

DRV8884 Evaluation Module (EVM) User's Guide

This document is provided with the DRV8884 customer EVM as a supplement to the DRV8884 ([SLVSDA5](#)) data sheet. This user's guide details the hardware implementation of the EVM.

Contents

1	Introduction	2
2	Connectors	3
3	Test Points.....	4
4	Jumpers	4
5	Motor Outputs	4
6	Operation of the EVM	5
7	Motion Control Frame (Includes Start/Stop Steps and Move Steps)	8
8	EVM Documentation	10
Appendix A	11

List of Figures

1	Top View of Typical Board Configuration (EVM Provided may Vary).....	2
2	Connections	3
3	GUI at startup	5
4	Wake and Enable Toggle Buttons.....	6
5	Reciprocate Toggle Button	7
6	Motor Motion Profile	8
7	Acceleration Profile	9
8	Stop Conditions.....	10
9	User Account Control Window.....	11
10	EVM Setup Wizard.....	12
11	License Agreement	12
12	Installation Folders	12
13	GUI Composer Runtime Selection	13
14	Possible Upgrade Question	13
15	Ready to Install	14
16	Completed.....	14

List of Tables

1	Connections to DRV8884 Using External Microcontroller.....	4
---	--	---

1 Introduction

The DRV8884 customer EVM is a platform revolving around the DRV8884, 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 a USB interface chip. The USB chip allows for serial communications from a PC computer where a Microsoft® Windows® application is used to schedule serial commands. These commands can be used to control each signal of the device, and drive the stepper motor by issuing the step commands at the desired rate.

The microcontroller firmware operates using internal index mode.

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

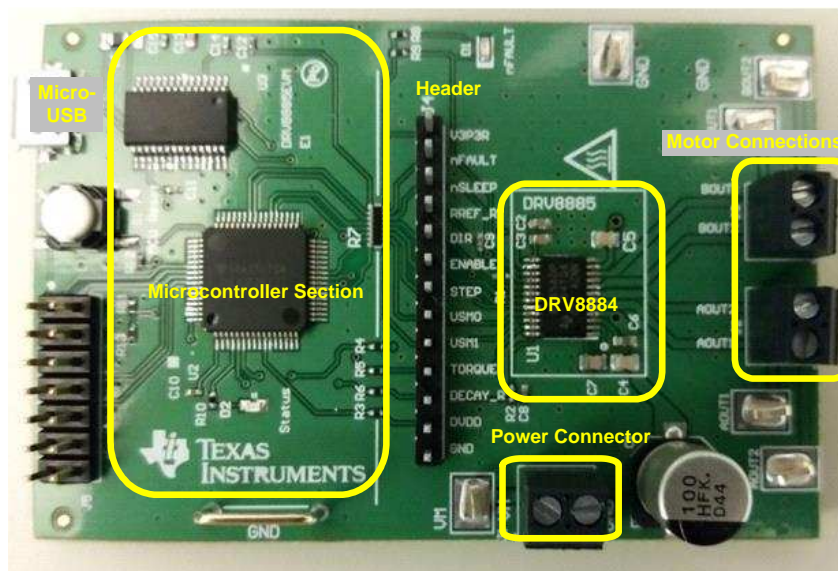


Figure 1. Top View of Typical Board Configuration (EVM Provided may Vary)

2 Connectors

The DRV8884EVM offers access to motor voltage (VM) 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.

User must apply VM according to data sheet recommended parameters.

NOTE: VDD for the microcontroller is derived from the micro USB connector.

