

TMP708/709EVM Evaluation Board and Software Tutorial

This user's guide describes the characteristics, operation, and use of the TMP708/709EVM evaluation board. It reviews the hardware and operation for the TMP708EVM and the TMP709EVM. Throughout this document, the terms *evaluation board*, *evaluation module*, and *EVM* are synonymous with the TMP708/709EVM. This user's guide also includes information regarding operating procedures and input/output connections, an electrical schematic, printed circuit board (PCB) layout drawings, and a parts list for the two EVMs.

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1 Overview

The TMP708 and TMP709 are fully-integrated, resistor-programmable temperature switches with temperature thresholds that are set by just one external resistor. The TMP708/709 provide an open-drain, active-low output and are operational over the +2.7-V to +5.5-V supply voltage range. The temperature threshold accuracy is typically $\pm 0.5^{\circ}\text{C}$ with a maximum of $\pm 2^{\circ}\text{C}$ (from $+60^{\circ}\text{C}$ to $+100^{\circ}\text{C}$) or $\pm 3^{\circ}\text{C}$ (from 0°C to $+125^{\circ}\text{C}$), and the quiescent current consumption is typically 25 μA . Hysteresis is pin-selectable.

The TMP708/709 are available in a 5-pin SOT-23 package. The devices are specified for operation over a temperature range of 0°C to $+125^{\circ}\text{C}$.

The TMP708/709EVM is a platform for evaluating the performance of the TMP108/709. This document gives a general overview of the TMP708/709EVM and provides a general description of the features and functions to be considered while using this evaluation module.

1.1 TMP708/709EVM Kit Contents

Table 1 summarizes the contents of the TMP708/709EVM kit. Figure 1 shows all of the included hardware. Contact the [Texas Instruments Product Information Center](#) nearest you if any component is missing. It is highly recommended that you also check the TMP708 and TMP709 product folders on the TI web site at www.ti.com to verify that you have the latest versions of the related software.

Table 1. TMP708/709EVM Kit Contents

Item	Quantity
TMP708/709EVM test board	1

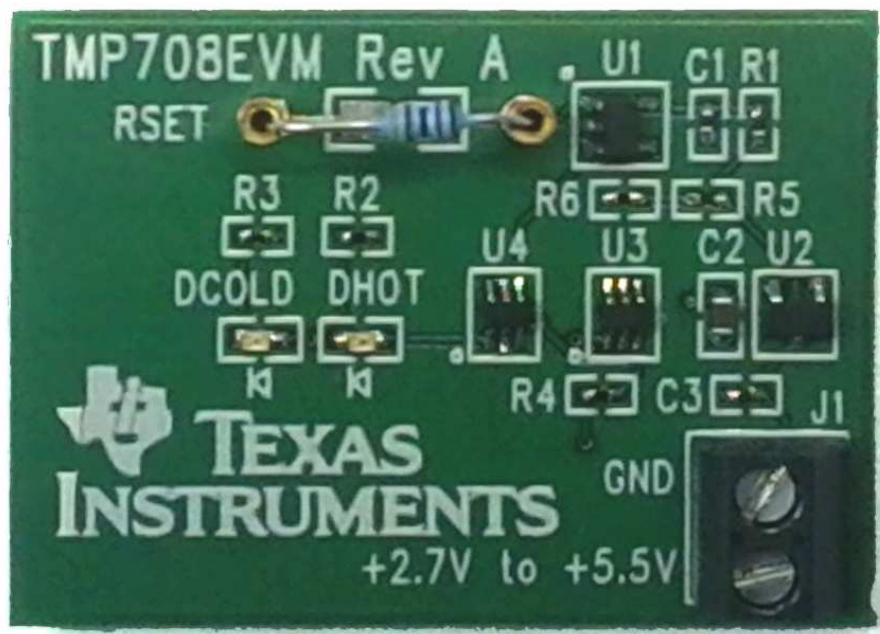


Figure 1. Hardware Included with TMP708/709EVM Kit

1.2 Related Documentation from Texas Instruments

The following documents provide information regarding Texas Instruments' integrated circuits used in the assembly of the TMP708/709EVM. This user's guide is available from the TI web site under literature number **SBOU120**. 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 may be available from the [TI web site](#), or call 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 2. Related Documentation

Document	Literature Number
TMP708 product data sheet	SBOSxxx
TMP709 product data sheet	SBOS583

2 TMP708/709EVM Hardware Overview and Setup

This section describes the hardware and setup for the TMP708/709EVM.

