

## **LP2951EVM**

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## 1 Introduction

The Texas Instruments LP2951EVM helps evaluate the operation and performance of the LP2951 family of LDOs. The LP2951 family can accommodate a wide input supply-voltage range of up to 30 V.

## 2 HW Description

This section describes the hardware of the LP2951EVM.

### 2.1 LP2951 Device

The LP2951EVM comes populated with LP2951-50-Q1 in the SON package. However, this EVM can be used to evaluate the SOIC package LP2951 device as well. [Figure 1](#) shows the EVM populated with the SON package and the pads for the SOIC package on the board. [Table 1](#) shows all LP2951 part numbers and packages that are compatible with the LP2951EVM.



**Figure 1. EVM With SON Package and SOIC Pads**

**Table 1. Compatible Parts and Packages for LP2951EVM**

Part Number	Packages
LP2951	SOIC (D)
LP2951-30	SOIC (D)
LP2951-33	SOIC (D), SON (DRG)
LP2951-33-Q1	SON (DRG)
LP2951-50	SOIC (D), SON (DRG)
LP2951-50-Q1	SOIC (D), SON (DRG)
LP2951-N	SOIC (D)

## 2.2 Input Capacitors

Capacitors  $C_1$ - $C_3$  are all capacitors routed to the input of the LP2951 device to ground.  $C_2$  comes populated on the board, and has a value of  $1\ \mu\text{F}$ .  $C_1$  and  $C_3$  are pads that allow for additional input capacitors to be put on the board and can accommodate different capacitor sizes.

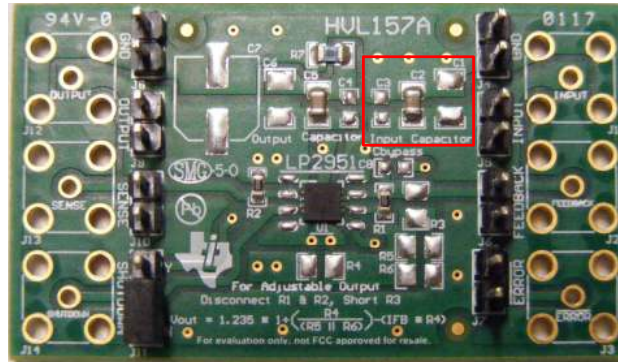


Figure 2. Input Capacitors  $C_1$ - $C_3$

## 2.3 Output Capacitors

Capacitors  $C_4$ - $C_7$  are all capacitors routed to the Output pin.  $C_4$ - $C_6$  are ceramic caps routed in series with a  $1\text{-}\Omega$  resistor,  $R_7$ , from the output to ground. This series resistance helps stabilize the internal amplifier of the LP2951 device. See the [LP2951](#) or [LP2951-N](#) data sheet for the recommended series resistance when using a ceramic output capacitor.  $C_5$  comes populated on the board and has a value of  $2.2\ \mu\text{F}$ .  $C_4$  and  $C_6$  are pads that allow for additional output capacitors to be put on the board and can accommodate different capacitor sizes.  $C_7$  is meant for an electrolytic capacitor. It is routed directly from the output to ground with no series resistance, but still functionally the same as  $C_4$ - $C_6$ . Electrolytic Capacitors do not require an external series resistance as the internal ESR of an electrolytic is typically enough to keep the device stable.



Figure 3. Output Capacitors  $C_4$ - $C_7$

## 2.4 Bypass Capacitor

Capacitor  $C_8$  is meant to give additional stability to the internal amplifier of the LP2951 device by placing additional capacitance between the Output and the Feedback pins. Stray capacitance to the LP2951 Feedback pin can cause instability. This may especially be a problem when using high value external resistors to set the output voltage. To fix this problem, populate  $C_8$  with a 100-pF capacitor and increase the output capacitor to at least 3.3  $\mu$ F. See the [LP2951](#) and [LP2951-N](#) data sheets for more information regarding the Cbypass.