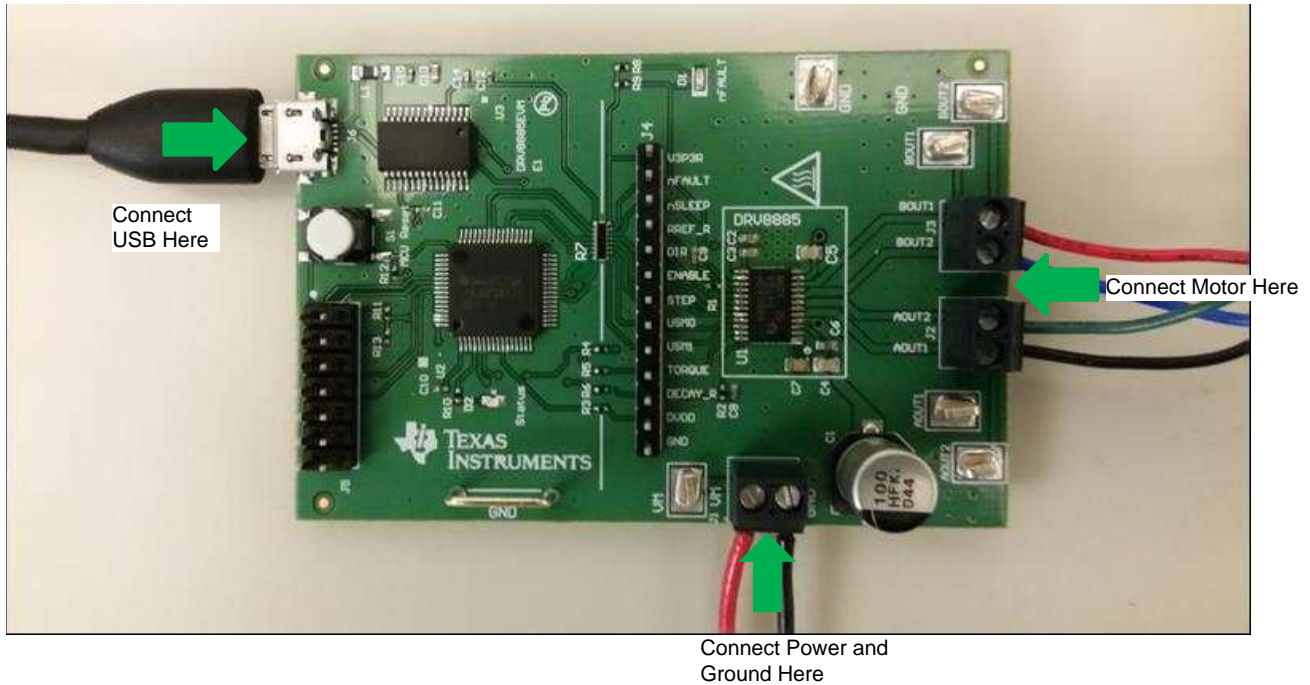


Figure 2. Connections

3 Test Points

A 0.100 inch pitch header connector (J4) provides access to every device signal in the event a different microcontroller is to be employed. To disconnect the internal MSP430 microcontroller, remove resistors R3, R4, R5, R6, 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 DRV8884.

Table 1. Connections to DRV8884 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

4 Jumpers

There are no jumpers on the DRV8884EVM.

5 Motor Outputs

Two motor connectors are provided. Connectors J2 and J3 are available as shown in [Figure 1](#).

6 Operation of the EVM

1. Install the drivers and GUI. Refer to [Appendix A](#) for instructions.
2. Connect the wires of the stepper motor to terminals AOUT1, AOUT2, BOUT1, and BOUT2.
3. Connect the VM power supply, but do not apply power at this step.
4. Connect the USB cable between the PC and the EVM. After the USB is connected to the EVM, the Status LED will begin to blink.
5. Open the GUI. The GUI can be found in the start menu at Texas Instruments → DRV8884EVM → DRV8884EVM vX.Y , where X and Y are the revision numbers. If a shortcut was created, the shortcut can also be double clicked to open the GUI. It may take up to 30 seconds to establish the connection. If the connection is not established, select the COM port under the *Options* menu. The BaudRate is 9600.
6. Apply desired voltage (8 to 37 V) to the VM and GND connections.
7. Configure the current settings, step mode, decay mode, and torque as desired as:

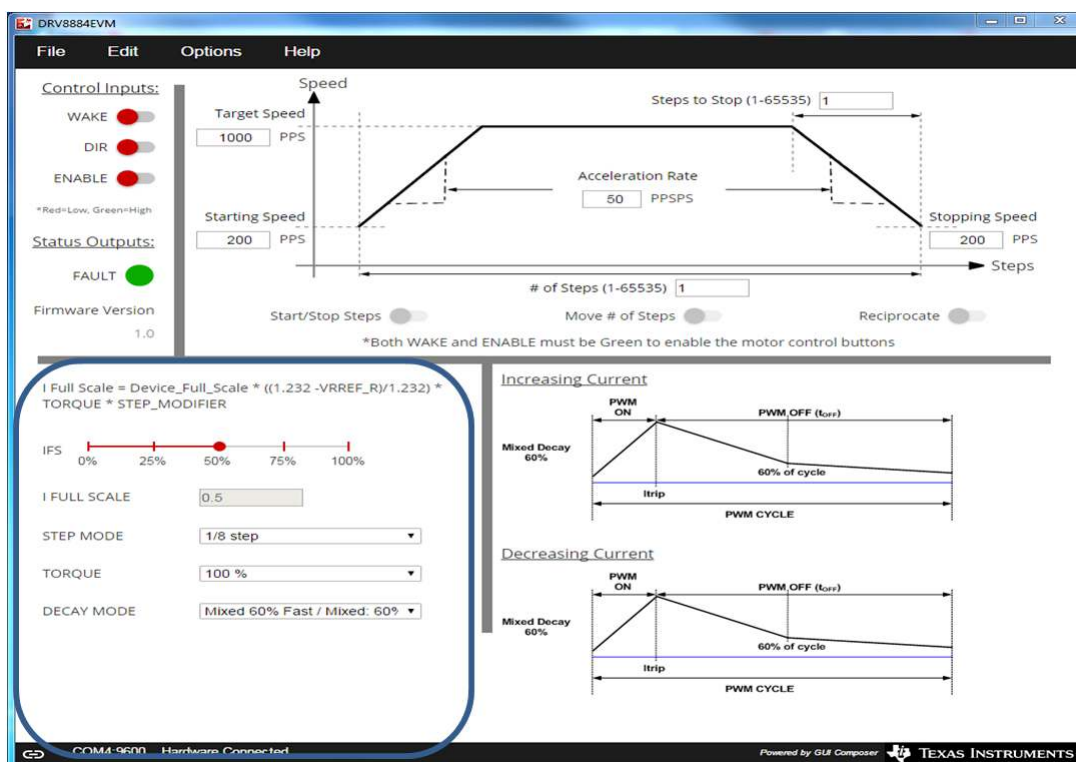


Figure 3. GUI at startup

- (a) The current is calculated using the V_{REF} slider, the *Sense* resistor value, the *Torque* setting, and the *Step* mode setting using [Equation 1](#).

$$I_{FS} = 1 \text{ A} \left(\frac{1.232 - V_{RREF_R}}{1.232} \right) \times \text{TORQUE} \times \text{StepModifier} \quad (1)$$

where **StepModifier** is 0.71 for full step and 1.0 for other STEP MODE settings

- (b) The number 1.232 is based on the maximum current allowed using the configuration. If $V_{RREF} = 0$ V, the maximum current is 1.0 A. The 12-bit DAC channel 1 is connected to the DRV8884 analog input RREF through a 30-k Ω series resistor. The DAC voltage begins at 1.232 V (0%) and ends at 0V (100%).

8. Wake and Enable the device for operation.
 - (a) After setting up the control signals for the DRV8884, enabling the DRV8884 requires selecting both the WAKE and ENABLE toggle buttons. When toggled, WAKE or ENABLE switches between red to green.
 - (b) The WAKE toggle button, which controls the nSLEEP pin, is used to wake the DRV8884. The ENABLE toggle button, which controls the ENABLE pin, is used to enable the DRV8884 outputs.
 - (c) A message which states that “*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. After these two toggle buttons have been activated, the message disappears and the Start/Stop and Move Steps toggle buttons become available.
 - (d) 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.

