

TMP392EVM

User's Guide



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TMP392EVM User's Guide

The TMP392 is an ultra-low power, dual-trip, dual-output, resistor-programmable temperature switch. This device enables thermal protection and thermal event monitoring over a wide temperature range. The TMP392 offers independent dual overtemperature (hot and warm) detection in the temperature range from +30°C to +124°C with $\pm 3.0^\circ\text{C}$ trip accuracy. The Texas Instruments TMP392EVM (Evaluation Module) is easy to use and can evaluate the performance of the TMP392 right out of the box. The EVM has pre-populated resistors corresponding to a hot and warm trip point with 5°C hysteresis, and LED indicators at the outputs of the device. The trip test function is available through the use of onboard push buttons to test the output of both channels. The sensor is also located on a perforated portion of the PCB that can be separated from the main board for prototyping. The TMP392EVM does not require any calibration or software programming, as the trip points are programmed through two resistors. This document provides detailed information about the device operation and evaluation board features.

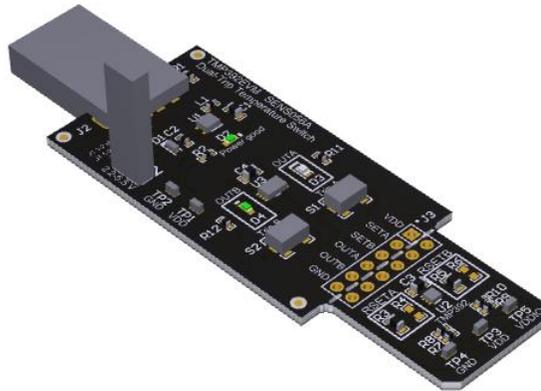


Figure 1. TMP392 Evaluation Board

1 Trademarks

All trademarks are the property of their respective owners.

2 Overview

The TMP392EVM allows users to evaluate the performance of the TMP392 dual-trip programmable temperature switch. The EVM comes in a USB stick form factor that can plug into a USB port to supply power and begin the evaluation of the temperature switch. The hardware is as shown in Figure 1. The module is designed so all of the features, including the manual trip test and reset of both channels, are readily available for testing. Two LED indicators are illuminated when either output of the TMP392 is triggered based on the temperature trip point. The EVM also features a perforated breakout portion of the board which can be wired to test the TMP392 in either an existing system or oven.

