DRV8881E Evaluation Module

This document is provided with the DRV8881E customer evaluation module (EVM) as a supplement to the DRV8881E (SLVSD19) datasheet. This user's guide details the hardware implementation of the EVM.

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1 PCB (Top View)

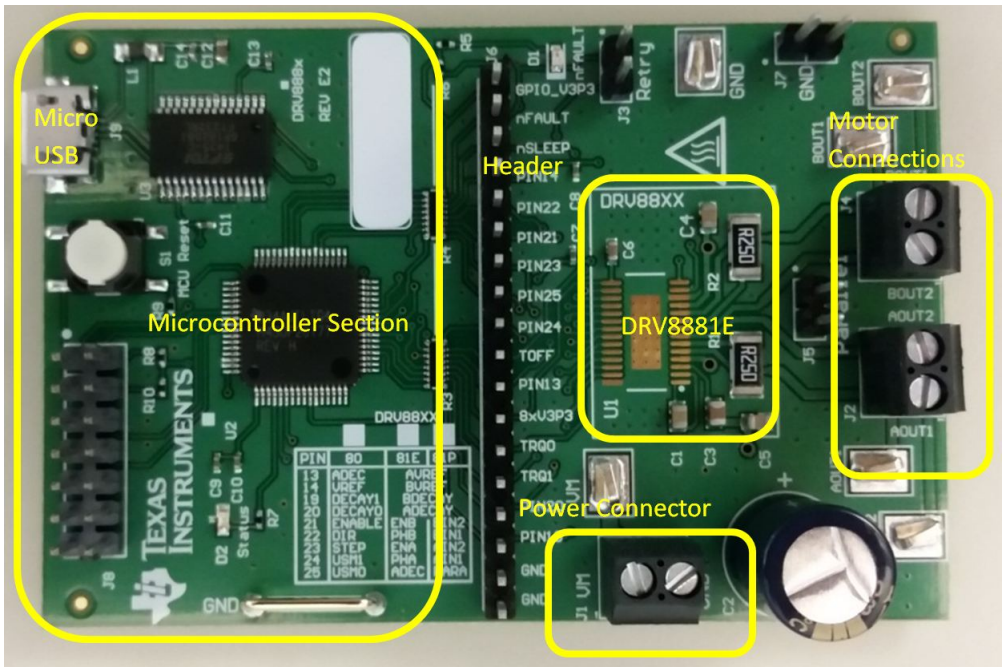


Figure 1. Typical Board Configuration (EVM Provided may Vary)

2 Introduction

The DRV8881E customer EVM is a platform revolving around the DRV8881E, 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 512 degrees of externally 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 Microsoft® Windows® application is used to schedule serial commands. These commands can be used to control each of the device's signals, and drive the stepper motor by issuing the step commands at the desired rate.

The microcontroller firmware operates using external indexing 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 DRV8881EEVM offers access to the VM (motor voltage) power rail via a terminal block (J1). A set of test clips in parallel with the terminal block allows for the monitoring of the input power rail.

Apply VM according to datasheet recommended parameters.