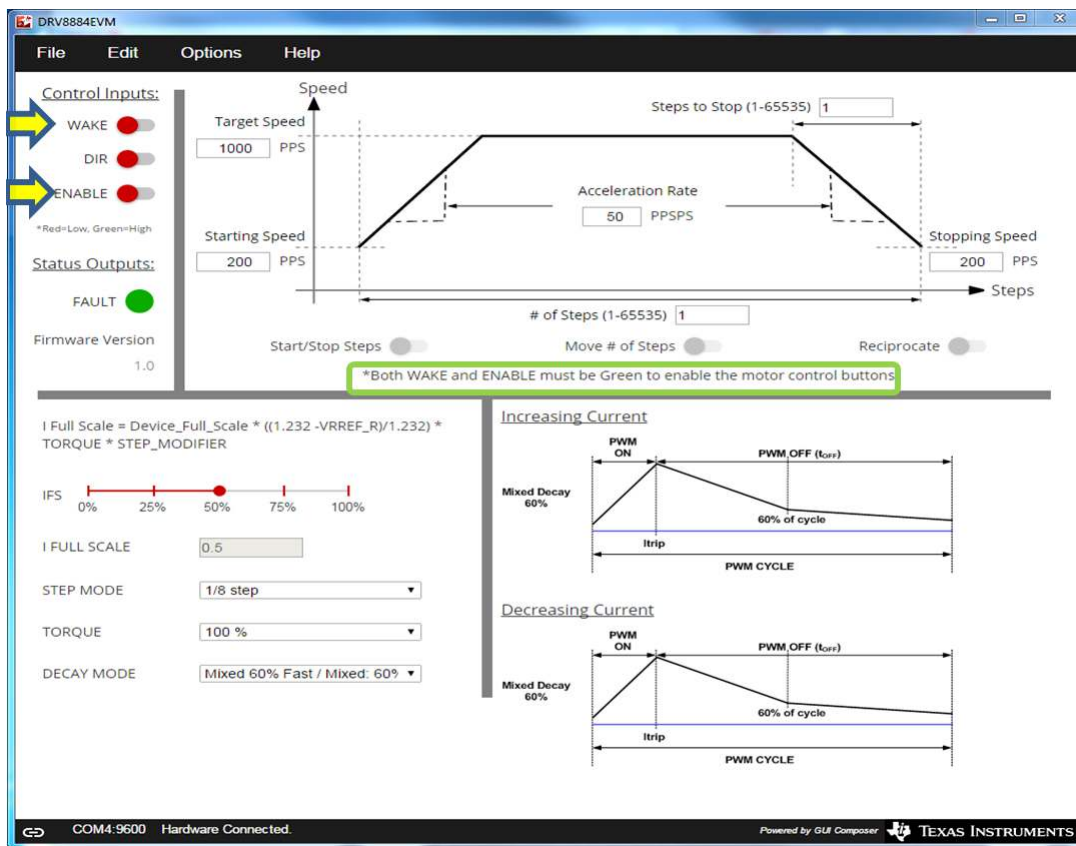


Figure 4. Wake and Enable Toggle Buttons

9. The DRV8884 EVM is now awake and can be commanded to turn the motor. This is done by either selecting *Start/Stop Steps*, *Move # of Steps*, or *Reciprocate*.
 - 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 will change to green, and the *Move Steps* and *Reciprocate* toggle buttons will be 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, *Move Steps* will turn 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*. When selected, the motor will advance the specified number of steps in the direction initially set by the control inputs. After a short pause, the motor will then advance 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, *Reciprocate* will turn green, and the *Start/Stop Steps* and *Move # of Steps* buttons are disabled until the *Reciprocate* toggle button is set to red, and the number of steps have completed.

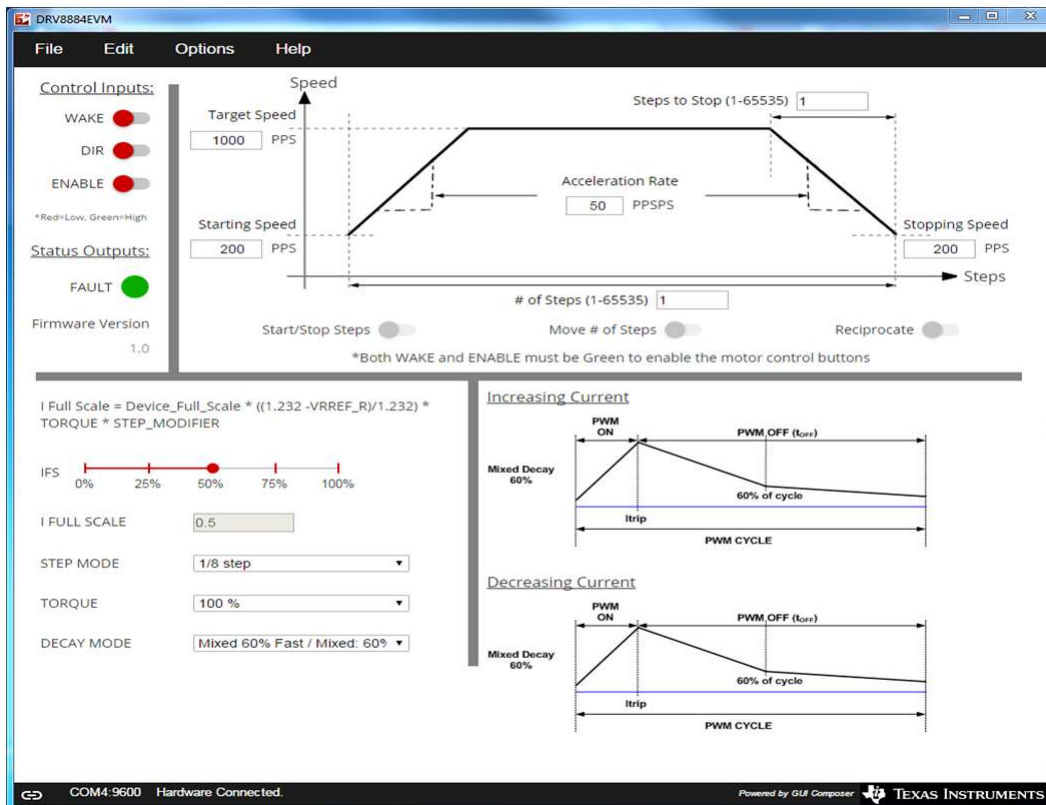
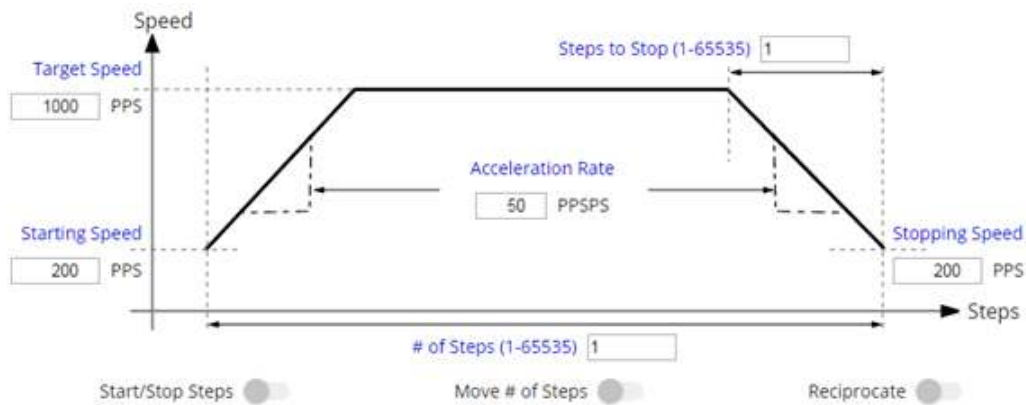


