User’s Guide

TPS53318 Step-Down Converter Evaluation Module User’s Guide

ABSTRACT

The TPS53319EVM-136 is designed to use a regulated 12-V bus to produce a regulated 1.5-V output at up to 14 A of load current. The TPS53319EVM-136 is designed to demonstrate the TPS53319 in a typical low voltage application while providing a number of test points to evaluate the performance of the TPS53319.

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1 Introduction

The TPS53319EVM-136 evaluation module (EVM) uses the TPS53319. The TPS53319 is a D-CAP mode, 14-A synchronous buck converter with integrated MOSFETs. The device provides a fixed 1.5-V output at up to 14 A from a 12-V input bus.

1.1 Typical Applications

- Server/storage
- Workstations and desktops
- Telecommunication infrastructure

1.2 Features

The TPS53319EVM-136 features:

- 14-A DC steady state output current
- Support pre-bias output voltage start-up
- J3 for selectable switching frequency setting
- J4 for selectable soft-start time
- J5 for auto-skip and forced CCM selection
- J6 for enable function
- Convenient test points for probing critical waveforms

2 Electrical Performance Specifications

Table 2-1. TPS53319EVM-136 Electrical Performance Specifications

<table>
<thead>
<tr>
<th>PARAMETER(1)</th>
<th>TEST CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT CHARACTERISTICS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage range</td>
<td>VIN</td>
<td>8</td>
<td>12</td>
<td>20</td>
<td>V</td>
</tr>
<tr>
<td>Maximum input current</td>
<td>VIN = 8 V, IO = 14 A</td>
<td></td>
<td>2.874</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>No load input current</td>
<td>VIN = 20 V, IO = 0 A with auto skip mode</td>
<td></td>
<td>0.7</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>OUTPUT CHARACTERISTICS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output voltage VOUT</td>
<td></td>
<td></td>
<td>1.5</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Output voltage regulation</td>
<td>Line regulation (VIN = 8 V–20 V)</td>
<td></td>
<td>0.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load regulation (VIN = 12 V, IO = 0 A–14 A), auto-skip</td>
<td></td>
<td></td>
<td>1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output voltage ripple</td>
<td>VIN = 12 V, IO = 14 A</td>
<td></td>
<td>15</td>
<td></td>
<td>mVpp</td>
</tr>
<tr>
<td>Output load current</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>Output over current</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>SYSTEMS CHARACTERISTICS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switching frequency</td>
<td></td>
<td></td>
<td>500</td>
<td></td>
<td>kHz</td>
</tr>
<tr>
<td>Peak efficiency</td>
<td>VIN = 12 V, 1.5 V/8 A</td>
<td></td>
<td></td>
<td></td>
<td>91.68%</td>
</tr>
<tr>
<td>Full load efficiency</td>
<td>VIN = 12 V, 1.5 V/14 A</td>
<td></td>
<td></td>
<td></td>
<td>90.04%</td>
</tr>
<tr>
<td>Operating temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25</td>
</tr>
</tbody>
</table>

(1) **Note:** Jumpers set to default locations. See Section 6.
3 Schematic

Figure 3-1. TPS53319EVM-136 Schematic
4 Test Setup

4.1 Test Equipment

Voltage Source:
The input voltage source, $V_{IN}$, should be a 0-V to 20-V variable DC source capable of supplying 10 A_{DC}. Connect $V_{IN}$ to J1 as shown in Figure 4-2.

Multimeters:
V1: $V_{IN}$ at TP1 ($V_{IN}$) and TP10 (GND). V2: $V_{OUT}$ at TP2 ($V_{OUT}$) and TP11 (GND). A1: $V_{IN}$ input current

Output Load:
The output load should be an electronic constant resistance mode load capable of 0 A_{DC} to 16 A_{DC} at 1.5 V.