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

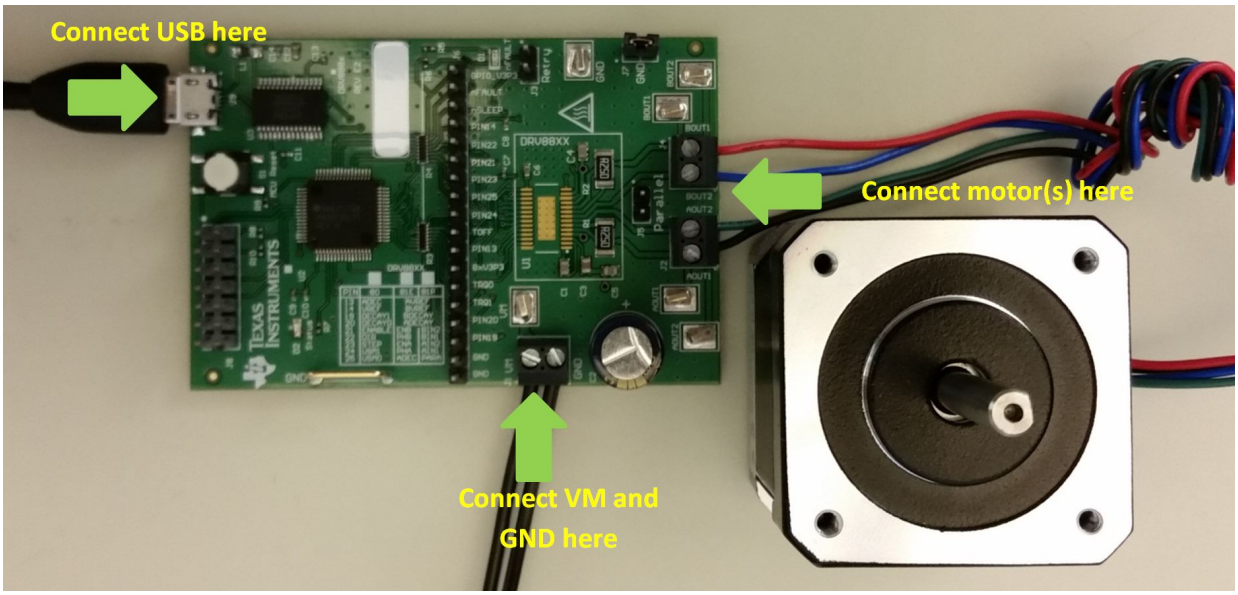


Figure 2. Connections

2.2 Test Points

A 0.100-in pitch header connector (J6) provides access to every device signal in the event a different microcontroller is to be employed. To disconnect the internal MSP430 microcontroller, remove resistor packs R3 and R4. Table 1 describes the connections available on the J6 header. Each header pin is labeled on the evaluation module, and matches the pin of the DRV8881E.

Table 1. Connections to DRV8881E Using External Microcontroller

Header Label	Description
V3P3R or V3P3_GPIO	3.3 V after 33-Ω resistor
nFAULT	Fault output
nSLEEP	Sleep mode input
PIN14	BVREF, Comparator reference input
PIN22	PHB, Phase B input
PIN21	ENB, Phase B enable
PIN23	ENA, Phase A enable
PIN25	AutoTune select
PIN24	PHA, Phase A input
TOFF	Off-time selection
PIN13	AVREF, Comparator reference input
8xV3P3	Internal supply voltage to set DAC voltage
TRQ0	Torque (current level)
TRQ1	Torque (current level)
PIN20	ADECAY, Decay mode
PIN19	BDECAY, Decay mode
GND	Ground
GND	Ground

2.3 Jumpers

NOTE: Jumpers J3, J5, and J7 are not used for the DRV8881E.

2.4 Motor Outputs

Two motor connectors are provided. Connectors J2 and J4 are available as shown in Figure 1.

2.5 Operation of the EVM

The following steps describe how to operate the EVM:

1. Install the drivers and GUI. Refer to Appendix A at the end of this document 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. Once the USB is connected to the EVM, the Status LED begins to blink.
5. Open the GUI by double clicking the icon. It may take up to 30 seconds to establish connection. If a connection is not established, select the COM port under the *Options* menu. The BaudRate is 9600.
6. Apply 6.5 to 45 V to the VM and GND connections.
7. Configure the current settings, step mode, torque, and PWM off-time as desired, as shown in Figure 3. Note that the *Decay Mode* selection is available only when AutoTune is disabled.

