This document is provided with the BOOSTXL-DRV8323Rx customer evaluation module (EVM) as a supplement to the DRV8323Rx data sheet (DRV832x 6 to 60-V Three-Phase Smart Gate Driver). This user’s guide details the hardware implementation of the EVM and how to install the various software packages.

IMPORTANT: As of 1 May 2017, all BOOSTXL-DRV8323RH EVMs with a MDBU017 A number have an SO offset that does not meet the value specified in the data sheet. All other EVMs with a MDBU017 letter greater than A meet the SO offset specification in the data sheet.

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Trademarks

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1 Introduction

1.1 Overview

The DRV8323Rx is a gate driver IC for three phase motor drive applications. It provides three high-accuracy trimmed and temperature compensated half bridge drivers, each capable of driving a high-side and low-side N-type MOSFET.

Both SPI and hardware interface variants provide detailed fault reporting and flexible parameter settings such as current control options for slew rate control of the gate drivers and various protection features.

Along with the hardware of DRV8323Rx, the MSP430F5529 microcontroller has loaded reference software that provides the necessary gating pulses to DRV8323Rx to control the BLDC motors.

Figure 1. Block Diagram

1.2 Purpose and Scope

This document is designed to be used as a startup guide and to supplement the DRV832X + MSP430F5529 BLDC motor control demo code kit. This document is intended for the engineers involved in the design, implementation, and validation of DRV832X + MSP430F5529 reference software.

The scope of this document is to provide the user with a guide to evaluate the DRV8323Rx device with an MSP430F5529 LaunchPad™ development kit. This document covers the hardware connections required between DRV8323Rx and the LaunchPad development kit. When the HW connections are complete, the user is required to download the necessary tools and SW to spin a motor. For step-by-step details to install Code Composer Studio™ (CCS) software, import the DRV832xx project into CCS, build the project and spin the motor, refer to Section 3.

This reference SW comprises trapezoidal sensored and sensorless algorithms for BLDC motor control. For additional information on these algorithms, refer to DRV832XX EVM Sensored Software User's Guide and DRV832XX EVM Sensorless Software User's Guide
2 Hardware and Software Overview

2.1 Hardware Connections Overview – DRV8323Rx + MSP430F5529

Figure 2 shows the major blocks of the hardware where the BOOSTXL-DRV8323Rx BoosterPack™ plug-in module is mounted on the MSP430F5529 XL LaunchPad development kit. The BOOSTXL-DRV8323Rx is designed for an input supply from 6 to 54 V and up to 15-A drive current. Three half h-bridges capable of driving a three-phase BLDC motor implementing sensored or sensorless control. Hall sensor pins a, b, c are connected to pins P2.0, P2.2, and P2.6 of the MSP430™ MCU respectively. The 3.3-V supply to the Hall sensors is derived by the LMR16006XDDCR buck converter integrated in the DRV8323Rx.

![Figure 2. Hardware Connections Overview](image)
2.2 Connection Details

Figure 3 shows the power connector and motor phase connector. A supply voltage ranging from 6 to 54 V from a battery or a DC voltage source is connected to the voltage supply pins. Three phases of the BLDC motor are connected to the three-phase motor socket provided on the BOOSTXL-DRV8323Rx.

Figure 3. Connections

Figure 4 and Figure 5 show the jumper pin connections required for the proper functioning of the software.
Figure 4. Jumper Connections 1

Figure 5. Jumper Connections 2

Figure 6 shows where the Micro-USB cable is plugged in to power the LaunchPad development kit and provide communication between the MSP430F5529 firmware and GUI.
Two LEDs and two push button switches are available on the MSP430F5529 LaunchPad development kit to notify the user of different motor statuses and to control the operation of the motor. These switches are configured in the reference software and preloaded with the following functions:

**P1.1 switch (motor direction reversal)** — This switch allows user to toggle the direction of motor spin either to be clockwise or counterclockwise rotation.

