User’s Guide
Using the UCC21520EVM-286, UCC20520EVM-286, UCC21521CEVM-286, and UCC21530EVM-286

ABSTRACT

UCC2x5xxEVM-286 evaluation modules are designed for evaluation of TI's 5.7-kVRMS isolated dual-channel gate driver family with 4-A source and 6-A sink peak current for driving Si MOSFETs, IGBTs and WBG devices such as SiC and GaN transistors. This user’s guide covers the UCC21520EVM-286, UCC20520EVM-286, UCC21521CEVM-286, and UCC21530EVM-286 used to evaluate the UCC21520DW, UCC20520DW, UCC21521CDW, and UCC21530DWK, respectively. To evaluate other Iso-Drivers in the UCC2x5xx family, TI recommends that the user read the data sheet thoroughly before switching the part in the EVMs covered by this user guide. In this user guide, the UCC21520EVM-286 evaluation module is shown as the primary example, and the key differences between the UCC21520EVM-286 and the UCC20520EVM-286, UCC21521CEVM-286, and UCC21530EVM-286 will be highlighted accordingly.

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Introduction

Developed for high voltage applications where isolation and reliability is required, the UCC2x5xx delivers reinforced isolation of 5.7 kV_{RMS} and a surge immunity tested up to 12.8 kV along with a common-mode transient immunity (CMTI) greater than 100 V/ns. It has the industry’s fastest propagation delay of 19 ns and the tightest channel-to-channel delay matching of less than 5 ns to enable high-switching frequency, high-power density, and efficiency.

The flexible, universal capability of the UCC2x5xx with up to 18-V VCCI and 25-V VDDA/VDDB allows the device to be used as a low-side, high-side, high-side/low-side, or half-bridge drivers with dual PWM input or single PWM input. With its integrated components, advanced protection features (UVLO, dead time and enable/disable), and optimized switching performances, the UCC2x5xx enables designers to build smaller, more robust designs for enterprise, telecom, automotive, and industrial applications with a faster time to market.

Description

The UCC2x5xx evaluation board has three independent screw terminal blocks for VCCI, VDDA, and VDDB. The 3-position headers with jumpers for all the key input signals, such as PWM INPUTs (INA, INB or PWM), dead time (DT) programming and enable/disable function (EN/DIS), allow designers to easily evaluate different protection functions. A variety of testing points also support most of the key feature probing of the UCC2x5xx. Moreover, the PCB layout is not only optimized with minimized loop area in each gate driver loop and power supply loop with bypassing capacitors, but the layout also supports high voltage test between the primary side and secondary side with 120-mil PCB board cutout. Importantly, the creepage distance between two output channels are maximized with bootstrap diode in footprint of TO252-2(DPAK), which facilitates high-voltage, half-bridge testing for a wide variety of power converter topologies. For detail device information, refer to UCC21520DW, UCC20520DW, UCC21521CDW and UCC21530DWK data sheets and TI's Isolated gate driver solutions.
3 Features

- Evaluation module for the UCC21520DW, UCC20520DW, and UCC21521CDW in a wide body SOIC-16 (DW), along with the UCC21530DWK in wide body SOIC-14 (DWK) package
- 3-V to 18-V VCCI power supply range, and up to 25-V VDDA/VDDB power supply range
- 4-A and 6-A source/sink current capability
- 5.7-kV_{RMS} isolation for 1 minute per UL 1577
- TTL/CMOS-compatible inputs
- Onboard trimmer potentiometer for dead-time programming
- 3-position header with for INA, INB, DT and enable/disable
- PCB layout optimized for power supply bypassing cap, gate driver loop
- PCB board cutout that facilitates high voltage isolation test between primary side and secondary side
- Maximized creepage distance between two output channels
- Support for half-bridge test with MOSFETs, IGBTs and SiC MOSFETs with connection to external power stage
- Testing points allows probing all the key pins of the UCC21520DW, UCC20520DW, UCC21521CDW, UCC21530DWK, and other wide-body ISO driver family parts.