Figure 5. Reciprocate Toggle Button

As an extra precaution, the motor can be stopped by selecting either the *WAKE* or *ENABLE* toggle buttons. When either is 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.

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

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



*Both WAKE and ENABLE must be Green to enable the motor control buttons.

Figure 6. Motor Motion Profile

Motor motion only happens by using an acceleration profile which is detailed later in this section. A detailed explanation of each stepper control is provided in the following sections.

This frame allows the configuration and running of the stepper with the direction as specified by the *DIR* checkbox, with the current decay mode as specified under the *Decay Mode* checkbox and the microstepping resolution as specified under the *Step Mode* drop-down box.

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

An internal 8-MHz timer is used to measure time and generate the steps in a timely manner. The GUI will send the information to the microcontroller as PPS, and the microcontroller will transform it into the respective clock cycles needed for the timer to generate accurate STEP pulse timing.

7.1 Start/Stop Steps

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

When accelerating or decelerating, PPS is adjusted every 32 ms based on the integer value of PPSPS / 32 ms. If a non-zero 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.

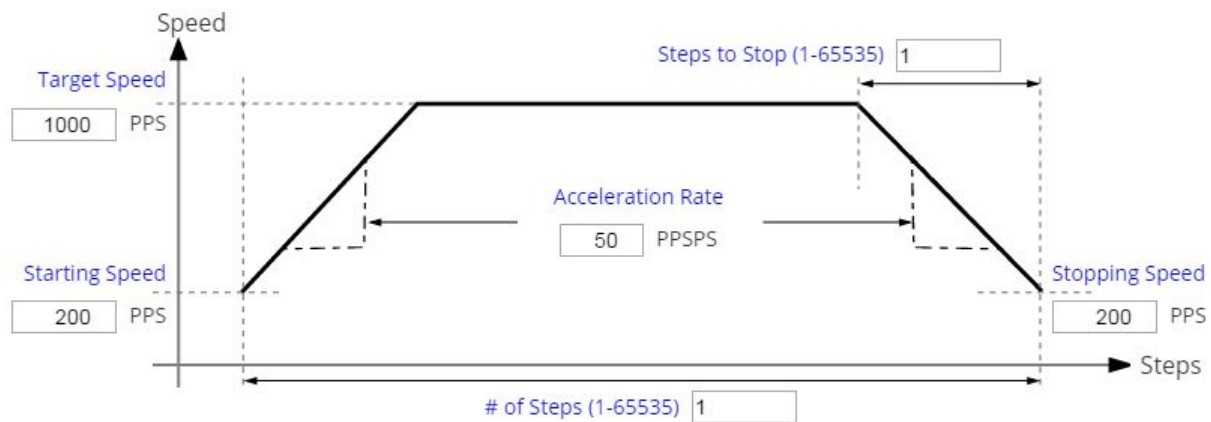
NOTE: If the starting speed is greater than or equal to the target speed, the acceleration rate is set to 0. This will prevent further speed changes until the motor is stopped, and new starting and target speeds are entered. TI recommends setting the starting speed to one-half the target speed to avoid this scenario.

The very same start steps command computes how frequent 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 is reached, the acceleration profile ends and the motor continues running until the stop stepper command is issued (*Start/Stop Steps* button is selected again). When the stepper is commanded to stop, the controller does exactly as it did while accelerating, but in reverse to decelerate until the stop speed PPS 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 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.



*Both WAKE and ENABLE must be Green to enable the motor control buttons.

Figure 7. Acceleration Profile

7.2 Move Steps

When moving the stepper a certain number of steps, use the move steps function. Parameters from the other frames are reused as explained previously. Two new parameters are added to properly control the limited number of steps actuation.

Number of Steps—Number of steps the controller issues.

