User's Guide
SLLU245–May 2016

# TUSB1002 Evaluation Module

This is the user guide for the evaluation module (EVM) of the TUSB1002. The purpose of this user guide is to facilitate an easy evaluation process of our TUSB1002 USB 3.1 SuperSpeed (5 Gbps) and SuperSpeed Plus (10 Gbps) Re-Driver.

The contents of this user's guide are meant to provide an overview of the TUSB1002, which includes highlighting its key features, operating conditions, and how to setup this EVM for use in a system-level evaluation.

The construction of the TUSB1002 EVM also serves as a reference design that can be easily modified for any intended application. Target applications include cell phones, computers, docking stations, TVs, and active cables. The schematics and layout information is included at the end of this manual.

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# 1 Introduction

The TUSB1002 is a dual-channel, USB 3.1 SuperSpeed Plus re-driver and signal conditioner supporting data rates of 10.0 Gbps. The device complies with USB 3.1 specification revision 1.0, supporting electrical idle condition and low-frequency periodic signals (LFPS) for USB 3.1 power management modes.

The device offers programmable equalization that extends the interconnect distance between two devices. Also, the device supports low-power modes when unplugged. The device can also function in USB-compliance mode to test the transmitter for compliance to voltage and timing specifications per USB 3.1 compliance specification.

This EVM is designed to be used as a medium connection between a USB host and a USB device. The interface to the EVM consists of a USB 3.1 Type-A Receptacle and a USB 3.1 Type-B Receptacle. Therefore, in order to connect the EVM to your system set up, you will most likely need 2 USB 3.1 Standard Type-A → B cables. Your test setup should look similar to the figure below:

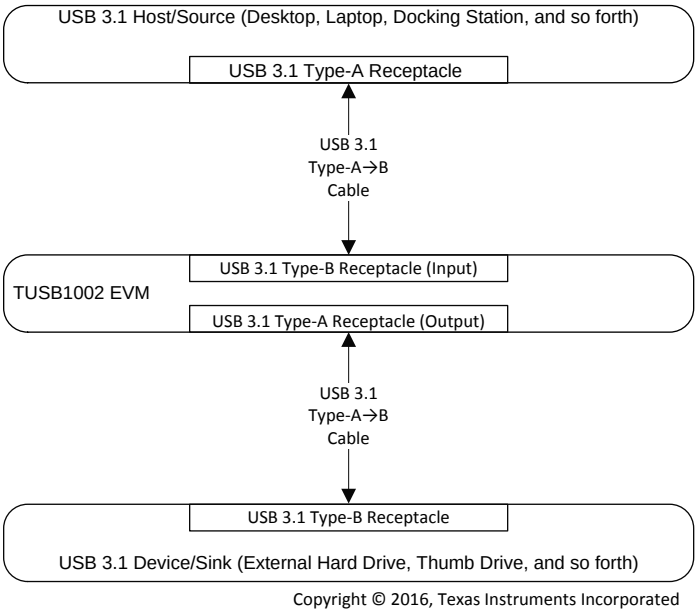



**Figure 1. TUSB1002 Functional System Level Block Diagram**


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# 2 TUSB1002 EVM Configuration

## 2.1 TUSB1002 EVM Kit Contents

This EVM kit contains the following items:

- TUSB1002 EVM board
- This user's manual

## 2.2 Description of EVM Board

The TUSB1002 EVM is designed to provide easy evaluation of the TUSB1002 device. It is also meant to serve as a reference design to show a practical example of how to use the device in a mass-production system. Figure 2 highlights the jumpers and switch installed on this EVM and Table 1 highlights their functionality and configuration.