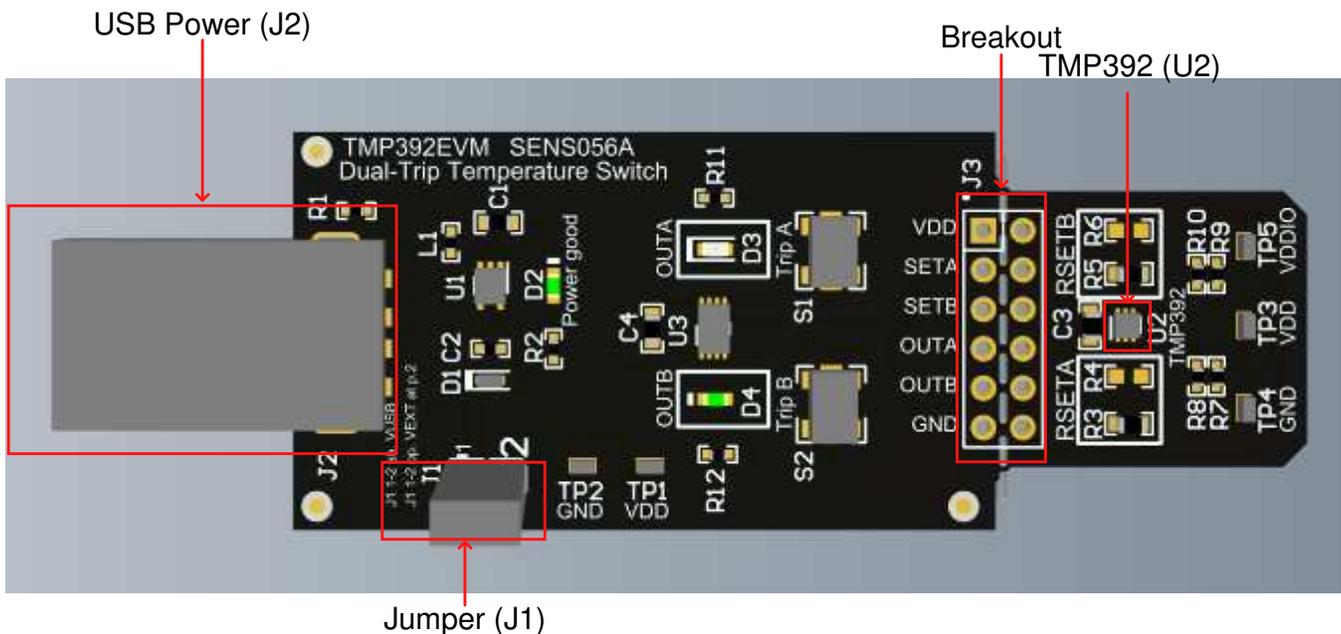


Figure 2. TMP392 Evaluation Board Top Side

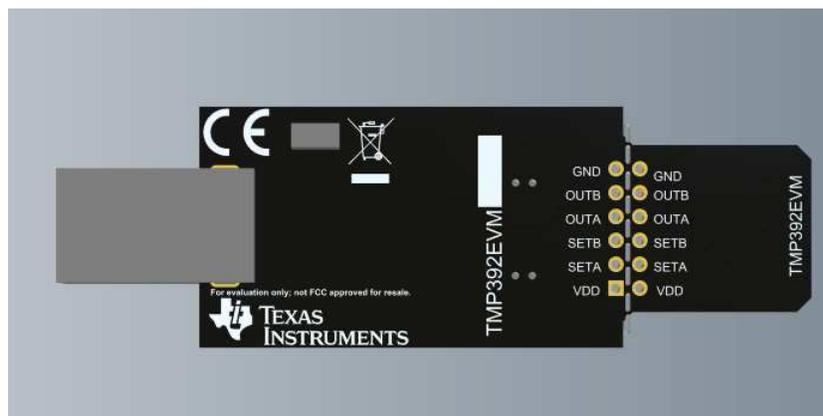


Figure 3. TMP392 Evaluation Board Bottom Side

2.1 TMP392EVM Kit Contents

Table 1 summarizes the contents of the TMP392EVM kit. Figure 1 shows all of the included hardware.

Table 1. TMP392EVM Kit Contents

Item	Quantity
PCB Test Board: TMP392EVM	1
USB Cable Extender	1

3 EVM Hardware Overview and Operation

The TMP392EVM block diagram is shown in Figure 4, and each block is described in detail in the following sections.