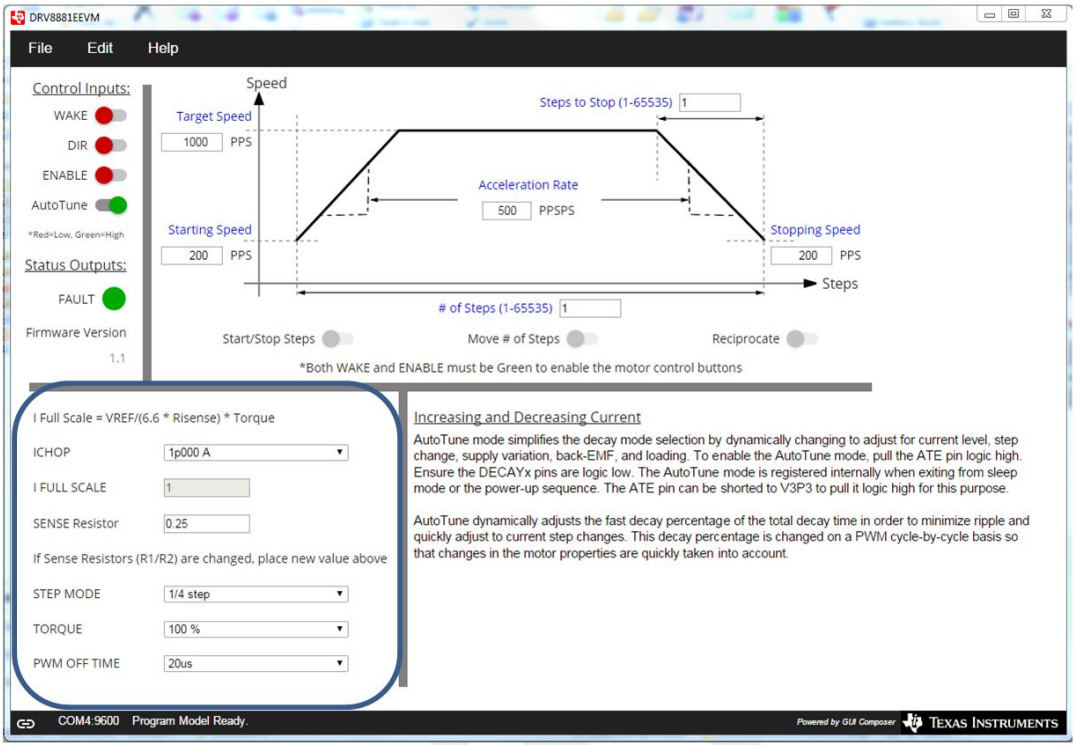


Figure 3. Initial GUI Screen

- The current is calculated using the ICHOP pulldown, the Sense resistor value, the Torque setting, and the Step mode setting using the formula.

$$I_{FS} = \frac{VREF}{6.6 \times RISENSE} \times TORQUE \times StepModifier \quad (1)$$

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

The 12-bit DAC channels 0 and 1 are connected to the DRV8881E analog inputs AVREF and BVREF. Changing the DAC digital value from 0 to 4092 in steps of 4, changes the analog voltage

at the xVREF pin from 0 V to VINT V. See Equation 2.

$$VREF = \frac{VINT}{4095} \times (VREF\_slider \times 4) \quad (2)$$

Where VINT is the output of the DRV8881E pin and VREF_slider is the slider value from 0 to 1023.

8. Wake and enable the device for operation.
   (a) After setting up the control signals for the DRV8881E, enable the DRV8881E by selecting both WAKE and ENABLE toggle buttons. When toggled, WAKE or ENABLE will toggle between red and green.
   (b) The WAKE toggle button, which controls the nSLEEP pin, is used to wake the DRV8881E. The ENABLE toggle button, which controls the nENBL pin, is used to enable the DRV8881E outputs.
   (c) A message which states that “Both WAKE and ENABLE must be green to enable motor control buttons” will be visible until both the WAKE and ENABLE toggle buttons are activated. Once these two toggle buttons have been activated, the message disappears and the Start/Stop and Move Steps toggle buttons will be 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.

