

DRV8886 Evaluation Module User's Guide

This document is provided with the DRV8886 customer evaluation module (EVM) as a supplement to the DRV8886 datasheet ([DRV8886 2-A Stepper Motor Driver With Integrated Current Sense](#)). This user's guide details the hardware implementation of the EVM.

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Trademarks

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1 Board Overview

shows the top view of the printed circuit board (PCB).

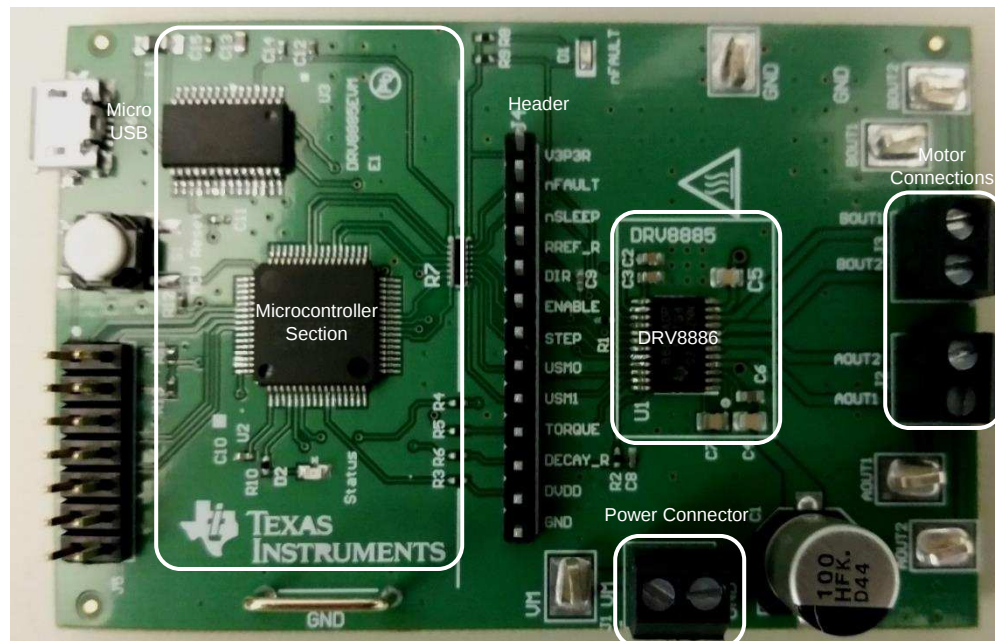


Figure 1. Top View of Typical Board Configuration (EVM Provided May Vary)



WARNING

The DRV8886 (U1) can operate at temperatures approaching 150°C. This device should not be touched.

2 Introduction

The DRV8886 customer EVM is a platform revolving around the DRV8886, a medium-voltage dual H-bridge driver and highly-configurable power stage. This device has been optimized to drive a single bipolar stepper with up to 16 degrees of internally generated microstepping.

The EVM houses an MSP430™ microcontroller and an USB interface chip. The USB chip allows for serial communications from a PC computer where a Windows® application is used to schedule serial commands. These commands can be used to control each of the device signals, and drive the stepper motor by issuing the step commands at the desired rate.

The microcontroller firmware operates using an internal index mode.

This user's guide details the operation of the EVM, as well as the hardware configurability of the evaluation module.

2.1 Connectors

The DRV8886 EVM offers access to the VM (motor voltage) power rail through a terminal block (J1). A set of test clips in parallel with the terminal block allows for the monitoring of the input power rail.

The user must apply the VM voltage according to recommended parameters listed in the data sheet.

NOTE: The VDD voltage for the microcontroller is derived from the microUSB connector.

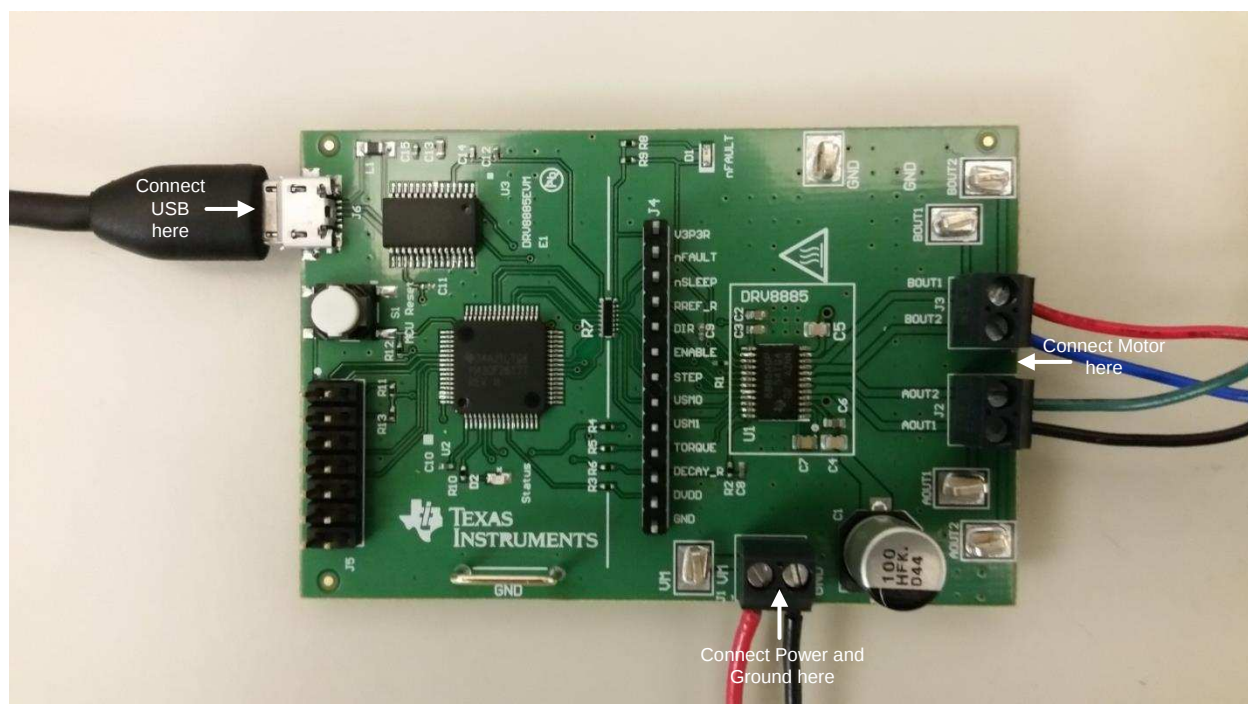


Figure 2. Connections (DRV8885 EVM Shown Has Similar Connections)

