BOOSTXL-DRV8323Rx EVM User's Guide

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

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

Contents

List of Figures

List of Tables

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1 Introduction

1.1 Overview

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

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

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

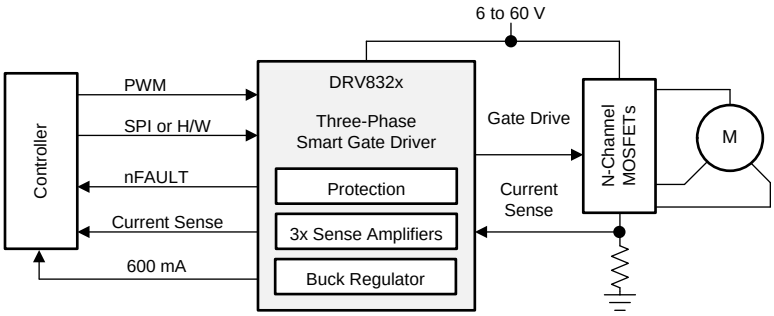

Figure 1. Block Diagram

1.2 Purpose and Scope

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

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

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

2 Hardware and Software Overview

2.1 Hardware Connections Overview – DRV8323Rx + MSP430F5529

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

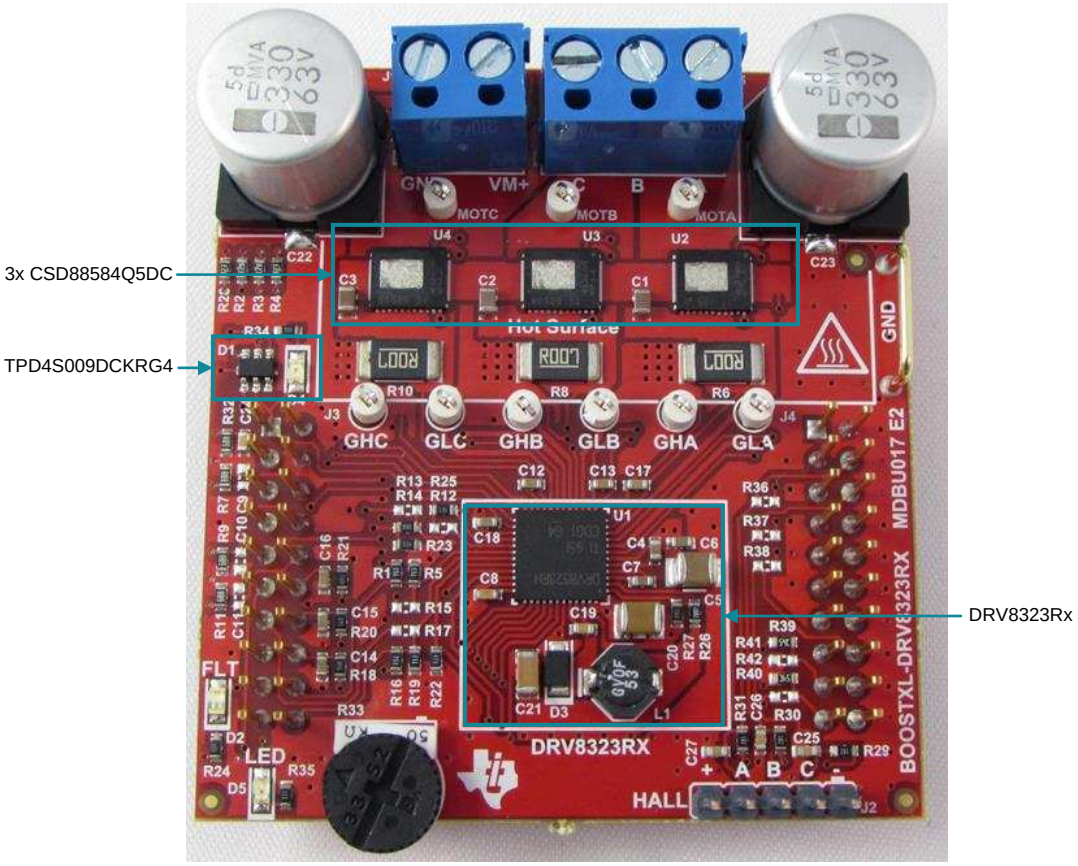

Figure 2. Hardware Connections Overview