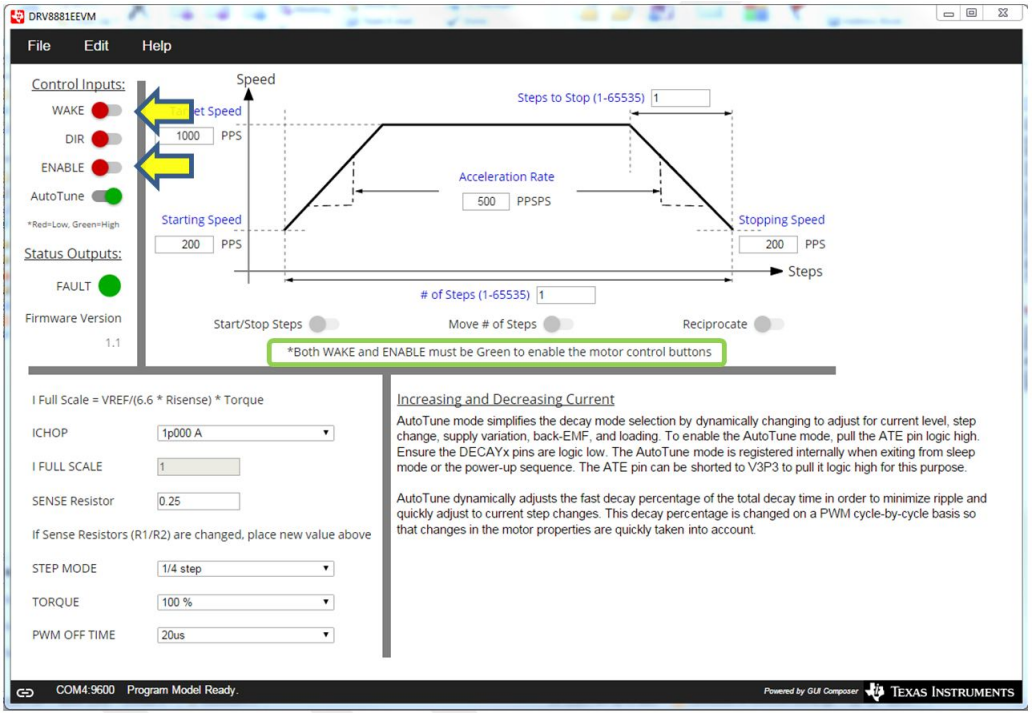


Figure 4. Wake and Enable Toggle Buttons

9. The DRV8881E EVM is now awake and can be commanded to turn the motor. This can be 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” 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.

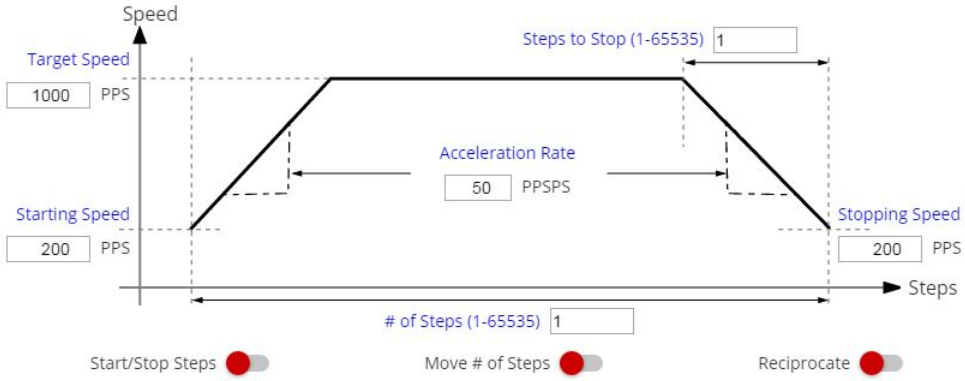
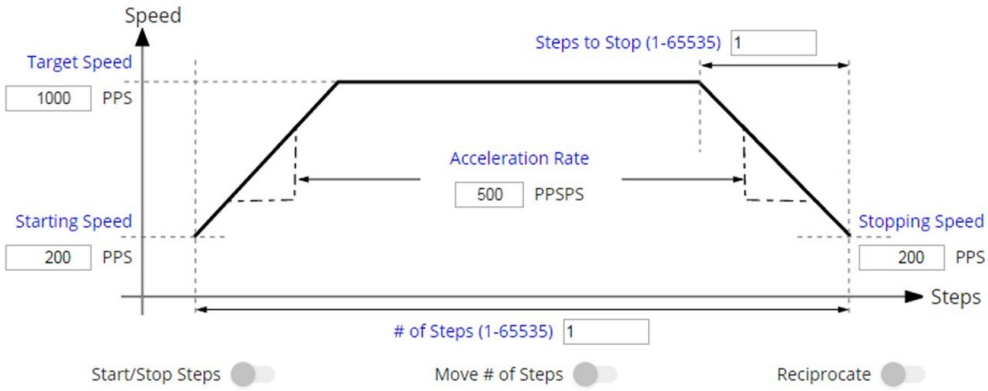


