TPD6S300 Evaluation Module

This user's guide describes the characteristics, operation, and use of the TPD6S300 evaluation module (EVM). This EVM is a TPD6S300 integrated chip set into a USB Type-C passthrough board to allow the user to test the operation of the TPD6S300 overvoltage protection and ESD protection in their own system. This user's guide includes setup instructions, schematic diagrams, a bill of materials, and printed-circuit board layout drawings for the EVM.

Contents

List of Figures

List of Tables

1 Introduction

Texas Instrument's TPD6S300 evaluation module helps designers evaluate the operation and performance of the TPD6S300 device. The TPD6S300 is a single-chip solution for protection of the USB Type-C configuration channel (CC), sideband use channel (SBU), and D± data lines. The device provides Short-to-VBUS Over Voltage Protection up to 22 V for CC1, CC2, SBU1, and SBU2 pins to prevent damage caused by a faulty connecter or mechanical twist shorting pins. The TPD6S300 also provides 6-channels of IEC 61000-4-2 ESD protection for CC1, CC2, SBU1, SBU2, D± pins of the USB Type-C connecter.

2 Board Setup

The pass-through EVM allows the user to ensure that the TPD6S300 will not impede typical operation of their USB port while also allowing the user to test the TPD6S300 protection during an overvoltage or ESD event.

To test the TPD6S300 EVM, plug the male ("system side", J1) connector on the EVM into a USB Type-C female port and plug a typical USB Type-C cable or peripheral into the EVM's female connector ("connector side", J2). The TPD6S300 is intended to be placed very close to the port in a typical system, so this setup will closely simulate a designed in TPD6S300. When plugged in, the user can ensure that the TPD6S300 will not impede standard USB operation.

The 0 Ω resistors R2 and R3 allow the user to determine whether the TPD6S300 dead battery resistors are active. By default, the resistors short the CC1 and CC2 pins to the RPD_G1 and RPD_G2 pins and enable the dead battery resistor function, allowing the TPD6S300 to serve as either a UFP or a DFP port. To simulate a use case where the TPD6S300 does not function as a UFP, turn off the dead battery functionality by manually removing these resistors.

The EVM requires 3.3 V between the Vpwr (TP1) and Ground (TP3) pins to power up the TPD6S300. If the system supports USB charging from a dead battery condition, it is recommended that the EVM be powered from the protected USB Controller to show that the dead battery functionality works properly. The EVM includes a 0.1-uF (C2) capacitor to ground on the Vbias pin of the TPD6S300, a 100-kΩ (R1) resistor to Vpwr on the $\overline{\text{FLT}}$ pin, and a 1-uF (C1) capacitor to ground on the Vpwr pin. These are recommended for proper operation of the TPD6S300 in all applications.

2.1 Overvoltage Protection Testing

The EVM is designed to allow the user to ensure that the TPD6S300 can protect their system from overvoltage events. By shorting either a CC line or SBU line to a high voltage on the connecter side of the EVM, the user can confirm that the TPD6S300 will protect their system. The short can be created by applying 20 V to one of the protected lines on a USB Type-C breakout board plugged into J2 or by using a custom board that discharges 20 V over a capacitor when plugged in. When the TPD6S300 sees a voltage over the overvoltage threshold on a protected line it will isolate all four CC and SBU lines within 100 ns to protect the system. Use an oscilloscope to measure the voltage on both the system side and the connector side of the EVM to view the clamped voltage that the protected system is seeing.

The waveform in Figure 1, where channel one is the system side of the TPD6S300EVM and channel two is the connector side, was taken when CC1 from a TPD6S300EVM in DFP mode in series with a TPD6S300EVM was shorted to a 24-V Vbus line. The event was created by a plugging in a one foot cable to a custom USB Type-C board that simulates a faulty peripheral, pulling Vbus to 24 V and discharging the voltage to the CC line over a capacitor. Measuring the voltage over the TPD6S300EVM shows the device clamping the overvoltage event to a maximum voltage of 7.5 V and completely isolating the controller within 60 ns.