2.2 Connection Details

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

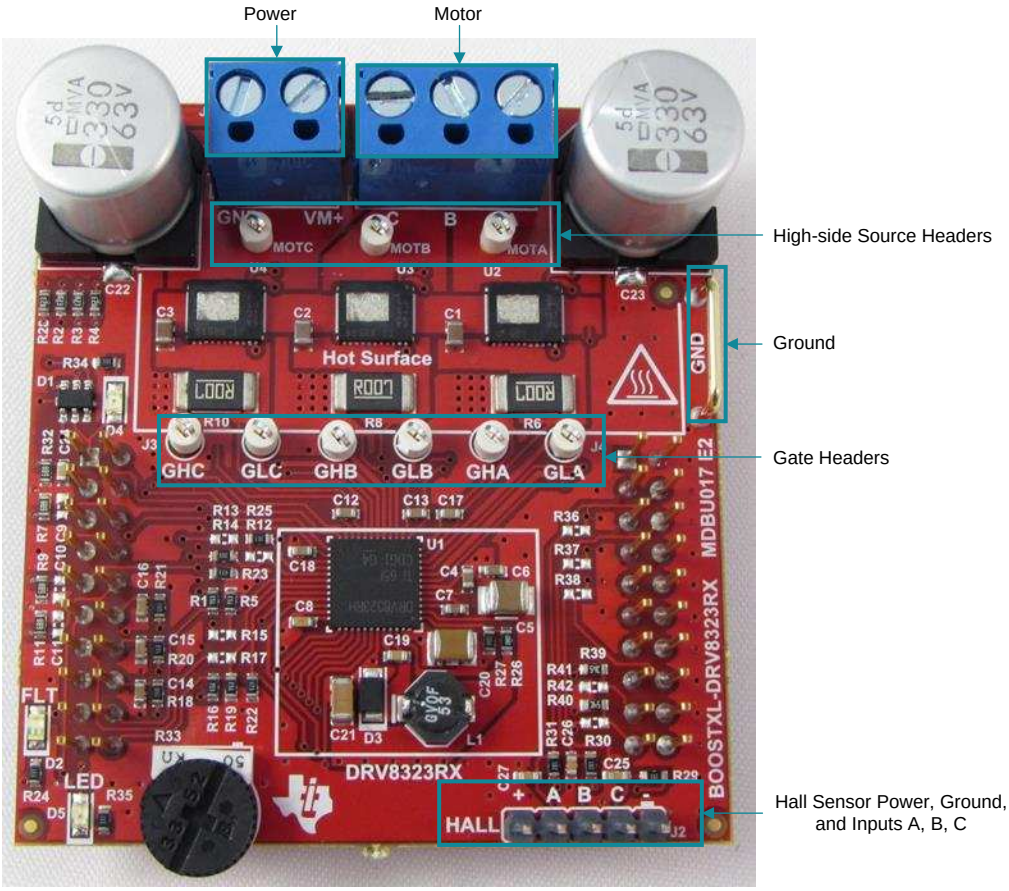

Figure 3. Connections

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

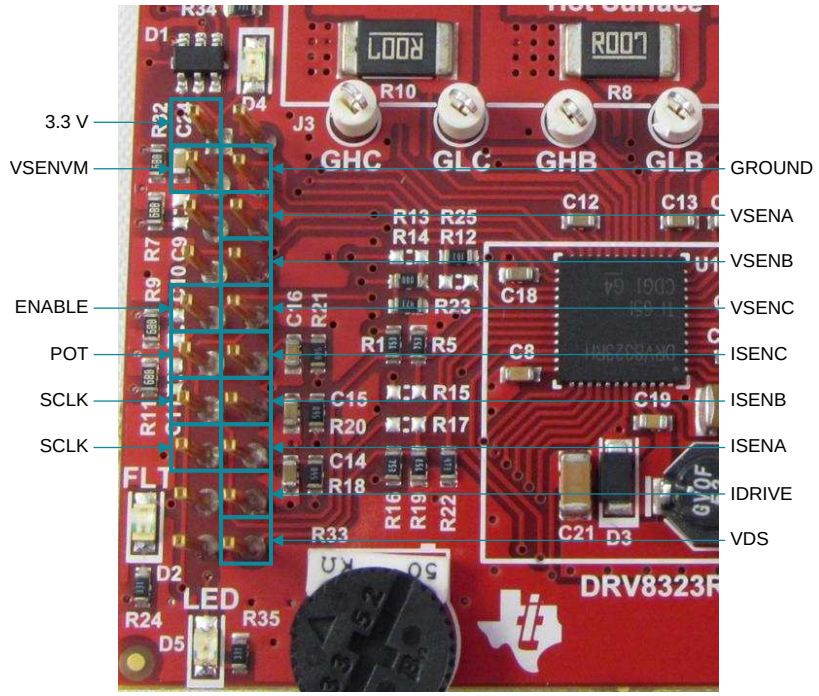

Figure 4. Jumper Connections 1

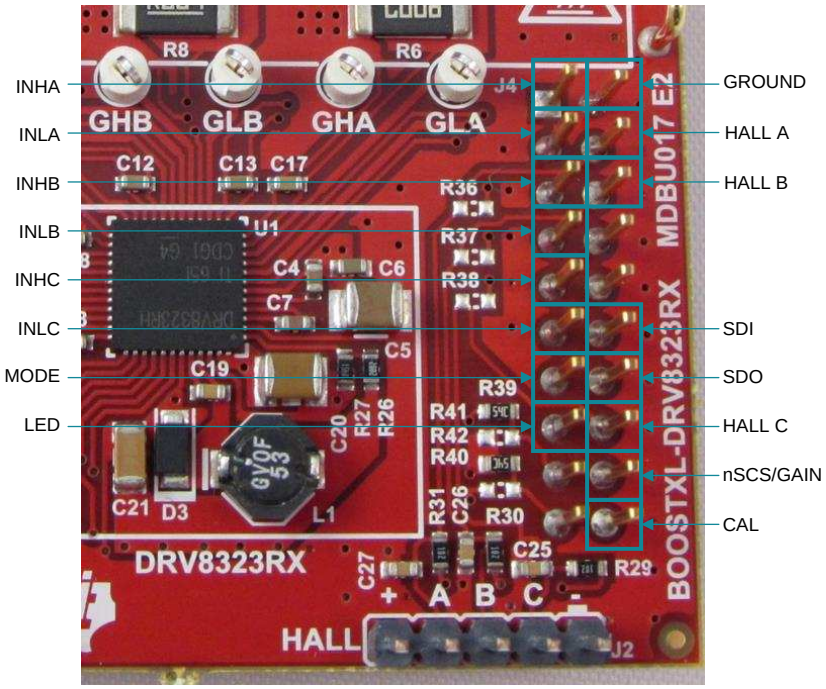

Figure 5. Jumper Connections 2

Figure 6 shows where the Micro-USB cable is plugged in to power the LaunchPad development kit and provide communication between the MSP430F5529 firmware and GUI.

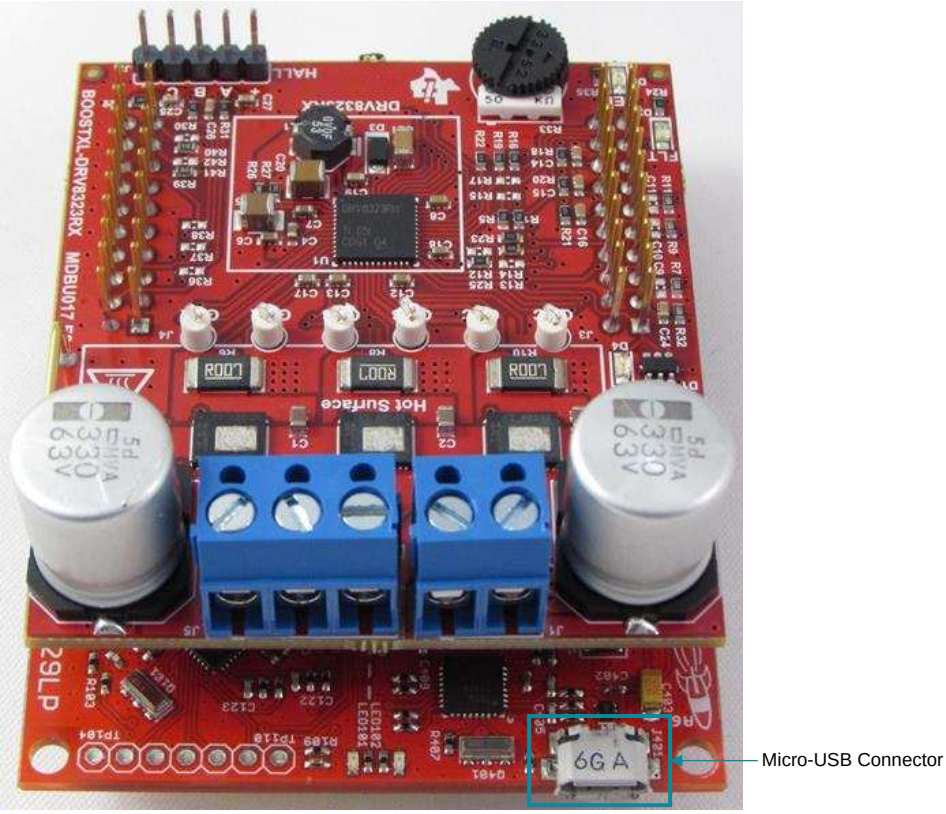

Figure 6. Micro-USB Connection

2.3 LED Lights and Switch Functions

Two LEDs and two push button switches are available on the MSP430F5529 LaunchPad development kit to notify the user of different motor statuses and to control the operation of the motor. These switches are configured in the reference software and preloaded with the following functions:

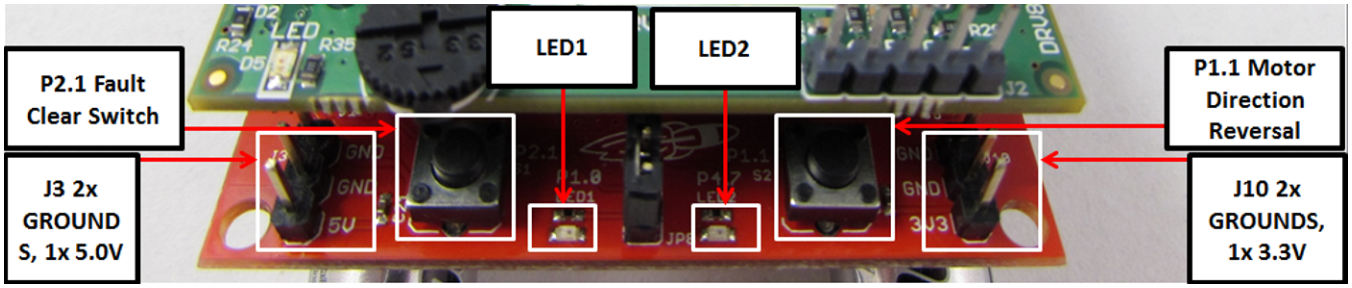

Figure 7. Switches and LED Functions

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

P2.1 switch (fault clear switch) — This switch is configured to clear the fault status in SPI registers and to restart the motor. When the user does not want automatic fault recovery when a fault occurs, it can be turned off in the parameter setup file. In such cases, this button helps in restarting motor after successful identification and mitigation of fault.

LED1 and LED2 — During normal motor operations LED1 and LED2 define the direction of spin. When any fault occurs. LED1 and LED2 flashes in different patterns to identify the fault. Table 1 describes the patterns observed with different fault conditions.

Table 1. Fault Status

Fault Status	LED 1	LED 2
Voltage	Toggle	Toggle
Motor stall	ON	Toggle
Overcurrent	Toggle	ON
Overtemperature	ON	OFF
Gate driver	ON	ON
Other	OFF	OFF
Hall sensor invalid (Sensored)	OFF	ON

2.4 Interfacing DRV8323Rx and MSP430F5529 LaunchPad

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

Table 2. BOOSTXL-DRV8323Rx J3 Pin Connections

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

Table 3. BOOSTXL-DRV8323RX J4 Pin Connections

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

3 Firmware Installation

3.1 Installing Code Composer Studio

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

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

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

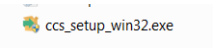

Figure 8. Downloaded Executable for Code Composer Studio Installation

Follow the installation process listed:

Step 1. Run the installer by double clicking the ccs_setup_win32.exe file.

Step 2. Read through and accept the license agreement to proceed with the installation (see Figure 9).

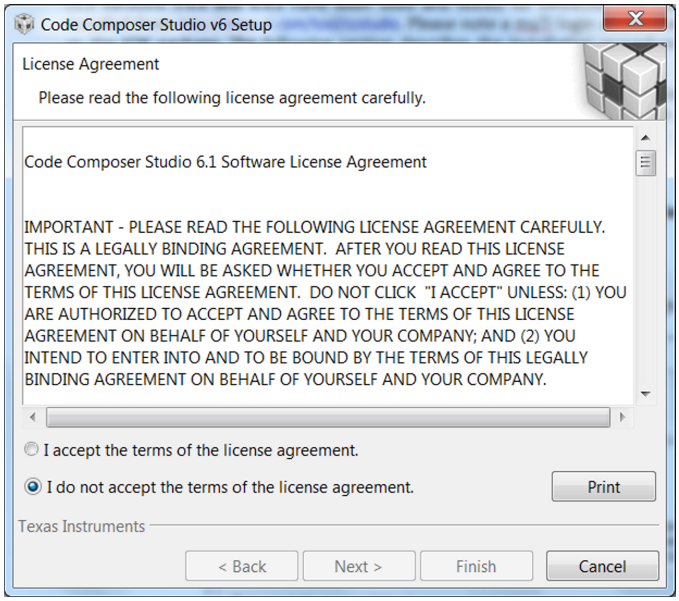

Figure 9. CCS License Agreement

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

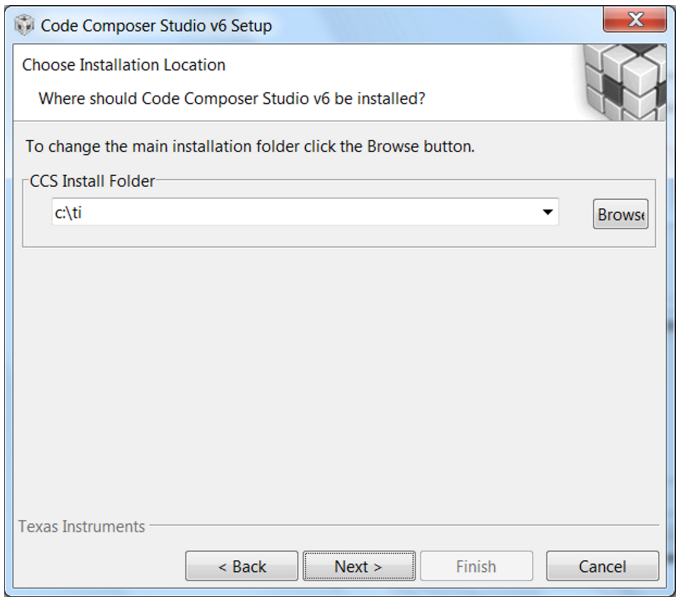

Figure 10. Default Installation Location for CCS

Step 4. Choose the processor architectures to install (see Figure 11).

For the DRV83xx, the MSP430 and C28x are the only needed processor packages. The compiler tools are required. Ensure that the box for the *TI MSP430 Compiler Tool* is checked.

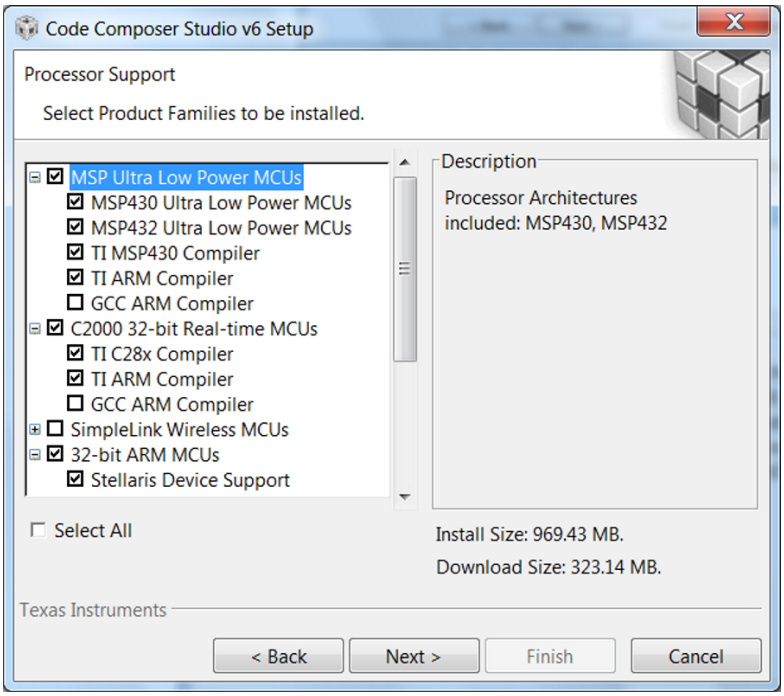

Figure 11. Processors Supported by CCS

Step 5. Select the emulator components to install.