Figure 5. Motor Controls Enabled

As an extra precaution, the motor can be stopped by selecting either the WAKE or ENABLE toggle buttons. Once 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 while 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 can only happen by using an acceleration profile which is detailed in this section. A detailed explanation of each stepper control section follows.

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, 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 16-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.

2.6.1 Start/Stop Steps

The acceleration profile is coded inside of 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 will generate steps at a rate specified by the start speed PPS parameter.

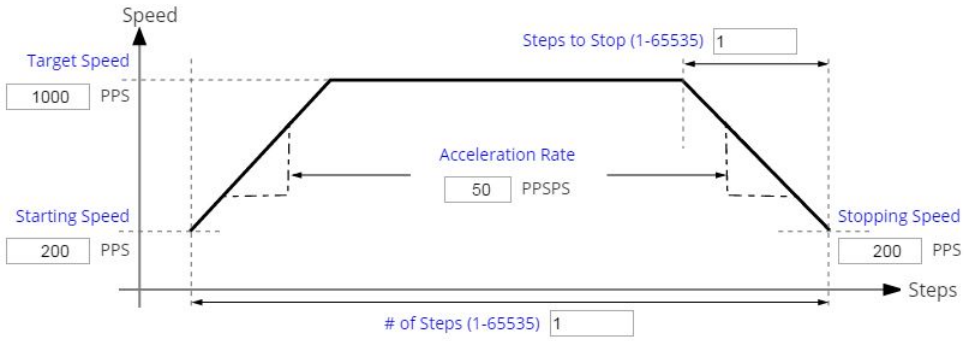
When accelerating or decelerating, PPS is adjusted every 32 ms, based on the integer value of PPSPS / 32 ms. If a non-zero value of PPSPS is entered, a minimum value of 1 is used. The step rate is increased by the calculated value until the target speed is reached.

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.

Once the target speed PPS is reached, the acceleration profile ends and the motor stays running until the stop stepper command is issued (Start/Stop Steps toggle 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 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.



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

Figure 7. Acceleration Profile

2.6.2 Move Steps

If the user desires to move the stepper a certain number of steps, this can be easily accomplished by using the move steps function. Parameters from the other frames are reused and its utilization is as explained previously. Two new parameters have been added to properly control the limited number of steps

Number of Steps: Number of steps 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 “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 good enough to ensure good motion quality and application performance.