3.1 I/O Description

<table>
<thead>
<tr>
<th>PINS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>J1–VCCI</td>
<td>VCCI positive</td>
</tr>
<tr>
<td>J1–INA</td>
<td>INA/PWM signal</td>
</tr>
<tr>
<td>J1–GND</td>
<td>VCCI ground</td>
</tr>
<tr>
<td>J2–VCCI</td>
<td>VCCI positive</td>
</tr>
<tr>
<td>J2–INB</td>
<td>INB signal</td>
</tr>
<tr>
<td>J2–GND</td>
<td>VCCI ground</td>
</tr>
<tr>
<td>J3–VCCI</td>
<td>VCCI positive</td>
</tr>
<tr>
<td>J3–EN/DIS</td>
<td>Enable/Disable signal</td>
</tr>
<tr>
<td>J3–GND</td>
<td>VCCI ground</td>
</tr>
<tr>
<td>J4–VCCI</td>
<td>VCCI positive</td>
</tr>
<tr>
<td>J4–DT</td>
<td>Dead-time programming pin</td>
</tr>
<tr>
<td>J4–R2</td>
<td>Connects to trimmer potentiometer</td>
</tr>
<tr>
<td>TP1</td>
<td>Primary VCC input</td>
</tr>
<tr>
<td>TP2/TP4/TP6/TP8/TP10</td>
<td>Primary Ground input</td>
</tr>
<tr>
<td>TP3</td>
<td>INA/PWM signal</td>
</tr>
<tr>
<td>TP5</td>
<td>INB signal</td>
</tr>
<tr>
<td>TP7</td>
<td>EN/DIS signal</td>
</tr>
<tr>
<td>TP9</td>
<td>Dead-time programing</td>
</tr>
<tr>
<td>TP17</td>
<td>VDDA secondary side supply</td>
</tr>
<tr>
<td>TP18</td>
<td>OUTA driver output</td>
</tr>
<tr>
<td>TP19</td>
<td>VSSA secondary side ground</td>
</tr>
<tr>
<td>TP20</td>
<td>VDDB secondary side supply</td>
</tr>
<tr>
<td>TP21</td>
<td>OUTB driver output</td>
</tr>
<tr>
<td>TP22</td>
<td>VSSB secondary side ground</td>
</tr>
</tbody>
</table>
3.2 Jumpers (Shunt) Setting

Table 3-2. Jumpers Setting

<table>
<thead>
<tr>
<th>JACK</th>
<th>Jumper Setting Options</th>
<th>FACTORY SETTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>J-INA</td>
<td>Option A: Jumper not installed, INA/PWM signal provided by external signal and this pin is default low if left open</td>
<td>Option A for UCC21520EVM-286, UCC21521CEVM-286 and UCC21530EVM-286; Option D for UCC20520EVM-286</td>
</tr>
<tr>
<td></td>
<td>Option B: Jumper on J1-INA and J1-GND set INA low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Option C: Jumper on J1-INA and J1-VCCI set INA high</td>
<td></td>
</tr>
<tr>
<td>J-INB</td>
<td>Option A: Jumper not installed, INB signal provided by external signal and this pin is default low if left open</td>
<td>Option A for UCC21520EVM-286 and UCC20520EVM-286; Option B for UCC21521CEVM-286 and UCC21530EVM-286</td>
</tr>
<tr>
<td></td>
<td>Option B: Jumper on J2-INB and J2-GND set INB low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Option C: Jumper on J2-INB and J2-VCCI set INB high</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Option D: Header J2-INB is not installed, and no connection on the device under test</td>
<td></td>
</tr>
<tr>
<td>J-DIS or J-DIS/EN</td>
<td>Option A: Jumper not installed, the devices under test are enabled when left open on enable/disable pin</td>
<td>Option C for UCC21520EVM-286 and UCC20520EVM-286; Option B for UCC21521CEVM-286 and UCC21530EVM-286</td>
</tr>
<tr>
<td></td>
<td>Option B: Jumper on J3-EN/DIS and J3-GND</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Option C: Jumper on J3-EN/DIS and J3-VCCI</td>
<td></td>
</tr>
<tr>
<td>J-DT</td>
<td>Option A: Jumper not installed, interlock with 8-ns dead time</td>
<td>Option B</td>
</tr>
<tr>
<td></td>
<td>Option B: Jumper on J4-DT and J4-VCCI allows driver output overlap or driver output follows PWM input for UCC21520EVM and UCC21521CEVM. The dead time will be around 0 ns in this option for UCC20520EVM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Option C: Jumper on J4-DT and J4-R2 set the dead time by DT (in ns) = RDT (in kΩ) × 10. For better noise immunity and dead-time matching, TI recommends to parallel a 2.2-nF or above bypassing capacitor from DT pin to GND.</td>
<td></td>
</tr>
</tbody>
</table>