For the provided tool, the MSP430 USB FET emulator is required.

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

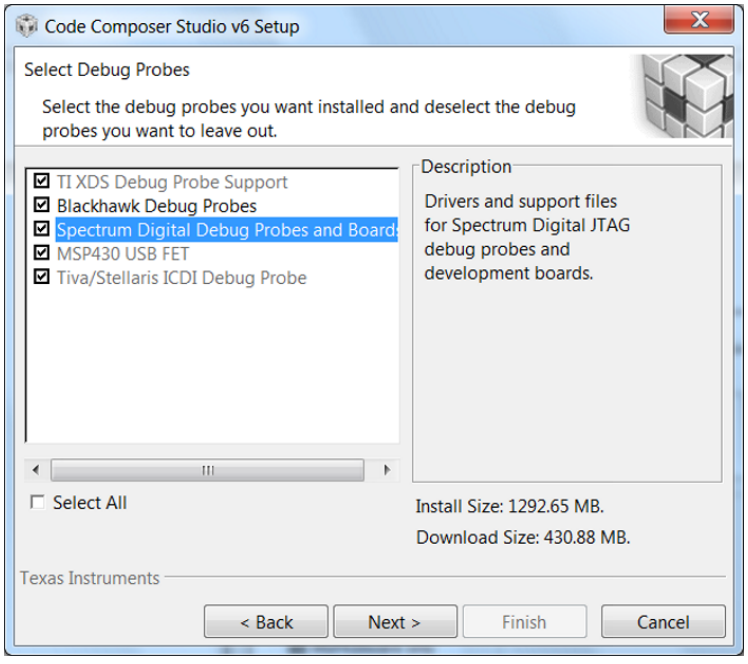

Figure 12. Components Available for Installation

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

Step 8. Review the installation and click the *Finish* button to finalize (see Figure 13).

Figure 13. Emulators Available for Installation

Step 9. After the installation has completed, click the *Finish* button to exit the set-up.

3.2 Installing DRV832X Reference Software Development Package

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

To instal of the reference software development package, follow these steps:

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

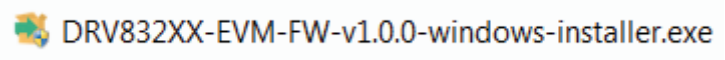

Figure 14. DRV832XX EVM Firmware Executable File

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

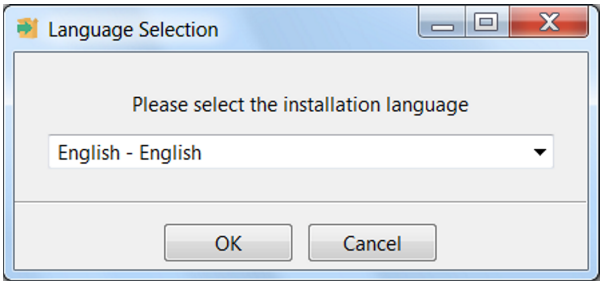

Figure 15. Language Selection

Step 3. Click the *Next* button on the DRV832XX Installer welcome screen (see Figure 16).

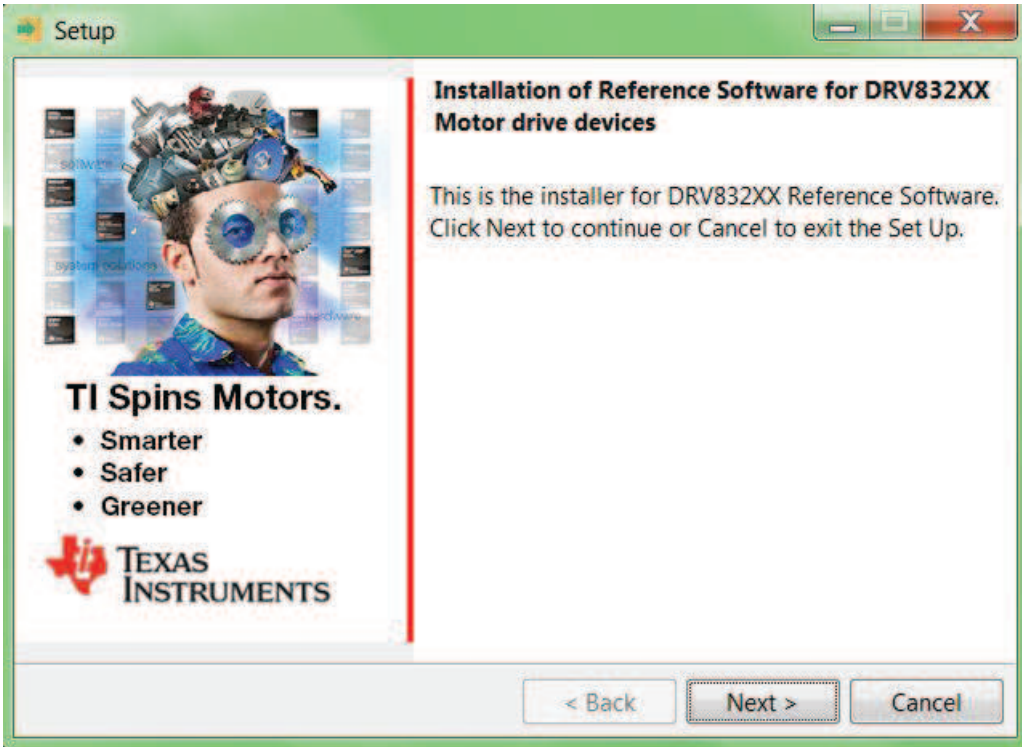

Figure 16. Setup Home Screen

Step 4. Read though and accept the license agreement to proceed with the installation (see Figure 17).