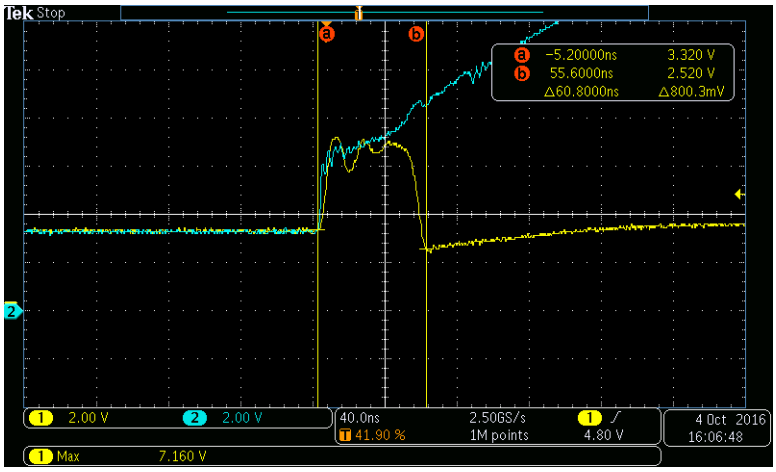

Figure 1. CC1 Line Short to 20-V Waveform

2.2 ESD Testing

Figure 2 shows the TPD6S300EVM. The EVM has four ESD test points, one on each CC and SBU line, that allow the user to use a ESD simulator in either contact or air-gap test mode to measure the ESD protection provided by the TPD6S300. Probe points one and two correspond to the SBU2 and SBU1 lines respectively. Probe points four and five correspond to the CC1 and CC2 lines respectively. To measure the ESD response on the D± lines use an ESD simulator on the respective points on a break-out board plugged into J2. Refer to the application report, *IEC 61000-4-x Tests for TI's Protection Devices* for specifics on proper ESD testing methods.