**P2.1 switch (fault clear switch)** — This switch is configured to clear the fault status in SPI registers and to restart the motor. When the user does not want automatic fault recovery when a fault occurs, it can be turned off in the parameter setup file. In such cases, this button helps in restarting motor after successful identification and mitigation of fault.
LED1 and LED2 — During normal motor operations LED1 and LED2 define the direction of spin. When any fault occurs, LED1 and LED2 flashes in different patterns to identify the fault. Table 1 describes the patterns observed with different fault conditions.

Table 1. Fault Status

<table>
<thead>
<tr>
<th>Fault Status</th>
<th>LED 1</th>
<th>LED 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>Toggle</td>
<td>Toggle</td>
</tr>
<tr>
<td>Motor stall</td>
<td>ON</td>
<td>Toggle</td>
</tr>
<tr>
<td>Overcurrent</td>
<td>Toggle</td>
<td>ON</td>
</tr>
<tr>
<td>Overtemperature</td>
<td>ON</td>
<td>OFF</td>
</tr>
<tr>
<td>Gate driver</td>
<td>ON</td>
<td>ON</td>
</tr>
<tr>
<td>Other</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>Hall sensor invalid (Sensored)</td>
<td>OFF</td>
<td>ON</td>
</tr>
</tbody>
</table>

2.4 Interfacing DRV8323Rx and MSP430F5529 LaunchPad

The DRV8323Rx device has 40 pins with different functions. These pins are interfaced with the MSP430F5529XL LaunchPad development kit which is mapped appropriately to receive the functionality of the BoosterPack plug-in module. These 40 pins are grouped into 4 ports. Table 2 and Table 3 list the interfacing of these ports with the MSP430F5529 device.

Table 2. BOOSTXL-DRV8323Rx J3 Pin Connections

<table>
<thead>
<tr>
<th>J3 Pin Number</th>
<th>BOOSTXL-DRV8323Rx Function</th>
<th>MSP430F5529 Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.3 V</td>
<td>3.3 V</td>
<td>3.3 V LaunchPad supply</td>
</tr>
<tr>
<td>2</td>
<td>No function</td>
<td>5 V</td>
<td>5 V supply</td>
</tr>
<tr>
<td>3</td>
<td>VSENVM</td>
<td>P6.5, ADC channel – A5</td>
<td>Sensing VCC supply voltage</td>
</tr>
<tr>
<td>4</td>
<td>GND</td>
<td>GND</td>
<td>ADC - GND connections</td>
</tr>
<tr>
<td>5</td>
<td>No function</td>
<td>P3.4, I/O PIN</td>
<td>Software debug pins (optional)</td>
</tr>
<tr>
<td>6</td>
<td>VSENA</td>
<td>P6.0, ADC channel – 0</td>
<td>Sensing A phase voltage</td>
</tr>
<tr>
<td>7</td>
<td>No function</td>
<td>P3.3, I/O PIN</td>
<td>Software debug pins (optional)</td>
</tr>
<tr>
<td>8</td>
<td>VSENB</td>
<td>P6.1, ADC channel – 1</td>
<td>Sensing B phase voltage</td>
</tr>
<tr>
<td>9</td>
<td>ENABLE</td>
<td>P1.6, I/O pin with Interrupt</td>
<td>Logic low to enter a low-power sleep mode</td>
</tr>
<tr>
<td>10</td>
<td>VSENC</td>
<td>P6.2, ADC channel – 2</td>
<td>Sensing C phase voltage</td>
</tr>
<tr>
<td>11</td>
<td>POT</td>
<td>P6.6, ADC channel – A6</td>
<td>Optional POT to vary the voltage 0-3.3 V on pin</td>
</tr>
<tr>
<td>12</td>
<td>ISENC</td>
<td>P6.3, ADC channel – 3</td>
<td>Sensing C phase current</td>
</tr>
<tr>
<td>13</td>
<td>SCLK</td>
<td>P3.2, UCBOCLK – SPI CLK</td>
<td>Secondary function for pin SPI CLK</td>
</tr>
<tr>
<td>14</td>
<td>ISENB</td>
<td>P6.4, ADC channel – 4</td>
<td>Sensing B phase current</td>
</tr>
<tr>
<td>15</td>
<td>NFAULT</td>
<td>P2.7, I/O pin with Interrupt</td>
<td>Pulled logic low during a fault condition</td>
</tr>
<tr>
<td>16</td>
<td>ISENA</td>
<td>P7.0, ADC channel – 12</td>
<td>Sensing A phase current</td>
</tr>
<tr>
<td>17</td>
<td>No function</td>
<td>P4.2, I/O pin</td>
<td>Software debug pins (optional)</td>
</tr>
<tr>
<td>18</td>
<td>IDRIVE</td>
<td>P3.6, I/O pin</td>
<td>Sets gate drive peak current, 7-level input pin (DRV8323RH devices only)</td>
</tr>
<tr>
<td>19</td>
<td>No function</td>
<td>P4.1, I/O pin</td>
<td>Software debug pins (optional)</td>
</tr>
<tr>
<td>20</td>
<td>VDS</td>
<td>P3.5, I/O pin</td>
<td>Sets VDS monitor threshold voltage, 7-level input pin (DRV8323RH devices only)</td>
</tr>
</tbody>
</table>
Table 3. BOOSTXL-DRV8323RX J4 Pin Connections