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 *Steps to Stop* 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 stop speed value. If the number 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, due to the particular parameters being chosen, stopping the motor at a speed very close to the stop speed is often sufficient to ensure good motion quality and application performance.

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

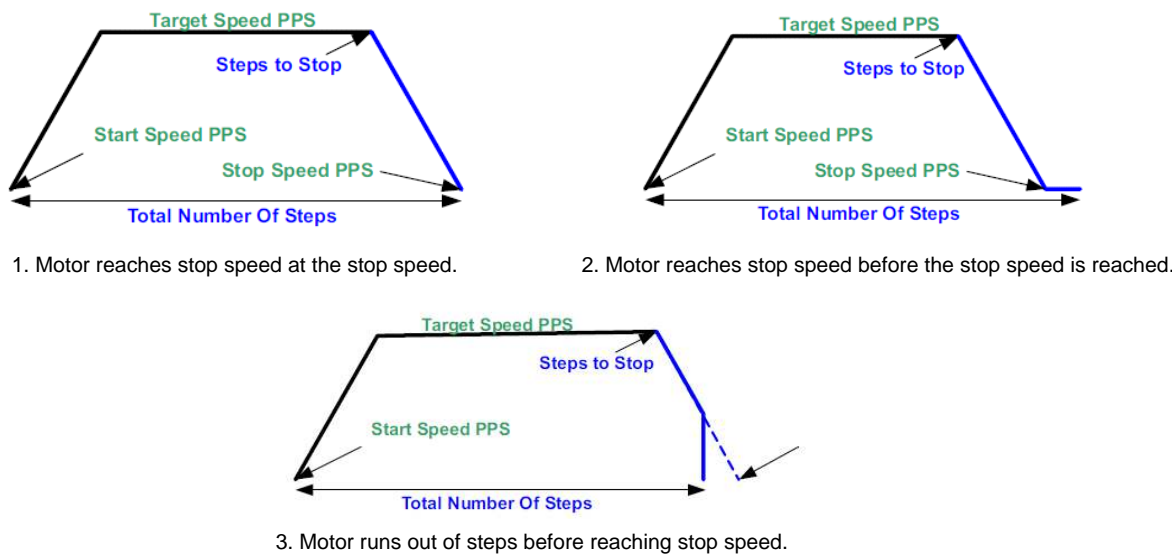


Figure 8. Stop Conditions

8 EVM Documentation

The EVM schematics, layout, and bill of materials (BOM) are provided in the hardware file ([SLVC657](#)). The GUI, USB drivers, and MSP430F2617 source code are provided in the software file ([SLVC658](#)).

A.1 Driver and GUI Installation Instructions

1. Installing the FTDI Driver:

In many cases, connecting the EVM to the computer automatically installs the FTDI driver.

If necessary, download the driver from the software file. Unzip the software file and install the USB driver:

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

2. Installing the GUI:

Locate the file *DRV8884EVM_installer.zip* in the Application folder. Unzip the file to any location, then double click the file *GUIComposerApp-v1.setup-win_2.0.3.exe* in the unzipped folder.

The installer begins. The following popup windows appear.

Select *Yes* to continue (see [Figure 9](#)).

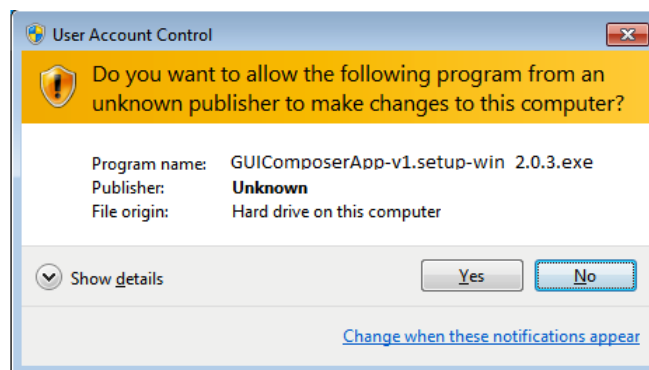


Figure 9. User Account Control Window

Select *Next* to continue (see [Figure 10](#)).

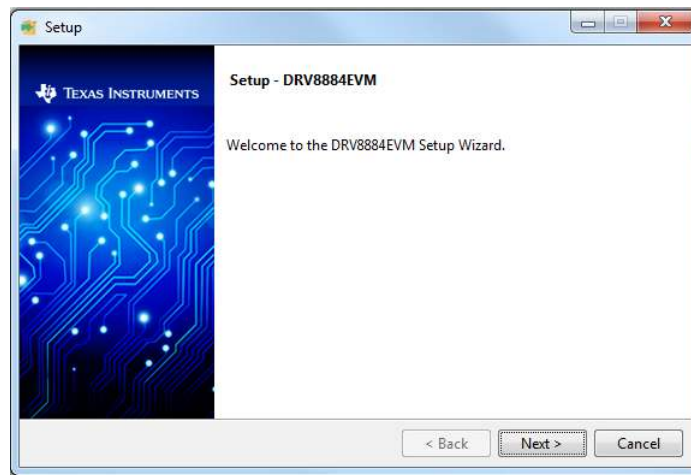


Figure 10. EVM Setup Wizard

Select *I accept the agreement* and *Next* to continue (see [Figure 11](#)).