4 Electrical Specifications

Table 4-1. UCC2x5xxEVM-286 Electrical Specifications

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCCI</td>
<td>3</td>
<td>18</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>VDDA, VDOB</td>
<td>9.2</td>
<td>25</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>F_S</td>
<td>0</td>
<td>5</td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>T_J</td>
<td>-40</td>
<td>125</td>
<td></td>
<td>°C</td>
</tr>
</tbody>
</table>

Using the UCC21520EVM-286, UCC20520EVM-286, UCC21521CEVM-286, and UCC21530EVM-286

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5 Test Summary

The UCC21520EVM-286 is used as the primary example for this section. Different Jumper settings, PWM signal input options and voltage source settings can be found in Section 2 and Section 4.

5.1 Definitions

This procedure details how to configure the UCC2x5xx evaluation board. Within this test procedure the following naming conventions are followed. Refer to the UCC21520EVM-286 Schematic in Figure 8-1 for details.

- \( V_{XX} \) External voltage supply name
- \( V_{(TPxx)} \) Voltage at test point TPxx. For example, \( V(TP12) \) means the voltage at TP12
- \( V_{(Jxx)} \) Voltage at jack terminal Jxx
- \( J_{xx(yy)} \) Terminal or pin yy of jack xx
- DMM Digital multi-meters
- UUT Unit under test
- EVM Evaluation module assembly, in this case the UUT assembly drawings have location for jumpers, test points and individual components

5.2 Equipment

5.2.1 Power Supplies

Three DC power supply with voltage/current above 25 V/1 A (for example, Agilent E3634A).

5.2.2 Function Generators

One two-channel function generator over 20 MHz (for example, Tektronics AFG3252).

5.3 Equipment Setup

5.3.1 DC Power Supply Settings

- DC power supply #1
  - Voltage setting: 5 V
  - Current limit: 0.05 A
- DC power supply #2
  - Voltage setting: 12 V for UCC21520EVM and UCC20520EVM
  - Voltage setting: 15 V for UCC21521CEVM and UCC21530EVM
  - Current limit: 0.1 A
- DC power supply #3
  - Voltage setting: 12 V for UCC21520EVM and UCC20520EVM
  - Voltage setting: 15 V for UCC21521CEVM and UCC21530EVM
  - Current limit: 0.1 A

5.3.2 Digital Multi-Meter Settings

- Digital multi-meter #1
  - DC current measurement, auto-range.
- Digital multi-meter #2
  - DC current measurement, auto-range.
5.3.3 Two-Channel Function Generator Settings

Table 5-1. Two-Channel Function Generator Settings

<table>
<thead>
<tr>
<th></th>
<th>MODE</th>
<th>FREQUENCY</th>
<th>DUTY</th>
<th>DELAY</th>
<th>HIGH</th>
<th>LOW</th>
<th>OUTPUT IMPEDANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel A</td>
<td>Pulse</td>
<td>DC ~ 5 MHz</td>
<td>50%</td>
<td>0 ns</td>
<td>3.3 V</td>
<td>0 V</td>
<td>High Z</td>
</tr>
<tr>
<td>Channel B</td>
<td></td>
<td></td>
<td></td>
<td>100 ns</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.3.4 Oscilloscope Setting

Table 5-2. Oscilloscope Settings

<table>
<thead>
<tr>
<th></th>
<th>BANDWIDTH</th>
<th>COUPLING</th>
<th>TERMINATION</th>
<th>SCALE SETTINGS</th>
<th>INVERTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel A</td>
<td>500 MHz or above</td>
<td>DC</td>
<td>1 MΩ or automatic</td>
<td>10× or automatic</td>
<td>OFF</td>
</tr>
<tr>
<td>Channel B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.3.5 Jumper (Shunt) Settings

There are two jumpers (shunts) need to be installed before test:

1. Install shunt #1 for header J3-DIS on pin EN/DIS-GND for the UCC21520EVM shown in Figure 5-1. For the UCC20520EVM, UCC21521CEVM and the UCC21530EVM, refer to Table 3-1. The UCC20520EVM is set as disable high on the DIS pin while the UCC21521CEM and UCC21530EVM is set as enable high on the EN pin.
2. Install shunt #2 on header J4-DT on pin VCCI-DT as shown in Figure 5-1.