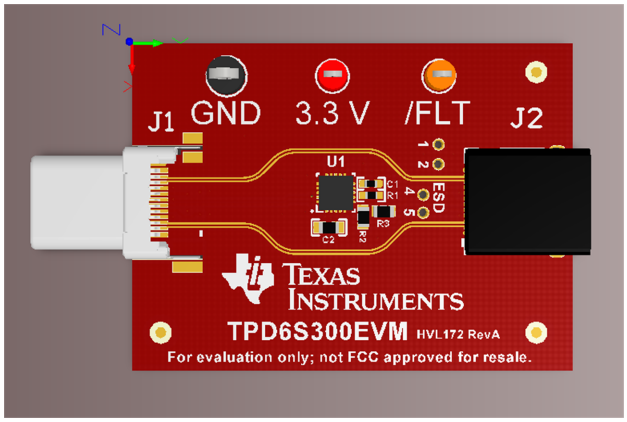

Figure 2. TPD6S300EVM

3 Schematic

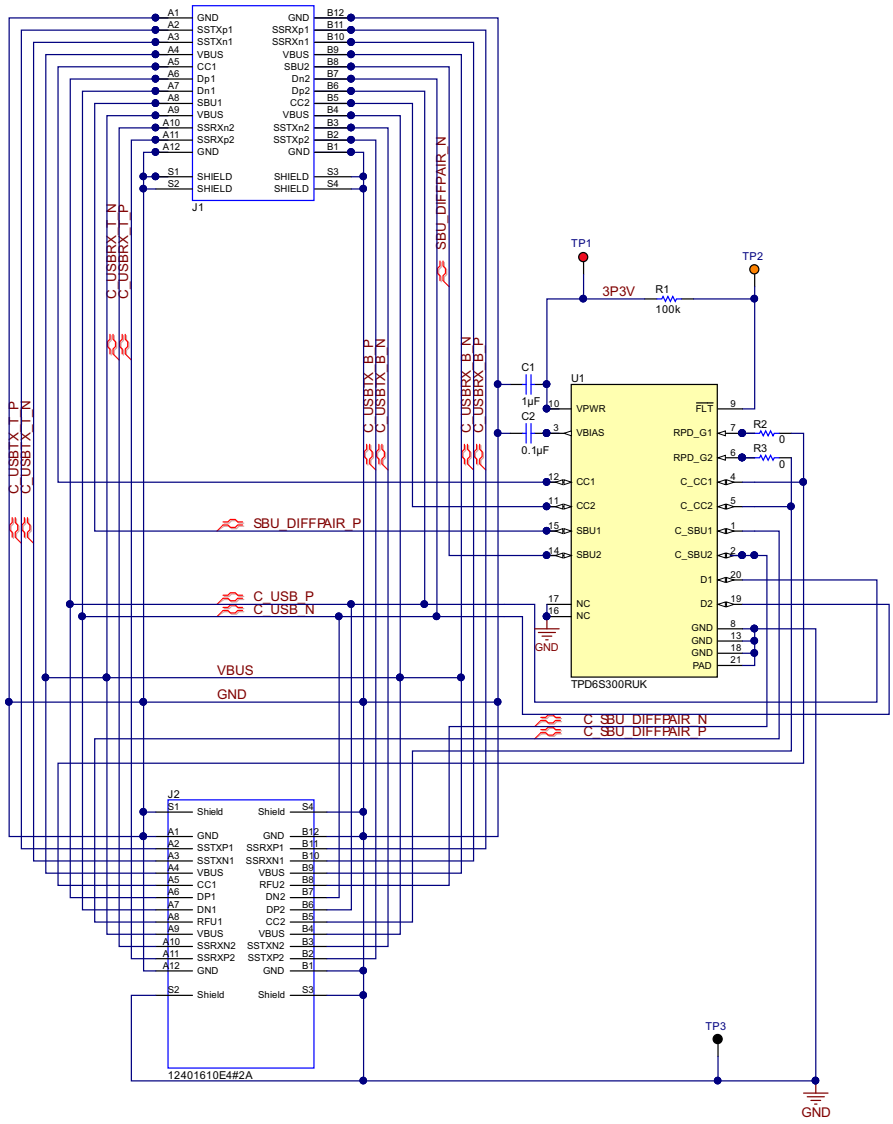

Figure 3. TPD6S300EVM Schematic

4 Board Layout

This section provides the TPD6S300EVM board layout. The TPD6S300 is an 8-layer board of FR-4 at 0.032" thickness.