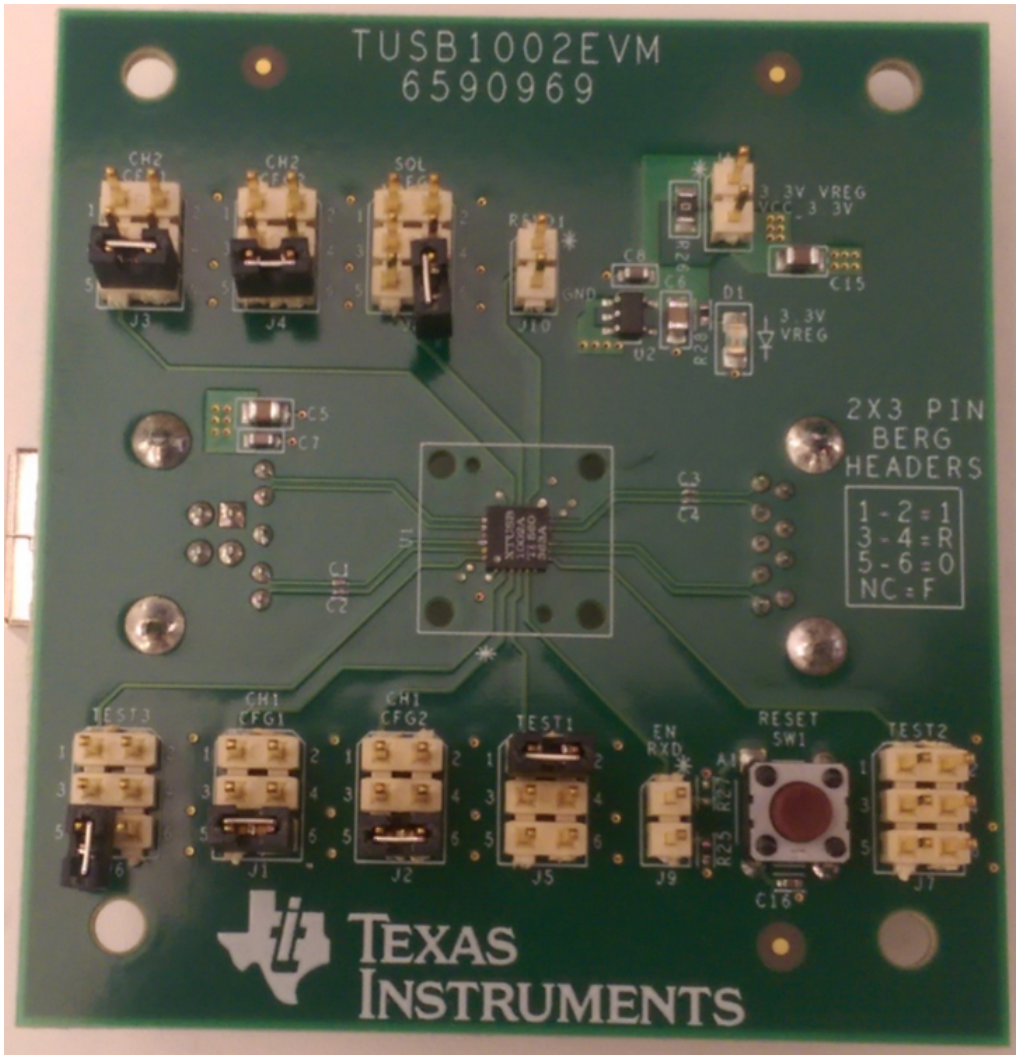



**Figure 2. TUSB1002 EVM (Top Side)**


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**Table 1. TUSB1002 EVM Jumper / Switch Description and Settings**

| Jumper | Functionality and Configuration |
|---|---|
| **J1** | **CH1_EQ1** |
| | 1-2 = 1 (1K to VCC)<br>3-4 = R (20K to GND)<br>5-6 = 0 (1K to GND)<br>NC = F (No Connect) |
| **J2** | **CH1_EQ2** |
| | 1-2 = 1 (1K to VCC)<br>3-4 = R (20K to GND)<br>5-6 = 0 (1K to GND)<br>NC = F (No Connect) |
| **J3** | **CH2_EQ1** |
| | 1-2 = 1 (1K to VCC)<br>3-4 = R (20K to GND)<br>5-6 = 0 (1K to GND)<br>NC = F (No Connect) |
| **J4** | **CH2_EQ2** |
| | 1-2 = 1 (1K to VCC)<br>3-4 = R (20K to GND)<br>5-6 = 0 (1K to GND)<br>NC = F (No Connect) |
| **J5** | **CFG1** |
| | 1-2 = 1 (1K to VCC)<br>3-4 = R (20K to GND)<br>5-6 = 0 (1K to GND)<br>NC = F (No Connect) |
| **J6** | **RSVD1** |
| | 1-2 = 1 (1K to VCC)<br>3-4 = R (20K to GND)<br>5-6 = 0 (1K to GND)<br>NC = F (No Connect) |
| **J7** | **MODE** |
| | 1-2 = 1 (1K to VCC)<br>3-4 = R (20K to GND)<br>5-6 = 0 (1K to GND)<br>NC = F (No Connect) |
| **J8** | **CFG2** |
| | 1-2 = 1 (1K to VCC)<br>3-4 = R (20K to GND)<br>5-6 = 0 (1K to GND)<br>NC = F (No Connect) |
| **J9/SW1** | **EN (Shutdown Mode)** |
| | 1-2 = 1K to GND<br>NC = Internal Pull-up (Default)<br>SW1 = Push to Short EN to GND |
| **J10** | **SLP_S0#** |
| | 1-2 = 1K to GND<br>NC = Internal Pull-up (Default) |
| **J11** | **VCC 3.3V** |
| | 1-2 = VCC_3.3V Provided from U2 (Default)<br>NC = Provide external 3.3V on Pin 2 |