<table>
<thead>
<tr>
<th>J4 Pin Number</th>
<th>BOOSTXL-DRV8323Rx Function</th>
<th>MSP430F5529 Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>INHA</td>
<td>P2.5, TA2.2</td>
<td>Secondary function, Timer 2 comparator output to generate PWM for A phase high-side switches</td>
</tr>
<tr>
<td>2</td>
<td>GND</td>
<td>GND</td>
<td>ADC - GND connections</td>
</tr>
<tr>
<td>3</td>
<td>INLA</td>
<td>P2.4, TA2.1</td>
<td>Secondary function, Timer 2 comparator output to generate PWM for A phase low-side switches</td>
</tr>
<tr>
<td>4</td>
<td>HALLA</td>
<td>P2.0, SPI enable</td>
<td>Hall sensor A from motor</td>
</tr>
<tr>
<td>5</td>
<td>INHB</td>
<td>P1.5, TA0.4</td>
<td>Secondary function, Timer 1 comparator output to generate PWM for B phase high-side switches</td>
</tr>
<tr>
<td>6</td>
<td>HALLB</td>
<td>P2.2, I/O PIN with Interrupt</td>
<td>Hall sensor B from motor</td>
</tr>
<tr>
<td>7</td>
<td>INLB</td>
<td>P1.4, TA0.3</td>
<td>Secondary function, Timer 1 comparator output to generate PWM for B phase low-side switches</td>
</tr>
<tr>
<td>8</td>
<td>No function</td>
<td>P7.4, I/O pin</td>
<td>No function</td>
</tr>
<tr>
<td>9</td>
<td>INHC</td>
<td>P1.3, TA0.2</td>
<td>Secondary function, Timer 1 comparator output to generate PWM for C phase high-side switches</td>
</tr>
<tr>
<td>10</td>
<td>No function</td>
<td>RST</td>
<td>No function</td>
</tr>
<tr>
<td>11</td>
<td>INLC</td>
<td>P1.2, TA0.1</td>
<td>Secondary function, Timer 1 comparator output to generate PWM for C phase low-side switches</td>
</tr>
<tr>
<td>12</td>
<td>SDI</td>
<td>P3.0,UCBOSIMO</td>
<td>Secondary function for data input to DRV832xx</td>
</tr>
<tr>
<td>13</td>
<td>MODE</td>
<td>P4.3, I/O pin</td>
<td>Sets the input control mode, 4-level input pin (DRV8323RH devices only)</td>
</tr>
<tr>
<td>14</td>
<td>SDO</td>
<td>P3.1,UCBOSOMI</td>
<td>Secondary function for data output from DRV832xx</td>
</tr>
<tr>
<td>15</td>
<td>LED</td>
<td>P4.0, I/O pin</td>
<td>Visual feedback for faults.</td>
</tr>
<tr>
<td>16</td>
<td>HALLC</td>
<td>P2.6, I/O pin With Interrupt</td>
<td>Hall sensor C from motor enable the gate driver and current shunt amplifiers</td>
</tr>
<tr>
<td>17</td>
<td>EVM ID</td>
<td>P3.7, I/O pin</td>
<td>Pulled low for DRV8320x, high for DRV8323x devices</td>
</tr>
<tr>
<td>18</td>
<td>nSCS/GAIN</td>
<td>P2.2, I/O PIN with Interrupt</td>
<td>Active low enables serial interface communication</td>
</tr>
<tr>
<td>19</td>
<td>EVM ID</td>
<td>P8.2, I/O pin</td>
<td>Pulled low for DRV832xH, high for DRV832xS devices</td>
</tr>
<tr>
<td>20</td>
<td>CAL</td>
<td>P8.1, I/O pin</td>
<td>Pull logic high to internally short all amplifier inputs together</td>
</tr>
</tbody>
</table>