Oscilloscope:
A digital or analog oscilloscope can be used to measure the output ripple. The oscilloscope should be set for the following:

- 1-MΩ impedance
- 20-MHz bandwidth
- AC coupling
- 2-μs/division horizontal resolution
- 20-mV/division vertical resolution

Test points TP2 and TP11 can be used to measure the output ripple voltage by placing the oscilloscope probe tip through TP2 and holding the ground barrel on TP11 as shown in Figure 4-1. Using a leaded ground connection can induce additional noise due to the large ground loop.

![Figure 4-1. Tip and Barrel Measurement for $V_{OUT}$ Ripple](image)

Recommended Wire Gauge:

1. $V_{IN}$ to J1 (12-V input):
The recommended wire size is AWG #16 per input connection, with the total length of wire less than four feet (two feet input, two feet return).

2. J2 to LOAD:
The minimum recommended wire size is AWG #14, with the total length of wire less than four feet (two feet output, two feet return).
4.2 Recommended Test Setup

Figure 4-2. TPS53319EVM-136 Recommended Test Setup

Figure 4-2 is the recommended test setup to evaluate the TPS53319EVM-136. Working at an ESD workstation, make sure that any wrist straps, bootstraps, or mats are connected referencing the user to earth ground before power is applied to the EVM.

**Input Connections:**
1. Prior to connecting the DC input source \( V_{IN} \), it is advisable to limit the source current from \( V_{IN} \) to 10-A maximum. Make sure \( V_{IN} \) is initially set to 0 V and connected as shown in Figure 4-2.
2. Connect a voltmeter V1 at TP1 (\( V_{IN} \)) and TP10 (GND) to measure the input voltage.
3. Connect a current meter A1 to measure the input current.

**Output Connections**
1. Connect the load to J2 and set the load to constant resistance mode to sink 0 A\(_{DC}\) before \( V_{IN} \) is applied.
2. Connect a voltmeter V2 at TP2 (\( V_{OUT} \)) and TP11 (GND) to measure the output voltage.
5 Configurations
All jumper selections should be made prior to applying power to the EVM. The user can configure this EVM per the following configurations.

5.1 Switching Frequency Selection
The switching frequency can be set by J3.
Default setting: 500 kHz

Table 5-1. Switching Frequency Selection

<table>
<thead>
<tr>
<th>JUMPER SET TO</th>
<th>RESISTOR (RF) CONNECTIONS (Ω)</th>
<th>SWITCHING FREQUENCY (kHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top (1–2 pin shorted)</td>
<td>0</td>
<td>250</td>
</tr>
<tr>
<td>2nd (3–4 pin shorted)</td>
<td>187 k</td>
<td>300</td>
</tr>
<tr>
<td>3rd (5–6 pin shorted)</td>
<td>619 k</td>
<td>400</td>
</tr>
<tr>
<td>4th (7–8 pin shorted)</td>
<td>Open</td>
<td>500</td>
</tr>
<tr>
<td>5th (9–10 pin shorted)</td>
<td>866 k</td>
<td>600</td>
</tr>
<tr>
<td>6th (11–12 pin shorted)</td>
<td>309 k</td>
<td>750</td>
</tr>
<tr>
<td>7th (13–14 pin shorted)</td>
<td>124 k</td>
<td>850</td>
</tr>
<tr>
<td>Bottom (15–16 pin shorted)</td>
<td>0</td>
<td>970</td>
</tr>
</tbody>
</table>

5.2 Soft Start Selection
The soft start time can be set by J4.
Default setting: 1.4ms

Table 5-2. Soft Start Time Selection

<table>
<thead>
<tr>
<th>Jumper set to</th>
<th>RMODE Connections(Ω)</th>
<th>Soft Start Time(ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top (1-2 pin shorted)</td>
<td>39.2k</td>
<td>0.7</td>
</tr>
<tr>
<td>2nd (3-4 pin shorted)</td>
<td>100k</td>
<td>1.4</td>
</tr>
<tr>
<td>3rd (5-6 pin shorted)</td>
<td>200k</td>
<td>2.8</td>
</tr>
<tr>
<td>Bottom (7-8 pin shorted)</td>
<td>475k</td>
<td>5.6</td>
</tr>
</tbody>
</table>