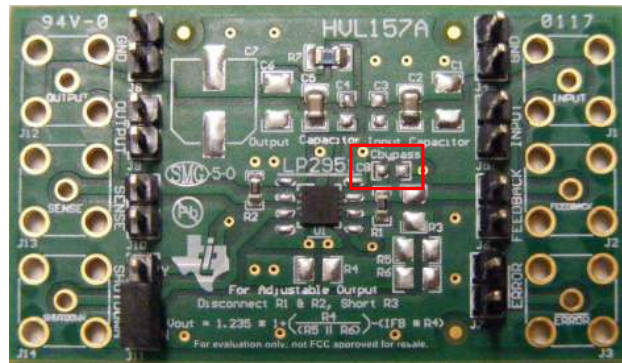


Figure 4. Location for Bypass Capacitor  $C_8$

## 2.5 Fixed Output Voltage Resistors

Resistors  $R_1$  and  $R_2$  are 0- $\Omega$  resistors that keep the output in the fixed output voltage mode when populated.  $R_1$  connects the Feedback pin to the  $V_{TAP}$  pin, while  $R_2$  connects the Sense pin and the Output pin.

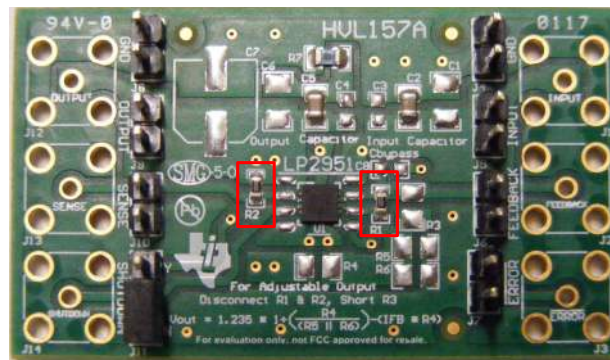


Figure 5.  $R_1$  and  $R_2$  Used to Set Fixed Voltage Mode on EVM

## 2.6 Adjustable Output Voltage Resistors

Resistors  $R_3$ - $R_6$  can be populated to set a desired output voltage. To do so, resistors  $R_1$  and  $R_2$  must first be removed. Resistors  $R_4$ - $R_6$  form a voltage divider and can be populated with values based on the desired output voltage by following the equation on the EVM.  $R_3$  must be populated with a  $0\text{-}\Omega$  resistor to short the Feedback pin of the device to the voltage divider of  $R_4$ - $R_6$ . See [Section 3.2.2](#) for additional information regarding setting an adjustable output voltage.

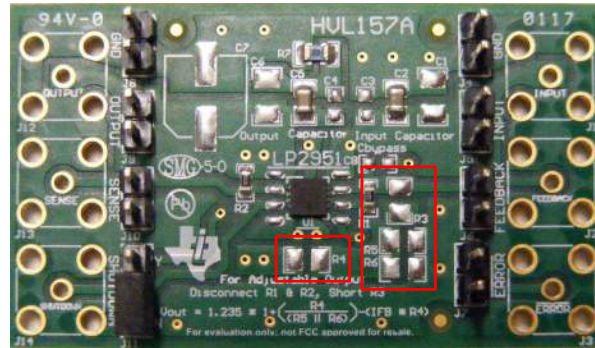


Figure 6. Resistors  $R_3$ - $R_6$  Used to Set Output Voltage in Adjustable Voltage Mode

### 3 Setup

These sections describe the jumpers and connectors on the EVM as well as how to properly connect, setup, and use the LP2951EVM.

#### 3.1 Input/Output Connectors and Jumper Description

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**NOTE:** Connectors J1-J3 and J12-J14 are blank SMB connectors. These can be populated, or wires can be soldered directly to them. The middle connection of the connector is the signal, while the four edge connections are all ground.

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##### 3.1.1 J5 - Input

Input for power. Connect supply to this connector.