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

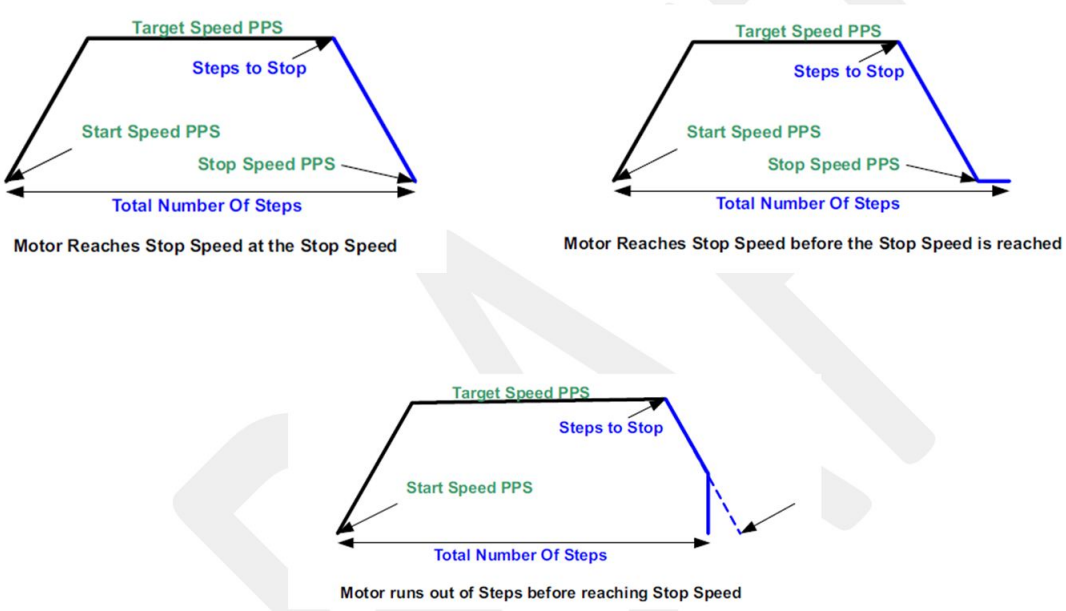


Figure 8. Three Stopping Conditions and Action Taken

2.7 EVM documentation

The EVM schematics, layout, and bill of materials (BOM) are provided in the hardware file (SLVC624). The GUI, USB drivers, and MSP430F2617 source code are provided in the software file (SLVC628).

A.1 Driver and GUI Installation Instructions

Use the following steps to install the driver and GUI:

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 software file. Unzip it 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 and select Properties, go to the Compatibility tab, check “Run this program in compatibility mode for”, select “Windows XP (Service Pack 2)”, OK. Then run CDM v2.10.00 WHQL Certified.exe and click “Yes” to the pop-up window.
2. Running the Application Software
   Locate the file DRV8881EEVM_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 will begin. The following images will appear:

   Select *Yes* to continue (see Figure 9).

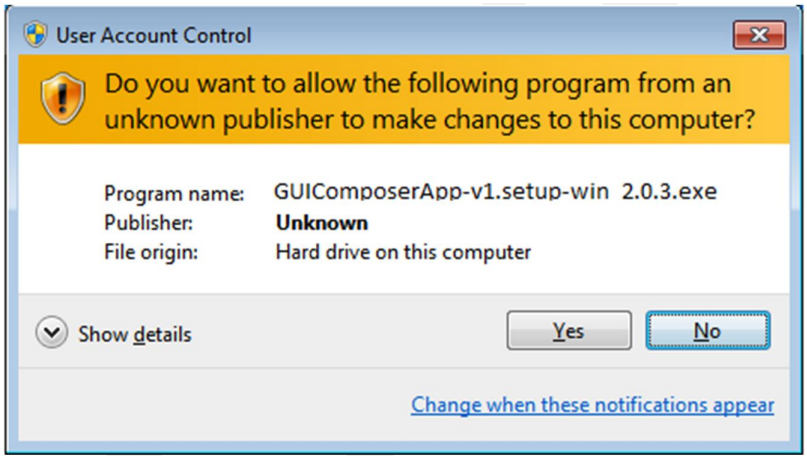


Figure 9. User Account Control Window

Select *Next* to continue (see Figure 10).

