

User's Guide for TPS92560MR16BSTEVM

This user's guide describes the characteristics, operation and use of the TPS92560MR16BSTEVM evaluation module. This EVM contains Texas Instruments' TPS92560 configured as a boost LED driver solution for MR16 applications. This EVM can deliver up to 12-W output power with a typical 12-V_{AC} (50Hz/60Hz) power source. The EVM is ideal for typical MR16 or AR111 applications that require high compatibility to different power sources. This user's guide includes EVM specifications, recommended test setup, test results, bill of materials, and a schematic diagram.

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1 Applications

5- to 10-W MR16 or AR111 LED lamps

2 TPS92560MR16BSTEVM Electrical Performance Specifications

[Table 1](#) provides a summary of the electrical performance specifications of the EVM. All specifications are given for an ambient temperature of 25°C.

Table 1. TPS92560MR16BSTEVM Electrical Performance Specifications

Parameter		Notes and Conditions	Min	Typ	Max	Unit
Input Characteristics						
V_{IN-DC}	DC input voltage	After proper system startup	3		18	V
V_{IN-AC}	AC input voltage (50Hz / 60Hz)	After proper system startup	6		14	V
$V_{IN-ELEC-XFR}$	Generic Electronic transformer for MR16/AR111 applications	RMS AC voltage		12		V
I_{IN}	Input current	Regulated input current		500		mA
Output Characteristics						
n_{LED}	Number of LED	LEDs connect in series as a load		6		pieces
V_{LED}	LED forward voltage	Total forward voltage of the LED string		20		V
Systems Characteristics						
f_{SW}	Switching frequency	Typical switching frequency at $V_{IN} = 12 V_{DC}$		1.6		MHz

Table 2. Bill of Materials

Designator	Value	Description	Size	Part Number	MFR
U1	TPS92560	Simple LED Driver for MR16 and AR111 Applications	10L mini SOIC w/exp. pad	TPS92560	Texas Instruments
C1	4.7μF	Capacitor, Ceramic, 4.7μF, 25V, +/-10%, X5R	0805	GRM21BR61E475KA12L	MuRata
C2	1μF	Capacitor, Ceramic, 1μF, 50V, +/-10%, X7R	0805	GRM21BR71H105KA12L	MuRata
C3, C4	1μF	Capacitor, Ceramic, 1μF, 16V, +/-10%, X7R	0603	GRM188R71C105KA12D	MuRata
C6	0.047μF	Capacitor, Ceramic, 0.047μF, 50V, +/-10%, X7R	0603	GRM188R71H473KA61D	MuRata
C7	330μF	Capacitor, AL, 330μF, 25V, +/-20%, TH	11.5mm x 8mm dia.	ECA-1EHG331	Panasonic
D1,D2,D3	40V, 3A	Diode, Schottky	SMA	CMSH3-40MA	Central Semi.
L1	15μH	Inductor, Shielded Drum Core, Ferrite, SMD	6 x 6 x 3mm	CDRH5D28NP-150NC	Sumida
Q1	100V, 1.15A	MOSFET, N-CH, 100V, 1.15A	SOT23	SI2328DS	Vishay Siliconix
R1	105Ω	Resistor, 105Ω, 1%, 0.125W	0805	CRCW0805105RFKEA	Vishay-Dale
R2	392kΩ	Resistor, 392kΩ, 1%, 0.1W	0603	RC0603FR-07392KL	Yageo America
R3	3.92kΩ	Resistor, 3.92kΩ, 1%, 0.1W	0603	RC0603FR-073K92L	Yageo America
R4	0.33Ω	Resistor, 0.33Ω, 1%, 0.125W	0805	ERJ-6RQFR33V	Panasonic
C5		No connection	0603		
D4, D5		No connection	SMA		
J1, J2, J3, J4		Jumper Wire, 300mil spacing, Orange	300mil spacing	923345-03-C	3M
AC1, AC2, LED+, LED-		Standard Banana Jack	8.9mm dia.	575-8	Keystone
H5, H6, H7, H8		Nylon Standoff	Hex, 0.5"L	1902C	Keystone
H1, H2, H3, H4		Nylon Screw	M3	NY PMS 440 0025 PH	B&F Fastener Supply

4 Connector Descriptions

Figure 2 shows the input and output connectors for this EVM.