3 Firmware Installation

3.1 Installing Code Composer Studio

CCS versions 5.x.x and 6.x.x have been used and tested for DRV832XX reference code. An authorized version can be installed from www.ti.com/tool/ccstudio.

NOTE: A myTI login account is required to download CCS as well as the SDK package. This section describes the installation procedure for CCS5.4; however, installing other versions of CCS v5.x including CCS v6.x is similar.

After following the required steps to download the CCS installer, the ccs_setup_5.4.0.00091.exe file should be located in the specified download directory. Figure 8 shows this file.

Figure 8. Downloaded Executable for Code Composer Studio Installation

3.1 Installing Code Composer Studio

Follow the installation process listed:

Step 1. Run the installer by double clicking the ccs_setup_win32.exe file.
Step 2. Read through and accept the license agreement to proceed with the installation (see Figure 9).

![Figure 9. CCS License Agreement](image)

Step 3. Choose a destination directory. Using the default (c:\ti) removes a step in the SDK installation procedure (see Figure 10).

![Figure 10. Default Installation Location for CCS](image)

Step 4. Choose the processor architectures to install (see Figure 11).
For the DRV83xx, the MSP430 and C28x are the only needed processor packages. The compiler tools are required. Ensure that the box for the *TI MSP430 Compiler Tool* is checked.
Step 5. Select the emulator components to install.
For the provided tool, the MSP430 USB FET emulator is required.

Step 6. Review the installation size and click the finish button to begin installation of the CCS software (see Figure 12).

Step 7. Choose add-on software (this step is optional).

Step 8. Review the installation and click the Finish button to finalize (see Figure 13).
Step 9. After the installation has completed, click the Finish button to exit the set-up.

3.2 Installing DRV832X Reference Software Development Package

The DRV832X Reference software contains the files required to program DRV832X devices along with the MSP430F5529 using CCS v5.x or CCS v6.x. All of these files are included in the installation package. To download this package, go to the respective EVM tool page on TI.com (BOOSTXL-DRV8323RH or BOOSTXL-DRV8323RS).

To install the reference software development package, follow these steps:

Step 1. Double click the executable file (.exe) for the DRV832XX reference software installer (see Figure 14).

![Figure 14. DRV832XX EVM Firmware Executable File](image)

Step 2. Follow the prompts to select another language from the default of English (see Figure 15).

![Figure 15. Language Selection](image)

Step 3. Click the Next button on the DRV832XX Installer welcome screen (see Figure 16).
Step 4. Read though and accept the license agreement to proceed with the installation (see Figure 17).

Step 5. Choose the destination location for the example CCS projects and the documentation (see Figure 18). This destination can be set to any location in the PC.
Step 6. Select each DRV8x components to Install (see Figure 19).

