DRV8350x-EVM User's Guide

This document is provided with the DRV8350x-EVM customer evaluation module (EVM) as a supplement to the *DRV835x 100-V Three-Phase Smart Gate Driver* data sheet. This user's guide details the hardware implementation of the EVM and how to install the various software packages.

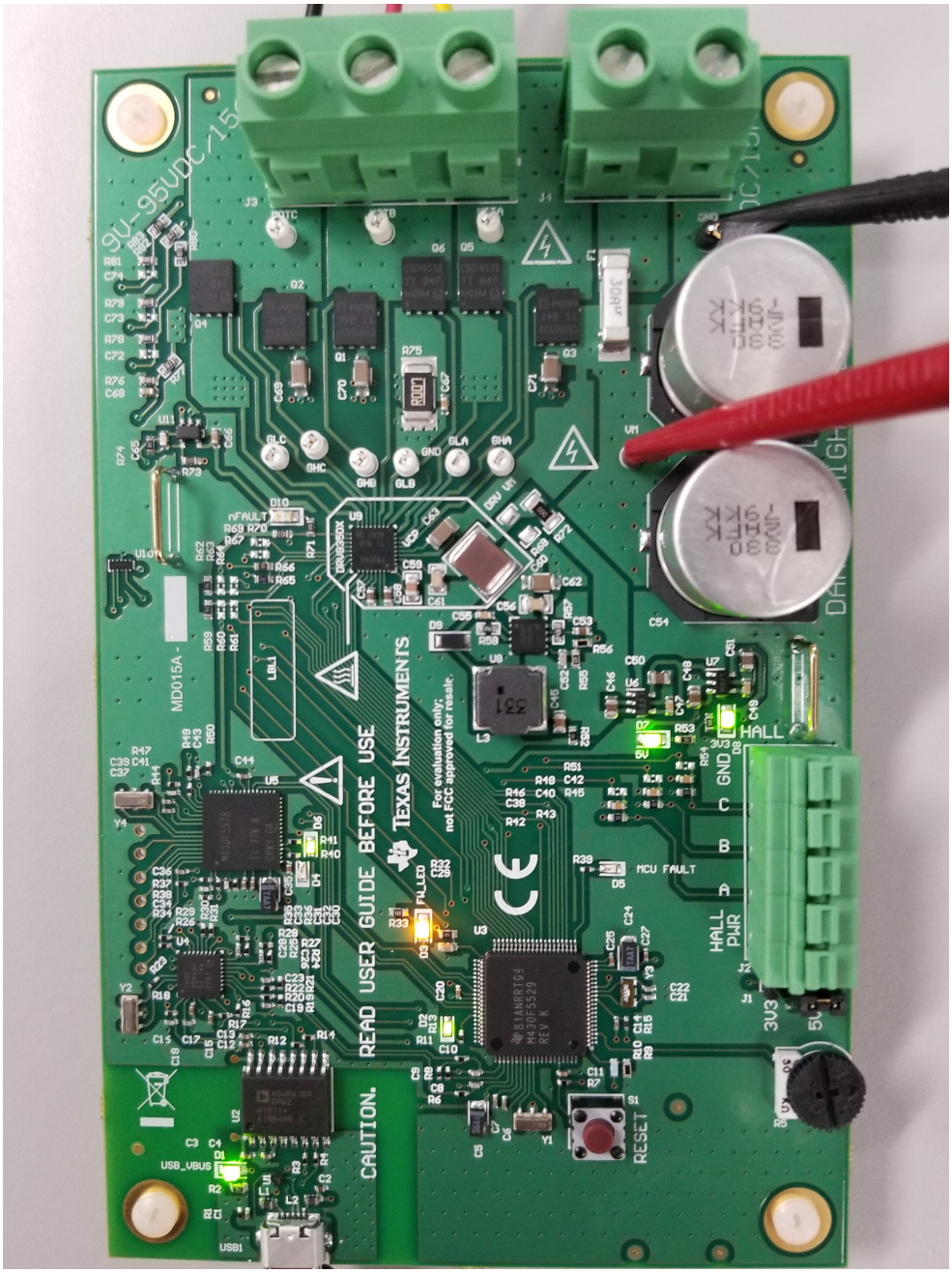

Figure 1. DRV8350x-EVM

NOTE: Operate this EVM only at the default IDRIVE setting 150 mA / 300 mA sink/source current.

WARNING

Hot surface. Contact may cause burns. Do not Touch.

WARNING

High Voltage. Electric shock is possible when connecting board to live wire. Board should be handled with care by a professional.

For safety, use of isolated test equipment with overvoltage and overcurrent protection is highly recommended.