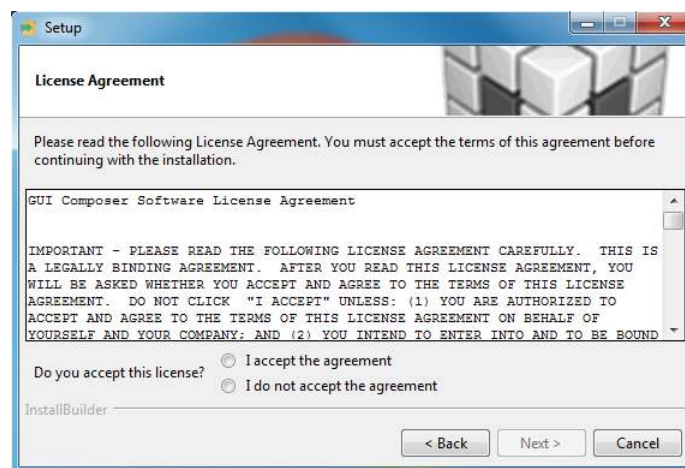


Figure 11. License Agreement

Select *Next* to continue (see [Figure 12](#)).

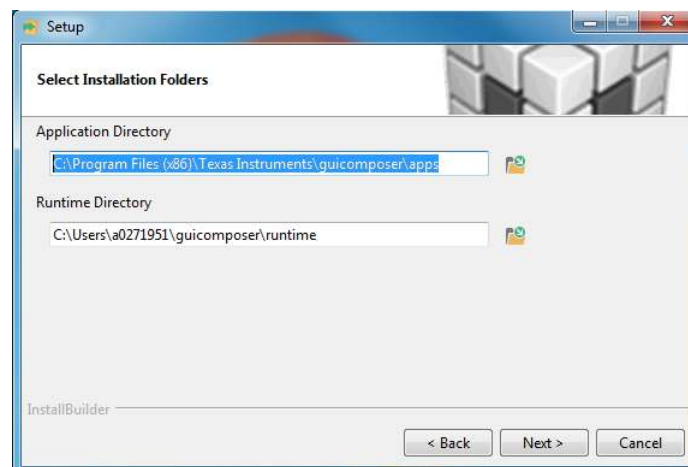


Figure 12. Installation Folders

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

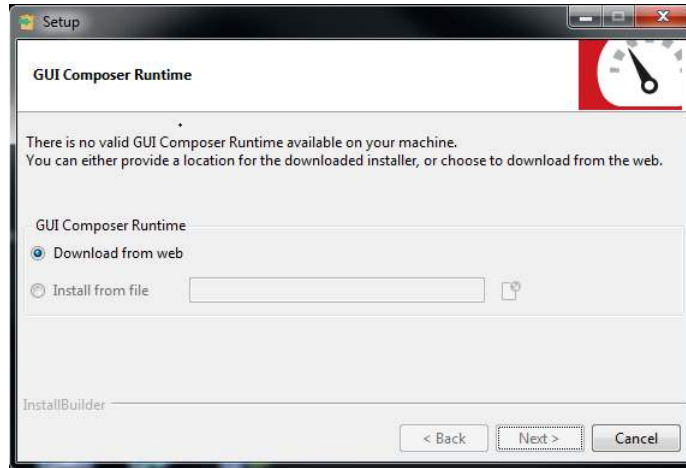


Figure 13. GUI Composer Runtime Selection

If the GUI has been previously installed a message similar to [Figure 14](#) may appear. If so, select *Yes*, then *Next* to continue (see [Figure 14](#)).

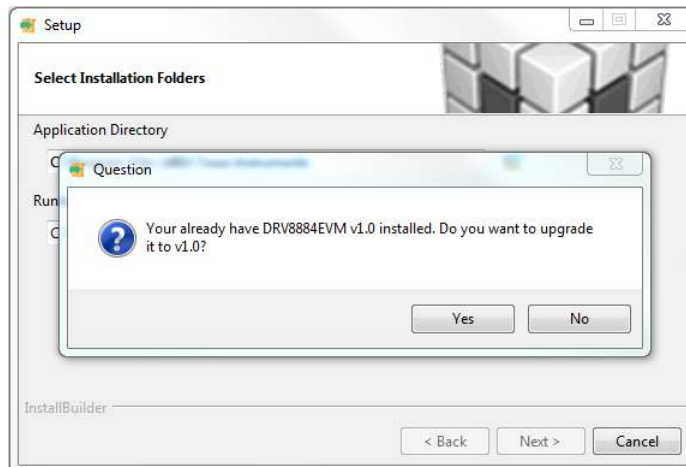


Figure 14. Possible Upgrade Question

Select *Next* to continue (see [Figure 15](#)).