##### 3.1.2 J6- Feedback

Determines the output voltage. Connected to  $V_{TAP}$  through  $R_1$  with standard setup.

##### 3.1.3 J7 - ERROR

Error output connector. This active low output determines if the output voltage is within 6% of its expected value.

##### 3.1.4 J4/J8 - GND

Return path connectors.

##### 3.1.5 J9 - Output

Regulated output voltage connectors.

##### 3.1.6 J10 - Sense

Output voltage sensing connectors.

##### 3.1.7 J11 - Shutdown

Device shutdown connectors. By shorting the middle pin of J11 to the pin labeled as N, the device remains active. If the middle pin of J11 is shorted to the pin labeled Y, the device will shutdown. See [Table 2](#) for shutdown jumper position connection.

**Table 2. Shutdown Jumper Position Versus Output**

Jumper Position	Output
N	Enabled
Y	Disabled

### 3.2 Operating Modes

There are two operating modes of the LP2951EVM. Either fixed voltage operation mode, which is what the EVM is set to out of the packaging, or adjustable voltage mode which the designer can enable.

#### 3.2.1 Fixed Output Voltage Mode

This is the standard way the EVM is populated out of the packaging. For this operation mode the 0-Ω resistors R<sub>1</sub> and R<sub>2</sub> must be populated. Resistor R<sub>1</sub> shorts the Feedback pin to the Shutdown pin, while R<sub>2</sub> shorts the Sense pin to the Output pin. This mode utilizes an internal resistor divider which sets the voltage of the output to a fixed level. The LP2951 device populated on the EVM has an output of 5 V.

#### 3.2.2 Adjustable Output Voltage Mode

To enable the adjustable voltage mode, the resistors R<sub>1</sub> and R<sub>2</sub> must be removed. Resistors R<sub>4</sub>-R<sub>6</sub> must be populated with specific values based on the desired output voltage, while R<sub>3</sub> is populated with a 0-Ω resistor.

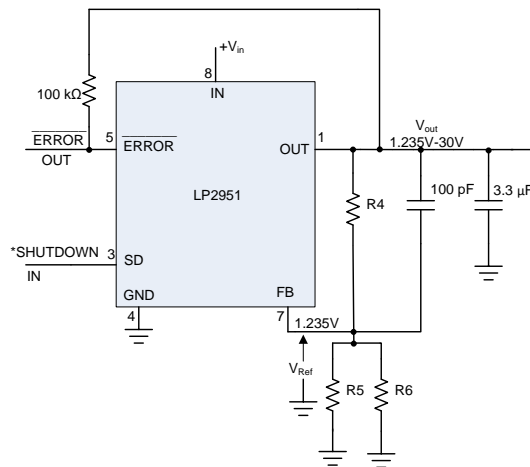
The complete equation for the output voltage is:

$$V_{out} = V_{REF} * 1 + \left( \frac{R_4}{R_5 || R_6} \right) + I_{FB} R_4$$

where

- V<sub>REF</sub> is the nominal 1.235-V reference voltage and I<sub>FB</sub> is the Feedback pin bias current, nominally -20 nA