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## 3 Selecting Equalization Level for TUSB1002

The equalization level of each channel is configured via the CHx_CFG1 and CHx_CFG2 pin states. Table 2 lists all possible equalization levels that can be achieved with the TUSB1002:

**Table 2. TUSB1002 Equalization Selection**

| Equalization Level Selector | | |
|---|---|---|
| **CHx_EQ2 Pin Level** | **CHx_EQ1 Pin Level** | **EQ Gain at 5 GHz (dB)** |
| 0 | 0 | 2.5 |
| 0 | R | 4.2 |
| 0 | F | 5.5 |
| 0 | 1 | 7 |
| R | 0 | 8 |
| R | R | 9 |
| R | F | 10 |
| R | 1 | 10.7 |
| F | 0 | 11.4 |
| F | R | 12.2 |
| F | F | 12.7 |
| F | 1 | 13.2 |
| 1 | 0 | 13.7 |
| 1 | R | 14.2 |
| 1 | F | 14.7 |
| 1 | 1 | 15.1 |

## 4 Adjustable VOD Linear Range and DC Gain

The CFG1 and CFG2 pins can be used to adjust the TUSB1002 output voltage swing linear range and receiver equalization DC gain. Table 3 details the available options.

**Table 3. TUSB1002 Adjustable VOD and DC Gain**

| Setting # | CFG1 Pin Level | CFG2 Pin Level | CH1 DC Gain (dB) | CH2 DC Gain (dB) | CH1 VOD Linear Range (mVpp) | CH2 VOD Linear Range (mVpp) |
|---|---|---|---|---|---|---|
| 1 | 0 | 0 | +1 | 0 | 900 | 900 |
| 2 | 0 | R | 0 | +1 | 900 | 900 |
| 3 | 0 | F | 0 | 0 | 900 | 900 |
| 4 | 0 | 1 | +1 | +1 | 900 | 900 |
| 5 | R | 0 | 0 | 0 | 1000 | 1000 |
| 6 | R | R | +1 | 0 | 1000 | 1000 |
| 7 | R | F | 0 | –1 | 1000 | 1000 |
| 8 | R | 1 | +2 | +2 | 1000 | 1000 |
| 9 | F | 0 | –1 | –1 | 1200 | 1200 |
| 10 | F | R | –2 | –2 | 1200 | 1200 |
| 11 | F | F | 0 | 0 | 1200 | 1200 |
| 12 | F | 1 | +1 | +1 | 1200 | 1200 |
| 13 | 1 | 0 | –1 | 0 | 1200 | 1200 |
| 14 | 1 | R | 0 | –1 | 1200 | 1200 |
| 15 | 1 | F | 0 | +1 | 1200 | 1200 |
| 16 | 1 | 1 | +1 | 0 | 1200 | 1200 |


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# 5 Monitoring the Device Current

The TUSB1002 EVM includes the option of monitoring the current draw of the device. In order to enable this feature, the following steps must be taken:

1. Un-install the shunt located at JMP11 and remove R26.
2. Obtain a power supply with the ability to display its current draw (or connect a current meter in series to the power supply).
3. Connect to 3.3 V of external power source to VCC_3.3V (J11-2) and GND of the external supply to a convenient GND location on the EVM (J10-2).
4. Turn on your power supply and observe the measured current on your power supply display (or current meter).