CAUTION

Do not leave the EVM powered when unattended.

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1 Introduction

1.1 Device Overview

The DRV835x 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 DRV8350x, the MSP430F5529 microcontroller has loaded reference software that provides the necessary gating pulses to DRV8350x to control the BLDC motors.

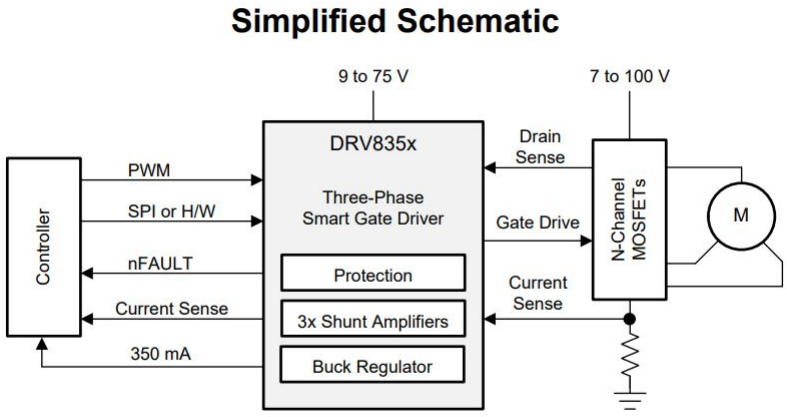

Figure 2. Block Diagram

1.2 Purpose and Scope

This document is designed to be used as a startup guide and to supplement the DRV835X + MSP430F5529 BLDC motor control demo code kit. This document is intended for the engineers involved in the design, implementation, and validation of DRV835X + MSP430F5529 reference software.

The scope of this document is to provide the user with a guide to evaluate the DRV8350x device with an MSP430F5529 development environment. This document covers the hardware connections required to power the DRV8350x-EVM, to drive the motor sensorless or sensored, and to interface to the PC. 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 the Code Composer Studio™ (CCS) software, import the DRV8350x 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 *DRV835xx EVM Sensored Software User's Guide* and *DRV835xx EVM Sensorless Software User's Guide*.

2 Hardware Overview

2.1 Hardware Connections Overview – DRV8350x + MSP430F5529

Figure 3 shows the major blocks of the DRV8350x-EVM hardware. The DRV8350x-EVM is designed for an input supply from 12 to 95 V and up to 15-A RMS 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 digital supplies are derived from the LP2992 LDOs that output 3.3 V and 5 V. The hall sensor power can be selected from these two power lines.