2.1 TMP708/709EVM Hardware Theory of Operation

The TMP708/709 test boards feature a power connector labeled J1. This off-board power is connected directly to the TMP708/709 (depending on which EVM you are using). A low-dropout (LDO) regulator provides power to two comparators which sense the output from the TMP708/709.

Depending on the output, either a green LED or a red LED illuminates to visually represent the status of the temperature switch. The temperature limit is determined by the resistor Rset; see **Section 2.4.3**.

The hysteresis setting is controlled by populating either R5 or R6 with a 0-Ω resistor. This behavior is described in **Section 2.4.2**.

[Figure 2](#) shows the basic interactions that occur on the TMP708/709 test board.

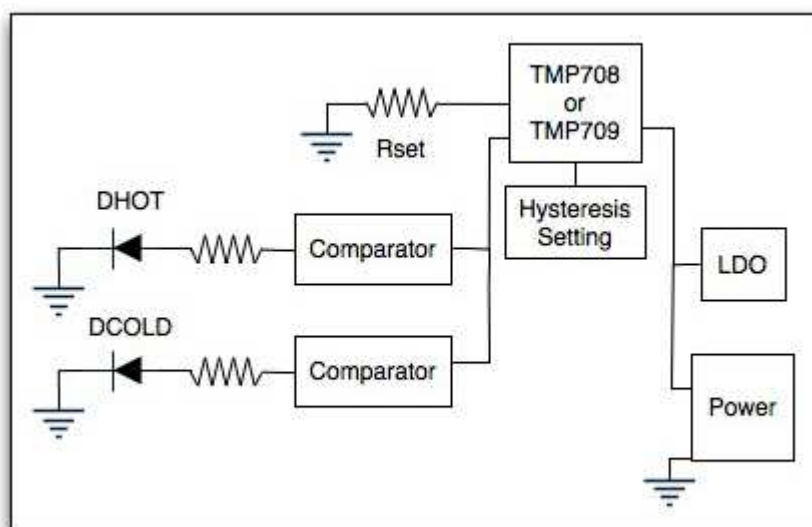


Figure 2. TMP708/709EVM Hardware Setup

2.2 Electrostatic Discharge Warning

CAUTION

Many of the components on the TMP708/709EVM are susceptible to damage by electrostatic discharge (ESD). Customers are advised to observe proper ESD handling precautions when unpacking and handling the EVM, including the use of a grounded wrist strap at an approved ESD workstation.

2.3 Connecting the Hardware

Provide power to the test board from a bench-top power supply using the terminal block labeled J1 in the bottom right corner of the test board, as shown in [Figure 3](#). As labeled, the power supply must be between +2.7 V and +5.5 V.



Figure 3. Connecting the Power Supply to the Test Board

2.4 TMP708/709EVM Features

This section describes some of the hardware features present on the TMP708/709EVM test boards.

2.4.1 External Power Header

The TMP708/709 test boards feature a terminal block to provide external power. This power is applied directly to the TMP708/709 device. The power is also regulated by an LDO to power the comparators and LEDs that indicate temperature switch status.

2.4.2 Hysteresis Options

The test boards ship with R6 populated by a 0-Ω resistor that pulls pin 4 (HYST pin) of the TMP708/709 to GND. The hysteresis function keeps the outputs from oscillating when the temperature is close to the threshold. Thus, the HYST pin should always be connected to either VCC or GND by populating either R5 or R6 with a 0-Ω resistor, respectively. The hysteresis setting is set by the HYST pin, as described in [Table 3](#).