![Figure 5-1. Jumpers Installation Position](image-url)
5.3.6 Bench Setup Diagram

The current bench setup diagram includes the function generator and oscilloscope connections.

Use the following connection procedure and also use Figure 5-2 as a reference:

• Make sure all the output of the function generator, voltage source are disabled before connection;
• Function generator channel-A channel applied on INA (TP3) ←→ GND (TP14) as seen in Figure 5-2;
• Function generator channel-B channel applied on INB (TP5) ←→ GND (TP6) as seen in Figure 5-2. For the UCC20520EVM, INB, J-INB and TP15 are not installed because the UCC20520 is a single PWM input, dual-channel output Iso-Driver;
• Power supply #1: positive node applied on VCCI (TP1), and negative node applied on GND (TP2);
• Power supply #2: positive node connected to input of DMM #1 and DMM #1 output connected to VDDA (TP17), negative node connected directly to VSSA (TP19);
• Power supply #3: positive node connected to input of DMM #2 and DMM #2 output connected to VDDB (TP20), negative node connected directly to VSSB (TP22);
• Oscilloscope channel-A probes TP14, smaller measurement loop is preferred;
• Oscilloscope channel-B probes TP16, smaller measurement loop is preferred;

---

**Figure 5-2. Bench Setup Diagram and Configuration**
6 Power-Up and Power-Down Procedure

6.1 Power Up

1. Make sure that Section 5.3.6 is implemented for setting up all the equipment before starting the power-up sequence. Figure 6-1 can be used as a reference.
2. Enable supply #1;
3. Enable supply #2 and #3, the quiescent current on DMM1 and DMM2 ranges from 1 mA to approximately 3 mA if everything is set correctly;
4. Enable the function generator, two-channel outputs: channel-A and channel-B;
5. There will be:
   a. Stable pulse output on the channel-A and channel-B in the oscilloscope (refer to Figure 6-1);
   b. Scope frequency measurement is the same with function generator output;
   c. DMM #1 and #2 read measurement results should be around 10 mA, ±2 mA under no load conditions. For more information about operating current, refer to the UCC21520 data sheet.

![Figure 6-1. Example Input and Output Waveforms (Channels 3 and 4 are PWM Inputs, Channels 1 and 2 are Outputs)](image-url)

6.2 Power Down

1. Disable function generator;
2. Disable power supply #2 and #3;
3. Disable power supply #1;
4. Disconnect cables and probes;
7 Test Waveforms \((C_L=0\text{pF})\) With Different DT Configurations

7.1 DT Connected to VCCI (J-DT Option B in Table 3-2)

The dead time (DT) between the outputs of the two channels is decided by inputs (see Figure 7-1). Overlap between two output channels is allowed. Figure 7-1 shows a waveform with overlapped operations.

Figure 7-1. Overlap is Allowed When DT Connected to VCCI (Channels 3 and 4 are PWM Inputs, Channels 1 and 2 are Driver Outputs)

7.2 DT Pin Floating or Left Open (J-DT Option A in Table 3-2)

The dead time (DT) between the outputs of the two channels is around 8 ns, which is preset for interlock protections (see Figure 7-2).

Figure 7-2. Test Waveforms if DT is Left Open (Channel 3 and 4 are PWM Inputs, and Channel 1 and 2 are Driver Outputs)
7.3 DT Pin Connected to RDT (J-DT Option C in Table 3-2)

The dead time (DT) between the outputs of the two channels is set according to: DT (in ns) = 10 × RDT (in kΩ).

The steady-state voltage at DT pin is around 0.8 V, and the DT pin current will be less than 10 µA when R\text{DT} = 100 kΩ. Therefore, TI recommends to parallel a ceramic bypass capacitor (2.2 nF or above) with R\text{DT} to achieve better noise immunity and better dead-time matching between two channels, especially when the dead time is larger than 300 ns. The major consideration is that the current through the R\text{DT} is used to set the dead time, and this current decreases as R\text{DT} increases. This bypass capacitor is not installed in the EVM, but the user can easily install it on the bottom layer where the R\text{DT} is located.