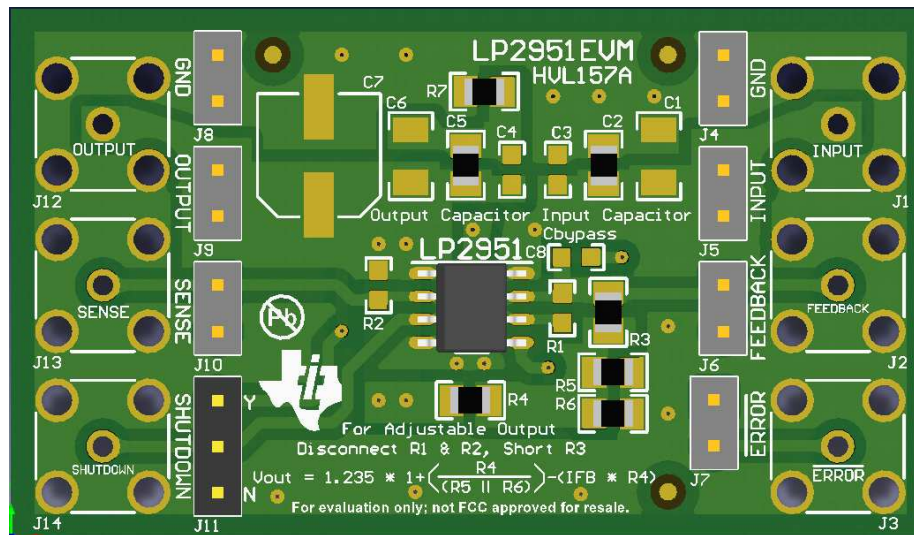
(1)



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**Figure 7. LP2951 Adjustable Output Voltage Block Diagram**

Figure 7 shows the LP2951 device setup in adjustable output voltage mode. The minimum recommended load current of 1 μA forces an upper limit of 1.2 MΩ on the value of R<sub>5</sub> in parallel with R<sub>6</sub>, if the regulator must work with no load (a condition often found in CMOS in standby). I<sub>FB</sub> produces a 2% typical error in V<sub>OUT</sub> which may be eliminated at room temperature by trimming R<sub>4</sub>. For better accuracy, choosing a parallel combination of R<sub>5</sub> with R<sub>6</sub> = 100 kΩ reduces this error to 0.17% while increasing the resistor program current to 12 μA. Because the LP2951 typically draws 60 μA at no load with pin 2 open-circuited, this is a small price to pay. Figure 8 shows how the LP2951EVM looks set up in adjustable voltage mode.



**Figure 8. EVM With Adjustable Mode Resistors Populated**

### 3.3 Equipment Connection

- Set power supply to desired input voltage. Verify that the supply is off. Connect positive voltage lead from supply to the input J5 header. Connect the ground lead from the power supply to GND J4/J8 header.
- Connect desired loading device from Output J9 header to GND J4/J8 header.
- Verify that J11 has the Shutdown pin shorted to the pin labeled N.

### 3.4 Operation

- Turn on the power supply.
- Vary respective load and input voltage, as necessary, for test purposes.

## 4 Thermal Guidelines and Layout Recommendations

Thermal management is a key component in the design of any power converter and is especially important when the power dissipation in the LDO is high. Use [Equation 2](#) to approximate the maximum power dissipation for the particular ambient temperature:

$$T_J = T_A + P_D * \theta_{JA}$$

where

- Where  $T_J$  is the junction temperature,  $T_A$  is the ambient temperature
- $P_D$  is the power dissipation in the device (Watts)
- $\theta_{JA}$  is the thermal resistance from junction to ambient (2)

All temperatures are in degrees Celsius. The maximum operating junction temperature,  $T_J$ , must not be allowed to exceed 125 °C. The layout design must be copper trace. Plane areas smartly, as thermal sinks, to prevent  $T_J$  to exceed the absolute maximum rating under all temperature conditions and voltage conditions across the part.