2.2 Test Points

A 0.100-inch pitch header connector (J4) provides access to every device signal in the event that a different microcontroller is used. To disconnect the internal MSP430 microcontroller, remove the R3, R4, R5, and R6 resistors, and resistor pack R7. [Table 1](#) describes the connections available on the J4 header. Each header pin is labeled on the evaluation module, and connects to a similarly named pin of the DRV8886.

Table 1. Connections to DRV8886 Using External Microcontroller

Header Label	Description
V3P3R	3.3 V after 0 Ω resistor
nFAULT	Fault output
nSLEEP	Sleep Mode input
RREF_R	Chopping current selection
DIR	DIR, Direction input
ENABLE	ENABLE, Stepper motor enable
STEP	STEP, Step input
USM0	M0, Step mode
USM1	M1, Step mode
TORQUE	TRQ, Output current scale
DECAY_R	Decay Mode select after 0- Ω resistor
DVDD	Internal supply voltage to set DAC voltage
GND	Ground

2.3 Jumpers

The DRV8886EVM has no jumpers.

2.4 Motor Outputs

Two motor connectors are provided. shows the available J2 and J3 connectors.

2.5 Operation of the EVM

Use the steps that follow to operate the EVM:

- Step 1. Install the drivers and GUI. For instructions see [Appendix A](#).
- Step 2. Connect the wires of the stepper motor to the AOUT1, AOUT2, BOUT1, and BOUT2 terminals.
- Step 3. Connect the VM power supply but do not apply power at this step.
- Step 4. Connect the USB cable between the PC and the EVM. When the USB is connected to the EVM, the status LED will begin to blink.
- Step 5. Open the GUI. The GUI can be found in the start menu at Texas Instruments → DRV8886_EVM → DRV8886_EVM X.Y.Z, where X, Y, and Z are the revision numbers. If a shortcut was created, double-click on the shortcut to open the GUI. The GUI can take up to 30 s to establish a connection. If connection is not established, select the COM port under the *Options* menu. The BaudRate is 9600.

NOTE: The DRV8886 EVM GUI is designed to control both the DRV8886 EVM and the DRV8886AT EVM. The GUI automatically identifies the device and changes the pulldown menus as needed.

- Step 6. Apply the desired voltage (6.5 to 37 V) to the VM and GND connections.
- Step 7. Configure the current settings, step mode, decay mode, and torque to the desired values as shown in [Figure 3](#).

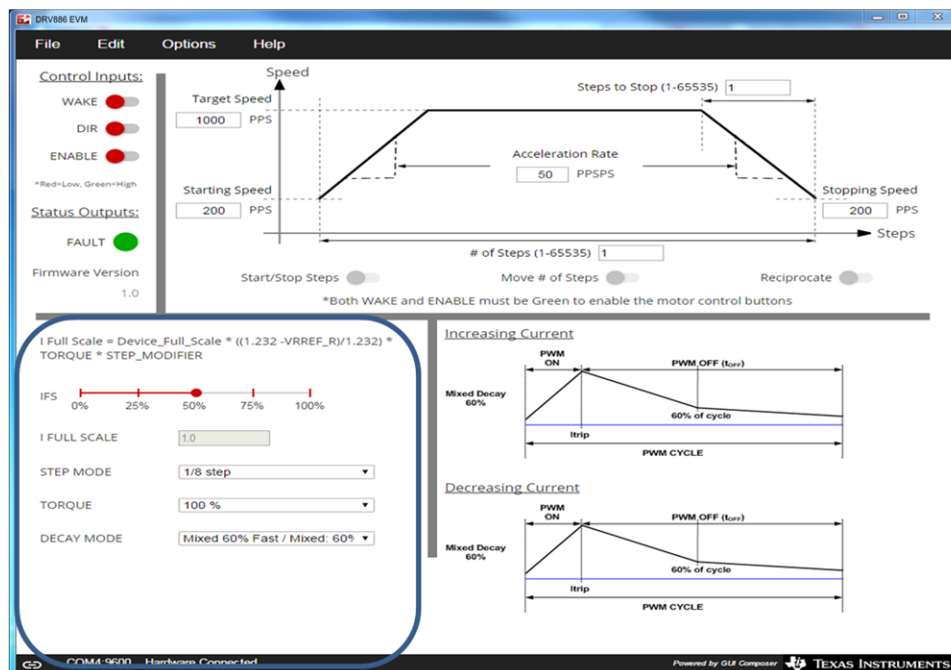


Figure 3. GUI at Startup

The current is calculated using the VREF slider, the sense resistor value, the torque setting, and the step mode setting using [Equation 1](#).

$$I_{FS} = \text{Device_Full_Scale} \times \left(\frac{1.232 - \text{VRREF_R}}{1.232} \right) \times \text{TORQUE} \times \text{StepModifier}$$

where

- StepModifier is 0.71 for full step and 1 for other STEP MODE settings (1)

The number 1.232 is based on the maximum current allowed using the configuration. If VRREF = 0 V, the maximum current is 1 A. The 12-bit DAC channel 1 is connected to the DRV8886 analog input RREF through a 15-kΩ series resistor. The DAC voltage begins at 1.232 V (0%) and ends at 0 V (100%).