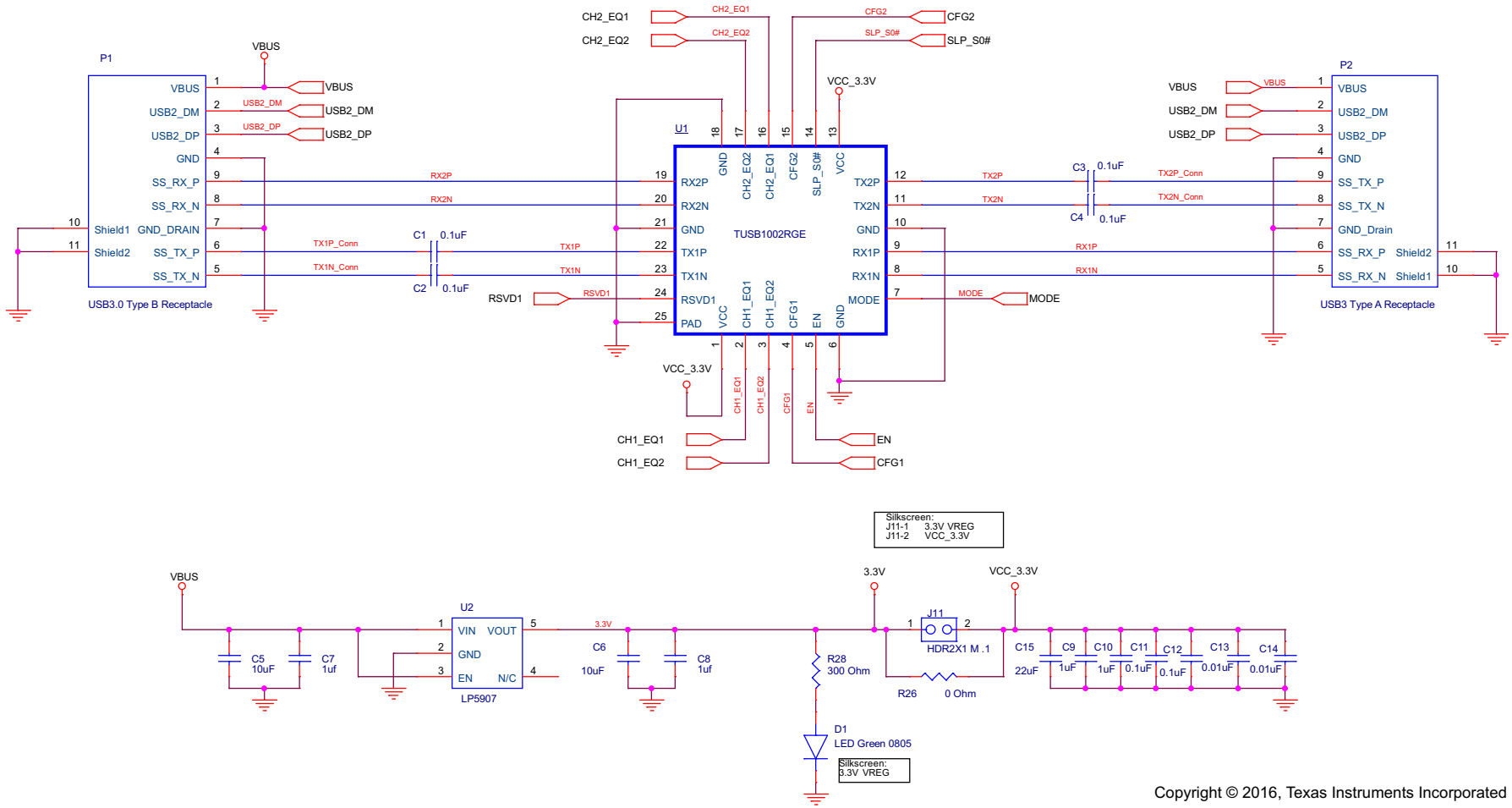

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# 6 PCB Construction

This section discusses the construction of the EVM boards. It includes the board schematics and layout files to show how the board was built.

## 6.1 TUSB1002 EVM Board Schematics

Figure 3 and Figure 4 illustrate the EVM schematics.

