LMH3401EVM-CVAL Evaluation Module (EVM)

The LMH3401EVM-CVAL is an evaluation module for the single LMH3401-SP amplifier in a 14-pin *Leadess Ceramic Chip Carrier* (LCCC) high-performance RF package. This evaluation module is designed to quickly and easily demonstrate the functionality and versatility of the amplifier. The EVM is ready to connect to power, signal source, and test instruments through the use of onboard connectors. The EVM comes configured for easy connection with common 50-Ω laboratory equipment on its inputs and outputs. The amplifier is configured for single-ended input with gain of 16 dB (6.31 V/V). The board has differential outputs, one for each of the amplifier outputs. The EVM can be easily configured for differential inputs, and single- or split-supply operation.

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Trademarks

All trademarks are the property of their respective owners.

1 Features

This EVM has the following features:

- Configured for split-supply operation and easily modified for single supply
- Single ended or differential input signals
- Fully differential output
- Designed for easy connection to standard 50-Ω input/output impedance test equipment
- Inputs and outputs include SMA connectors

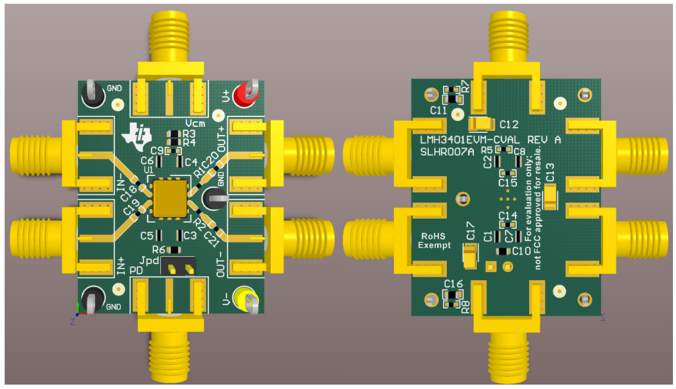

Figure 1. LMH3401EVM-CVAL

2 EVM Specifications

Table 1 displays the EVM specifications:

Table 1. EVM Specifications

Parameter		Value
V_S	Single-supply voltage range (V– = ground)	3.15 V to 5.25 V
V_S±	Split-supply voltage range	±1.58 V to ±2.625 V
GND	Ground reference pins	(V+ – 2 V) to V–
PD	Power down (PD) input voltage	GND to Vcc
I_S±	Supply current	58 mA
I_{IN}	Input voltage	V_S±, Max
I_{OUT}	Output drive	±40 mAV_S±, Max

3 Power Connections

The LMH3401EVM-CVAL is equipped with test loops for easy power connection. The positive supply input is red and is labeled V+. The negative supply input is yellow and is labeled V–. Ground is black and is labeled GND.

3.1 Split-Supply Operation

To operate as split supply, apply the positive supply voltage to V+, negative supply voltage to V– , and the ground reference from supply to GND. Note that supply voltages do not need to be symmetrical, provided the total supply voltage is between 3.3 V and 5.25 V, any combination of positive and negative supply voltages is acceptable. This feature is often used when the output common-mode voltage must be set to a particular value. For best performance, the power supply voltages should be symmetrical around the desired output common-mode voltage.

3.2 Single-Supply Operation

To operate as single supply, connect jumper V– to GND, and apply the positive supply voltage to V+. Inputs and outputs must be biased as in *LMH3401 7-GHz, Ultra-Wideband, Fixed-Gain, Fully-Differential Amplifier*, specifications for proper operation.

4 Input and Output Connections

The LMH3401EVM-CVAL is equipped with SMA connectors for easy connection of signal generators and analysis equipment. As shipped, the EVM is configured for a gain of 16 dB, split supply, single-ended input and differential outputs each with 50-Ω termination. For best results, signals must be routed to and from the EVM with cables having 50-Ω characteristic impedance. The input connectors for single-ended input signals are IN+ and IN–, which are symmetrical. The output connectors are OUT+ and OUT–. See *LMH3401 7-GHz, Ultra-Wideband, Fixed-Gain, Fully-Differential Amplifier* for more detail and how to reconfigure the EVM.

4.1 CM (Output Common-Mode Voltage) Input

The LMH3401-SP has an output common-mode control pin that is used to set the output common-mode voltage. The evaluation board is configured with a resistive divider to set the output common-mode voltage at the mid-supply voltage. If a different output common-mode voltage is specified, the SMA connector can be used to connect an external voltage source provided the AC-coupling capacitors on board are removed.