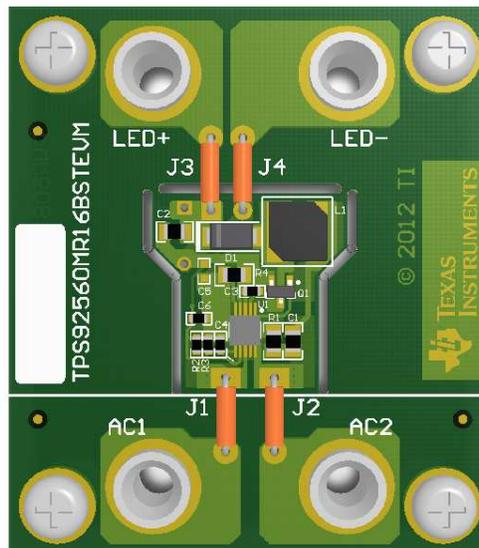


Figure 2. TPS92560MR16BSTEVM Input and Output Terminals

4.1 Output Connections

The output terminals of the EVM are described in [Section 4.1.1](#) and [Section 4.1.2](#).

4.1.1 LED+

The LED+ is the positive output terminal of the EVM (banana jack) to the anode of the LED string.

4.1.2 LED-

The LED- is the negative output terminal of the EVM (banana jack) to the cathode of the LED string.

4.2 Input Connections

The input terminals of the EVM are described in [Section 4.2.1](#) and [Section 4.2.2](#).

4.2.1 AC1

AC1 is the AC voltage input terminal to the input power source. Differential to the AC2 terminal, the EVM accepts a DC voltage, AC voltage or an electronic transformer as its input power source.

4.2.2 AC2

AC2 is the AC voltage input terminal to the input power source. Differential to the AC1 terminal, the EVM accepts a DC voltage, AC voltage or an electronic transformer as its input power source.

5 PCB Cutouts

The EVM can fit into the plastic compartment of a generic MR16 by removing the outer frame of the PCB as indicated in the following figure:

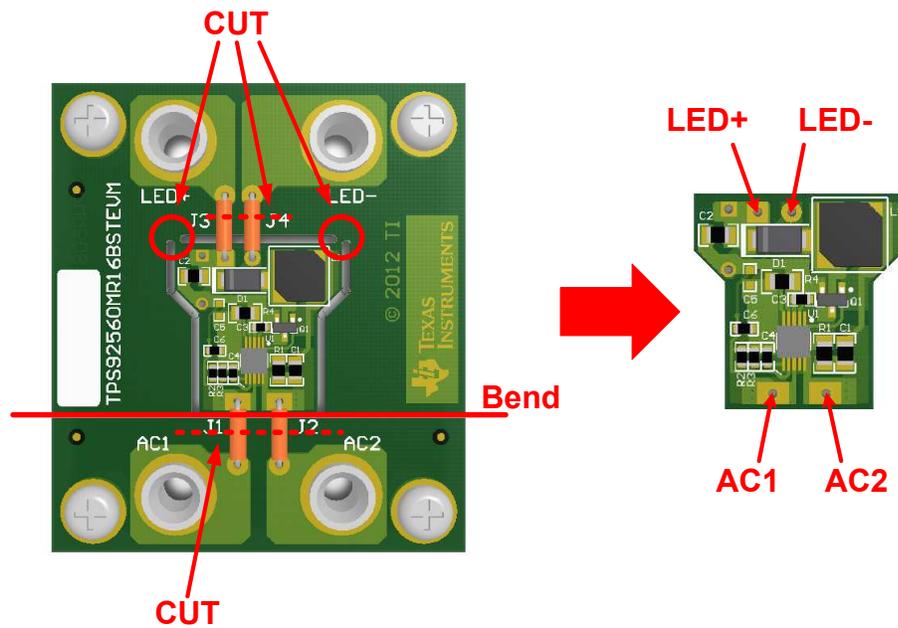


Figure 3. Removing Outer Frame of the TPS92560MR16BSTEMV

6 Test Requirements and Setup

6.1 Hardware Requirements

The EVM has different requirements on the power source depending on the type of power source being used. The requirements are as listed in the following table:

Table 3. Hardware Requirements

Item	Description	Characteristics
Input Power Source		
DC power source	Generic DC power supply	0 V _{DC} -18 V _{DC} , 1.5 A
AC power source	12-V _{AC} AC power supply (50/60Hz) Magnetic transformer with 12-V _{AC} output (50/60Hz)	12 V _{AC} nominal, 10 W
Electronic transformer	Generic electronic transformer for MR16/AR111 applications	110 V _{AC} /220 V _{AC} nominal input
Load		
Serial LED string	Power LED string of 6 serial LEDs	20-V nominal LED forward voltage