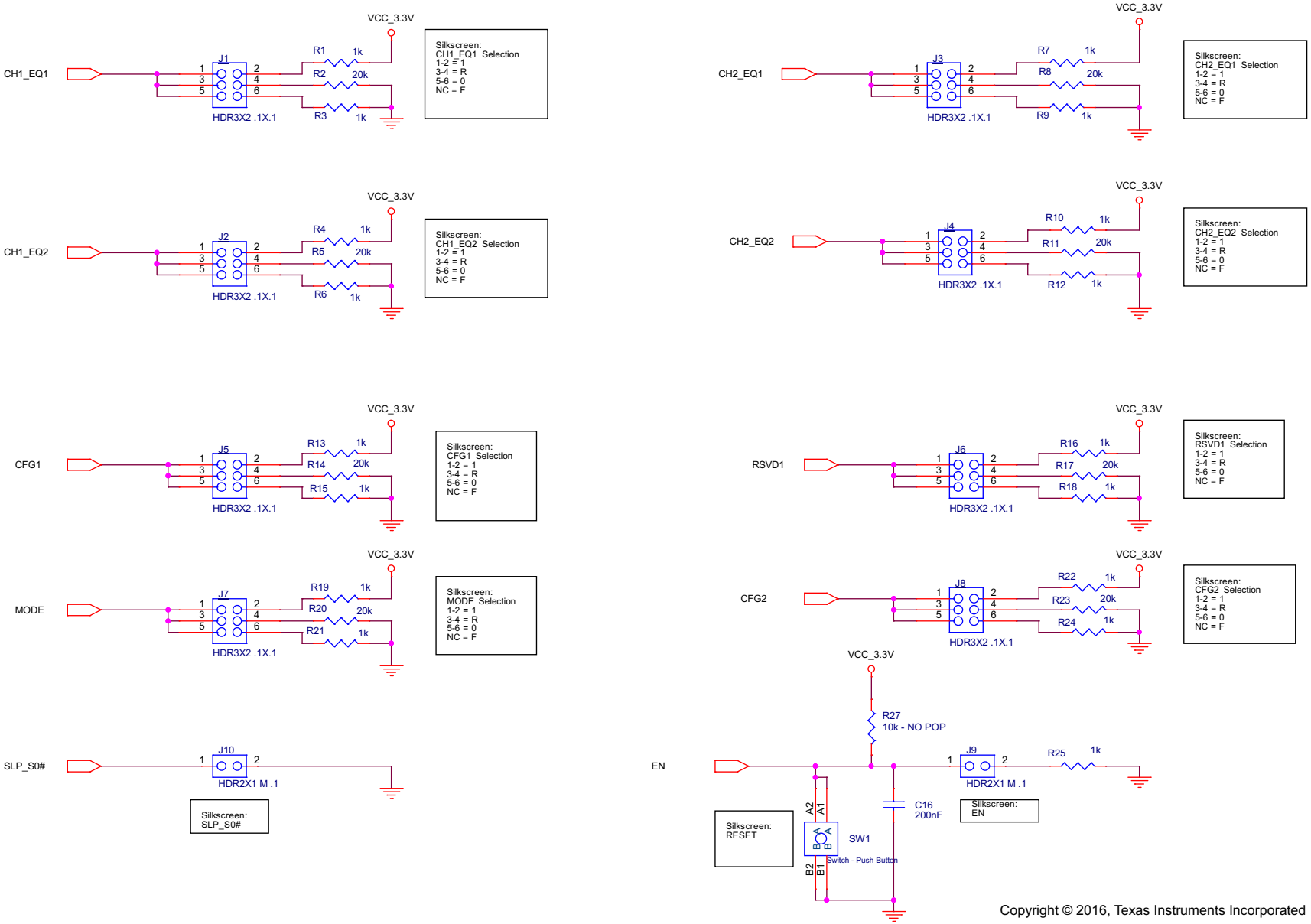



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**Figure 3. TUSB1002 EVM Schematic (High Speed Pins and Power)**



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**Figure 4. TUSB1002 EVM Schematic (Device Control Pins)**



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## 6.2 TUSB1002 EVM Board Layout

This EVM was designed to show the implementation on a 4-layer board.