## 5 Board Layout

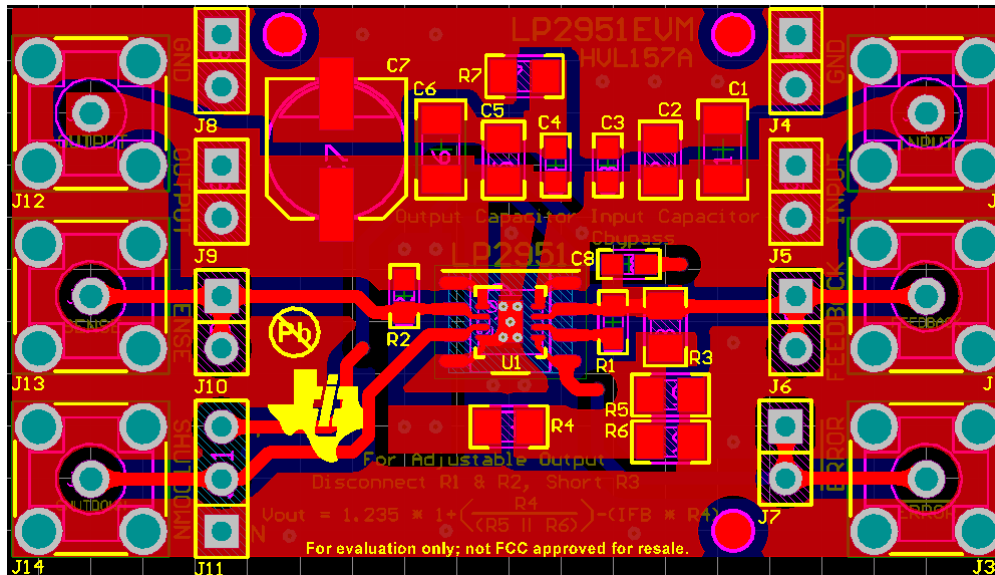
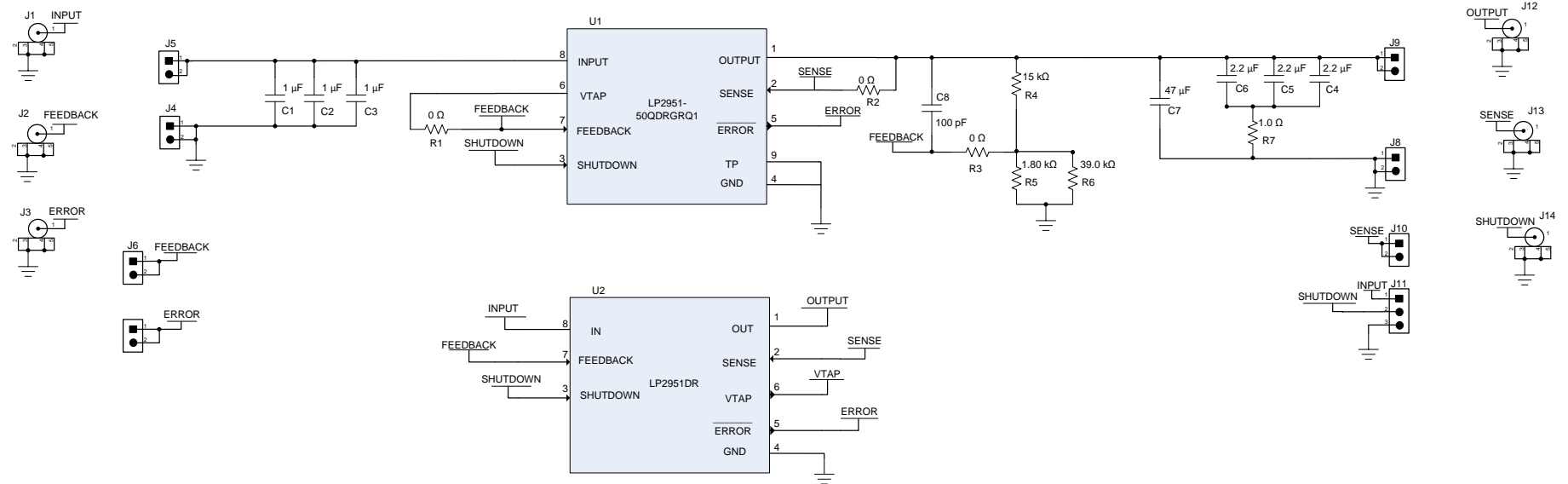


Figure 9. LP2951EVM Board Layout

## 6 EVM Schematic



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Figure 10. LP2951EVM Schematic