5.3 Mode Selection
The MODE can be set by J5.
Default setting: Auto Skip

Table 5-3. MODE Selection

<table>
<thead>
<tr>
<th>Jumper set to</th>
<th>MODE Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top (1-2 pin shorted)</td>
<td>Auto Skip</td>
</tr>
<tr>
<td>Bottom (3-4 pin shorted)</td>
<td>Forced CCM</td>
</tr>
</tbody>
</table>

5.4 Enable Selection
The controller can be enabled and disabled by J6.
Default setting: Jumper shorts on J6 to disable the controller

Table 5-4. Enable Selection

<table>
<thead>
<tr>
<th>Jumper set to</th>
<th>Enable Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jumper shorts on J6</td>
<td>Disable the controller</td>
</tr>
<tr>
<td>No Jumper shorts on J6</td>
<td>Enable the controller</td>
</tr>
</tbody>
</table>
6 Test Procedure

6.1 Line/Load Regulation and Efficiency Measurement Procedure

1. Set up EVM as described in Section 4 and Figure 4-2.
2. Ensure Load is set to constant resistance mode and to sink 0Adc
3. Ensure all jumpers configuration settings per section 5.
4. Ensure the jumper provided in the EVM shorts on J6 before Vin is applied.
5. Increase Vin from 0V to 12V. Using V1 to measure input voltage.
6. Remove the jumper on J6 to enable the controller.
7. Use V2 to measure Vout voltage.
8. Vary Load from 0-14Adc, Vout should be remain in load regulation.
9. Vary Vin from 8V to 20V, Vout should remain in line regulation.
10. Put the jumper on J6 to disable the controller.
11. Decrease Load to 0A
12. Decrease Vin to 0V.

6.2 Control Loop Gain and Phase Measurement Procedure

TPS53319EVM-136 contains a 10Ω series resistor in the feedback loop for loop response analysis.

1. Set up EVM as described in Section 4 and Figure 4-2.
2. Connect isolation transformer to test points marked TP6 and TP7.
3. Connect input signal amplitude measurement probe (channel A) to TP6. Connect output signal amplitude measurement probe (channel B) to TP7.
4. Connect ground lead of channel A and channel B to TP9.
5. Inject around 20mV or less signal through the isolation transformer.
6. Sweep the frequency from 100Hz to 1MHz with 10Hz or lower post filter. The control loop gain and phase margin can be measured.
7. Disconnect isolation transformer from bode plot test points before making other measurements (Signal injection into feedback may interfere with accuracy of other measurements).

6.3 List of Test Points

<table>
<thead>
<tr>
<th>Test Points</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP1</td>
<td>VIN</td>
<td>Controller input</td>
</tr>
<tr>
<td>TP2</td>
<td>Vout</td>
<td>Output Voltage</td>
</tr>
<tr>
<td>TP3</td>
<td>VREG</td>
<td>5V LDO output</td>
</tr>
<tr>
<td>TP4</td>
<td>PGOOD</td>
<td>Power Good</td>
</tr>
<tr>
<td>TP5</td>
<td>EN</td>
<td>Enable</td>
</tr>
<tr>
<td>TP6</td>
<td>CHA</td>
<td>Input A for loop injection</td>
</tr>
<tr>
<td>TP7</td>
<td>CHB</td>
<td>Input B for loop injection</td>
</tr>
<tr>
<td>TP8</td>
<td>LL</td>
<td>Switching node</td>
</tr>
<tr>
<td>TP9</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>TP10</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>TP11</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>TP12</td>
<td>GND</td>
<td>Ground</td>
</tr>
</tbody>
</table>

6.4 Equipment Shutdown

1. Shut down the load.
2. Shut down Vin.
7 Performance Data and Typical Characteristic Curves

Figure 7-1 through Figure 7-15 present typical performance curves for TPS53319EVM-136.