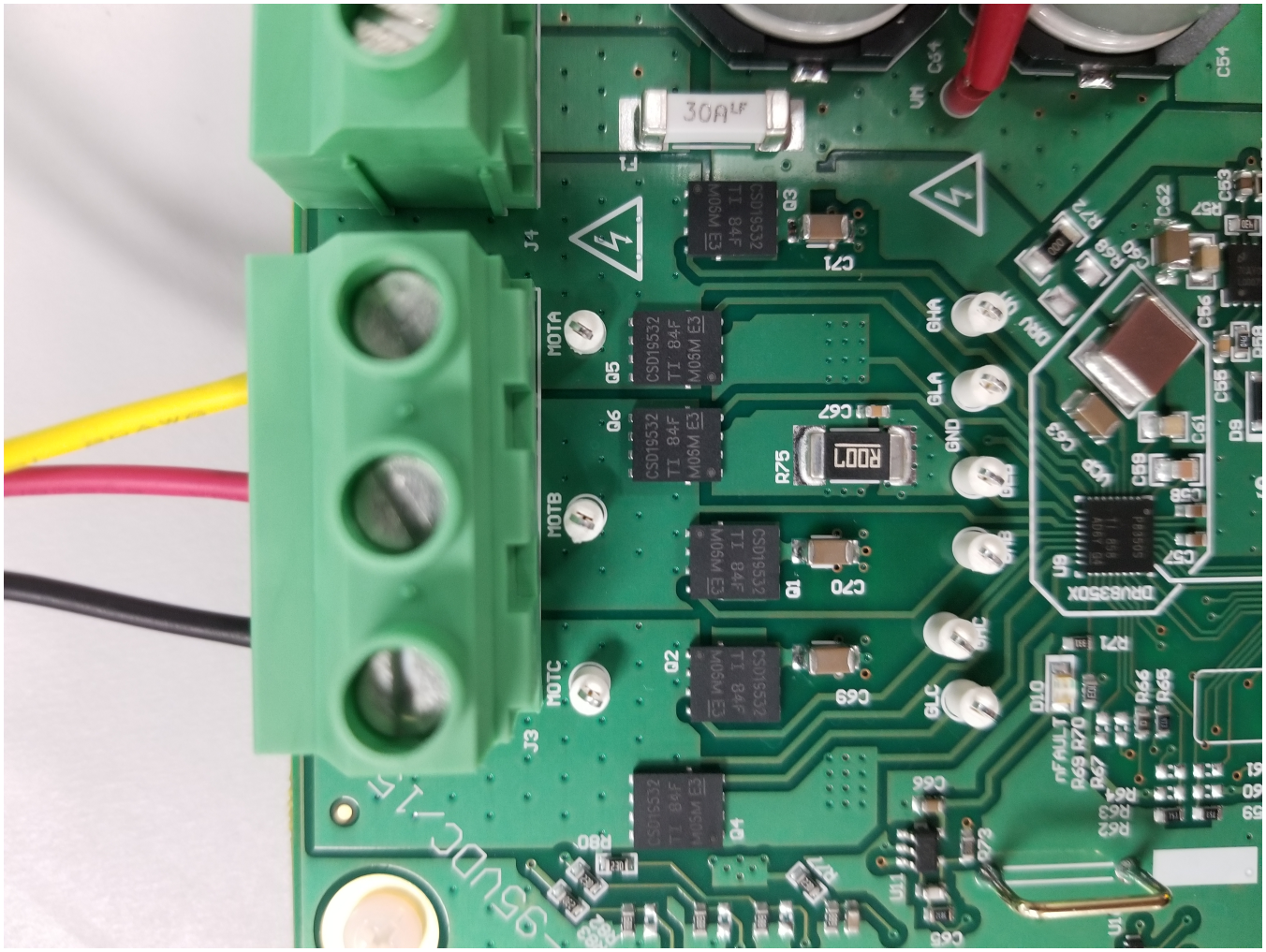

Figure 3. Power and Motor Connectors J4 and J3

2.2 Connection Details

The image above shows the power connector and motor phase connector. A supply voltage ranging from 6 to 95 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 DRV8350x-EVM.

The image below shows where the Micro-USB cable is plugged in to power the EVM and provides communication between the MSP430F5529 firmware and GUI. Also, you can see the emulation environment of the EVM.