Figure 7-3. Test Waveforms if DT Connected to R\text{DT} (Channel 3 and 4 is PWM Inputs, and Channel 1 and 2 is Driver Outputs)
8 Schematic

Figure 8-1 only shows the schematic diagram for UCC21520EVM. The schematic diagrams for the UCC20520EVM, UCC21521CEVM, and UCC21530EVM are similar to Figure 8-1, with the exception that the device under test (U1) could be in one of the following driver ICs: UCC21520DW, UCC20520DW, UCC21521CDW, or UCC21530DWK.

Figure 8-1. UCC21520EVM-286 Schematic
9 Layout Diagrams

The PCB layout information for UCC21520EVM is shown in Figure 9-1, Figure 9-2, Figure 9-3, and Figure 9-4. The layouts are the same for UCC20520EVM, UCC21521CEVM, and UCC21530EVM except for the labels that designate the EVM part number with the device under test.

Figure 9-1. Top Overlay

Figure 9-2. Top Layer

Figure 9-3. Bottom Layer

Figure 9-4. Bottom Overlay
### Table 10-1. UCC2x5xxEVM-286 List of Materials

<table>
<thead>
<tr>
<th>QTY</th>
<th>DES</th>
<th>DESCRIPTION</th>
<th>MANUFACTURE</th>
<th>PART NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>C1, C13</td>
<td>CAP, CERM, 1 µF, 50 V, +/- 10%, X7R, 0805</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>1</td>
<td>C2</td>
<td>CAP, CERM, 0.1 uF, 25 V, +/- 10%, X7R, 0603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>2</td>
<td>C4, C5</td>
<td>CAP, CERM, 33 pF, 50 V, +/- 5%, C0G/NP0, 0603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>2</td>
<td>C6, C7</td>
<td>CAP, CERM, 2200 pF, 50 V, +/- 10%, X7R, 0603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>1</td>
<td>C9</td>
<td>CAP, CERM, 10 uF, 50 V, +/- 10%, X7R, 1206</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>2</td>
<td>C14, C10</td>
<td>CAP, CERM, 0.1 uF, 50 V, +/- 5%, X7R, 0805</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>2</td>
<td>C11, C12</td>
<td>CAP, CERM, 1000 pF, 50 V, +/- 5%, C0G/NP0, 1206</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>4</td>
<td>H1, H2, H3, H4</td>
<td>Bumpon, Hemisphere, 0.44 X 0.20, Clear</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>4</td>
<td>J1, J2, J3, J4</td>
<td>Header, 2.54 mm, 3x1, Tin, TH</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>1</td>
<td>R2</td>
<td>Trimmer, 100 K, 0.25 W, SMD</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>3</td>
<td>R3, R5, R7</td>
<td>RES, 100, 1%, 0.1 W, AEC-Q200 Grade 0, 0603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>6</td>
<td>R4, R6, R8, R10, R16, R17</td>
<td>RES, 10.0 k, 1%, 0.1 W, 0603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>3</td>
<td>R9, R18, R19</td>
<td>RES, 0, 0%, 0.25 W, AEC-Q200 Grade 0, 0603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>2</td>
<td>R12, R13</td>
<td>RES, 10.0, 1%, 0.5 W, AEC-Q200 Grade 0, 0608</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>2</td>
<td>SH1, SH2</td>
<td>Shunt, 100mil, Flash Gold, Black</td>
<td>Std</td>
<td>Std</td>
</tr>
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<td>16</td>
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<td>Texas Instruments</td>
<td>UCC21520DW, UCC20520DW, UCC21521CDW, or UCC21530DWK</td>
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### 11 Revision History

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

**Changes from Revision B (November 2018) to Revision C (October 2021)**

- Updated Jumpers Setting table ................................................................. 3
- Updated Jumpers (Shunt) Setting table ....................................................... 4
- Updated Jumper Installation Position image ............................................. 6
- Updated the Bench Setup Diagram and Configuration image .................... 7
- Updated Schematic ..................................................................................... 11
- Updated list of materials .......................................................................... 13
### Changes from Revision A (November 2016) to Revision B (November 2018) Page
- Added device type to include the UCC21530EVM-286 Evaluation Module.................................................. 1

### Changes from Revision * (June 2016) to Revision A (November 2016) Page
- Added device type to include the UCC20520EVM-286 and UCC21521CEVM-286 Evaluation Modules........ 1
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 DEGRATION 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 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 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/ti_ja/general/eStore/notice_01.page 日本国に
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/ti_ja/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
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.

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 designers. 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 designers.

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.

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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 EVMs, 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.

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