7.1 Efficiency

![Efficiency Chart](image)

**Figure 7-1. Efficiency**

7.2 Load Regulation

![Load Regulation Chart](image)

**Figure 7-2. Load Regulation**
7.3 Line Regulation

![Line Regulation Graph]

**Figure 7-3. Line Regulation**

7.4 Enable Turn-On/ Turn-Off

![Enable Turn-On Graph]

*Figure 7-4. Enable Turn-On*

![Enable Turn-Off Graph]

*Figure 7-5. Enable Turn-Off*
7.5 Output Ripple

Figure 7-6. Output Ripple

7.6 Switching Node

Figure 7-7. Switching Node
7.7 Output Transient with Auto-skip Mode

Figure 7-8. Output Transient from DCM to CCM

Figure 7-9. Output Transient from CCM to DCM

7.8 Output Transient with FCCM mode

Figure 7-10. Output Transient with FCCM mode
7.9 Output 0.75-V Pre-bias Turn-On

Figure 7-11. Output 0.75-V Pre-bias Turn-On

7.10 Output Overcurrent and Short Circuit Protection

Figure 7-12. Output Overcurrent Protection

Figure 7-13. Output Overvoltage Protection
7.11 Bode plot

Figure 7-14. Bode plot at 12Vin, 1.5V/14A

7.12 Thermal Image

Figure 7-15. Top Board at 12 VIN, 1.5 V/14 A, 25°C Ambient Without Airflow
8 EVM Assembly Drawing and PCB Layout

*Figure 8-1 through Figure 8-8* show the design of the TPS53319EVM-136 printed circuit board. The EVM has been designed using a 6-layer, 2-oz copper circuit board.

*Figure 8-1. TPS53319EVM-136 Top Layer Assembly Drawing*
Figure 8-2. TPS53319EVM-136 Bottom Assembly Drawing
Figure 8-3. TPS53319EVM-136 Top Copper
Figure 8-4. TPS53319EVM-136 Layer 2 Copper
Figure 8-5. TPS53319EVM-136 Layer 3 Copper
Figure 8-6. TPS53319EVM-136 Layer 4 Copper
Figure 8-7. TPS53319EVM-136 Layer 5 Copper
Figure 8-8. TPS53319EVM-136 Bottom Layer Copper
9 Bill of Materials

Table 9-1 list the EVM components according to the schematic shown in Figure 3-1.