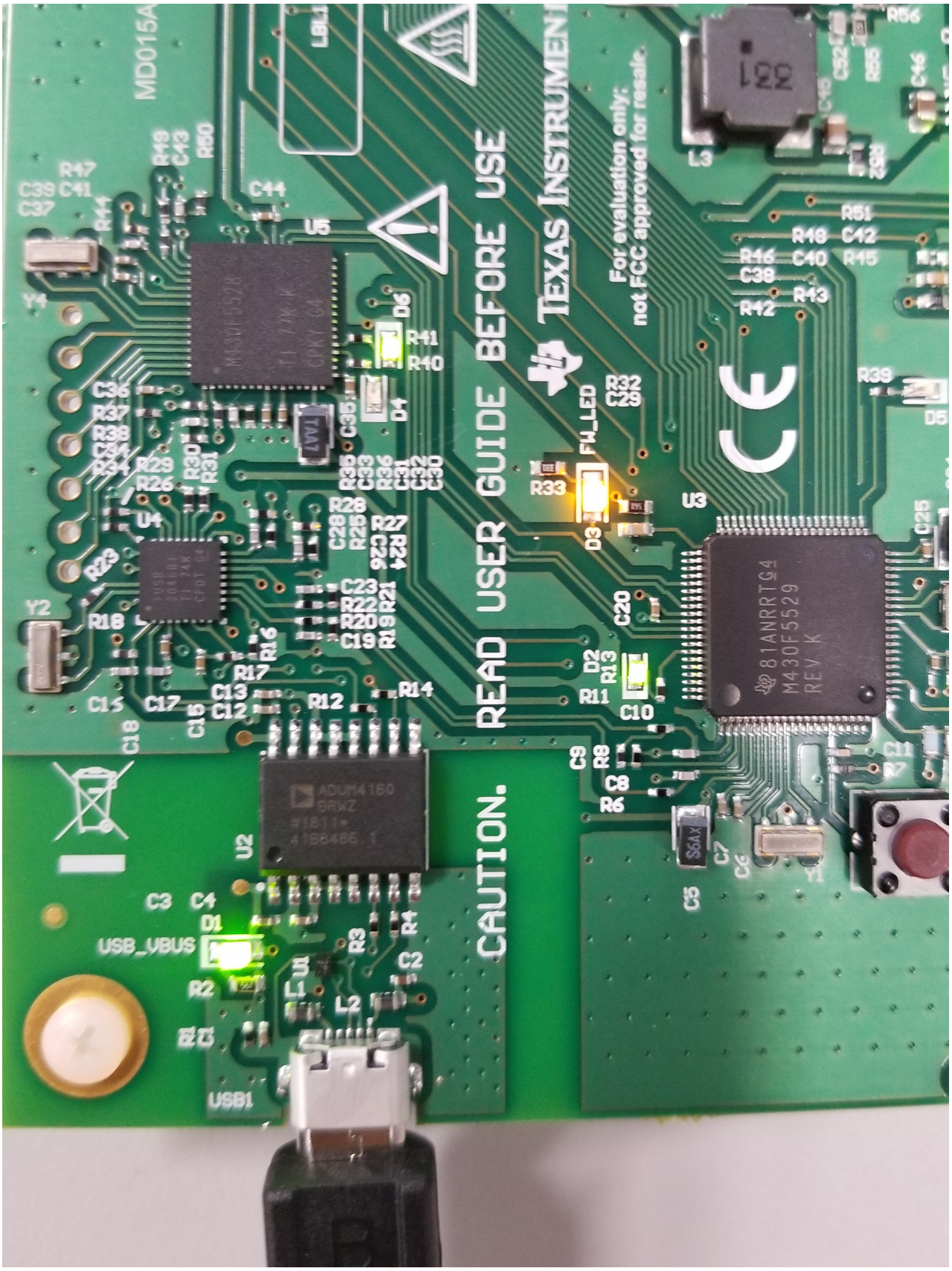

Figure 4. Micro-USB Connection

Below is a clearer view of the MSP430F5529 MCU. The component D3 is an LED that indicates if the firmware is running on this target MCU. Press the reset button whenever you wish to reset the firmware loaded on this target MCU