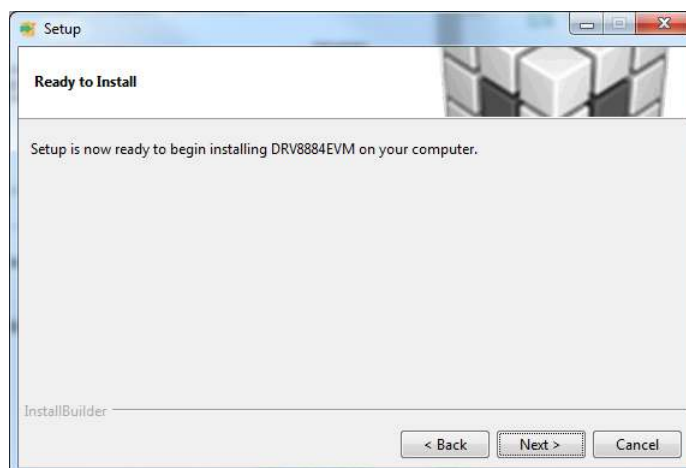


Figure 15. Ready to Install

Click the desired results, then select *Finish* to complete (see [Figure 16](#)).

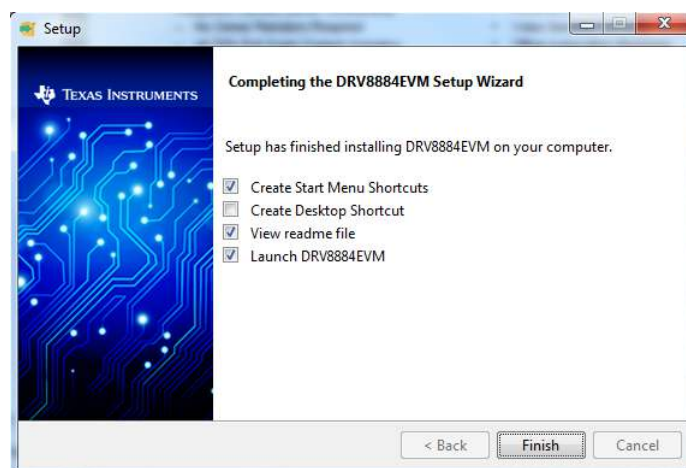


Figure 16. Completed

STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.
 - 1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms and conditions that accompany such Software
 - 1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.
2. *Limited Warranty and Related Remedies/Disclaimers:*
 - 2.1 These terms and conditions do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
 - 2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for any defects that are caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.
 - 2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.
3. *Regulatory Notices:*
 - 3.1 *United States*
 - 3.1.1 *Notice applicable to EVMs not FCC-Approved:*

This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.
 - 3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

3.2 Canada

3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210

Concerning EVMs Including Radio Transmitters:

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

Concernant les EVMs avec appareils radio:

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

Concerning EVMs Including Detachable Antennas:

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

Concernant les EVMs avec antennes détachables

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

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 by Radio Law of Japan to follow the instructions below with respect to EVMs:

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。技術適合証明を受けていないものご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

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。

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 2 4 番 1 号
西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/llds/ti_ja/general/eStore/notice_02.page
電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。http://www.tij.co.jp/llds/ti_ja/general/eStore/notice_02.page

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 WRITTEN DESIGN MATERIALS PROVIDED WITH THE EVM (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 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 AND CONDITIONS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT MADE, CONCEIVED OR ACQUIRED PRIOR TO OR AFTER DELIVERY OF THE EVM.
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 AND CONDITIONS. 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 AND CONDITIONS OR THE USE OF THE EVMS PROVIDED HEREUNDER, 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 ONE YEAR AFTER THE RELATED CAUSE OF ACTION HAS OCCURRED.
- 8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY WARRANTY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS AND CONDITIONS, OR ANY USE OF ANY TI EVM PROVIDED HEREUNDER, EXCEED THE TOTAL AMOUNT PAID TO TI FOR THE PARTICULAR UNITS SOLD UNDER THESE TERMS AND CONDITIONS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM AGAINST THE PARTICULAR UNITS SOLD TO USER UNDER THESE TERMS AND CONDITIONS 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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2015, Texas Instruments Incorporated

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com