<table>
<thead>
<tr>
<th>QTY</th>
<th>RefDes</th>
<th>Description</th>
<th>MFR</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>C1, C2</td>
<td>Capacitor, Ceramic, 22 μF, 25 V, X5R, 20%, 1210</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>3</td>
<td>C7, C8, C9</td>
<td>Capacitor, Ceramic, 100 μF, 6.3 V, X5R, 20%, 1210</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>C13</td>
<td>Capacitor, Ceramic, 4.7 μF, 25 V, X5R, 20%, 0805</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>C14</td>
<td>Capacitor, Ceramic, 1 μF, 50 V, X7R, 10%, 0603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>2</td>
<td>C18, C19</td>
<td>Capacitor, Ceramic, 1000 pF, 50 V, X7R, 10%, 0603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>3</td>
<td>C5, C15, C17</td>
<td>Capacitor, Ceramic, 0.1 μF, 50 V, X7R, 10%, 0603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>C20</td>
<td>Capacitor, Ceramic, 100 pF, 50 V, X7R, 10%, 0603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>L1</td>
<td>Inductor, SMT, 500 nH±15%, 17 A, DCR: 0.29 mΩ±10%, 7 mm × 11 mm</td>
<td>Delta</td>
<td>HCB1175-501TI</td>
</tr>
<tr>
<td>1</td>
<td>R1</td>
<td>Resistor, Chip, 0, 1/16W, 1%, 0603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>R7</td>
<td>Resistor, Chip, 3.01, 1/16W, 1%, 0603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>2</td>
<td>R10, R23</td>
<td>Resistor, Chip, 14.7 k, 1/16W, 1%, 0603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>R11</td>
<td>Resistor, Chip, 10, 1/16W, 1%, 0603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>R13</td>
<td>Resistor, Chip, 187 k, 1/16W, 1%, 0603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>R14</td>
<td>Resistor, Chip, 619 k, 1/16W, 1%, 0603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>R16</td>
<td>Resistor, Chip, 866 k, 1/16W, 1%, 0603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>R17</td>
<td>Resistor, Chip, 309 k, 1/16W, 1%, 0603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>R18</td>
<td>Resistor, Chip, 124 k, 1/16W, 1%, 0603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>R19</td>
<td>Resistor, Chip, 39.2 k, 1/16W, 1%, 0603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>R2</td>
<td>Resistor, Chip, 169 k, 1/16W, 1%, 0603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>R22</td>
<td>Resistor, Chip, 475 k, 1/16W, 1%, 0603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>2</td>
<td>R3, R21</td>
<td>Resistor, Chip, 200 k, 1/16W, 5%, 0603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>R4</td>
<td>Resistor, Chip, 86.6 k, 1/16W, 1%, 0603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>R5</td>
<td>Resistor, Chip, 1.00 k, 1/16W, 1%, 0603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>2</td>
<td>R6, R20</td>
<td>Resistor, Chip, 100 k, 1/16W, 1%, 0603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>R9</td>
<td>Resistor, Chip, 3.01 k, 1/16W, 1%, 0603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>2</td>
<td>R12, R24</td>
<td>Resistor, Chip, 10.0 k, 1/16W, 1%, 0603</td>
<td>STD</td>
<td>STD</td>
</tr>
<tr>
<td>1</td>
<td>U1</td>
<td>IC, 14-A synchronous buck converter with integrated MOSFETs, DQP-22</td>
<td>TI</td>
<td>TPS53319DQP</td>
</tr>
</tbody>
</table>

10 Revision History

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

Changes from Revision * (May 2012) to Revision A (December 2021)

- Updated the numbering format for tables, figures, and cross-references throughout the document. ..................3
- Updated the user's guide title........................................................................................................................................3
STANDARD TERMS FOR EVALUATION MODULES

1. **Delivery:** TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

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 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 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 a nonconforming EVM if (a) the nonconformity was 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, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, 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.

WARNING

Evaluation Kits 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 shall operate the Evaluation Kit within TI's recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI's recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI's instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:
EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.
Regulatory Notices:

3.1 United States

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 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 isotope
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/lsds/tiJa/general/eStore/notice_01.page

３.３．１ 開発キット（EVM）の日本国内への輸入

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/lsds/tiJa/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 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
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.

3.3.3 Notice for EVMs for Power Line Communication: Please see http://www.tij.co.jp/lsds/tiJa/general/eStore/notice_02.page

電力線送信装置についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。http://
www.tij.co.jp/lsds/tiJa/general/eStore/notice_02.page

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.
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 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.

6. Disclaimers:

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED “AS IS” AND “WITH ALL FAULTS.” TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. User’s Indemnity Obligations and Representations. User will 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 handling or use of the EVM that is not in accordance with these terms. This obligation shall apply whether claims arise under statute, regulation, or the law of tort, contract or any other legal theory, and even if the EVM fails to perform as described or expected.
8. **Limitations on Damages and Liability:**

8.1 **General Limitations.** IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVM(S), REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

8.2 **Specific Limitations.** IN NO EVENT SHALL TI’S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMNITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. **Return Policy.** Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

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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