Table 3. Hysteresis Setting

Device	HYST Pin Connection	
	VCC (°C)	GND (°C)
TMP708	10	30
TMP709	10	2

2.4.3 SMD Pads and Pin Sockets for Rset

The test boards features SMD pads and pin sockets for Rset so that either a surface-mount resistor or a through-hole resistor may be used to set the temperature threshold. The resistor value is determined by [Equation 1](#):

$$R_{set} \text{ (k}\Omega\text{)} = 0.0012 \times T^2 - 0.9308 \times T + 96.147$$

where:

T is the temperature threshold in degrees Celsius.

(1)

2.5 LED Status Indicators

The status of the temperature switch may be monitored at a glance by the on-board LEDs. The temperature threshold is set by Rset and the hysteresis setting. An illuminated green LED (as shown in [Figure 4](#)) indicates that the current temperature is below the threshold. An illuminated red LED (as shown in [Figure 5](#)) indicates that the current temperature is above the threshold.



Figure 4. On-Board LEDs Indicating that Current Temperature is Below the Limit Set by Rset



Figure 5. On-Board LEDs Indicating that Current Temperature is Above the Limit Set by Rset

For example, a TMP709 with its trip point set to 100°C asserts when its temperature rises above +100°C, and does not de-assert until its temperature drops below +100°C minus the selected hysteresis value (that is, +98°C if 2°C hysteresis is chosen). Conversely, if the trip temperature of the TMP709b is -40°C, the output asserts at -40°C as temperature falls, and de-asserts when temperature rises above -40°C plus the hysteresis value (that is, -38°C if 2°C hysteresis is chosen). This behavior is shown in Figure 6.

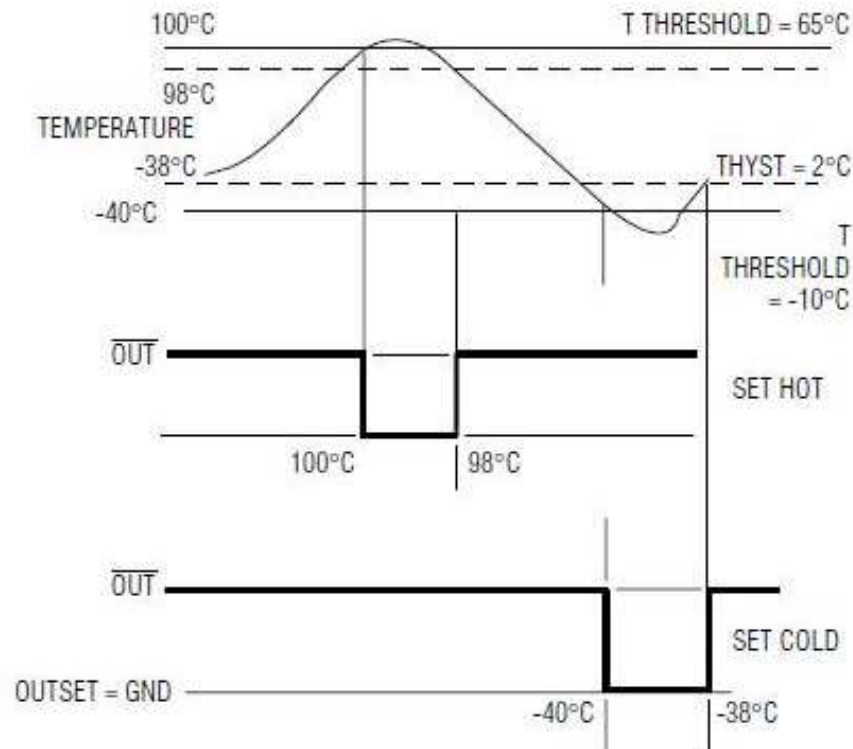


Figure 6. Hysteresis Behavior Example

3 TMP708/709EVM Test Board Documentation

This section contains the component layout, schematic diagram, and bill of materials for the TMP708/709EVM test boards.

3.1 TMP708/709EVM Test Board Schematic

Figure 7 shows the schematic for the TMP708/709EVM test boards.