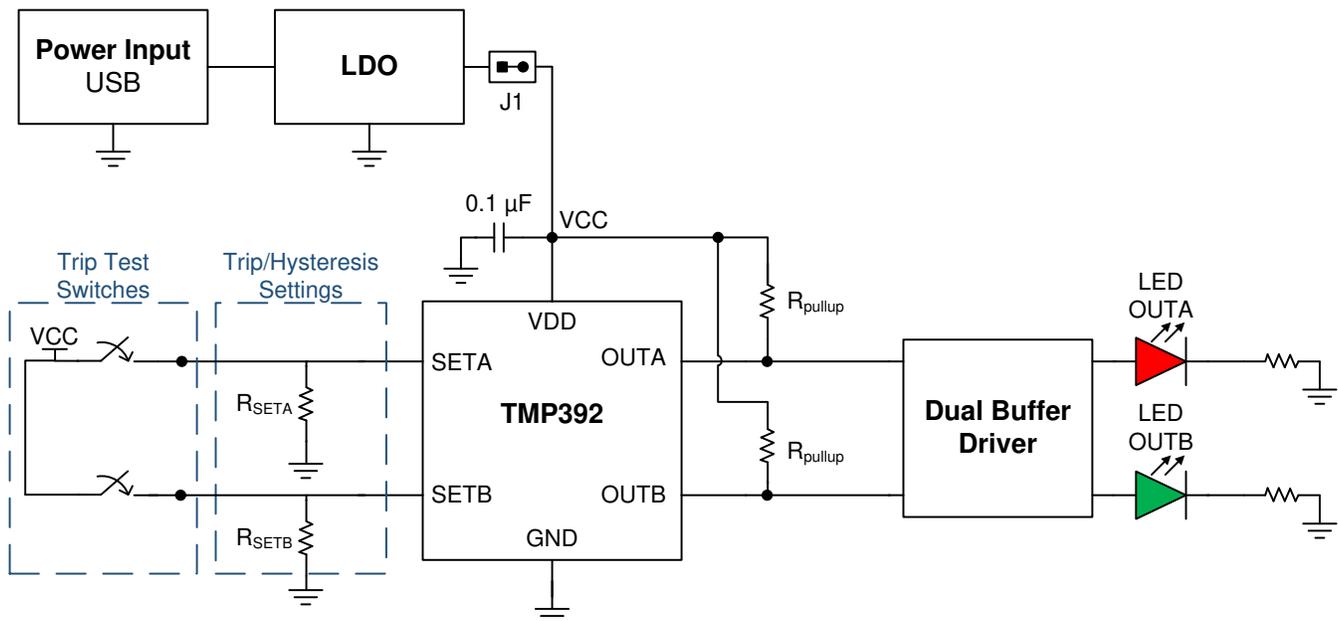


Figure 4. TMP392 Evaluation Board Block Diagram

3.1 Power Input and Regulation

Power is supplied from the USB connector, J2, with +5 V. This input can connect to the USB port of a laptop or desktop. The evaluation board does not require an external power supply, but one may be used if desired (such as when the breakout board is disconnected), so long as the voltage is within the maximum rated voltage of the TMP392.

USB power is used when J1 is shorted at pins 1-2 using a jumper. This connects +5 V to the LDO (low dropout regulator), providing a regulated output voltage of +3.3 V. If an external supply is required, then jumper J1 can be removed and power may be connected to pin 2 of J1. If an external supply is used, the input voltage can be from +2.2 V to +5.5 V. The input voltage can be measured at test pin TP1 (VDD). The LED, D2, will illuminate when power is good.

3.2 Perforated Breakout Board

The EVM board is perforated along the unpopulated J3 designator to break away the sensor portion of the board from the power and LED output for additional prototyping and testing. J3 provides connections for the breakout board for power, inputs, and outputs. The pins located on both sides of the J3 designator are labeled with silkscreen on the EVM, including SETA, SETB, OUTA, OUTB, VDD, and GND. All components on the breakout board are rated up to +150°C. The EVM was not designed with high-temperature PCB material, and thus was not designed for prolonged testing at high temperature.

3.3 Dual-Channel Resistor Programmable Trip Points

The application can use standard 1.05-k Ω to 909-k Ω E96-series resistors to set the hot trip point (Channel A) and standard 10.5-k Ω to 909-k Ω E96-series resistors warm temperature trip points (Channel B). There are 48 available trip points in the hot trip point range and 32 available trip points corresponding to a warm trip point and hysteresis setting. The hot trip point may be in the +30°C to +124°C range, while the warm trip point is in the +30°C to +105°C range. These settings can be found in the TMP392 device data sheet.