Step 8. After setting up the control signals for the DRV8886, select both the WAKE and ENABLE toggle buttons to enable the DRV8886. When toggled, the WAKE or ENABLE status toggles between red and green.

The WAKE toggle button, which controls the nSLEEP pin, is used to wake the DRV8886. The ENABLE toggle button, which controls the ENABLE pin, is used to enable the DRV8886 outputs.

A message stating *Both WAKE and ENABLE must be green to enable the motor control buttons* is visible until both the WAKE and ENABLE toggle buttons are activated. When these two toggle buttons have been activated, the message disappears and the *Start/Stop Steps* and *Move # of Steps* toggle buttons are available.

If the WAKE or ENABLE toggle buttons are selected during motor operation, the motor is immediately stopped and the STEP control signal from the microcontroller is reset.

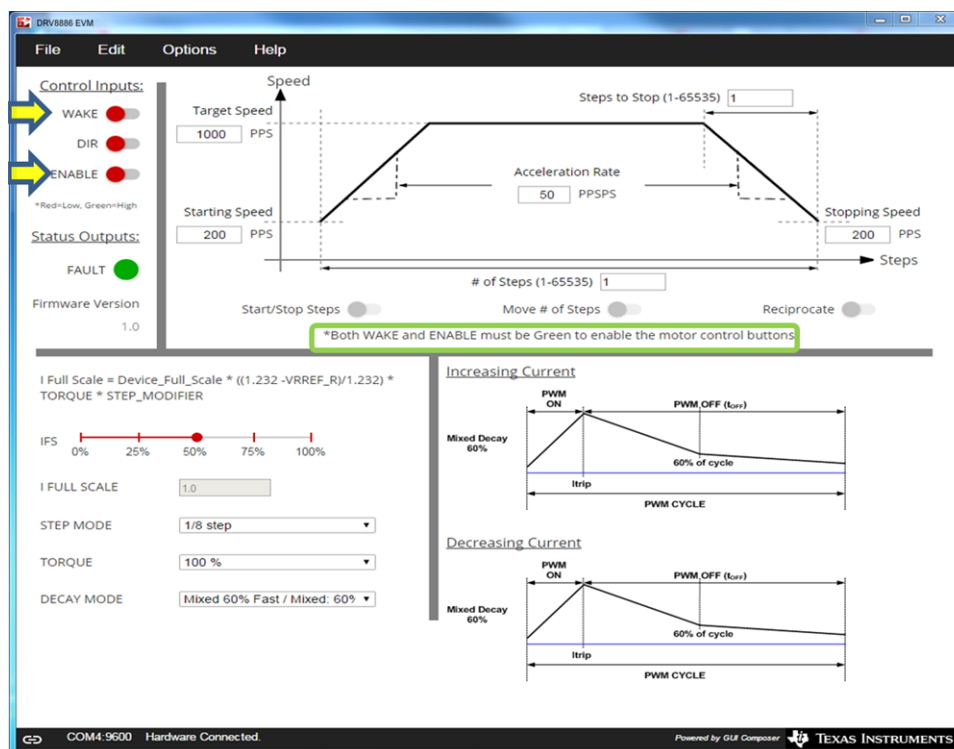


Figure 4. Wake and Enable Toggle Buttons

Step 9. The DRV8886 EVM is now awake and can be commanded to turn the motor. Turning the motor occurs by either selecting the *Start/Stop Steps*, *Move # of Steps*, or *Reciprocate* toggle button.

The *Start/Stop Steps* toggle button is used to run the motor indefinitely. The motor will accelerate to the target speed and run until the *Start/Stop Steps* toggle button is selected. When the *Start/Stop Steps* toggle button is selected, the red button changes to green, and the *Move Steps* and *Reciprocate* toggle buttons are disabled.

The *Move Steps* toggle button is used to allow movement of an exact number of steps. When the *Move Steps* toggle button is selected, the *Move Steps* toggle button turns green, and the *Start/Stop Steps* and *Reciprocate* toggle buttons are disabled until the number of steps have completed.

The *Reciprocate* toggle button is a special case of the *Move Steps* option. When selected, the motor advances the specified number of steps in the direction initially set by the control inputs. After a short pause, the motor then advances the same number of steps in the opposite direction. This sequence is repeated until the *Reciprocate* toggle button is selected.

When the *Reciprocate* toggle button is selected, the *Reciprocate* toggle button turns green, and the *Start/Stop Steps* and *Move # of Steps* toggle buttons are disabled until the *Reciprocate* toggle button is set to red and the number of steps have completed.