4.2 PD (Power Down) Input

The LMH3401-SP device has a power-down input pin that allows the amplifier to be put into a low-power state when it does not need to be active. The LMH3401-SP PD pin is referenced to the GND pin. The threshold voltage is 1.1 V. Any voltage over 1.2 V above the ground reference pins will disable the amplifier. Any input below 1.0 V enable- the amplifier. Because the PD pin is not referenced to either of the supply pins the same logic level can be used for the PD function regardless of the configuration of the supply voltages. The LMH3401EVM-CVAL has a jumper (JPD) that allows the amplifier to be manually disabled. In order to facilitate driving the PD pin with a high-speed signal source, the resistor-capacitor combination (R6, C10) provides high-frequency termination for signals from a 50-Ω pulse generator.

4.3 Single-Ended Inputs

The LMH3401-SP device was designed for use with 50-Ω single-ended inputs. Even though the board was designed for single-ended inputs, the board is fully symmetrical, so either input can be used. Connect a 50-Ω signal source to either IN+ or IN- and connect a 50-Ω SMA termination to the other input. This way both inputs have the same termination condition and the circuit is balanced. In the case where no SMA 50-Ω termination is available, soldering a 50-Ω resistor from the unused input signal trace to the ground plane is acceptable. A small section of the ground plane has no solder mask that can be used for this purpose.

4.4 Differential Inputs

Using the LMH3401-SP for differential inputs is possible. The LMH3401-SP has an internal resistance of 25 Ω (differential). In order to impedance match a 100-Ω differential source, cut the signal traces and solder 37.5-Ω resistors in place to create a 100-Ω input or install these resistors in place of the series AC coupling capacitors.

4.5 Differential Outputs

The LMH3401EVM-CVAL has two output SMA connectors that are designed to mate to 50-Ω test equipment. By connecting both outputs to 50-Ω test equipment, the output load is 100-Ω differential. With the on-chip and onboard matching resistors, the total load to the amplifier is 200 Ω. The matching resistors cause a 6-dB loss in voltage gain. The evaluation board has 40-Ω resistors on the board because there are 10-Ω output resistors on-chip inside the device.

4.6 Single-Ended Outputs

Using an external balun to combine the two differential outputs creates a single-ended signal that can be interfaced to most 50-Ω test equipment. This is the method used by TI engineers to create the data sheet plots. To match the performance of the LMH3401-SP, a very broadband balun must be selected. TI recommends the Marki B0100 or the PicoPulse Labs 5310A baluns.

5 LMH3401EVM-CVAL Schematic, Layout, and Bill of Materials

This section contains the EVM schematic, PCB layouts, and the bill of materials (BOM).

5.1 Schematic

Figure 2 illustrates the LMH3401EVM-CVAL schematic.