Step 7. Ensure all running instances of CCS are closed (see Figure 20).
Step 8. Continue with the installation process.
Step 9. Click the Next button to install after reviewing the settings.
Step 10. Click the Finish button when the files are successfully installed in the destination folder (see Figure 21).
3.3 Creating or Importing a DRV8x Project into CCS

When the CCS software is started, the user must first select a workspace. A workspace is the structure in which projects are kept. Multiple projects can be saved in one workspace. TI recommends starting with the project for the specific DRV8x device. After importing an existing project, the user can explore the features of CCS to become familiar with the IDE. Follow these steps to import the provided project:

Step 1. Double click the CCS icon to open the application. A CCS icon is placed on the desktop after installation.

Step 2. Select the location and name of the workspace. The location and naming convention can be changed based on the user's preference (see Figure 22).

Step 3. Click the OK button to accept.

Step 4. Import a project either from the welcome menu by selecting Import Project or go to the Project menu and select Import Existing CCS Eclipse Project (see Figure 23).

Step 5. In the new window that appears showing the import options, click the Browse... button and find the provided projects through the folder browser. These projects are located in the SDK installation directory. The example location is C:\ti\DRV832XX-V1.0 (see Figure 24). When selected, the provided project appears under Discovered Projects.

Step 6. Make sure the correct box is checked and then click the Finish button (see Figure 24).
When the projects are imported to the workspace, the project should appear in the Project Explorer window as shown in Figure 25.

Step 7. Explore the project files, build the project to create an image to be downloaded on the MSP430F5529 hardware, and download the project from here. Make sure the MSP430F5529 is connected to the PC through USB interface before downloading the code.
Step 8. When the CCS software is connected to the device, run the program from CCS to execute the program in hardware by clicking the green play button (see Figure 27). Click the red stop button (see Figure 27) to disconnect the MSP-FET430UIF from.

![Figure 27. Execute Buttons](image)

A new window appears showing loading of the program on MSP430 hardware (see Figure 28).

![Figure 28. Flashing Firmware](image)

Step 9. To create a new project, start by clicking on the File menu, select New, and then CCS Project. A new window appears. Complete these steps to proceed:

1. Fill in the Project Name text field.
2. Under the Family drop-down menu, select MSP430x5xx Family.
3. Select MSP430F5529 from the Variant drop-down menu and the specific device in the adjoining field.
3.4 **Updating the MSP430 USB-FET**

After the reference project is imported and selected in the CCS software, the provided software builds and runs on the MSP430 device. The device is programmed by the MSP430 USB-FET. When this device is used, the CCS software automatically detects the firmware version and notifies of an update. The process takes a few minutes, let the update complete before unplugging the USB cable or closing CCS. Figure 30 and Figure 31 show the update process.

**CAUTION**

To help prevent any device damage, wait for the update to finish before unplugging the MSP430 device or closing CCS.
4 GUI Application

4.1 Installation

Follow these steps to install the GUI application:

Step 1. Download and run the Setup_boostxldrv832x-1.0.0_EVM.exe installer file to install the GUI application.

Step 2. Install the COM port driver for TI MSP430 USB (the firmware on MSP430F5529 LaunchPad development kit plug-in module).

This driver is automatically installed during the GUI installation process. Click the Install button when the window shown in Figure 32 appears during the GUI installation. If this pop-up does not appear, then the drivers are already installed.
If the automatic driver installation fails for some reason, or if the Don’t Install button was clicked, install the drivers manually. First find the driver .inf file (msp430_ti_signed.inf) in the following folder: C:\Program Files (x86)\Texas Instruments\BOOSTXL-DRV832X\TI MSP430 USB Driver. Right click on the .inf file and select the Install option. Follow the installation instructions to successfully install the driver.

If any issues occur during the driver installation steps or to learn more about the process, download and extract the MSP430 USB Developers Package from www.ti.com/tool/msp430usbdevpack and refer to sections 2.5.2 for Windows 7 and 2.5.3 for Windows 8 in the document Examples_Guide_MSP430_USB.pdf based on the appropriate Windows. This document can be found under the MSP430USBDevelopersPackage_5_10_00_17\MSP430_USB_Software\Documentation directory of the extracted MSP430 USB Developers Package.