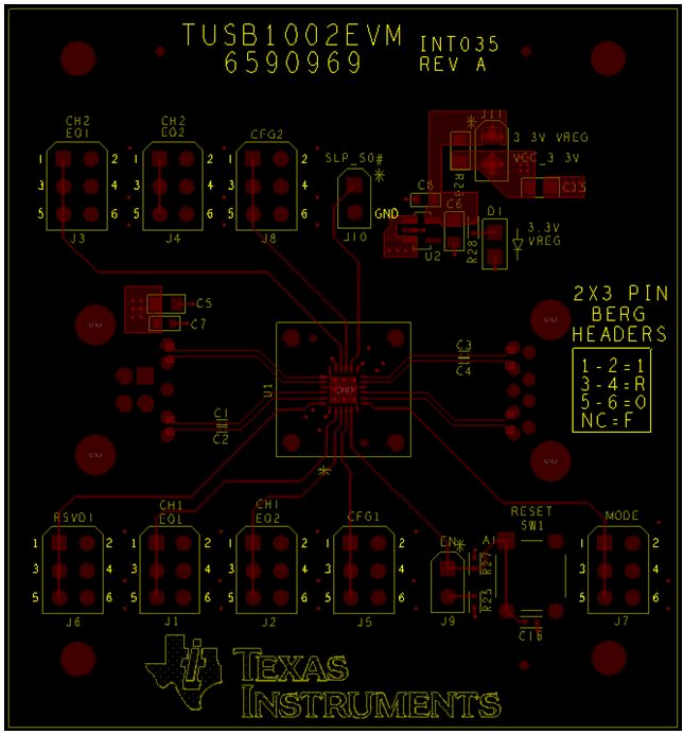



**Figure 5. TUSB1002 EVM Layout Layer 1 (Top)**

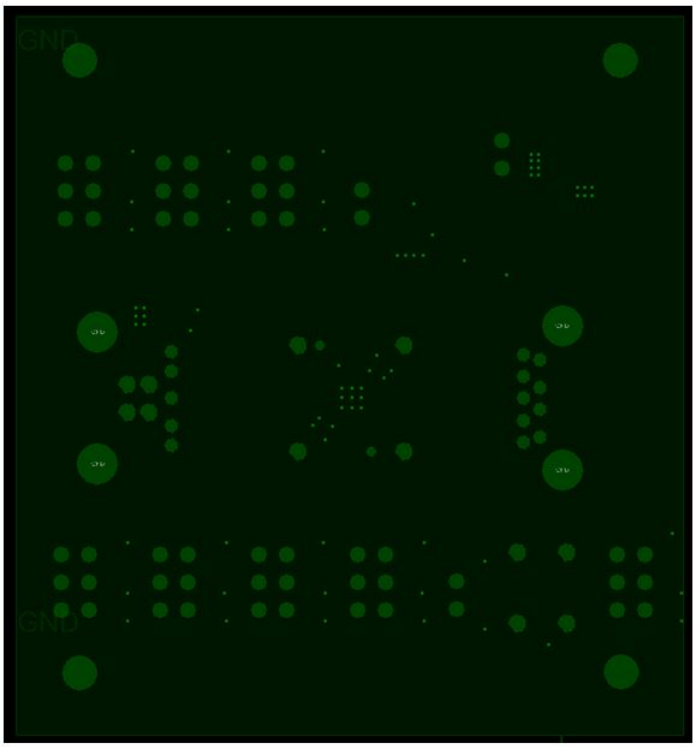



**Figure 6. TUSB1002 EVM Layout Layer 2 (GND)**


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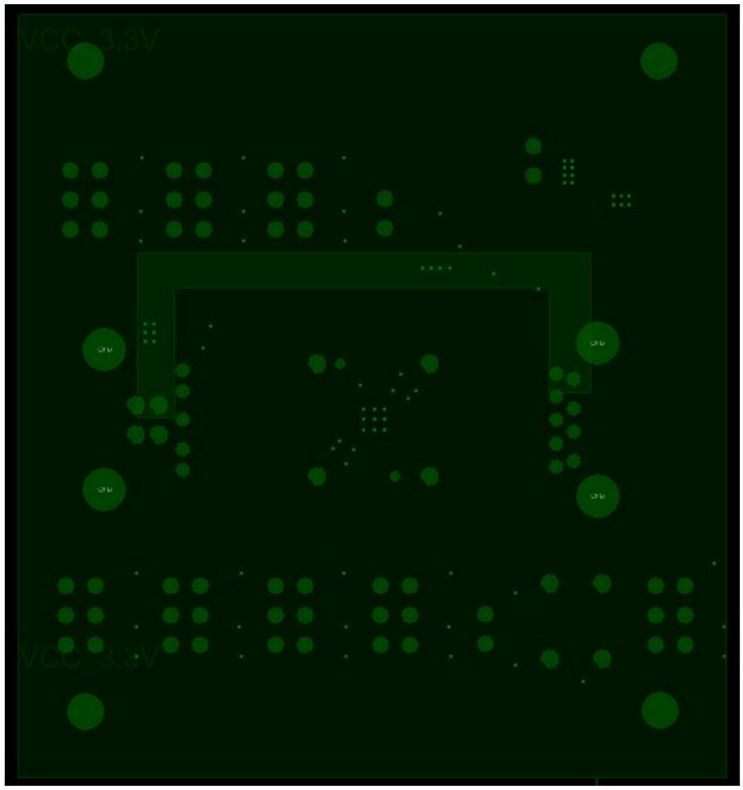