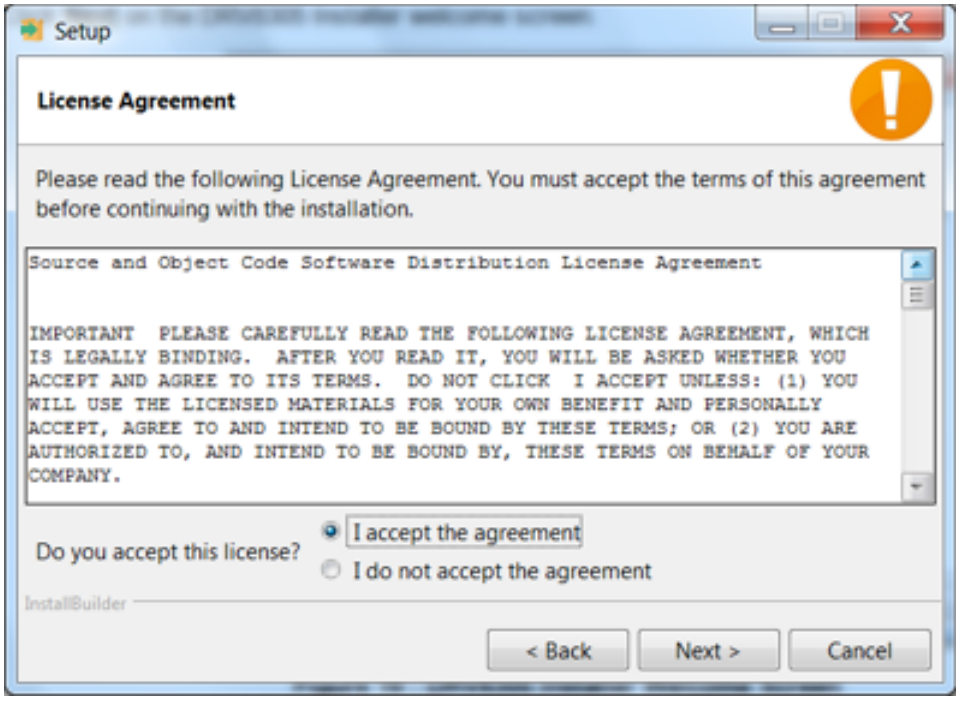

Figure 17. DRV832XX Software License Agreement

Step 5. Choose the destination location for the example CCS projects and the documentation (see Figure 18). This destination can be set to any location in the PC.

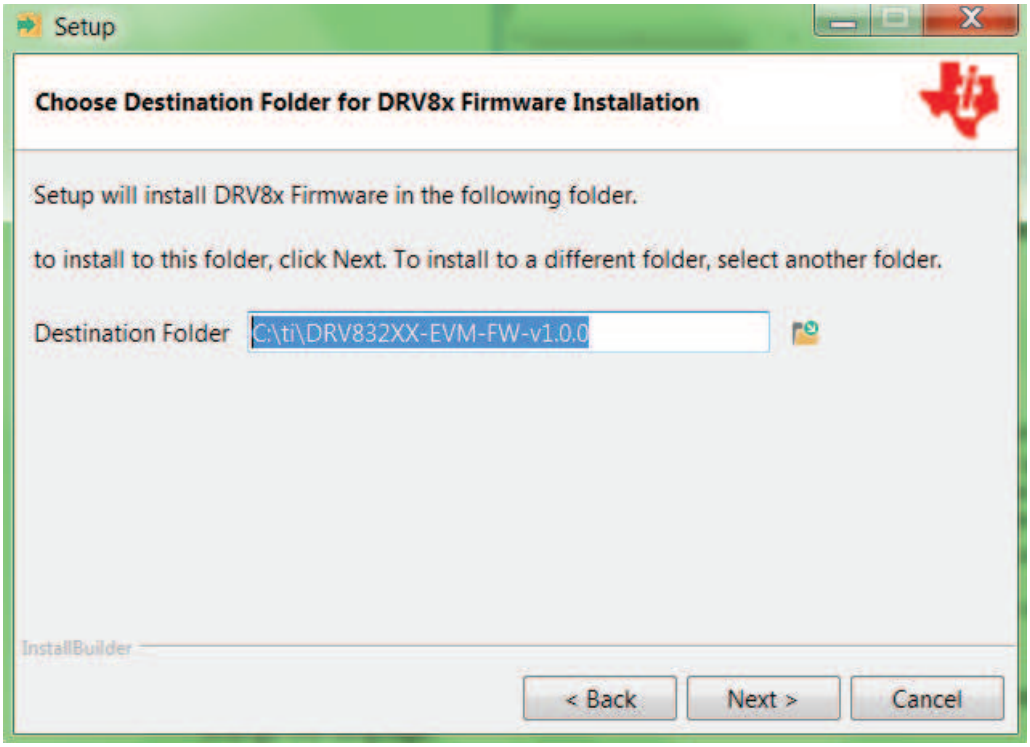

Figure 18. Setup Destination Folder

Step 6. Select each DRV8x components to Install (see Figure 19).

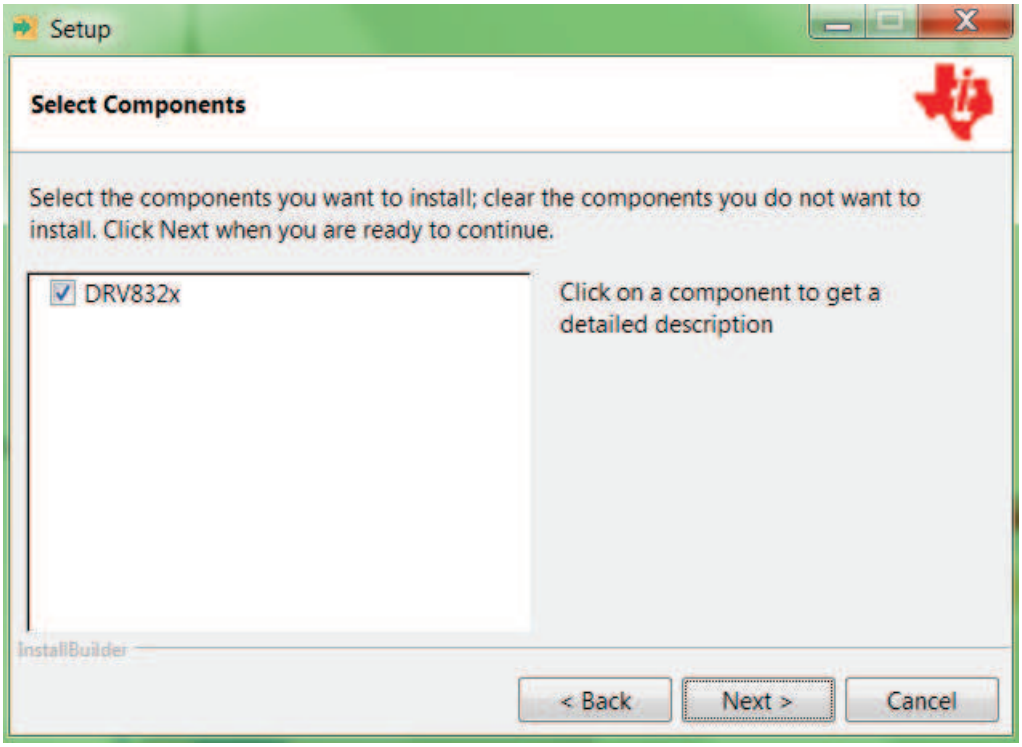

Figure 19. Select Setup Components

Step 7. Ensure all running instances of CCS are closed (see Figure 20).