6.2 Hardware Setup

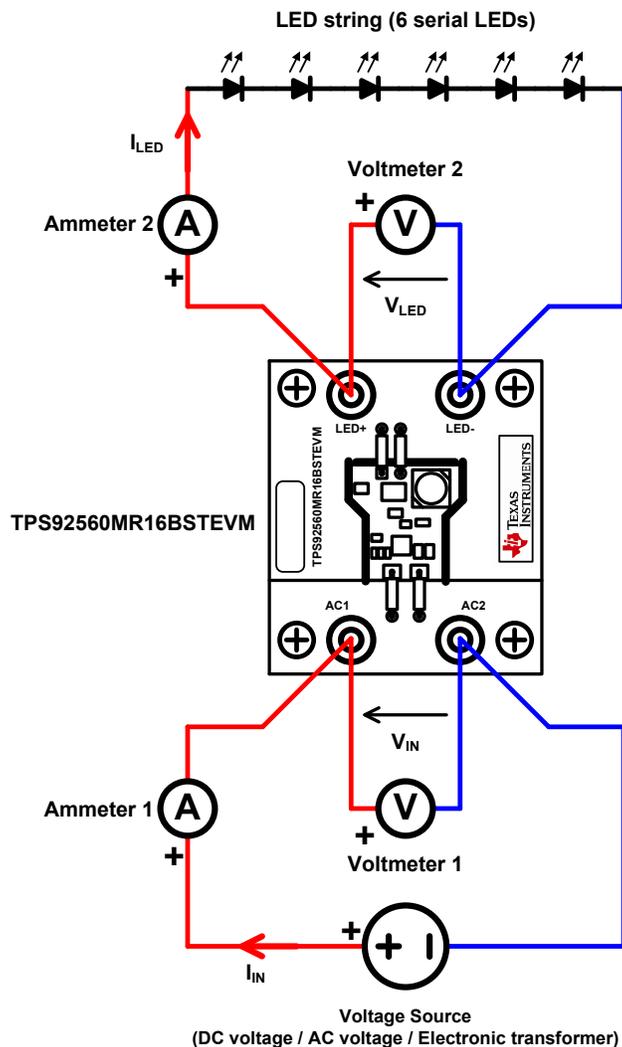


Figure 4. Connection Diagram of the TPS92560MR16BSTEVM

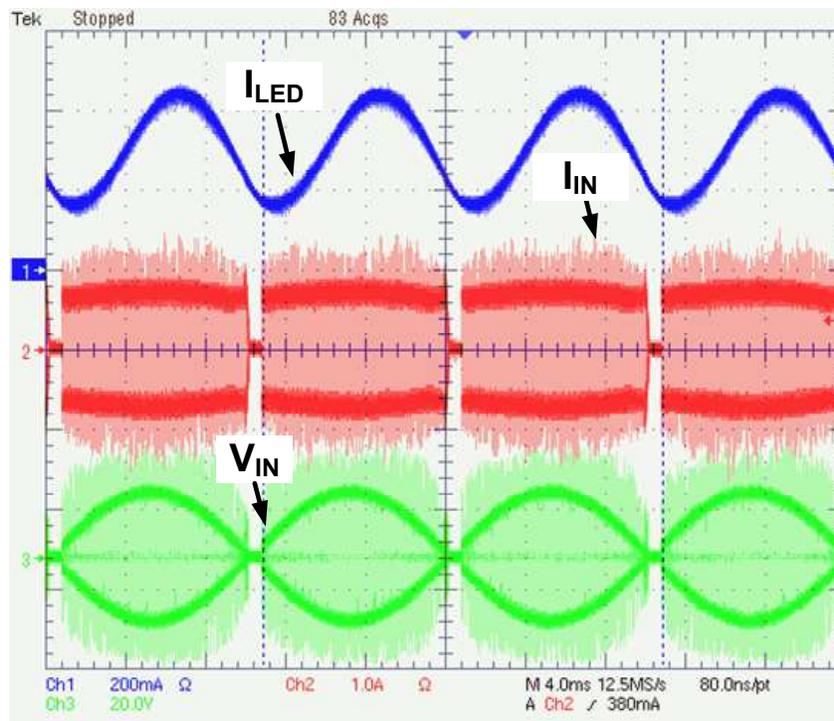
- Connect an LED string of 6 serial LEDs to the terminals LED+ and LED– of the EVM. An external ammeter (Ammeter 2) can be used in series to the LED string as shown in Figure 4 to measure the RMS LED current.
- Connect the power source (a 12- V_{DC} power source, 12- V_{AC} power source or electronic transformer) to the terminals AC1 and AC2 of the EVM. An external ammeter (Ammeter 1) can be used in series to the power source as shown in Figure 4 to measure the RMS input current. Do not make the connection when the power source is turned on.
- A voltmeter (Voltmeter 2) can be connected across the LED+ and LED– terminals of the EVM to measure the RMS forward voltage of the LED string.
- A voltmeter (Voltmeter 1) can be connected across the AC1 and AC2 terminals of the EVM to measure the RMS input voltage of the EVM.
- Using the measured RMS input current, input voltage, output current and output voltage, the input power, output power and efficiency are calculated using the following equations:

$$P_{IN} = V_{IN} \times I_{IN} \quad (1)$$

$$P_{OUT} = V_{OUT} \times I_{OUT} \quad (2)$$

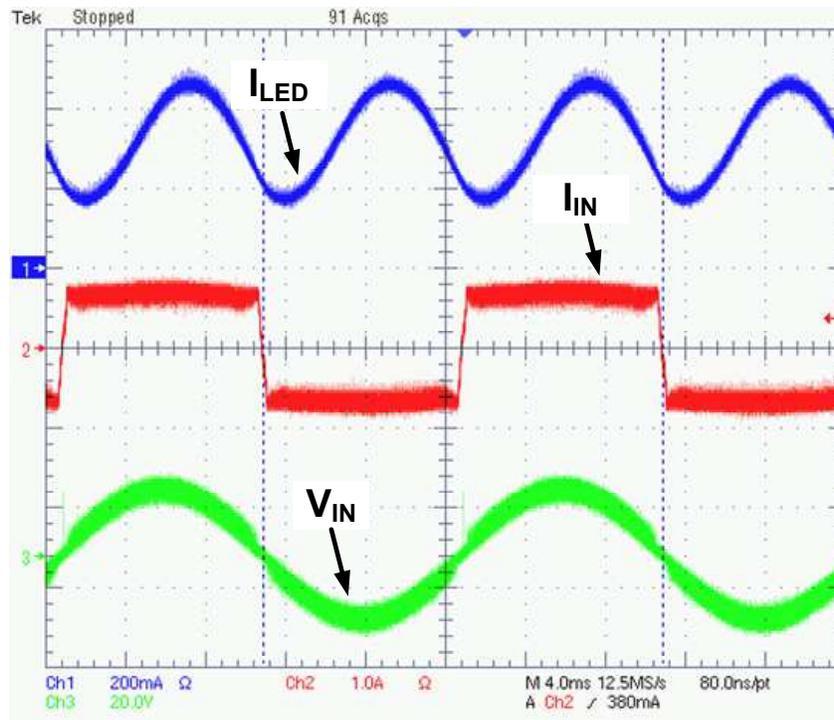
$$\text{Efficiency} = \frac{P_{OUT}}{P_{IN}} \times 100\% \quad (3)$$

6.3 Typical Waveforms



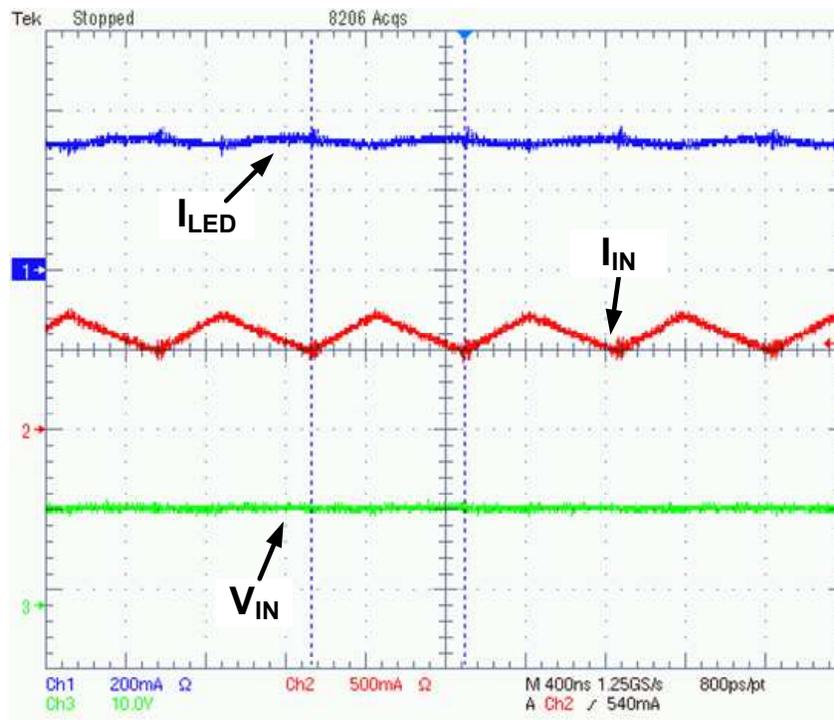
6 serial LEDs, $T_A = 25^\circ\text{C}$
 $I_{LED}: 200 \text{ mA/DIV}$, $I_{IN}: 1 \text{ A/DIV}$, $V_{IN}: 20 \text{ V/DIV}$