## 7 Bill of Materials

**Table 3. Bill of Materials**

Designator	Quantity	Value	Description	Package reference	Part Number	Manufacturer
PCB1	1		Printed Circuit Board		HVL157	Any
C2	1	1 $\mu$ F	CAP, CERM, 1 $\mu$ F, 50 V, +/- 10%, X7R, 0805	0805	GRM21BR71H105K A12L	MuRata
C5	1	2.2 $\mu$ F	CAP, CERM, 2.2 $\mu$ F, 50 V, +/- 10%, X5R, 0805	0805	C2012X5R1H225K1 25AB	TDK
J4, J5, J6, J7, J8, J9, J10	7		Header, 100mil, 2x1, Gold, TH	Header, 100mil, 2x1, TH	HTSW-102-07-G-S	Samtec
J11	1		Header, 100mil, 3x1, Gold, TH	PBC03SAAN	PBC03SAAN	Sullins Connector Solutions
R1,R2	2	0	RES, 0, 5%, 0.1 W, 0603	0603	ERJ-3GEY0R00V	Panasonic
R7	1	1.0	RES, 1.0, 5%, 0.125 W, 0805	0805	ERJ-6GEYJ1R0V	Panasonic
U1	1		Fixed Regulator with 1 to 30 V Input and 1.2 to 30 V Output, -40 to 125 degC, 8-Pin SON (DRG), Green (RoHS & no Sb/Br)	DRG0008A	LP2951-50QDRGRQ1	Texas Instruments
C1	0	1 $\mu$ F	CAP, CERM, 1 $\mu$ F, 50 V, +/- 10%, X7R, 1206	1206	C3216X7R1H105K	TDK
C3	0	1 $\mu$ F	CAP, CERM, 1 $\mu$ F, 35 V, +/- 10%, X7R, 0603	0603	C1608X7R1V105K0 80AC	TDK
C4	0	2.2 $\mu$ F	CAP, CERM, 2.2 $\mu$ F, 35 V, +/- 10%, X5R, 0603	0603	GRM188R6YA225K A12D	MuRata
C6	0	2.2 $\mu$ F	CAP, CERM, 2.2 $\mu$ F, 50 V, +/- 10%, X7R, 1206	1206	GRM31CR71H225K A88L	MuRata
C7	0	47 $\mu$ F	CAP, AL, 47 $\mu$ F, 35 V, +/- 20%, 1 ohm, SMD	F55	EMVY350ADA470M F55G	Chemi-Con
C8	0	100 pF	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	GRM1885C1H101J A01D	MuRata
J1, J2, J3, J12, J13, J14	0		Connector, SMB, Vertical RCP 0-4GHz, 50 ohm, TH	236x293x236mil	131-3701-261	Emerson Network Power
R3	0	0	RES, 0, 5%, 0.125 W, 0805	0805	ERJ-6GEY0R00V	Panasonic
R4	0	15.0 k	RES, 15.0 k, 0.1%, 0.125 W, 0805	0805	RG2012P-153-B-T5	Susumu Co Ltd
R5	0	1.80 k	RES, 1.80 k, 0.1%, 0.125 W, 0805	0805	RG2012P-182-B-T5	Susumu Co Ltd
R6	0	39.0 k	RES, 39.0 k, 0.1%, 0.125 W, 0805	0805	RG2012P-393-B-T5	Susumu Co Ltd
U2	0		Adjustable Micropower Voltage Regulator with Shutdown, D0008A (SOIC-8)	D0008A	LP2951DR	Texas Instruments

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## Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

<b>Changes from Original (March 2017) to A Revision</b>	<b>Page</b>
• Changed C7 value from 4.7 $\mu$ F to 47 $\mu$ F in Bill of Materials table .....	11

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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

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- 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.

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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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[http://www.tij.co.jp/lstds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/lstds/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 to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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#### 3.4 *European Union*

##### 3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive):*

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

#### 4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

##### 4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

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