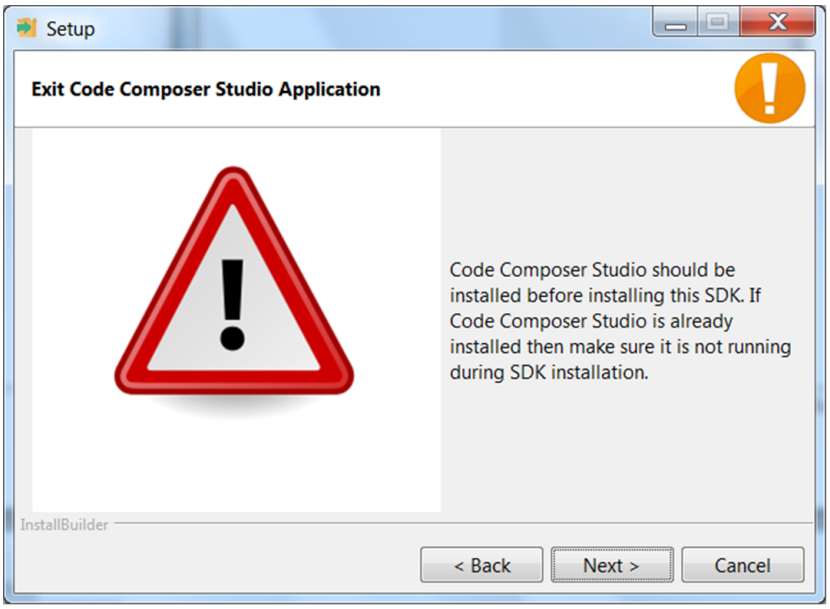

Figure 20. Warning Message to Close CCS

Step 8. Continue with the installation process.

Step 9. Click the *Next* button to install after reviewing the settings.

Step 10. Click the *Finish* button when the files are successfully installed in the destination folder (see Figure 21).

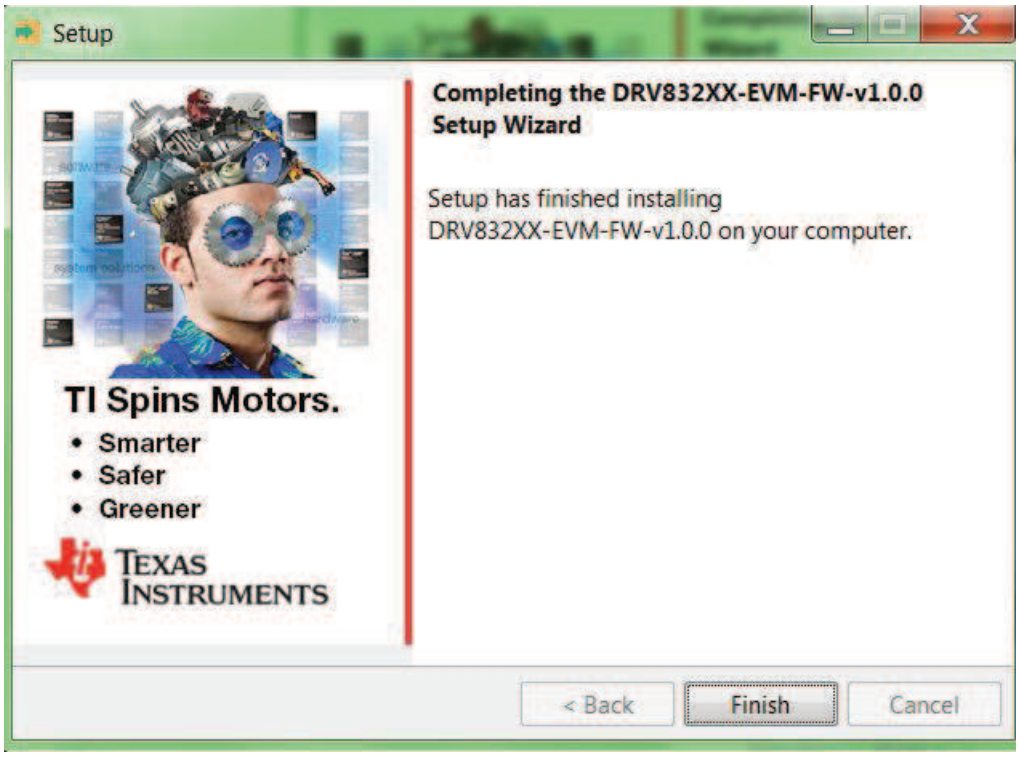

Figure 21. Firmware Setup Complete

3.3 Creating or Importing a DRV8x Project into CCS

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

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

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

Step 3. Click the *OK* button to accept.

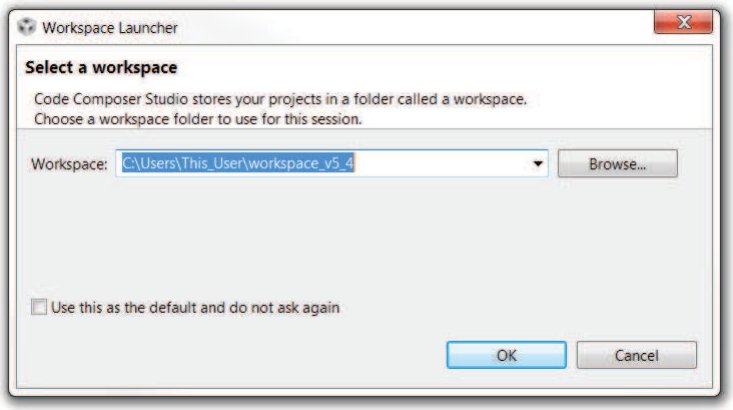

Figure 22. Workspace Launcher

After selecting the workspace, the CCS software opens displaying a welcome menu.

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

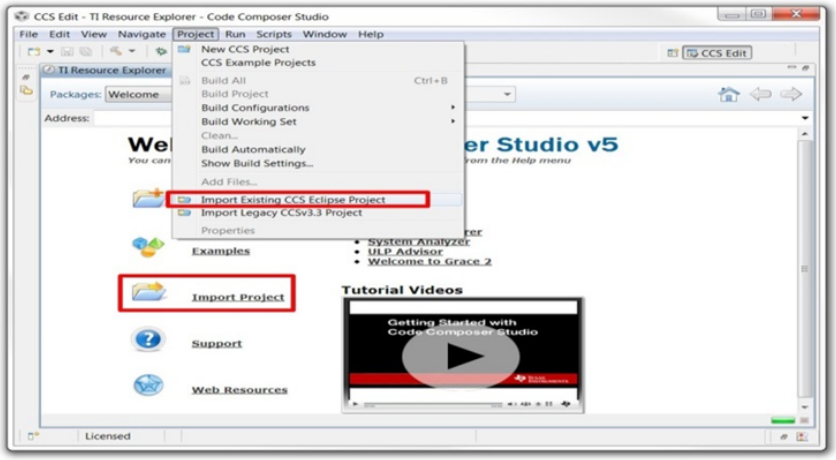

Figure 23. Importing Existing Projects

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

Step 6. Make sure the correct box is checked and then click the *Finish* button (see Figure 24.