On the TMP392EVM, resistors R3 and R5 are populated to set the trip points for SETA and SETB, respectively. These are located on the same breakout board where the TMP392 is located, and are designated as RSETA and RSETB. The resistor in the SETA programs the hot trip point, while the resistor in the SETB programs the warm trip point and the hysteresis settings for both channels. R3 is populated on the EVM with a 9.09-k Ω resistor, corresponding to the hot trip point at +60°C. R5 is 90.9 k Ω , corresponding to the warm trip point at +30°C and hysteresis of 5°C. With the trip point at +30°C, the user can immediately visualize the tripped output after opening the EVM.

Two additional footprints for 0603 resistors, R4 and R6, are available to solder different resistors and program alternate hot and warm trip points. Remember that R3 and R4 should not be populated at the same time, and that R5 and R6 should also not be populated at the same time. Standard resistor values in the E96-series that have 1% tolerance should be used for best performance.

Figure 5 shows the behavior of the output using hysteresis. When the hot trip point of +60°C is reached, OUTA is tripped and the output will remain low until the temperature drops below the hysteresis level subtracted from the hot threshold temperature. In this case, the hysteresis is set at 5°C, so OUTA returns high when the temperature drops to +55°C. The same goes for the lower threshold, which is set at +30°C. When the sensor goes to +30°C, OUTB goes low and will return high when the temperature drops to +25°C.

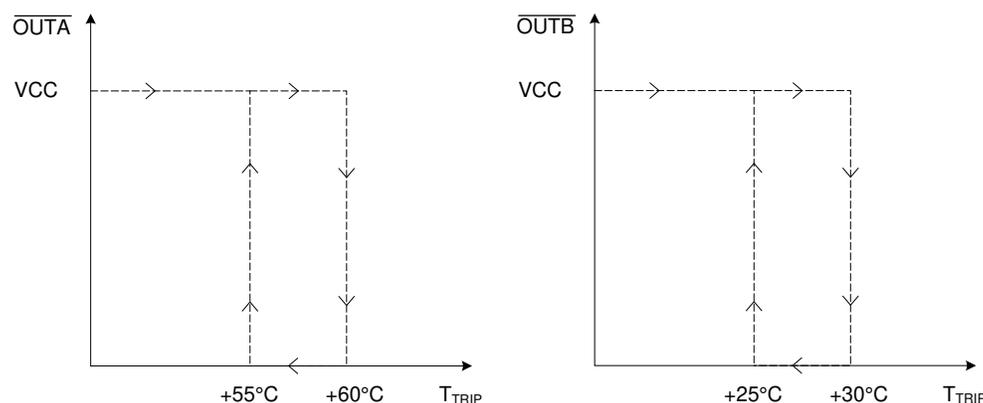


Figure 5. Hysteresis Behavior Example

3.4 Manual Trip Test and Reset

Both outputs can be tripped manually by applying a logic high to the SETA and SETB inputs to evaluate the functionality of the outputs. On the evaluation board, there are two designated push buttons—S1 and S2—to trip OUTA and OUTB, respectively. The output LEDs for OUTA and OUTB, D3 (red) and D4 (green), will illuminate when the trip point is reached or if the output is forced by the trip test.

3.5 Open-Drain Output

Pullup resistors are located at the open-drain OUTA and OUTB outputs. TI recommends to tie the pullup voltage to the VDD of the TMP392. If this is not possible, however, an external voltage may be used for VDDIO that must be less than or equal to $V_{\text{DD}} + 0.3 \text{ V}$ of the TMP392. To connect an external VDDIO, the 0- Ω resistor at R7 may be desoldered to remove connection to VDD, then resoldered at R9 to connect an external supply at TP5 as shown in Figure 6.

4 Board Layout

The PCB is a four-layer board that includes a power regulator, the TMP392 sensor, all of the necessary auxiliary circuitry, and various test points. The portion of the board where the sensor and resistors is located may be broken off for evaluation separately from the rest of the EVM. This breakout board was minimized in size to reduce the thermal mass for improving the thermal response of the TMP392.

