacitor footprint C_user allows users to evaluate this specification. The label above each jumper option set by J1 is the intended cathode voltage set when also connecting pins 1 and 2 of jumper J2. Populate only one shunt voltage reference device at a time.

Note

Resistor R6 is rated for 0.5W power rating. If the test configuration cathode current exceeds 50mA, then replace this resistor with one that has a higher power rating.

3.2 PCB Layouts

TLA431EVM is a two layer board. The layout is illustrated in this section.

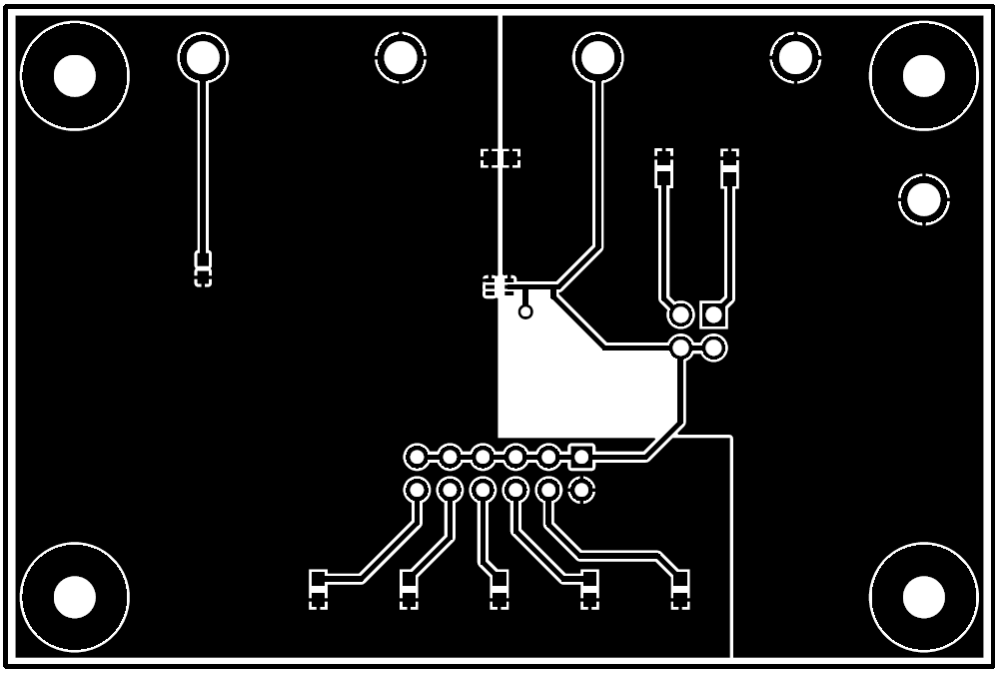


Figure 3-2. TLA431EVM Top Layer

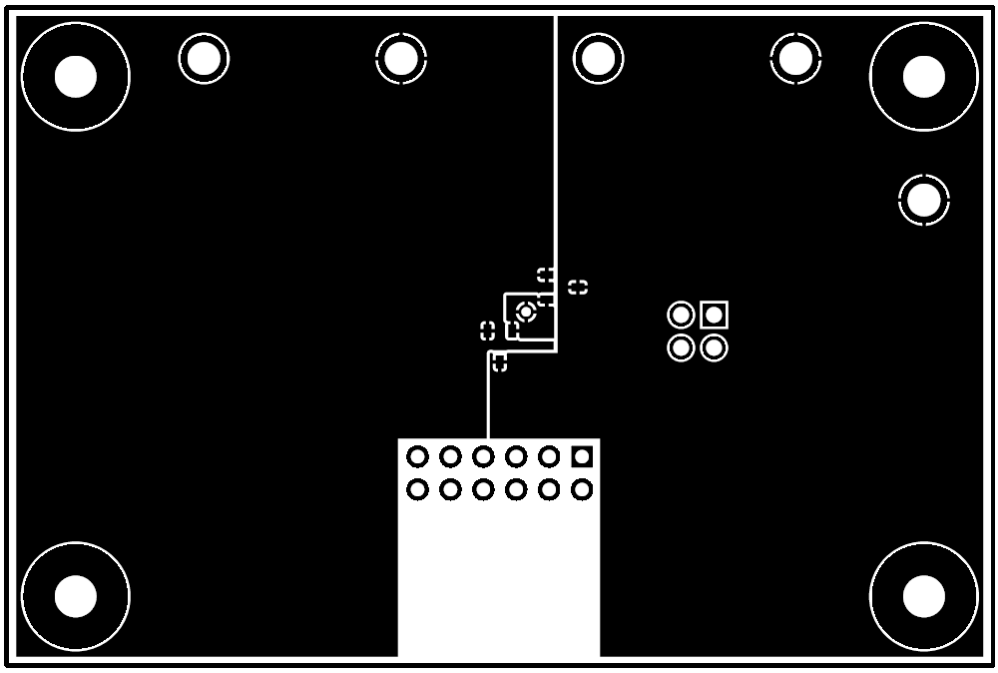


Figure 3-3. TLA431EVM Bottom Layer

3.3 Bill of Materials (BOM)

Table 3-1 lists the bill of materials for TLA431EVM.

Table 3-1. TLA431EVM Bill of Materials (BOM)

Designator	Qty	Description	Package Reference	Part Number	Manufacturer	Fitted
C_user	0	CAP, CERM, 0.22µF, 50V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	GCJ188R71H224KA01D	Murata Electronics	Not Fitted
H1, H2, H3, H4	4	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	Bfirst Industrial	Fitted
H6, H7, H8, H9	4	Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone Electronics	Fitted
J1	1	Header, 100mil, 6x2, Gold, TH	6x2 Header	TSW-106-07-G-D	Samtec Inc	Fitted
J2	1	Header, 2.54mm, 2x2, Gold, TH	2x2 Header	PBC02DAAN	Sullins Connector Solutions	Fitted
LBL1	1	Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650 x 0.200 Inch	THT-14-423-10	Brady Corporation	Fitted
R1_user, R2_user, R3, R7	2	RES, 10.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0710KL	YAGEO	R1_user, R2_user not fitted
R2	1	RES, 3.16 k, 1%, 0.1 W, 0603	0603	RC0603FR-073K16L	YAGEO	Fitted
R4	1	RES, 38.3 k, 1%, 0.1 W, 0603	0603	RC0603FR-0738K3L	YAGEO	Fitted
R5	1	RES, 86.6 k, 1%, 0.1 W, 0603	0603	RC0603FR-0786K6L	YAGEO	Fitted
R6	1	RES, 200, 0.1%, 0.5 W, 0603	0603	RA73F1J200RBTD	TE Connectivity Passive Product	Fitted
SH-J1, SH-J2	2	Shunt, 100mil, Gold plated, Black	2x1 Shunt Jumper	SNT-100-BK-G	Samtec Inc	Fitted
TP1, TP2, TP3, TP4, TP5	5	Terminal, Turret, TH, Triple	Keystone1598-2	1598-2	Keystone Electronics	Fitted
U1	1	TLA431BQDRLR	DRL0006A-MFG	TLA431BQDRLR	Texas Instruments	Fitted

4 Compliance Information

4.1 Compliance and Certifications

TLA431EVM EU Declaration of Conformity (DoC) for Restricting the Use of Hazardous Substances (RoHS)

5 Additional Information

5.1 Trademarks

All trademarks are the property of their respective owners.

6 Related Documentation

The documents in Table 6-1 provide information regarding Texas Instruments integrated circuits used in the assembly of the TLA431EVM. This user's guide is available from the TI web site under literature number SLVUDI8. Any letter appended to the literature number corresponds to the document revision that is current at the time of the writing of this document. Newer revisions are available from the TI web site at www.ti.com, or call Evaluation Module the Texas Instruments Literature Response Center at (800) 477-8924 or the Product Information Center at (972) 644-5580. When ordering, identify the document by both title and literature number.

Table 6-1. Related Device Documentation

Item	Literature Number
TLA431 product data sheet	SNVSCR4

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying 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 set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   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 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 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 a nonconforming EVM if (a) the nonconformity was 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, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, 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.

WARNING

Evaluation Kits 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 shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

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

FCC NOTICE: 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 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. 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/lsds/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。

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

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 to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。 技術適合証明を受けていないもの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 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

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

4.3 *Safety-Related Warnings and Restrictions:*

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

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

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

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

6. *Disclaimers:*

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

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

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

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

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

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

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

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