Figure 5. Waveforms of Powering the TPS92560MR16BSTEVM with an Electronic Transformer



6 serial LEDs, $T_A = 25^\circ\text{C}$
 I_{LED} : 200 mA/DIV, I_{IN} : 1 A/DIV, V_{IN} : 20 V/DIV

Figure 6. Waveforms of Powering the TPS92560MR16BSTEVM with 12 V_{AC} at 50 Hz



6 serial LEDs, $T_A = 25^\circ\text{C}$
 I_{LED} : 200 mA/DIV, I_{IN} : 1 A/DIV, V_{IN} : 10 V/DIV

Figure 7. Waveforms of Powering the TPS92560MR16BSTEVM with 12 V_{DC}

7 TPS92560MR16BSTEVM Assembly Drawings and Layout

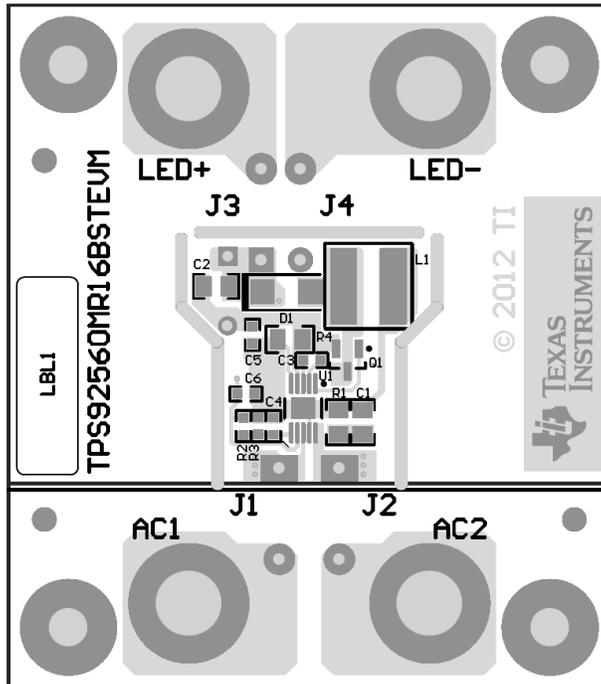


Figure 8. TPS92560MR16BSTEVM Top View

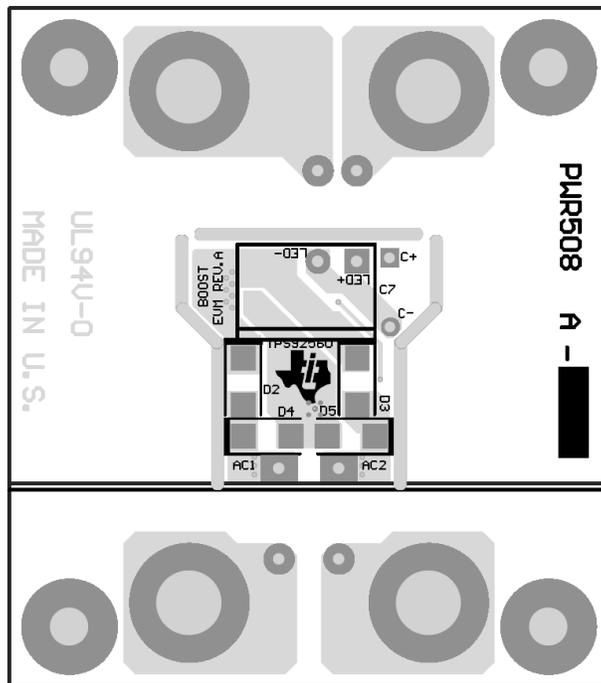


Figure 9. TPS92560MR16BSTEVM Bottom View

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

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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.

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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.

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

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3. *Regulatory Notices:*
 - 3.1 *United States*
 - 3.1.1 *Notice applicable to EVMs not FCC-Approved:*

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

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-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.

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 by Radio Law of Japan to follow the instructions below with respect to EVMs:

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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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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