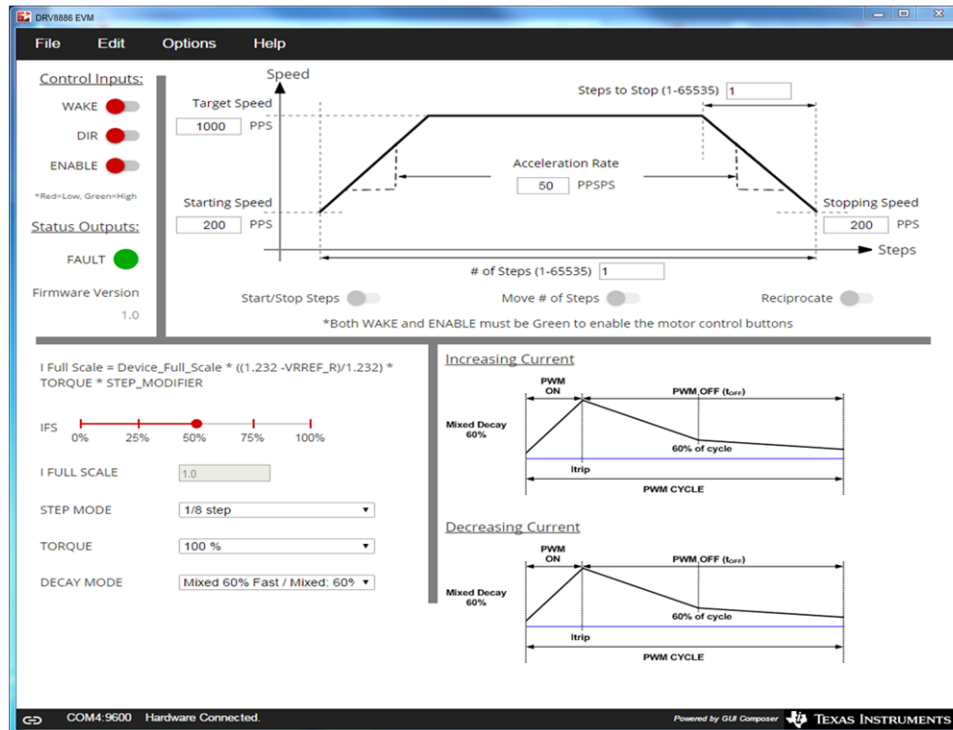
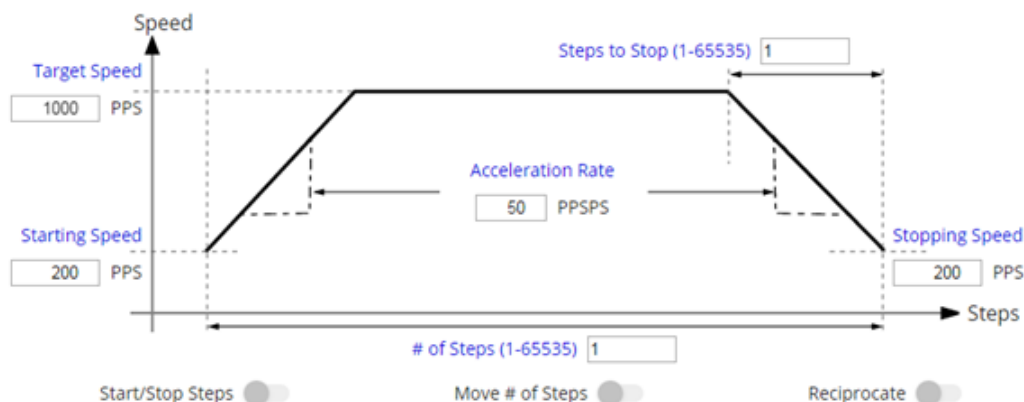


Figure 5. Reciprocate Toggle Button

As an extra precaution, the motor can be stopped by selecting either the WAKE or ENABLE toggle buttons. When selected, the STEP commands are stopped and the motor control buttons are disabled. To re-enable motor control, set the WAKE and ENABLE toggle buttons to green.

2.6 Motion Control Frame (Includes Start/Stop Steps and Move Steps)

The GUI has an area which offers access to a series of very useful stepper-control algorithms. This area allows for determining the best current settings during running at various speeds, and when holding torque is applied.



Note: Both the WAKE and ENABLE toggle buttons must be green to enable the motor control buttons.

Figure 6. Motor Motion Profile

Motor motion can only happen by using an acceleration profile which is described in [Section 2.6.1](#). A detailed explanation of each stepper control section follows (see [Section 2.6.1](#) and [Section 2.6.2](#)).

This frame allows the configuration and running of the stepper with the direction as specified by the *DIR* toggle button, with the current decay mode as specified under the *Decay Mode* drop-down menu, and the microstepping resolution as specified under the *STEP MODE* drop-down menu.

The *Motion Control* frame gathers user information regarding stepping rate or motor speed. An acceleration profile is used to start at a programmable speed and increase the stepping rate until reaching the programmable desired speed.

An internal 8-MHz timer is used to measure time and generate the steps on a timely manner. The GUI sends the information to the microcontroller as pulse-per-second (PPS) signal, and the microcontroller transforms it into the respective clock cycles required for the timer to generate accurate STEP pulse timing.

2.6.1 Start/Stop Steps

The acceleration profile is coded inside of the microcontroller to accept both the starting-speed PPS signal and target-speed PPS signal as a clock cycle number. When the START STEPS command is issued (the *Start/Stop Steps* toggle button is selected), the PWM timer generates steps at a rate specified by the start speed PPS parameter.

When accelerating or decelerating, the PPS signal is adjusted every 32 ms based on the integer value of PPSPS / 32 ms. If a nonzero value of PPSPS is entered, a minimum value of 1 is used. The step rate is increased by the calculated value until the target speed is reached.

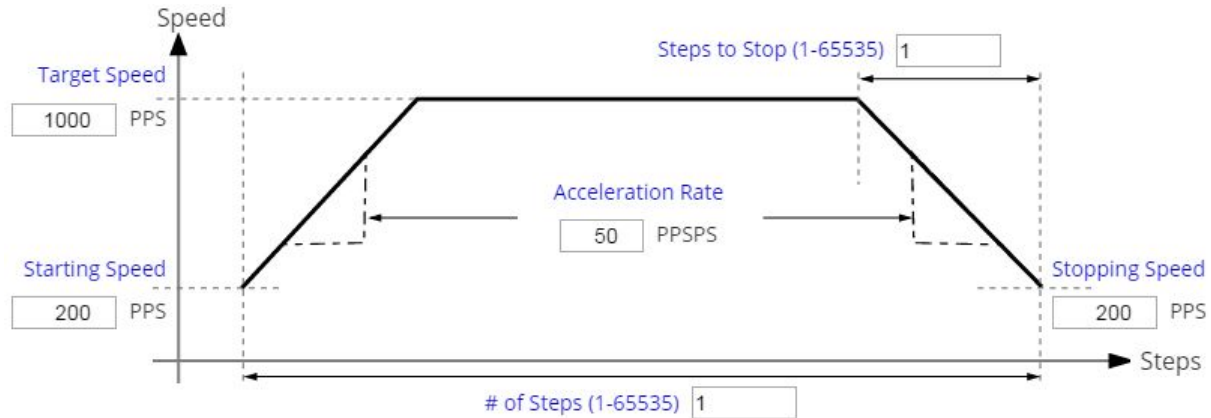
If the starting speed is greater than or equal to the target speed, the acceleration rate is set to 0. This setting will prevent further speed changes until the motor is stopped, and new starting and target speeds are entered. Texas Instruments recommends setting the starting speed to $\frac{1}{2}$ the target speed to avoid this scenario.