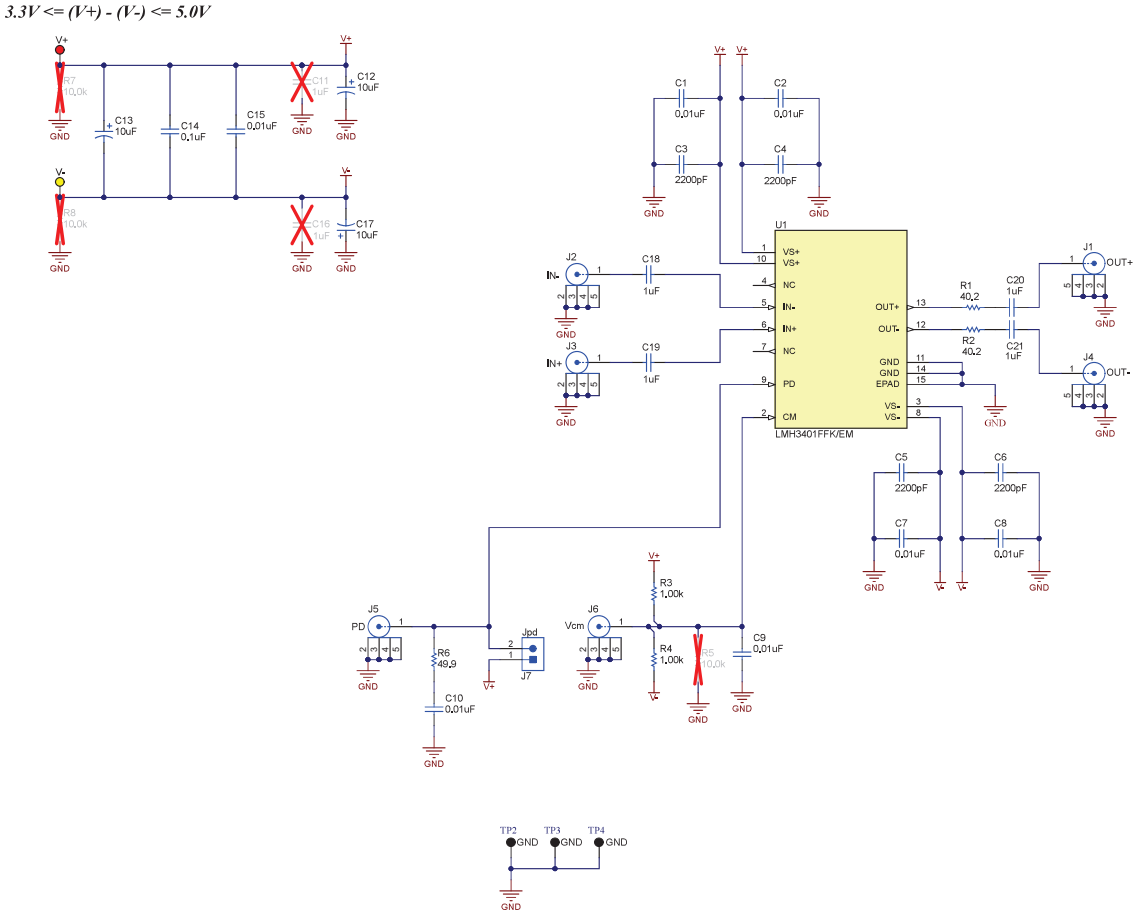

Figure 2. LMH3401EVM-CVAL Schematic

5.2 LMH3401EVM-CVAL Layers

Figure 3 through Figure 8 show the LMH3401EVM-CVAL layers.