Further layout considerations in the final design using the TMP392 may be required based on the application. Refer to [Temperature Sensors: PCB Guidelines for Surface Mount Devices](#) for design and layout recommendations for temperature sensors. The breakout board includes resistors rated up to 150°C for high-temperature testing, as well as the decoupling capacitor C7, which is placed as close as possible to the TMP392.

NOTE: This PCB will not withstand temperatures of 150°C for extended periods of time because it was not manufactured with high-temperature material.

5 Schematic and Bill of Materials

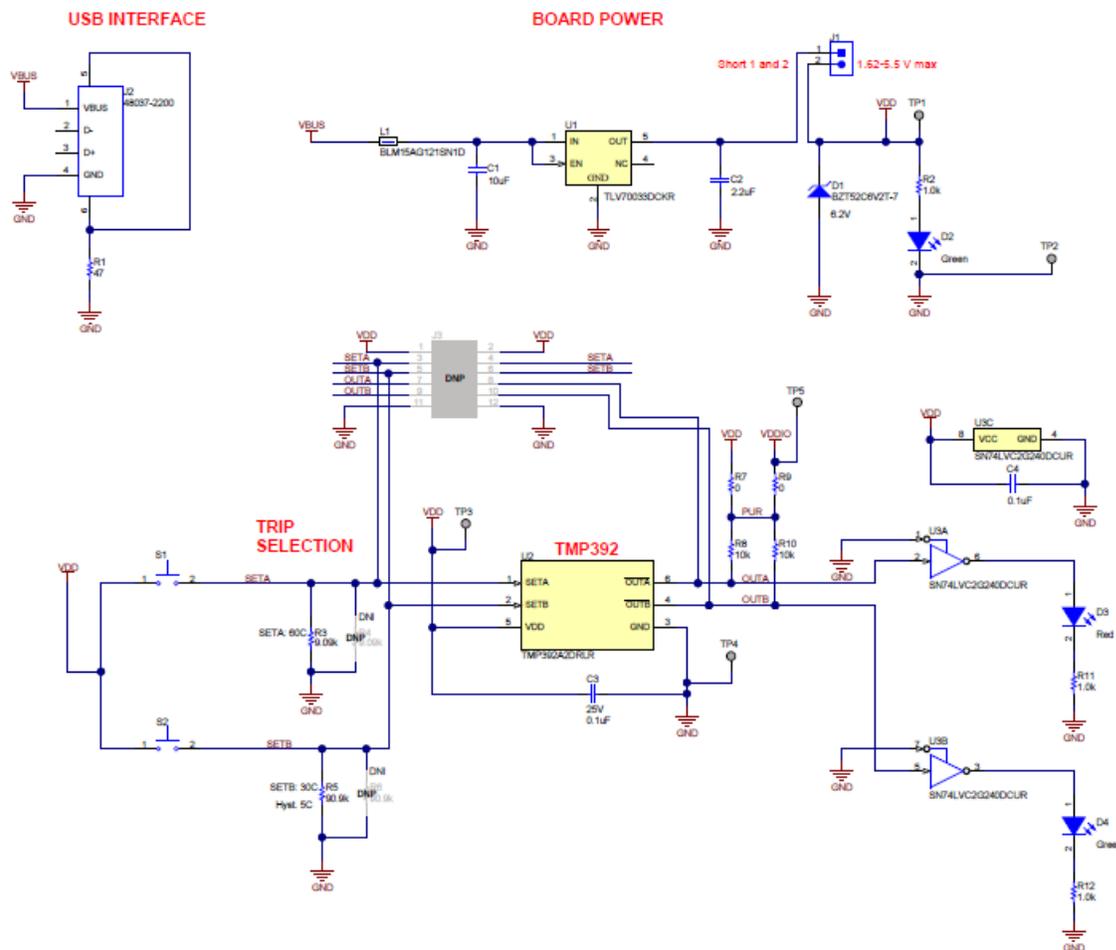


Figure 6. TMP392 Evaluation Board Schematic

Table 2. TMP392 Test Board Bill of Materials

ITEM NO.	QTY	VALUE	REF DES	DESCRIPTION	VENDOR/MFR	PART NUMBER
1	1	10 μ F	C1	CAP, CERM, 10 μ F, 10 V, \pm 20%, X5R, 0603	TDK	C1608X5R1A106M080AC
2	1	2.2 μ F	C2	CAP, CERM, 2.2 μ F, 16 V, \pm 10%, X5R, 0402	MuRata	GRM155R61C225KE11D
4	2	0.1 μ F	C7, C8	CAP, CERM, 0.1 μ F, 25 V, \pm 10%, X8R, AEC-Q200 Grade 0, 0603	TDK	CGA3E2X8R1E104K080AA
5	1	6.2 V	D1	Diode, Zener, 6.2 V, 300 mW, SOD-523	Diodes Inc.	BZT52C6V2T-7
6	2	Green	D2, D4	LED, Green, SMD	Lumex	SML-LX0603GW-TR
7	1	Red	D3	LED, Red, SMD	Lite-On	LTST-C191KRKT
8	1		J1	Header, 2.54 mm, 2x1, Gold, TH	Würth Elektronik	61300211121
9	1		J2	Connector, Plug, USB Type A, R/A, Top Mount SMT	Molex	48037-2200
10	1	120	L1	Ferrite Bead, 120 Ω at 100 MHz, 0.55 A, 0402	MuRata	BLM15AG121SN1D
11	1	47	R1	RES, 47, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	Panasonic	ERJ-2GEJ470X
12	3	1k	R2, R11, R12	RES, 1.0 k Ω , 5%, 0.1 W, AEC-Q200 Grade 0, 0402	Panasonic	ERJ-2GEJ102X
13	1	9.09k	R3	RES, 9.09 k, 1%, 0.1 W, 0603	Vishay-Dale	CRCW06039K09FKEA