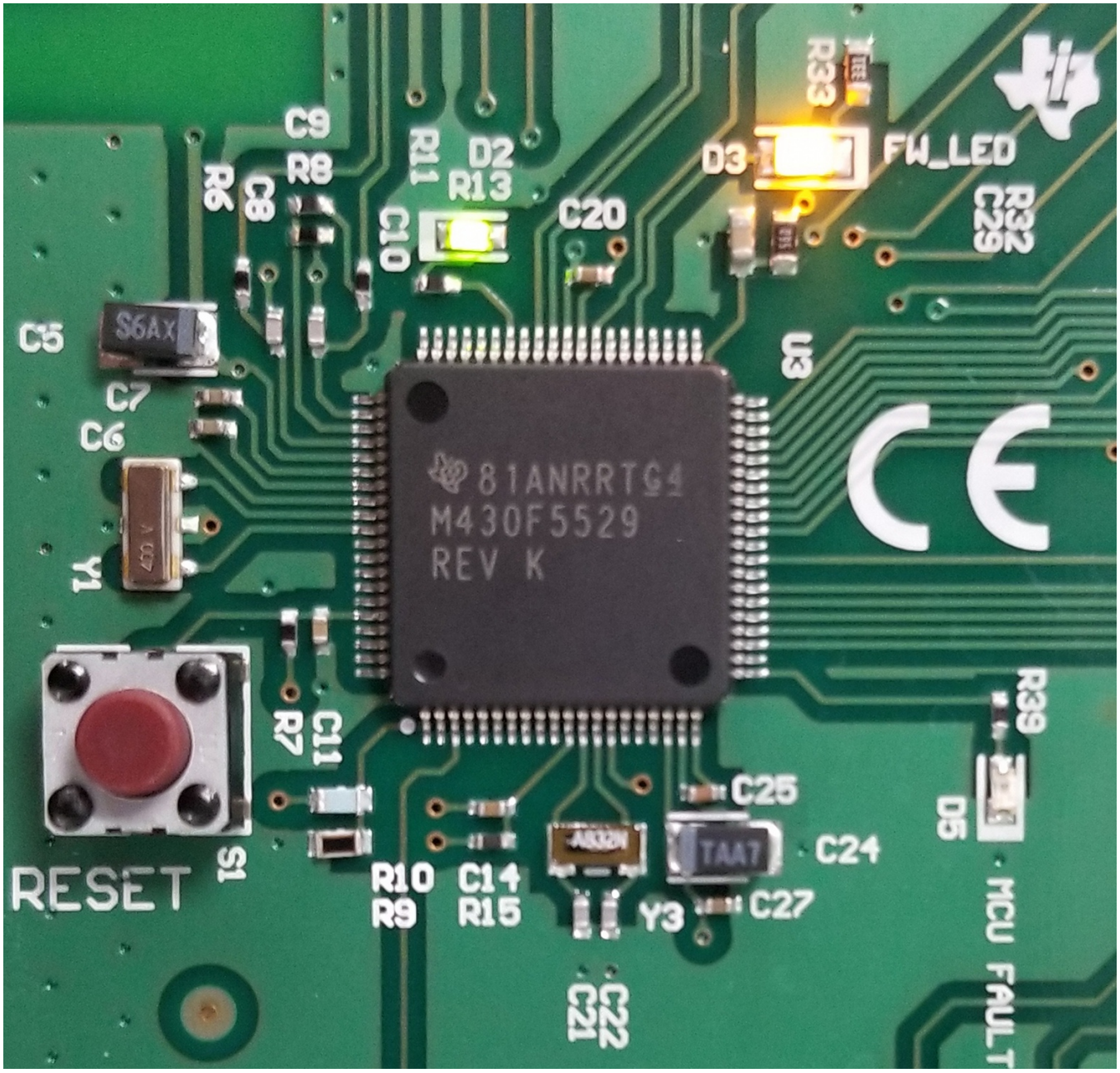

Figure 5. MSP430F5529

Each device variant has different sets of resistors required for S variant or H variant. See the schematic in the Hardware Design Files for more information.

The image below exhibits the 12 V buck converter, LM50008A, that powers the DRV8350x IC in split rail configuration. The U6 component is a LP2992 LDO that converts the 12 V into a 5 V output for the digital environment. Finally, the U7 component is a LP2992 LDO that converts the 5 V and drops it down to 3.3 V for the digial environment and for the driver pull up resistor power.

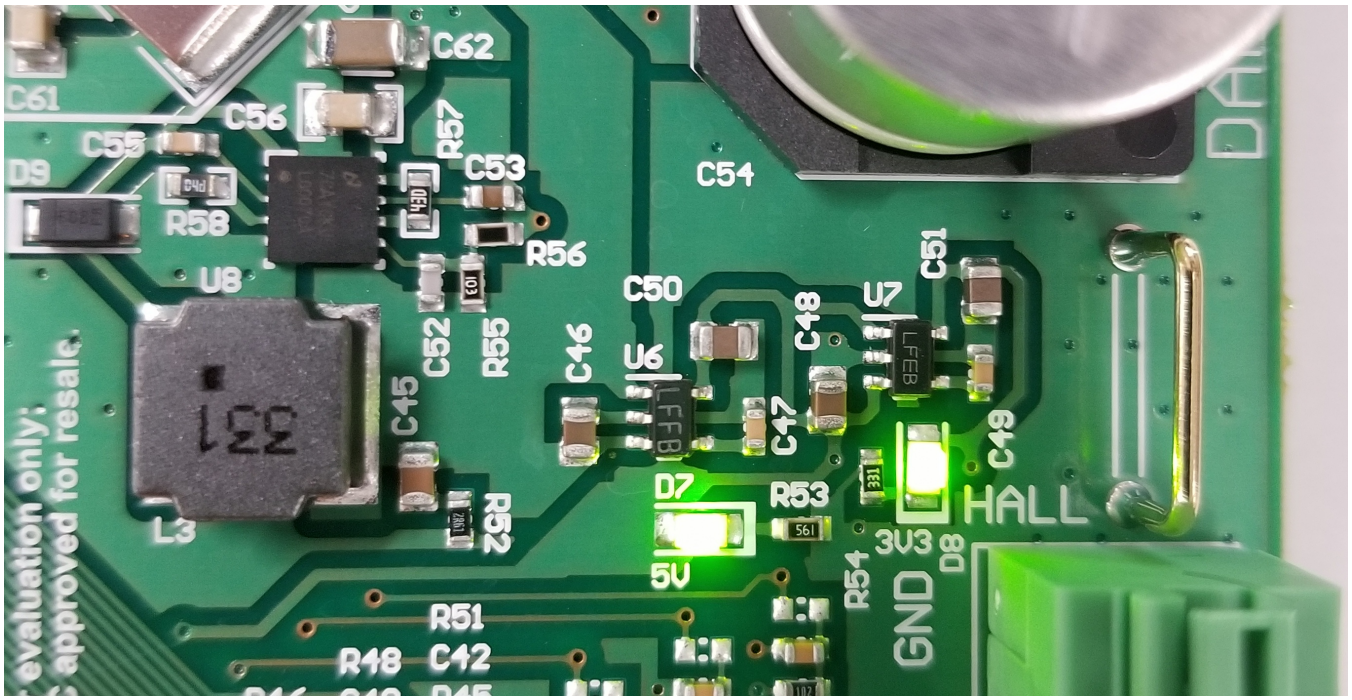

Figure 6. Power Environment for EVM

The DRV8350x-EVM GUI has a resistor divider tied to an ADC channel of the MSP430F5529 (pin 6.4). The bottom resistor varies in value between 2.0 k and 4.0 k to vary the ADC input voltage. The firmware reads this voltage and interprets what device is connected. Thus, the correct device is identified in the GUI.