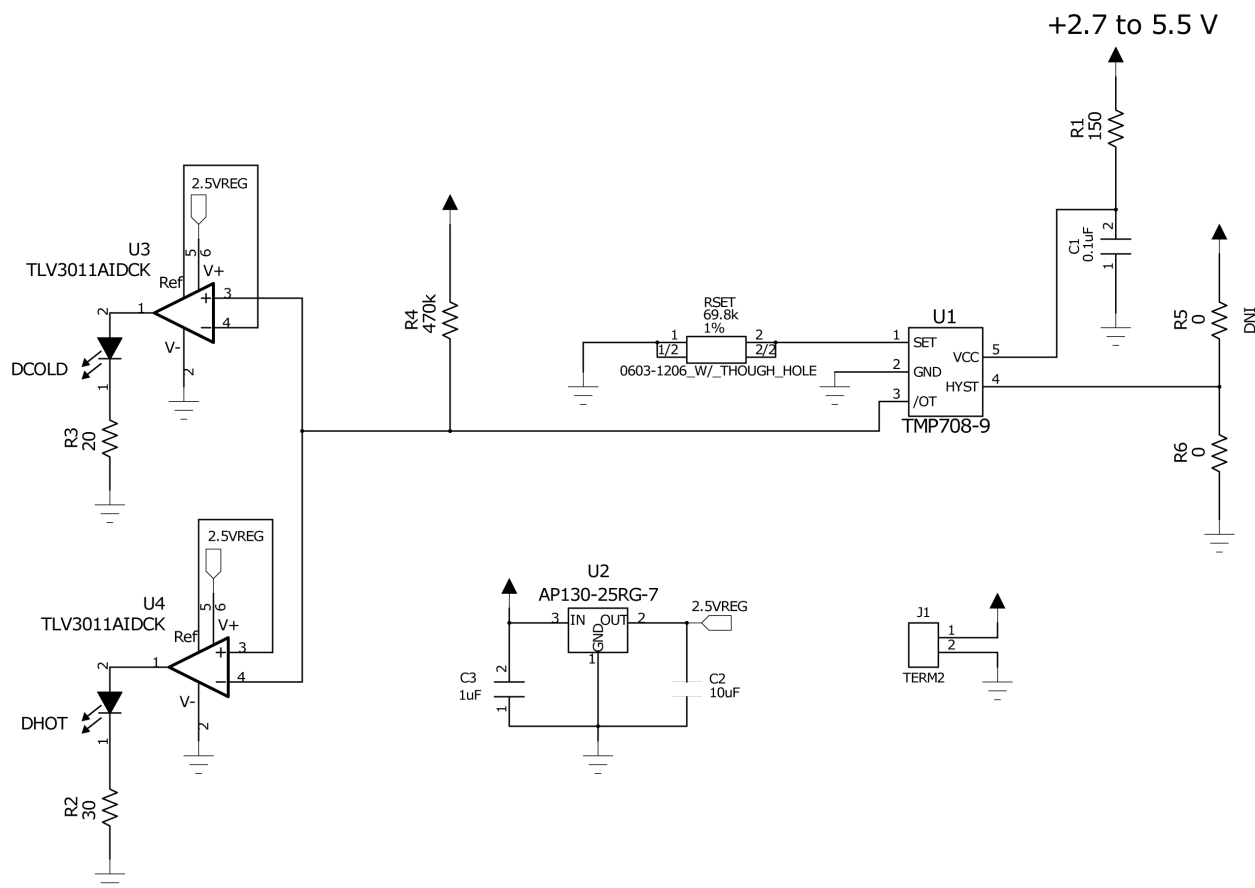


Figure 7. TMP708/709EVM Test Board Schematic

3.2 TMP708/709 Test Board Components Layout

Figure 8 and Figure 9 show the top-side layout of the components for the TMP708/709EVM test boards. Note that they are identical except for the EVM label on the top silkscreen layer.