The very same START STEPS command computes how frequently automatic speed updates are issued and a second timer is used to change the speed according to the programmed acceleration rate profile.

When the target speed PPS value is reached, the acceleration profile ends and the motor continues running until the STOP STEPPER command is issued (the *Start/Stop Steps* toggle button is selected again). When the stepper is commanded to stop, the controller performs the same actions as it did while accelerating, but in reverse order to decelerate until the stop speed PPS value is reached, in which case the motor fully stops.

A second motor actuation is provided by the *Move # of Steps* and *Reciprocate* commands in which a programmed number of steps are issued and then the motor is stopped. The acceleration and deceleration profiles work similarly as before, except when the deceleration starts and when the motor actually stops are a function of the *Steps to Stop* and deceleration rate parameters.

Figure 7 shows the acceleration profile and the role each parameter plays during speed computation.



Note: Both the WAKE and ENABLE toggle buttons must be green to enable the motor control buttons.

Figure 7. Acceleration Profile

2.6.2 Move Steps

To move the stepper a certain number of steps, use the move steps function to easily perform this action. Parameters from the other frames are reused and their use is as previously explained. Two new parameters have been added to properly control the limited number of steps actuation. These parameters are described as follows:

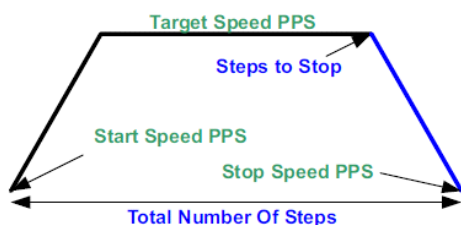
Number of Steps — This parameter is the number of steps that the controller will issue.

Steps to Stop — The controller is continuously monitoring the step being issued and when the current step is equal to the *Steps to Stop* parameter, a deceleration profile is issued. If the value of the *Steps to Stop* parameter is larger than the number of steps, then the motor stops abruptly and without undergoing a deceleration profile.

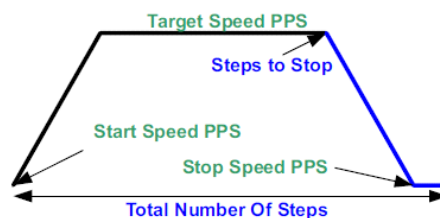
When a deceleration profile is issued, the controller decreases the speed until reaching the value of the *Stopping Speed* parameter. If the *# of Steps* parameter is met before the deceleration profile is complete, then the motor stops at the current speed. If the stop speed is met before all the number of steps is issued, then the motor rotates at the stop speed value until all the steps are executed.

Ideally, the system should be tuned to resemble the case in which the controller executes all the commanded steps at a speed as close as possible to the stop speed. In the event this is not possible because of the particular parameters that were selected, stopping the motor at a speed very close to the *Stopping Speed* parameter is often good enough to ensure good motion quality and application performance.

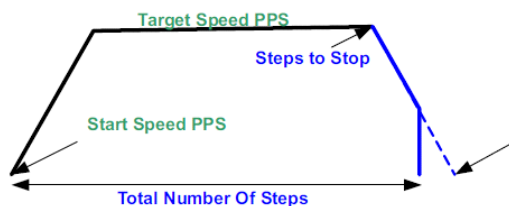
Figure 8 shows the three conditions possible when stopping and the action taken.



1. Motor reaches stop speed at the stop speed.



2. Motor reaches stop speed before the stop speed is reached.



3. Motor runs out of steps before reaching stop speed.

Figure 8. Stop Conditions

2.7 EVM documentation

The EVM schematics, layout, and BOM are provided in the [DRV8886 EVM Hardware Files](#). The GUI, USB drivers, and MSP430F2617 source code are provided in the [DRV8886EVM Firmware and GUI](#) software file.

Driver and GUI Installation Instructions

A.1 Installing the FTDI Driver

In many cases, connecting the EVM to the computer will automatically install the FTDI driver. If necessary, download the driver from the [DRV8886EVM Firmware and GUI](#). Unzip the file and install the USB driver following these steps based on the operating system:

- If using Windows XP, run \USB driver\CDM v2.10.00 WHQL Certified.exe.
- If using Windows 7, go to the \USB driver\ folder and right-click the CDM v2.10.00 WHQL Certified.exe file. Then select *Properties*, go to the *Compatibility* tab, check the *Run this program in compatibility mode for* option, select the *Windows XP (Service Pack 2)* option, and click the *OK* button. Next run the CDM v2.10.00 WHQL Certified.exe file and click the *Yes* button in the pop-up window.

A.2 2. Installing the GUI

NOTE: The DRV8886 EVM GUI is designed to control both the DRV8886 EVM and the DRV8886AT EVM. The GUI automatically identifies the device and changes the pulldown menus as needed. If the DRV8886EVM GUI has been previously installed, installing the GUI again is not required.