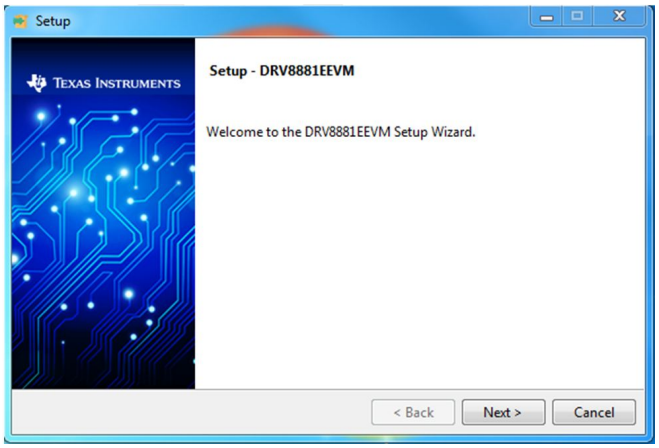


Figure 10. EVM Setup Wizard

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

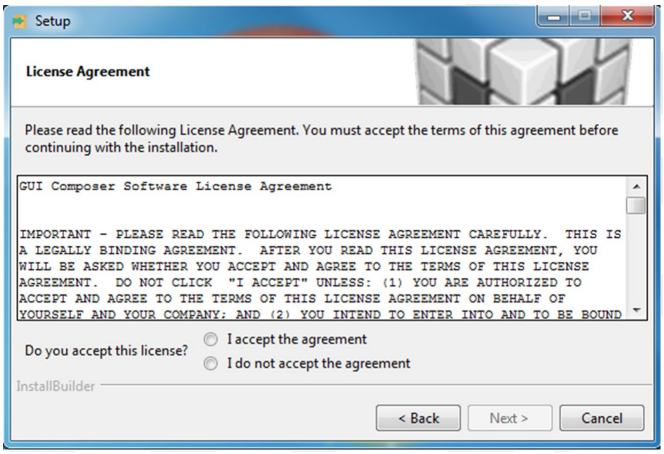


Figure 11. License Agreement

Select *Next* to continue (see Figure 12).

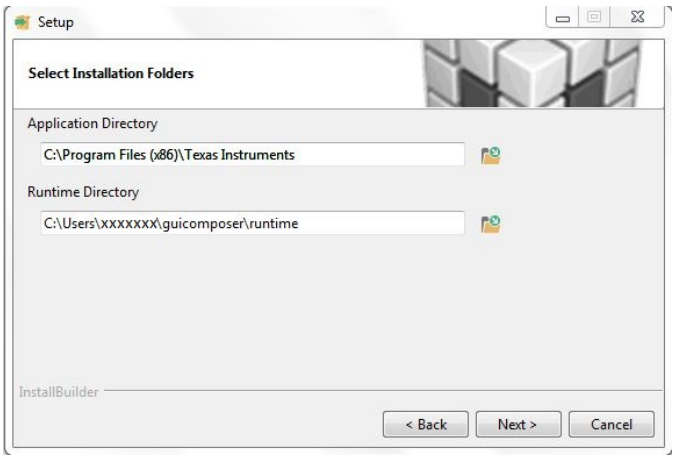


Figure 12. Installation Folders

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).

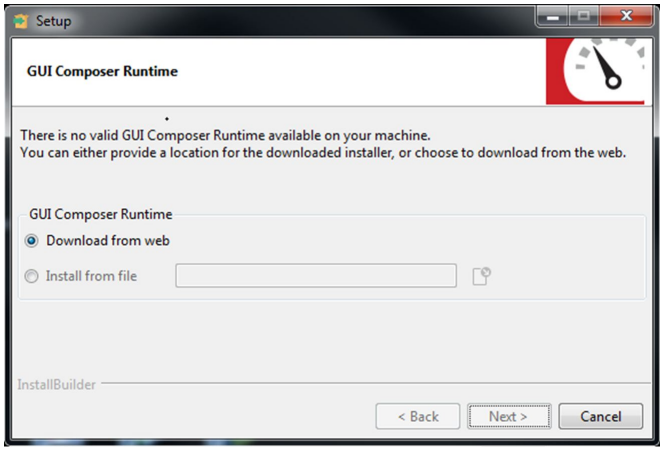


Figure 13. GUI Composer Runtime Selection

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).