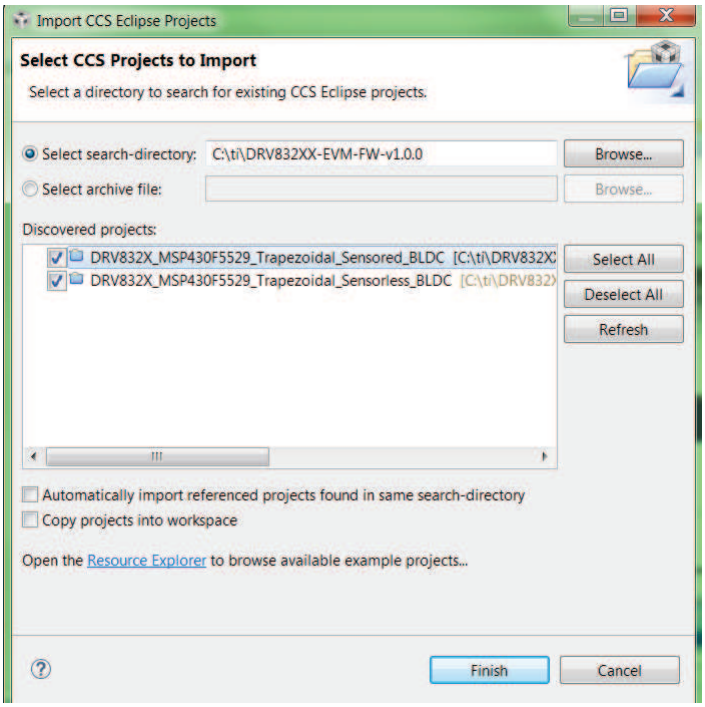

Figure 24. Selecting Existing Projects

When the projects are imported to the workspace, the project should appear in the *Project Explorer* window as shown in Figure 25.

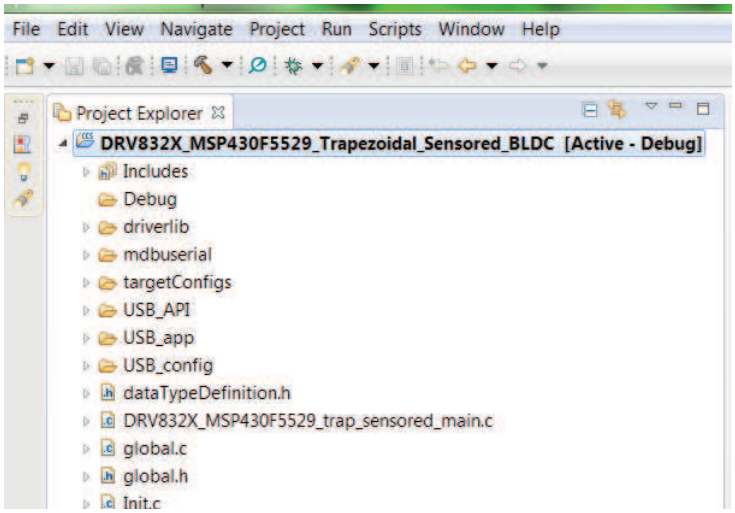

Figure 25. DRV832x Project Explorer

Step 7. Explore the project files, build the project to create an image to be downloaded on the MSP430F5529 hardware, and download the project from here. Make sure the MSP430F5529 is connected to the PC through USB interface before downloading the code.

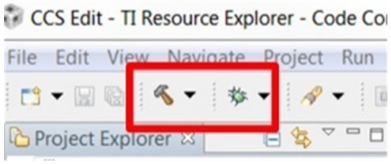

Figure 26. Build Project Files Buttons

Step 8. When the CCS software is connected to the device, run the program from CCS to execute the program in hardware by clicking the green play button (see Figure 27. Click the red stop button ((see Figure 27) to disconnect the MSP-FET430UIF from.