4.2 Hardware Setup

The hardware required to run the motor control is an MSP430F5529 LaunchPad development kit, the BOOSTXL-DRV8323Rx BoosterPack plug-in module, a Micro-USB cable, and a power supply with a DC output from 8 to 54 V. Follow these steps to start up the BoosterPack plug-in module:

   Step 1. Dock the BOOSTXL-DRV8323Rx BoosterPack plug-in module to the MSP430F5529 LaunchPad development kit through the two 40-pin headers J3 and J4.

   NOTE: Observe the correct polarity of the 40-pin LaunchPad headers. The MSP430F5529 LaunchPad header J1 should be connected to BOOSTXL-DRV8323Rx BoosterPack header J3 and MSP430F5529 LaunchPad header J2 should be connected to BOOSTXL-DRV8323Rx BoosterPack header J4.

   Step 2. Connect the three phases from the brushless DC motor to the J5 connector on the BOOSTXL-DRV8323Rx BoosterPack plug-in module. Phase A, B, and C are labeled in white silkscreen on the PCB top layer.

   NOTE: If using the sensored firmware on the MSP430F5529 LaunchPad development kit, connect a brushless DC motor Hall sensor inputs to header J2. If using sensorless firmware header J2 can be left unconnected.

   NOTE: If using 1x PWM Mode with the sensored firmware R36, R37, and R38 must be populated with 0-Ω resistors.

   Step 3. Connect the DC power supply to header J1.

   NOTE: Observe the correct polarity of +VM and GND connections on the BOOSTXL-DRV8323Rx BoosterPack connection J1.

   Step 4. Connect a Micro-USB cable to the LaunchPad development kit and computer.

   Step 5. Turn on the power supply and power up the PCB.
4.3 **Launching BOOSTXL-DRV832X EVM GUI**

The BOOSTXL-DRV832X EVM GUI along with the four different BOOSTXL-DRV832X EVMs facilitate control of brushless DC motors. The BOOSTXL-DRV832x GUI provides functionality for adjusting the speed and direction of the motor, setting various fault parameters such as voltage and current protection limits, observing the motor drive speed, and monitoring the device fault status. The GUI can also be used to tune the motor for best performance using various parameters available in the motor control parameter page.

To launch the GUI, click on the BOOSTXL-DRV832X EVM shortcut on the desktop or navigate to the Windows Start Menu and click *All Programs*. Navigate to the *Texas Instruments* folder and select the BOOSTXL-DRV832X folder.

The Device *Launch* page (see Figure 33) is displayed to launch one of the 4 device variants (DRV8323S, DRV8320S, DRV8323H, DRV8320H). Click on one of the *Launch* buttons to launch next either the *DRV8323RS* or *DRV8323RH* labels.

For a guide on the different attributes of the BOOSTXL-DRV832x EVM GUI, refer to the *BOOSTXL-DRV832X GUI User’s Guide*.

![Figure 33. BOOSTXL-DRV832X EVM Device Launch](image-url)
## Revision History

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

<table>
<thead>
<tr>
<th>Changes from B Revision (March 2018) to C Revision</th>
<th>Page</th>
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</thead>
<tbody>
<tr>
<td>• Changed some DRV832XX references to DRV832x</td>
<td>12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Changes from A Revision (May 2017) to B Revision</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Added links to download the installation package for the reference software</td>
<td>12</td>
</tr>
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<table>
<thead>
<tr>
<th>Changes from Original (February 2017) to A Revision</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Added the note about the revision A MDBU017 board not meeting the SO offset specification</td>
<td>1</td>
</tr>
</tbody>
</table>
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.

3 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 isotrope rayonnée équivalente (p.i.r.e) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

3.3 Japan

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

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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1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の“ご使用にあたっての注意”を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

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

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。

日本テキサス・インスツルメンツ株式会社
東京都新宿区西新宿6丁目24番1号
西新宿三井ビル

3.4 European Union

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

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

4 EVM Use Restrictions and Warnings:

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

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

4.3 Safety-Related Warnings and Restrictions:

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

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

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

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

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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