2.3 Interfacing DRV8350x and MSP430F5529

The DRV8350x device interfaces with the MSP430F5529 through a number of device to device pins. To find out more about what pin is which, proceed to look at the schematic. Below you can get a functional overview of the pin connections.

Table 1. DRV8350x-EVM DRV to MCU Pin Connections

DRV8350x Function	MSP430F5529 Function	Description
3.3 V	3.3 V	3.3-V supply for Hall sensor
No function	5 V	5-V supply
VSENVM	P6.5, ADC channel – A5	Sensing VCC supply voltage
GND	GND	ADC - GND connections
No function	P3.4, I/O PIN	Software debug pins(optional)
VSENA	P6.0, ADC channel – 0	Sensing A phase voltage
No function	P3.3, I/O PIN	Software debug pins(optional)
VSENB	P6.1, ADC channel – 1	Sensing B phase voltage
ENABLE	P1.6, I/O pin with interrupt	Logic low to enter a low-power sleep mode
VSENC	P6.2, ADC channel – 2	Sensing C phase voltage
POT	P6.6, ADC channel – A6	Optional POT to vary the voltage 0 to 3.3 V on pin
No function	P6.3, ADC channel – 3	Sensing C phase current (only DRV8353Rx devices)
SCLK	P3.2,UCBOCLK – SPI CLK	Secondary function for pin SPI CLK
No function	P6.4, ADC channel – 4	Sensing B phase current (only DRV8353x devices)
NFAULT	P2.7, I/O pin with interrupt	Pulled logic low during a fault condition

Table 1. DRV8350x-EVM DRV to MCU Pin Connections (continued)

DRV8350x Function	MSP430F5529 Function	Description
ISEN	P7.0, ADC channel – 12	Sensing total current
No function	P4.2, I/O pin	Software debug pins(optional)
IDRIVE	P3.6, I/O pin	Sets gate drive peak current, 7-level input pin (DRV8350H devices only)
No function	P4.1, I/O pin	Software debug pins(optional)
VDS	P3.5, I/O pin	Sets VDS monitor threshold voltage, 7-level input pin (DRV8350H devices only)

Table 2. DRV8350x-EVM J2 Pin Connections

J2 Pin Number	DRV8350x-EVM 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 DRV835xx
13	MODE	P4.3, I/O pin	Sets the input control mode, 4-level input pin (DRV8350H devices only)
14	SDO	P3.1,UCBOSOMI	Secondary function for data output from DRV835xx
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 DRV8350x, high for DRV8353x 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 (DRV8353RH devices only)
19	EVM ID	P8.2, I/O pin	Pulled low for DRV835xH, high for DRV835xS devices
20	No function	P8.1, I/O pin	Pull logic high to internally short all amplifier inputs together (DRV8353Rx devices only)

3 Firmware Installation

3.1 Installing Code Composer Studio

CCS versions 5.x.x and 6.x.x have been used and tested for DRV835XX 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 7 shows this file.

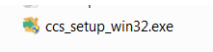

Figure 7. Downloaded Executable for Code Composer Studio Installation

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 8).

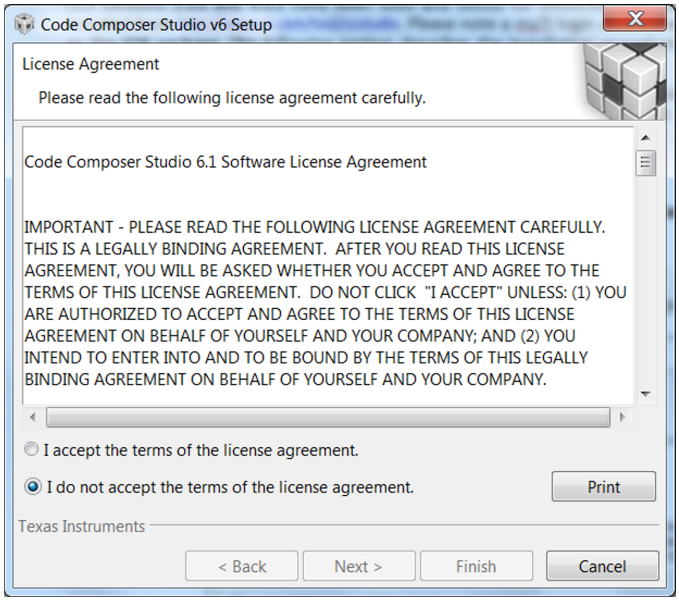

Figure 8. CCS License Agreement

Step 3. Choose a destination directory. Using the default (c:\ti) removes a step in the SDK installation procedure (see Figure 9).