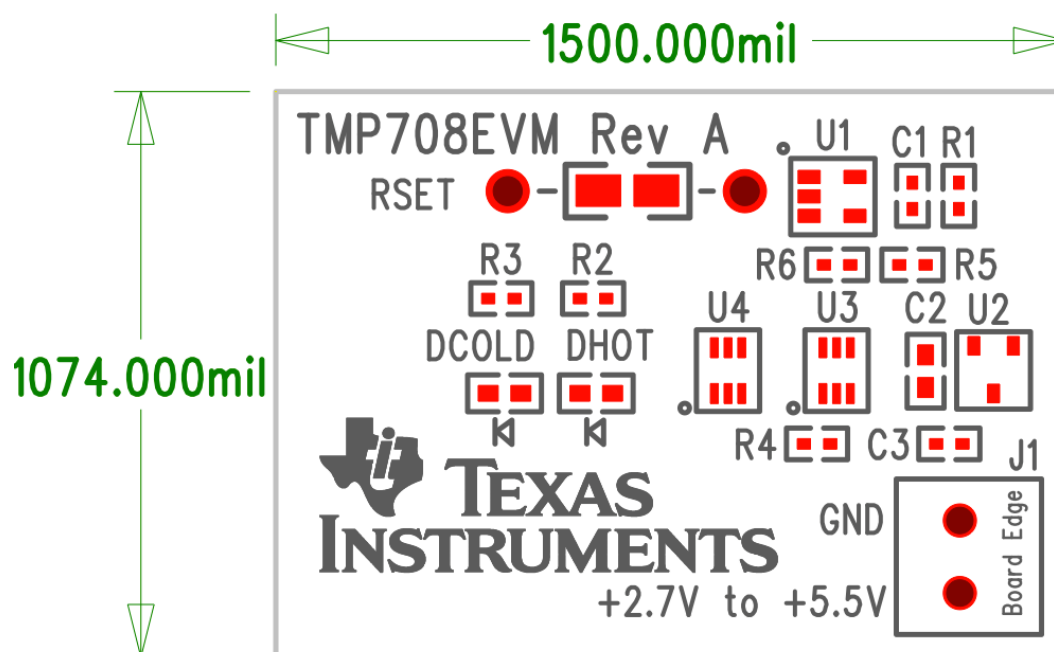


Figure 8. TMP708EVM Test Board Components Layout

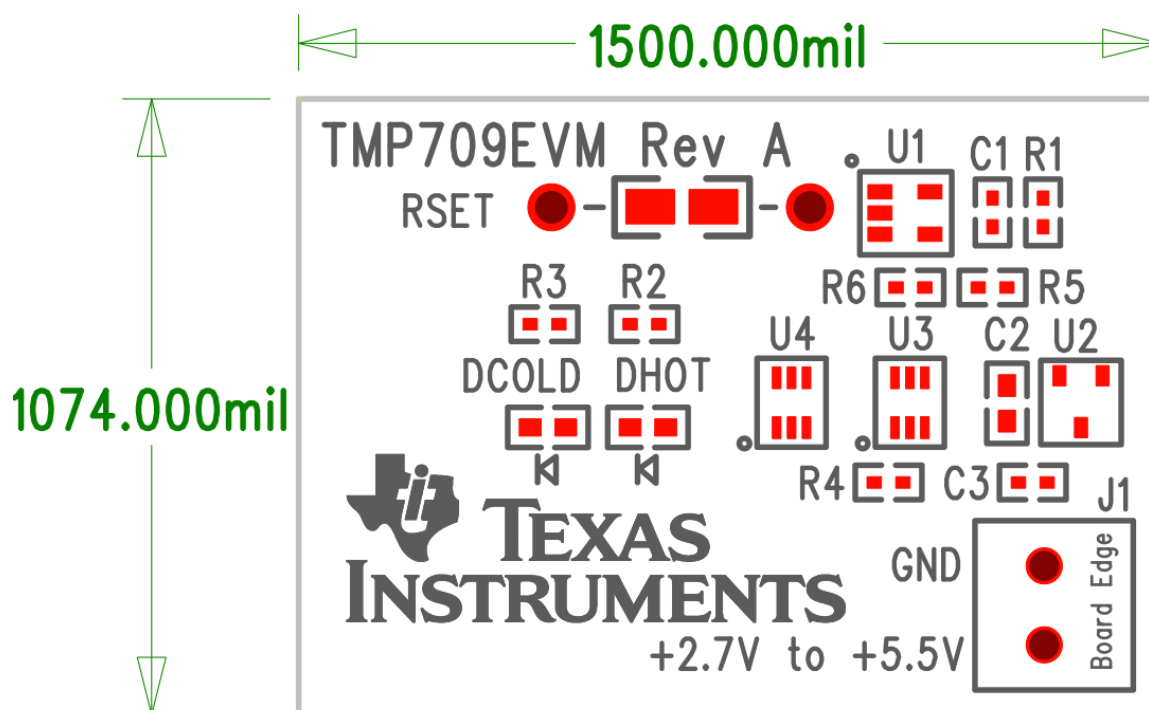


Figure 9. TMP709EVM Test Board Components Layout

3.3 Bill of Materials

Table 4 lists the bill of materials for the TMP708/709EVM.

Table 4. TMP104 Test Board Bill of Materials

Item No.	Qty	Value	Ref Des	Description	Vendor/Mfr	Part Number
1	1	TMP708 or TMP709	U1	Resistor-programmable SOT temperature switch	Texas Instruments	TMP708AIDBV or TMP709AIDBV
2	1	LDO	U2	Device, regulator, LDO, 300 mA, 2.5 V, SC59-3	Diodes Inc	AP130-25RG-7
3	2	Comparator	U3, U4	Device, comparator, 1.8 V with reference, SC70-6	Texas Instruments	TLV3012AIDCKR
4	4	Bump-ons	n/a	Bumper, clear, 0.312-inch × 0.085-inch dome	Richco Plastic Co	RBS-7
5	1	DHOT	DHOT	LED, red, orange, clear, 0603, SMD	Lite-On Inc	LTST-C190EKT
6	1	DCOLD	DCOLD	LED, green, clear, 0603, SMD	Lite-On Inc	LTST-C190GKT
7	1	150 Ω	R1	Resistor, TF, 150 Ω, 5%, 1/16 W, 0402	Stackpole Electronics Inc	RMCF0402JT150R
8	1	30 Ω	R2	Resistor, 30 Ω, 1/10 W, 5%, 0402, SMD	Panasonic - ECG	ERJ-2GEJ300X
9	1	20 Ω	R3	Resistor, TF, 20 Ω, 5%, 1/16 W, 0402	Stackpole Electronics Inc	RMCF0402JT20R0
10	1	470 kΩ	R4	Resistor, TF, 470 kΩ, 1%, 1/16 W, 0402	Stackpole Electronics Inc	RMCF0402FT470K
11	DNI	0 Ω	R5	Resistor, 0 Ω, 1/16 W, 0402, SMD	Stackpole Electronics Inc	RMCF0402ZT0R00
12	1	0 Ω	R6	Resistor, 0 Ω, 1/16 W, 0402, SMD	Stackpole Electronics Inc	RMCF0402ZT0R00
13	1	43 kΩ	Rset	Resistor, 43 kΩ, metal film, 2 W, 5%	Vishay/BC Components	PR02000204302JR500
14	1	0.1 μF	C1	Capacitor, ceramic, 0.10 μF, 10 V, X5R, 0402	Taiyo Yuden	LMK105BJ104KV-F
15	1	10 μF	C2	Capacitor, ceramic, 10 μF, 6.3 V, Y5V, 0603	TDK Corporation	C1608Y5V0J106Z
16	1	1μF	C3	Capacitor, ceramic, 1.0 μF, 6.3 V, X5R, 0402	Taiyo Yuden	JMK105BJ105KV-F
17	1	Terminal block	J1	Terminal block, 3.5 mm, 2 pos, PCB	On Shore Technology Inc	ED555/2DS
18	2	Pin socket	Rset	Conn recept pin, 0.110 inch, 0.025 inch	Mill-Max Manufacturing Corp.	0300-1-15-15-47-27-10-0

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EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 2.7 V to 5.5 V and the output voltage range of 2.7 V to 5.5 V .

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. 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 +25°C. The EVM is designed to operate properly with certain components above +25°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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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.

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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.

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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.

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