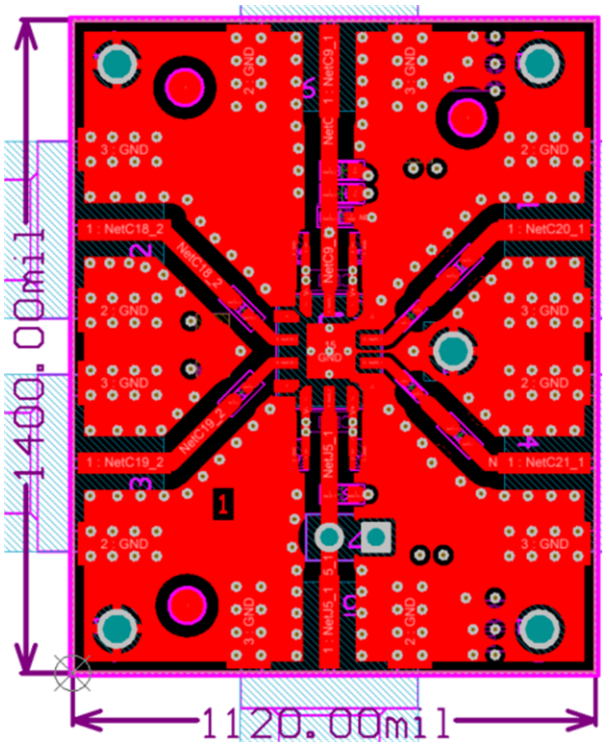

Figure 3. LMH3401EVM-CVAL Top Layer

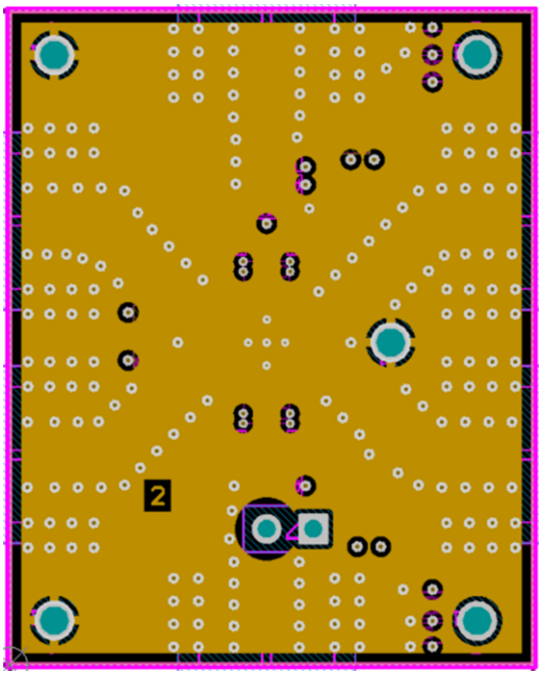

Figure 4. Layer 2

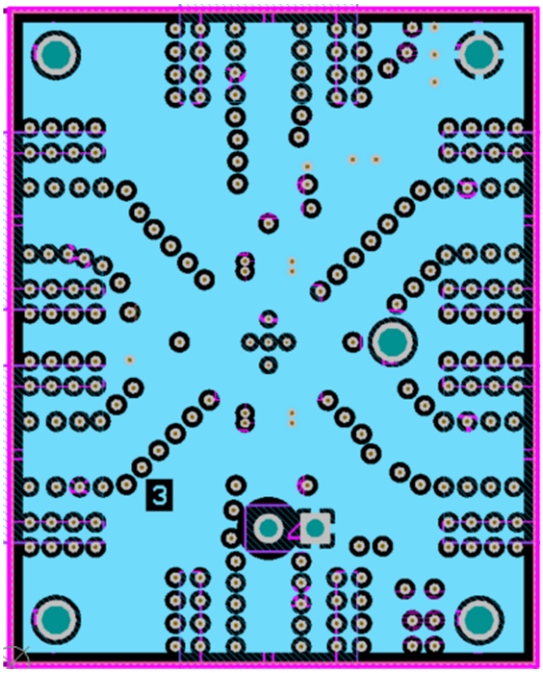

Figure 5. Layer 3

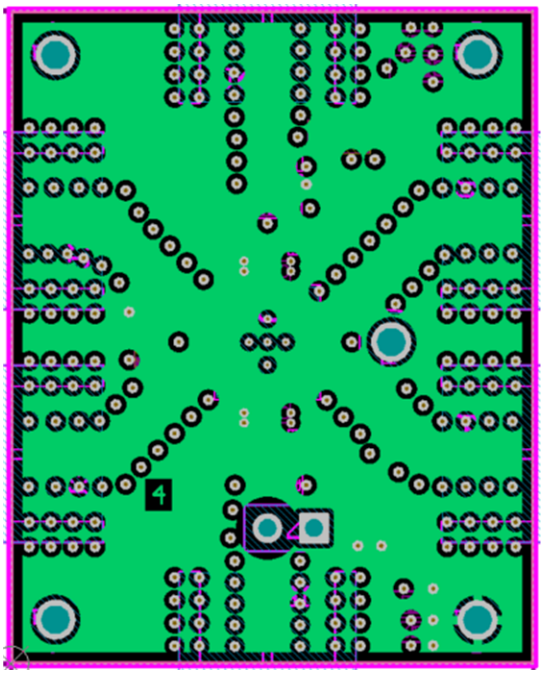

Figure 6. Layer 4

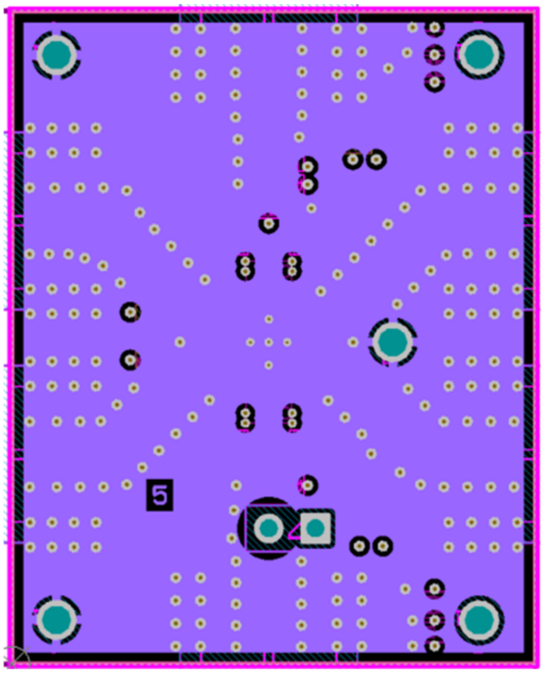

Figure 7. Layer 5

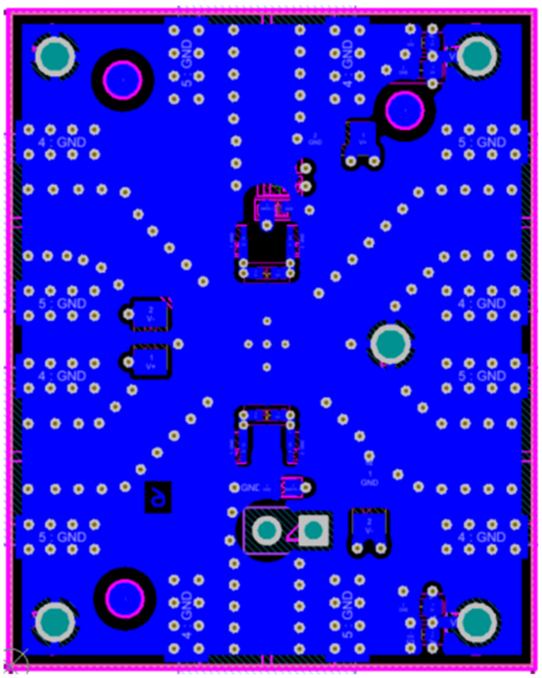

Figure 8. Bottom Layer

5.3 Bill of Materials

Table 2 lists the EVM BOM.

Table 2. LMH3401EVM-CVAL Bill of Materials

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
!PCB1	1		Printed Circuit Board		SLHR007	Any
C1, C2, C7, C8	4	0.01uF	CAP, CERM, 0.01 uF, 25 V, ±20%, X7R, 0306	0306	LLL185R71E103MA01L	Murata
C3, C4, C5, C6	4	2200pF	CAP, CERM, 2200 pF, 50 V, ±20%, X7R, 0306	0306	LLL185R71H222MA01L	Murata
C9, C15	2	0.01uF	CAP, CERM, 0.01 uF, 16 V, ±10%, X7R, 0402	0402	C1005X7R1C103K050BA	TDK
C10	1	0.01uF	CAP, CERM, 0.01 uF, 16 V, ±10%, X7R, 0603	0603	GRM188R71C103KA01D	Murata
C12, C13, C17	3	10uF	CAP, TA, 10 uF, 10 V, ±10%, 0.9 ohm, SMD	3216-18	TPSA106K010R0900	AVX
C14	1	0.1uF	CAP, CERM, 0.1 uF, 10 V, ±10%, X5R, 0402	0402	C1005X5R1A104K050BA	TDK
C18, C19, C20, C21	4	1uF	CAP, CERM, 1 uF, 35 V, ±10%, X5R, 0402	0402	GRM155R6YA105KE11D	Murata
FID1, FID2, FID3, FID4, FID5, FID6	6		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
J1, J2, J3, J4, J5, J6	6		Connector, End launch SMA, 50 ohm, SMT	SMA End Launch	142-0701-851	Cinch Connectivity