**Figure 7. TUSB1002 EVM Layout Layer 3 (VCC)**

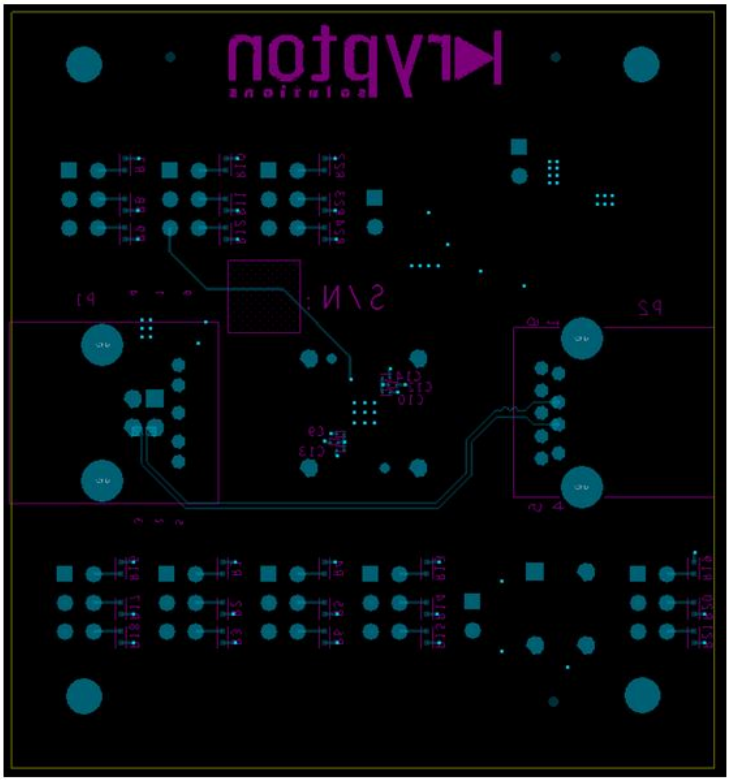


**Figure 8. TUSB1002 EVM Layout Layer 4 (Bottom)**


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## 6.3 TUSB1002 EVM Material Listing

Table 4 lists the complete BOM for the TUSB1002 EVM.

**Table 4. TUSB1002 EVM Bill of Materials**

| Item | Quantity | Reference | Part |
|---|---|---|---|
| 1 | 6 | C1,C2,C3,C4,C11,C12 | 0.1uF |
| 2 | 2 | C5,C6 | 10uF |
| 3 | 4 | C7,C8,C9,C10 | 1uF |
| 4 | 2 | C13,C14 | 0.01uF |
| 5 | 1 | C15 | 22uF |
| 6 | 1 | C16 | .22uF |
| 7 | 1 | D1 | LED Green 0805 |
| 8 | 8 | J1,J2,J3,J4,J5,J6,J7,J8 | HDR3X2 .1X.1 |
| 9 | 3 | J9,J10,J11 | HDR2X1 M .1 |
| 10 | 1 | P1 | USB3.0 Type-B Receptacle |
| 11 | 1 | P2 | USB3 Type-A Receptacle |
| 12 | 17 | R1,R3,R4,R6,R7,R9,R10,R12,R13,R15,R16,R18,R19,R21, R22, R24,R25 | 1k |
| 13 | 8 | R2,R5,R8,R11,R14,R17,R20,R23 | 20k |
| 14 | 1 | R26 | 0 Ohm |
| 15 | 1 | R27 | 10k - NO POP |
| 16 | 1 | R28 | 300 Ohm |
| 17 | 1 | SW1 | Switch - Push Button |
| 18 | 1 | U1 | TUSB1002RGE |
| 19 | 1 | U2 | LP5907 |


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1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms and conditions that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms and conditions do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for any defects that are caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.

   2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

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

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3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/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。
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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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