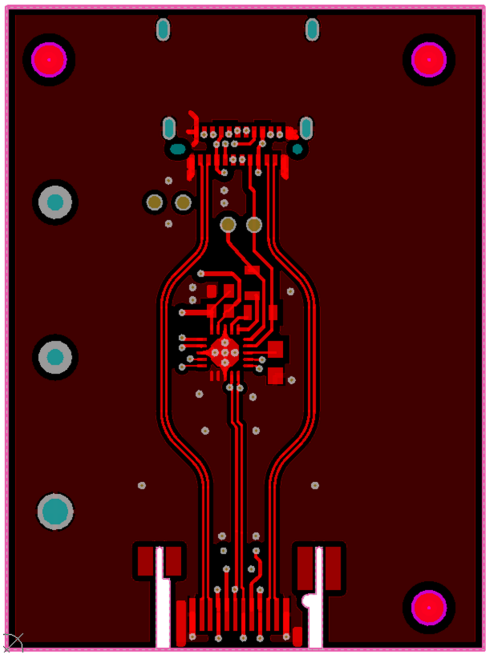

Figure 4. Top Layer

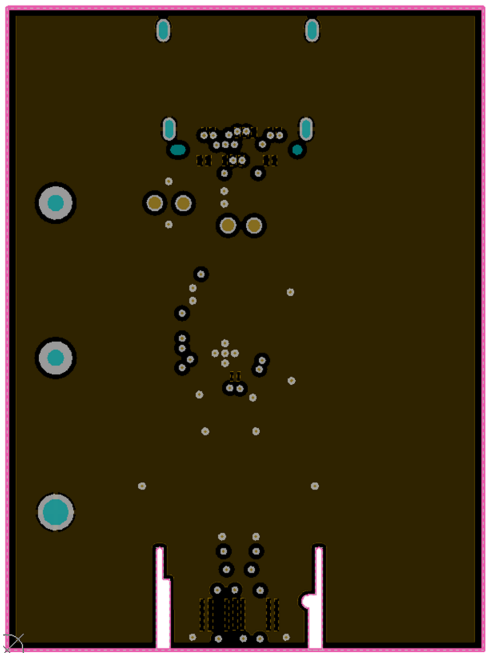

Figure 5. Ground Plane 1

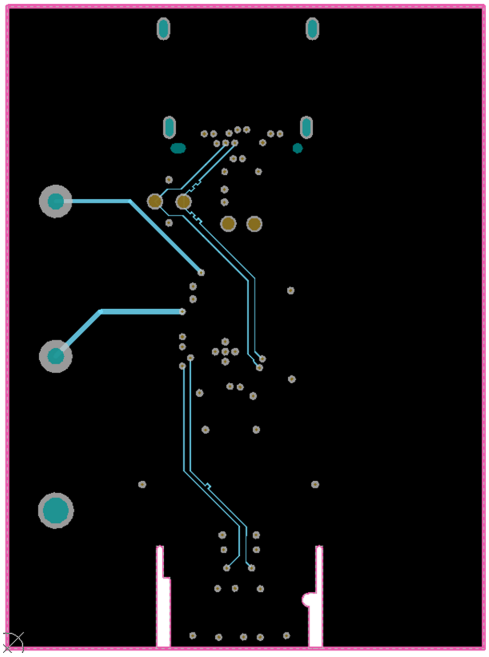

Figure 6. Midlayer 1

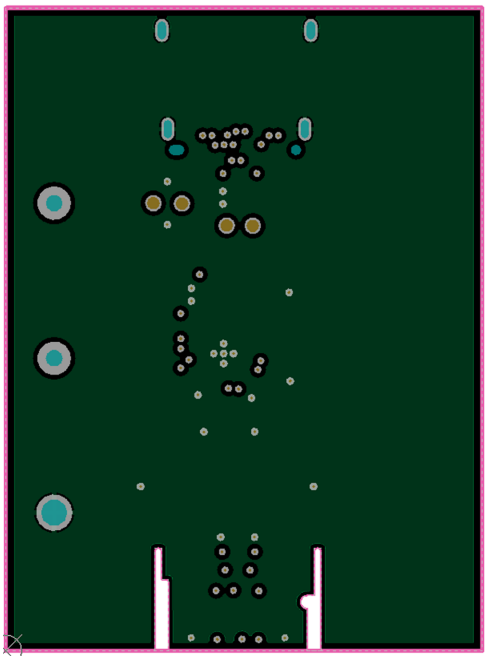

Figure 7. Ground Plane 2

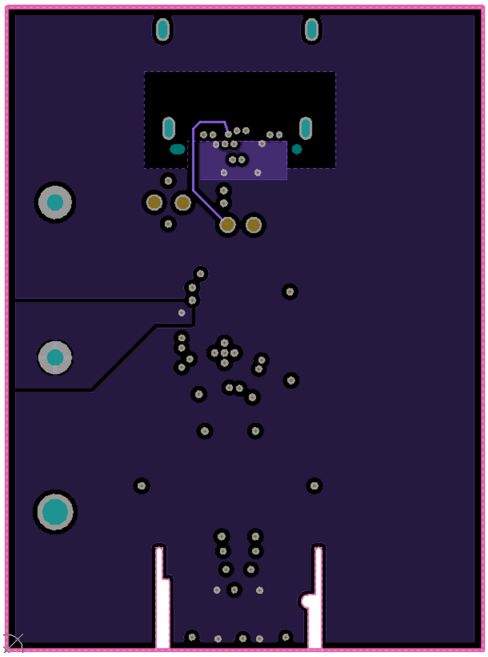

Figure 8. Power Plane 1

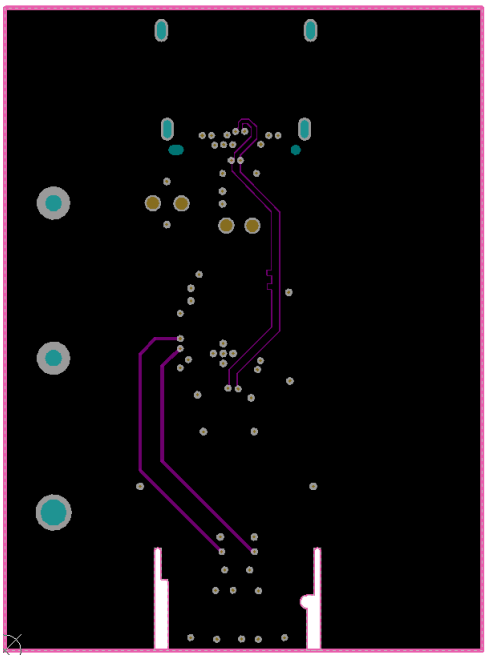

Figure 9. Ground Plane 3

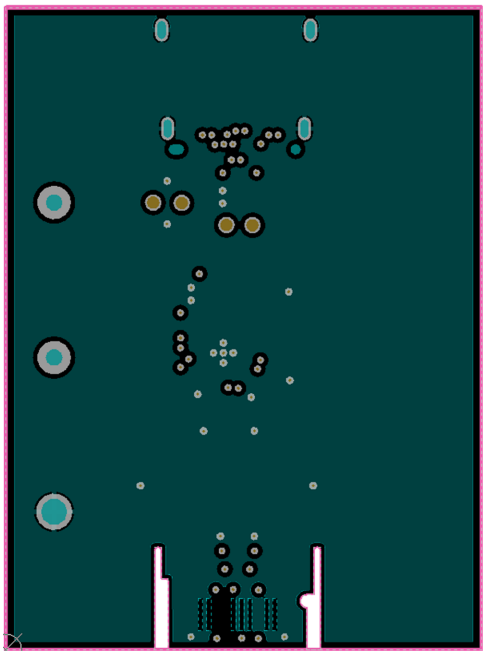

Figure 10. Ground Plane 3

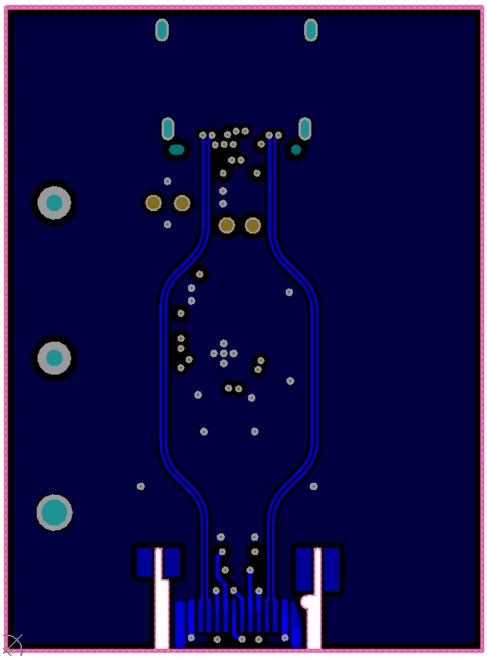

Figure 11. Bottom Layer

5 Bill of Materials

Table 1. Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
C1	1	1 uF	CAP, CERM, 1 uF, 35 V, ±10%, JB, 0402	0402	C1005JB1V105K050BC	TDK
C2	1	0.1 uF	CAP, CERM, 0.1uF, 50 V, ±10%, X7R,, 0603	0603	GRM188R71H104KA93D	MuRata
J1	1		Plug, USB3.1 Type C, 24 V Position, R/A, SMT	Plug, USB3.1 Type C, 24 V Position, R/A, SMT	DX07P024MJ1R1500	JAE Electronics
J2	1		Receptacle, 0.5 mm, USB TYPE C, R/A, SMT	Receptacle, 0.5mm, USB TYPE C, R/A, SMT	12401610E4#2A	Amphenol Canada
R1	1	100 kΩ	RES, 100 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2GEJ104X	Panasonic
R2, R3	2	0	RES, 0, 5%, 0.1 W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
TP1	1		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone
TP2	1		Test Point, Miniature, Orange, TH	Orange Miniature Testpoint	5003	Keystone
TP3	1		Test Point, Compact, Black, TH	Black Compact Testpoint	5006	Keystone
U1	1		USB Type C Interface Protector: Short-to-VBUS Over Voltage and IEC 61000-4-2 ESD Protection, RUK0020b	RUK0020B	TPD6S300RUK	Texas Instruments

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      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

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http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

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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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4.1 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.

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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.

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