Locate the *DRV8886_EVM_installer.zip* file in the GUI folder. Unzip the file to any location and then double click the *GUIComposerApp-1.0.0.setup-win_2.0.6.exe* file in the unzipped folder.

The installer will begin and the window shown in [Figure 9](#) will appear.

Click the *Yes* button to continue (see [Figure 9](#)).

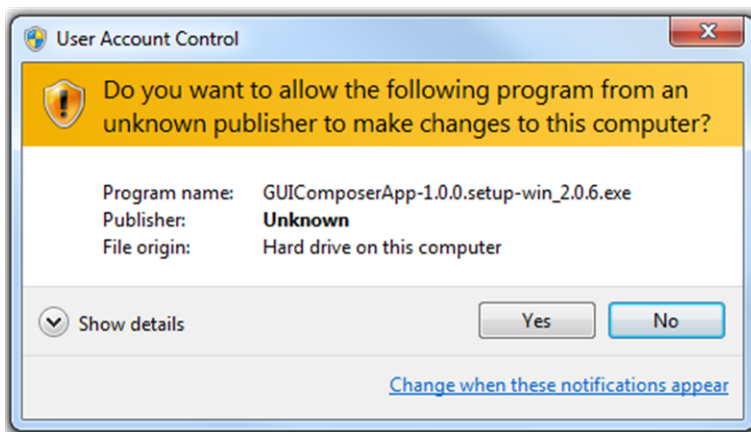


Figure 9. User Account Control Window

Click the Next button to continue (see [Figure 10](#)).

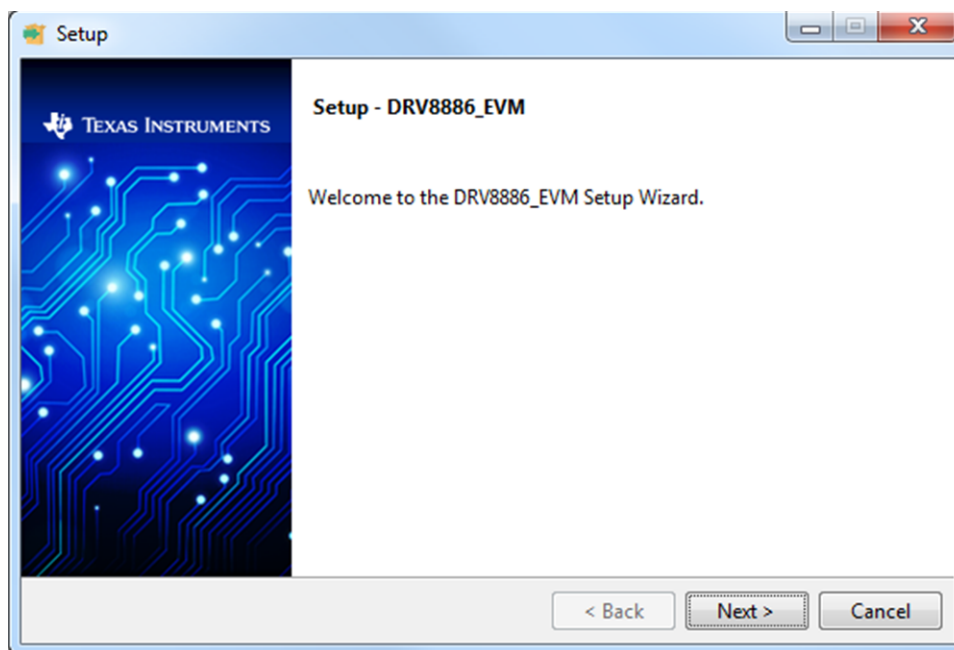


Figure 10. EVM Setup Wizard

Click the *I accept the agreement* radio button and click the Next button to continue (see [Figure 11](#)).

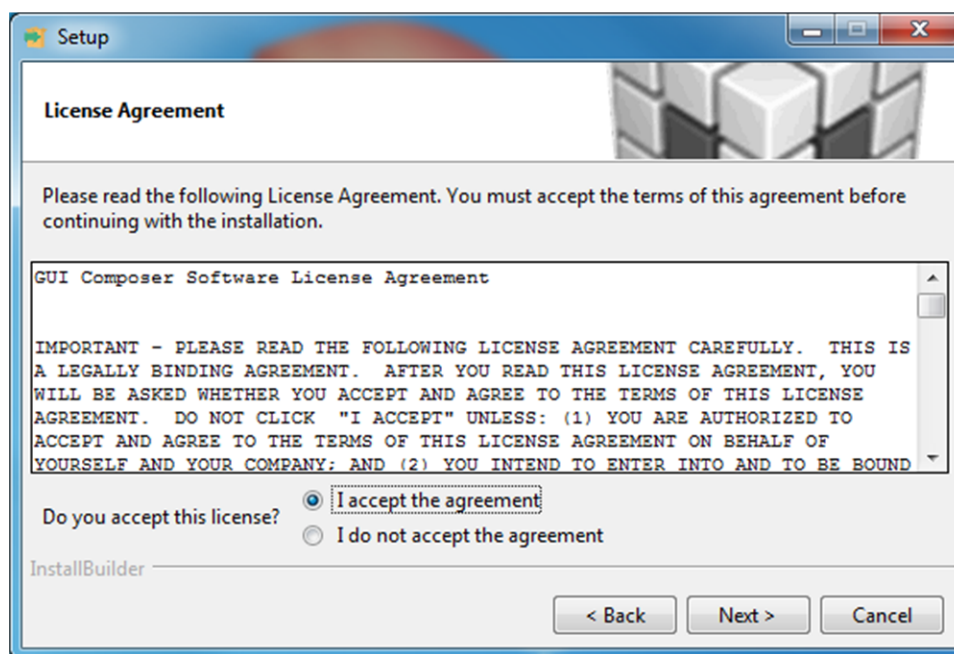


Figure 11. License Agreement

Click the Next button to continue (see [Figure 12](#)).