14	1	90.9k	R5	RES, 90.9 k, 1%, 0.1 W, 0603	Vishay-Dale	CRCW060310K5FKEA
15	1	0	R7	RES, 0, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	CRCW060390K9FKEA
16	2	10k	R8, R10	RES, 10 k Ω , 5%, 0.1 W, AEC-Q200 Grade 0, 0402	Panasonic	ERJ-2GEJ103X
17	2		S1, S2	Switch, SPST-NO, Off-Mom, 0.05A, 12VDC, SMD	C&K Components	PTS820 J20M SMTR LFS
18	1		SH-J1	Shunt, 100mil, Tin plated, Black	Samtec	SNT-100-BK-T-H
19	5		TP1, TP2, TP3, TP4, TP5	Natural PC Test Point Brass, SMT	Harwin	S2761-46R
20	1		U1	Single Output LDO, 200 mA, Fixed 3.3 V Output, 2 to 5.5 V Input, with Low IQ	Texas Instruments	TLV70033DCKR
21	1		U2	Dual-Trip, Resistor-Programmable Temperature Switch	Texas Instruments	TMP392A2DRLR
22	1		U3	Dual Buffer/Driver With 3-State Outputs	Texas Instruments	SN74LVC2G240D CUR
23	0		J3	Header, 100 mil, 6x2, Gold, TH	Samtec	TSW-106-07-G-D

Table 2. TMP392 Test Board Bill of Materials (continued)

ITEM NO.	QTY	VALUE	REF DES	DESCRIPTION	VENDOR/MFR	PART NUMBER
24	0	9.09k	R3	RES, 9.09 k, 1%, 0.1 W, 0603	Vishay-Dale	CRCW06039K09F KEA
25	0	90.9k	R5	'RES, 90.9 k, 1%, 0.1 W, 0603	Vishay-Dale	CRCW060310K5F KEA
26	0	0	R9	RES, 0, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	CRCW04020000Z0 ED

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 semiconductor 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 DEGRADATION 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/lstds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required 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.

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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.
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