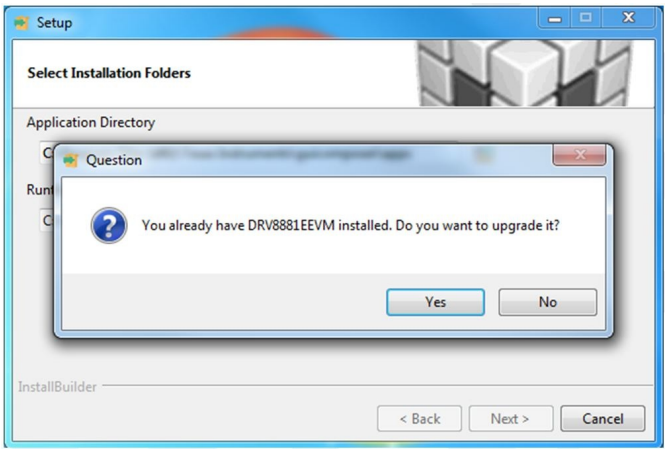


Figure 14. Possible Upgrade Question

Select *Next* to continue (see Figure 15).

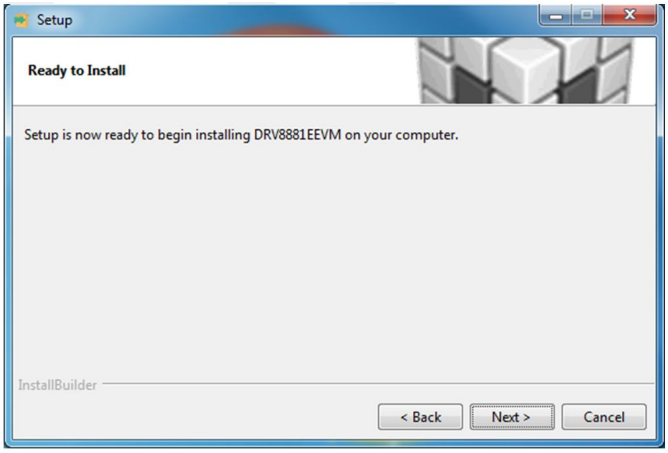


Figure 15. Ready to Install

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

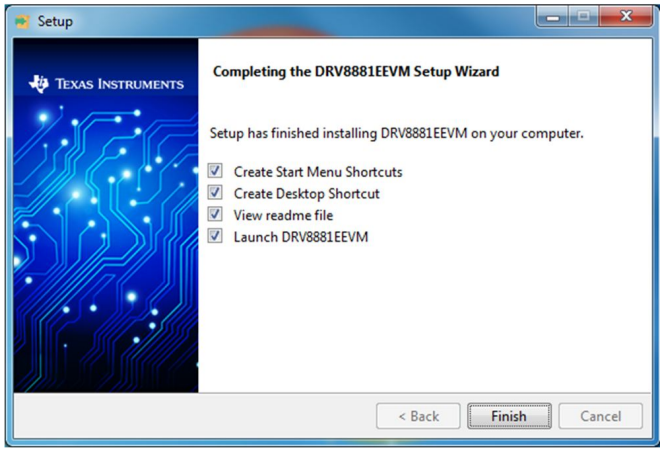


Figure 16. Completed

Revision History

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

Changes from Original (July 2015) to A Revision	Page
• Changed J4 to J6 in the first paragraph of the *Test Points* section	3

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.

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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/lsds/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/lsds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required 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.

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

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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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