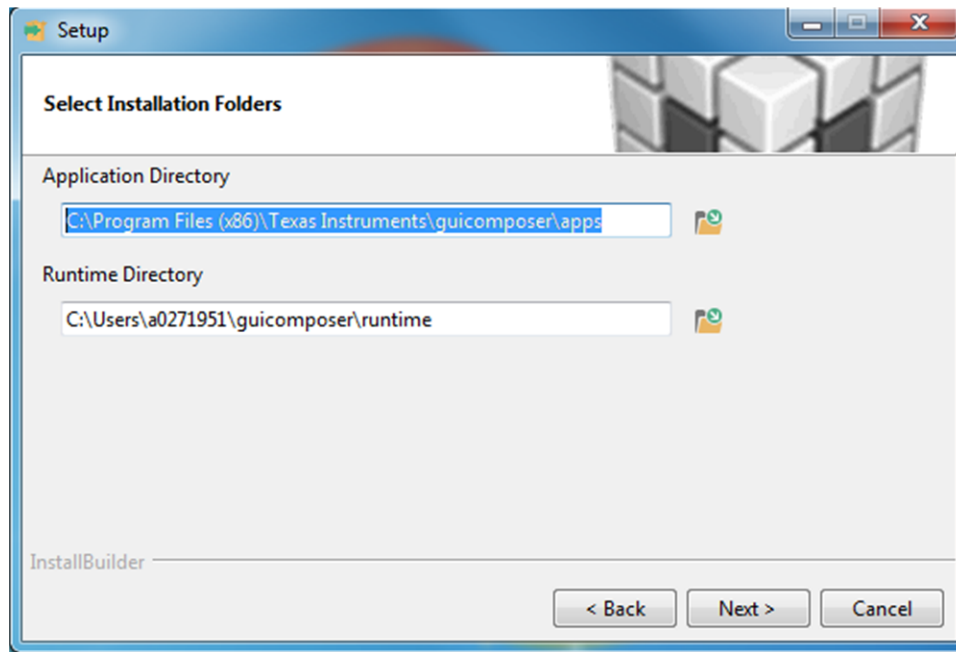


Figure 12. Installation Folders

At this point, a few options may appear. If the GUI Composer Runtime has not been previously installed, select the *Download from web* radio button and click the *Next* button to continue (see [Figure 13](#)).

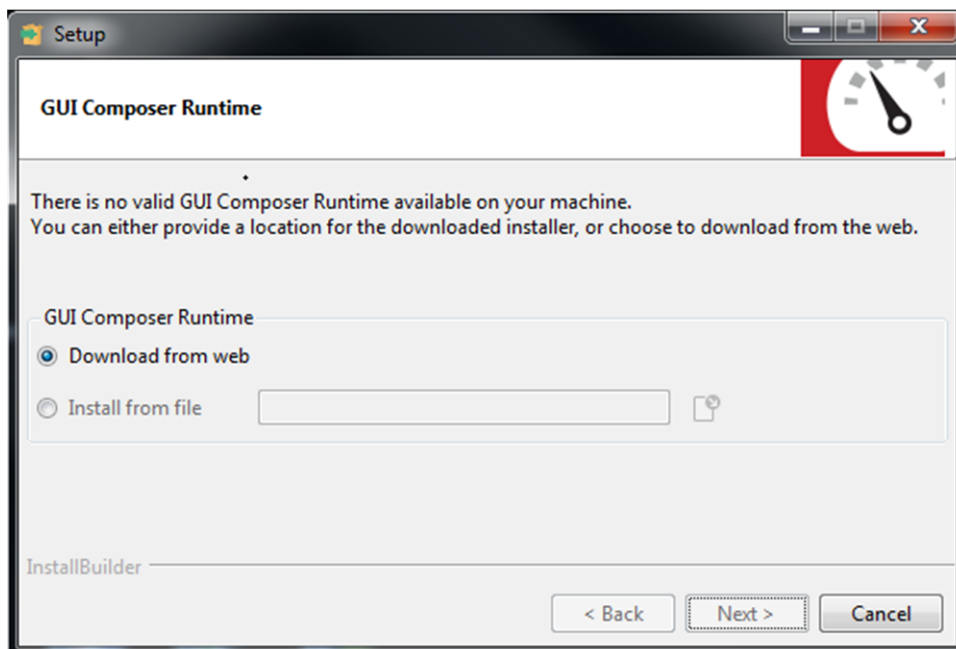


Figure 13. GUI Composer Runtime Selection

If the GUI has been previously installed a message similar to the one in [Figure 14](#) appears. If this message appears, click the Yes button and then click the *Next* button to continue (see [Figure 14](#)).