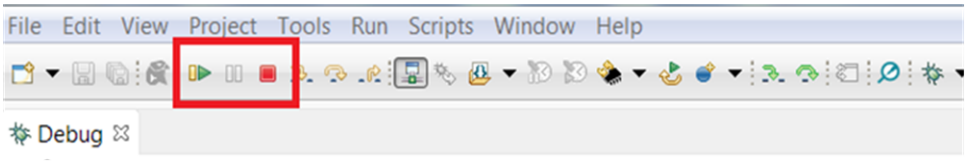

Figure 27. Execute Buttons

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

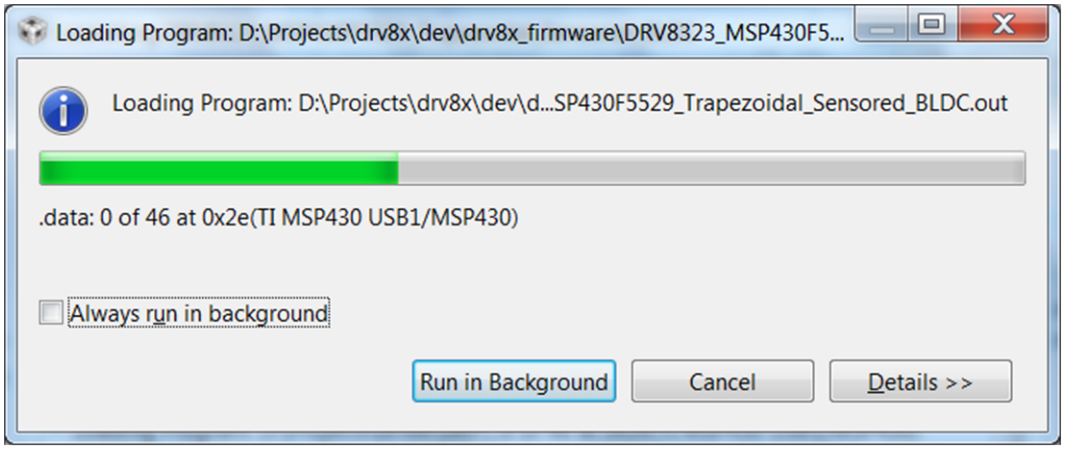

Figure 28. Flashing Firmware

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

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

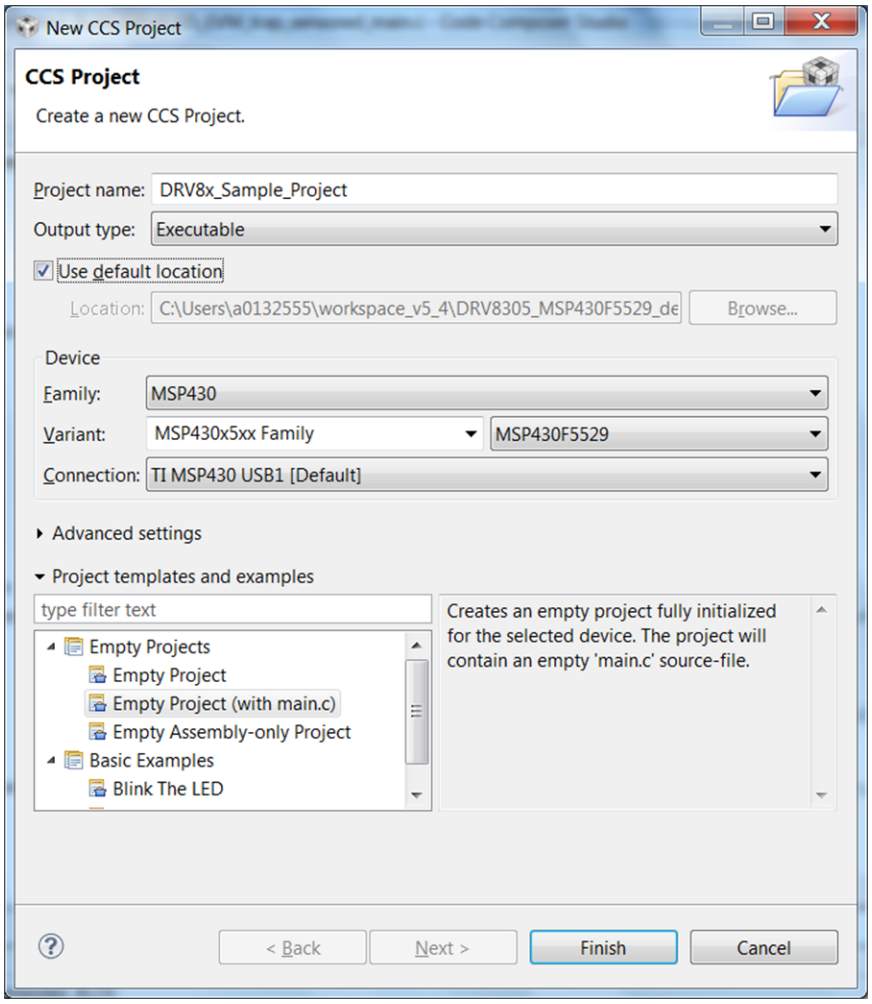

Figure 29. New CCS Project

3.4 Updating the MSP430 USB-FET

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

CAUTION

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

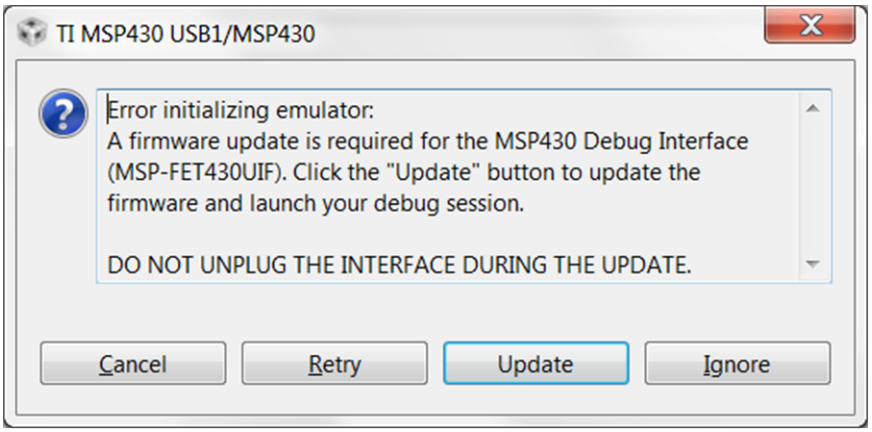

Figure 30. Error Initializing Emulator

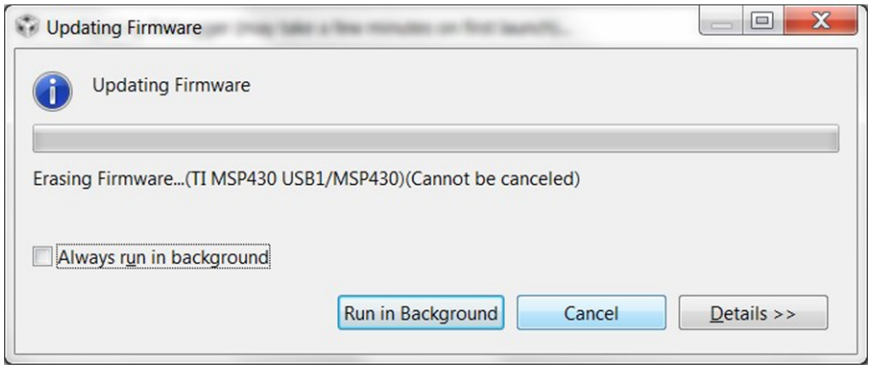

Figure 31. Updating LaunchPad development kit Firmware

4 GUI Application

4.1 Installation

Follow these steps to install the GUI application:

Step 1. Download and run theSetup_boostxldrv832x-1.0.0_EVM.exe installer file to install the GUI application.

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

This driver is automatically installed during the GUI installation process. Click the *Install* button when the window shown in Figure 32 appears during the GUI installation. If this pop-up does not appear, then the drivers are already installed.

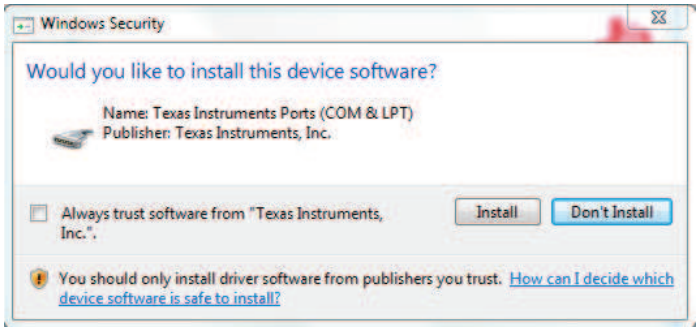

Figure 32. TI MSP430 USB Installer

If the automatic driver installation fails for some reason, or if the *Don't Install* button was clicked, install the drivers manually. First find the driver .inf file (msp430_ti_signed.inf) in the following folder: C:\Program Files (x86)\Texas Instruments\BOOSTXL-DRV832X\TI MSP430 USB Driver. Right click on the .inf file and select the *Install* option. Follow the installation instructions to successfully install the driver.

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

4.2 Hardware Setup

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

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

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

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

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

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

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

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

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

Step 5. Turn on the power supply and power up the PCB.

4.3 Launching BOOSTXL-DRV832X EVM GUI

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

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

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

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

Figure 33. BOOSTXL-DRV832X EVM Device Launch

Revision History

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

Changes from B Revision (March 2018) to C Revision	Page
• Changed some DRV832XX references to DRV832x	12

Changes from A Revision (May 2017) to B Revision	Page
• Added links to download the installation package for the reference software	12

Changes from Original (February 2017) to A Revision	Page
• Added the note about the revision A MDBU017 board not meeting the SO offset specification	1

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- *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.*
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