J7	1		Header, 100mil, 2x1, Gold, TH	2x1 Header	TSW-102-07-G-S	Samtec
R1, R2	2	40.2	RES, 40.2, 1%, 0.063 W, 0402	0402	CRCW040240R2FKED	Vishay-Dale
R3, R4	2	1.00k	RES, 1.00 k, 1%, 0.1 W, 0603	0603	CRCW06031K00FKEA	Vishay-Dale
R6	1	49.9	RES, 49.9, 1%, 0.1 W, 0603	0603	CRCW060349R9FKEA	Vishay-Dale
SH-Jpd_1	1	1x2	Shunt, 100mil, Gold plated, Black		382811-6	AMP
TP1	1		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone
TP2, TP3, TP4	3		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone
TP5	1		Test Point, Multipurpose, Yellow, TH	Yellow Multipurpose Testpoint	5014	Keystone
U1	1		Space Grade, 7-GHz, Ultra-Wideband, Fixed-Gain, Fully-Differential Amplifier, FFK0014A (LCCC-14)	FFK0014A	LMH3401FFK/EM	Texas Instruments
C11, C16	0	1uF	CAP, CERM, 1 uF, 35 V, ±10%, X5R, 0603	0603	GMK107BJ105KA-T	Taiyo Yuden
R5, R7, R8	0	10.0k	RES, 10.0 k, 1%, 0.1 W, 0402	0402	ERJ-2RKF1002X	Panasonic

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3 *Regulatory Notices:*

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      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*

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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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3.4.1 *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.

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