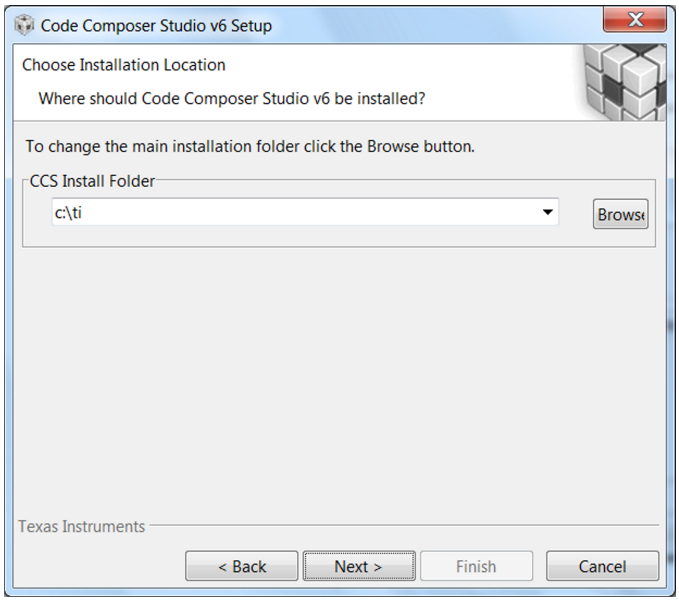

Figure 9. Default Installation Location for CCS

Step 4. Choose the processor architectures to install (see Figure 10).

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.

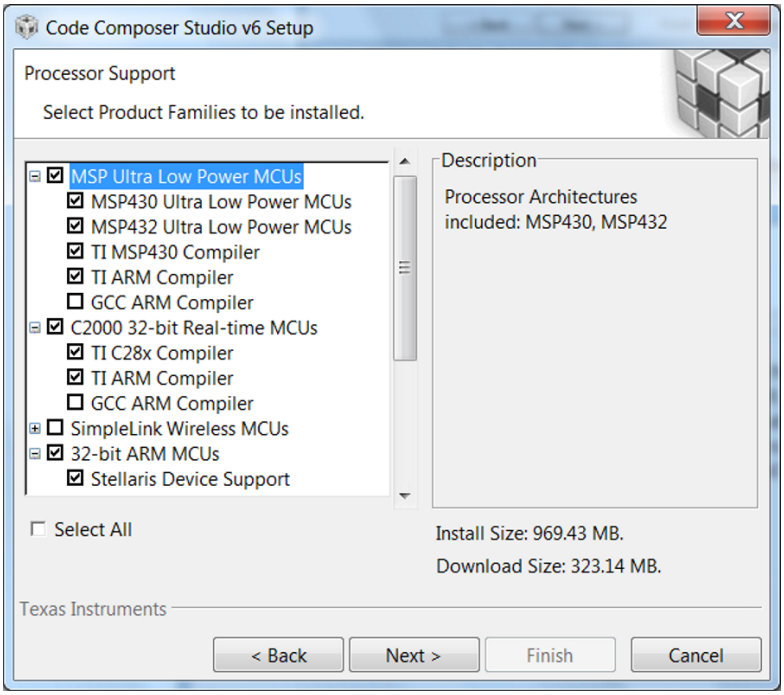

Figure 10. Processors Supported by CCS

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 11).

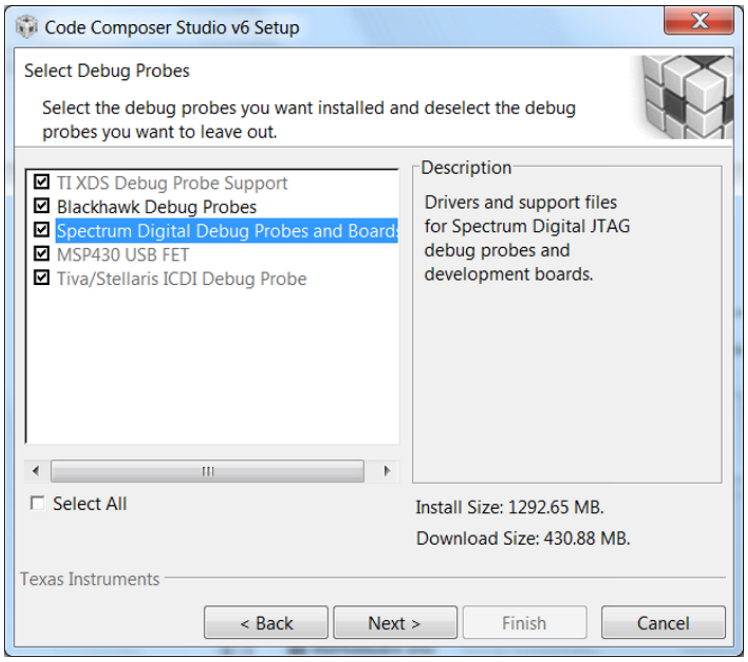

Figure 11. Components Available for Installation

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

Step 8. Review the installation and click the *Finish* button to finalize (see Figure 12).