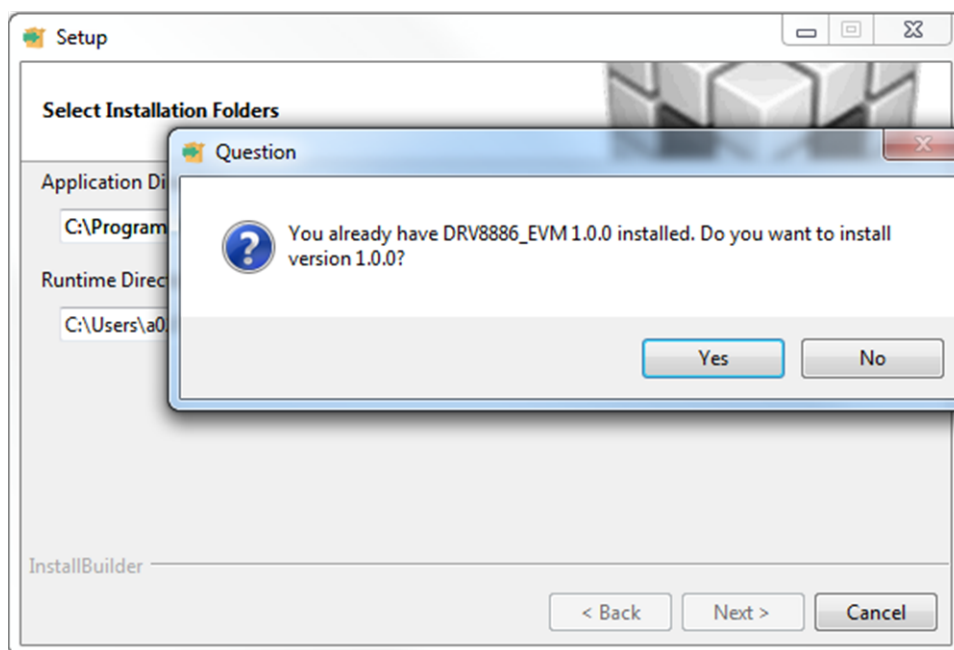


Figure 14. Possible Upgrade Question

Click the *Next* button to continue (see [Figure 15](#)).

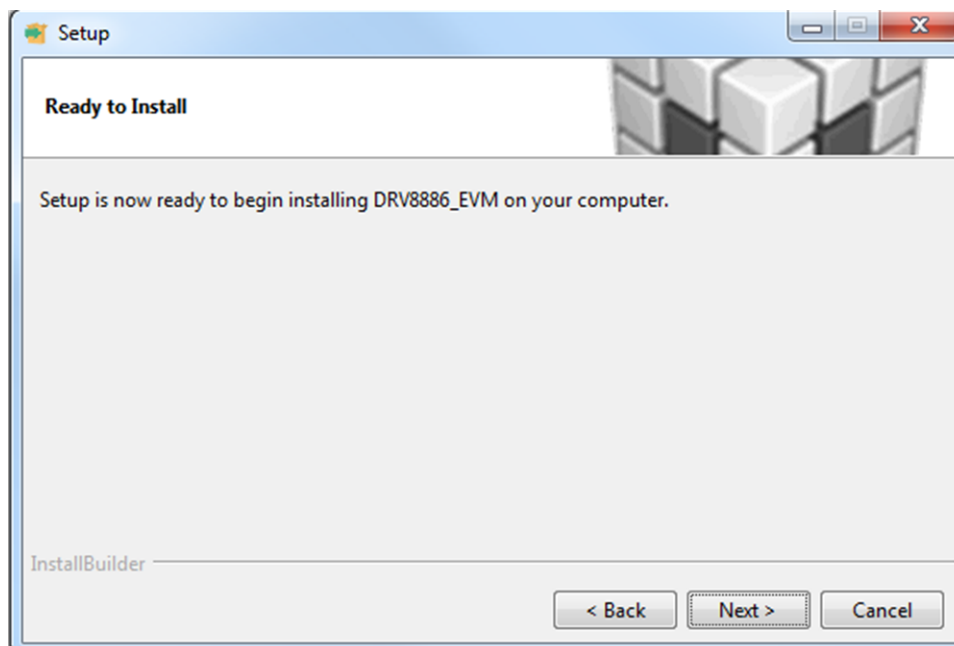


Figure 15. Ready to Install

Click the check box next to the desired results and then click the *Finish* button to complete the setup wizard (see [Figure 16](#)).

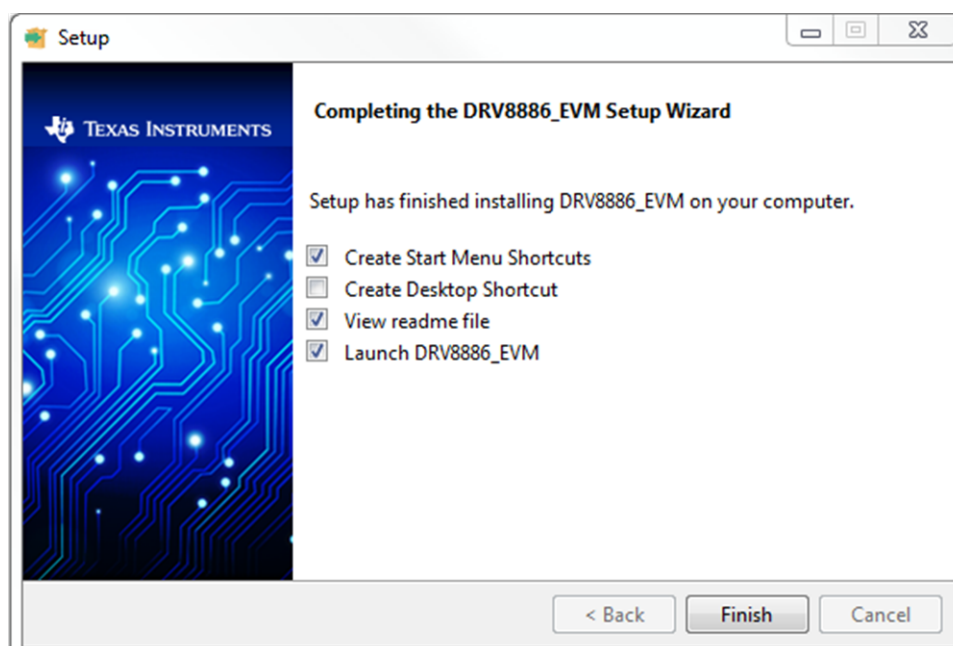


Figure 16. Completed

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

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

3.3 Japan

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

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2. 実験局の免許を取得後ご使用いただく。
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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_02.page
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3.4 *European Union*

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

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

4 *EVM Use Restrictions and Warnings:*

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

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

4.3 *Safety-Related Warnings and Restrictions:*

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

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

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

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

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