Figure 12. Emulators Available for Installation

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

3.2 Installing DRV835X Reference Software Development Package

The DRV835X Reference software contains the files required to program DRV835X devices along with the MSP430F5529 using CCS v5.x or CCS v6.x. All of these files are included in the installation package. To access this package, contact the DRV8x applications team or the respective field-sales engineer.

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

Step 1. Double click the executable file (.exe) for the DRV835XX reference software installer (see Figure 13).

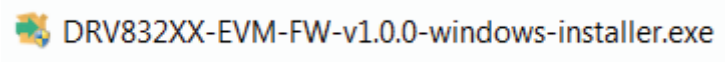

Figure 13. DRV835XX Firmware Installer Executable File

Step 2. Follow the prompts to select another language from the default of English (see Figure 14).

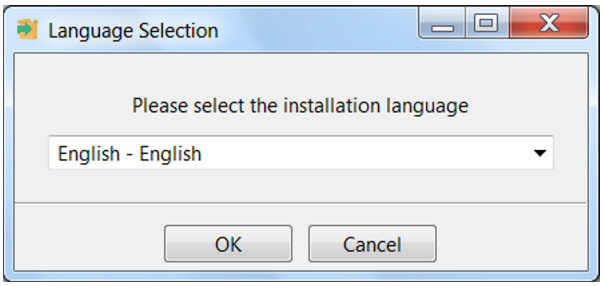

Figure 14. Language Selection

Step 3. Click the *Next* button on the DRV835XX Installer welcome screen (see Figure 15).

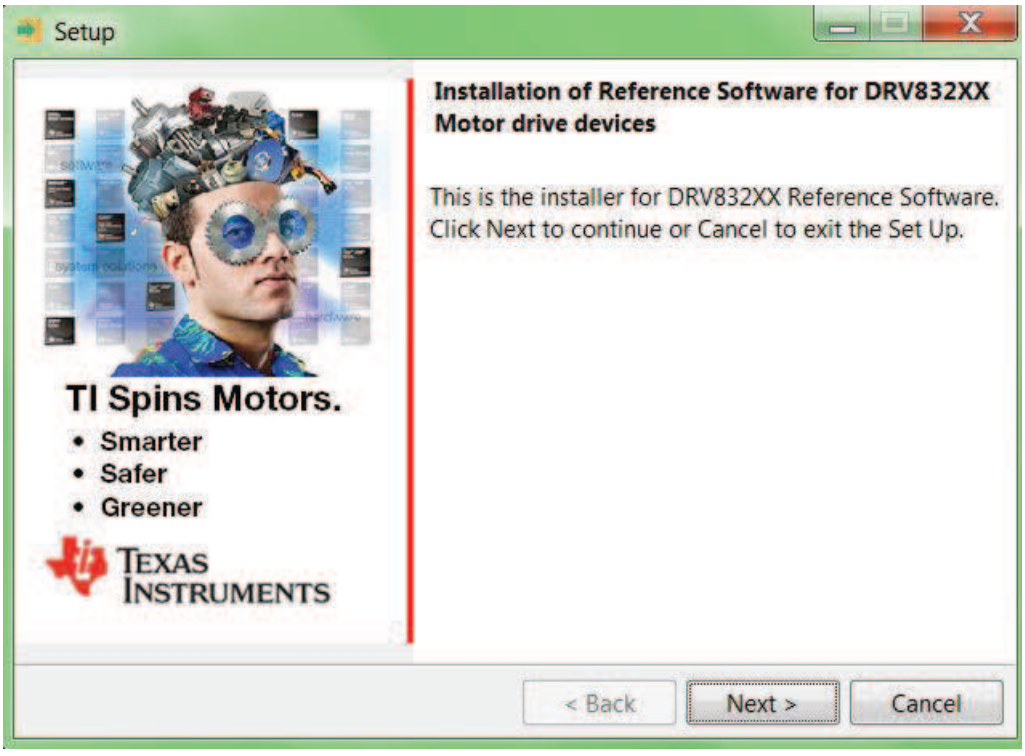

Figure 15. Setup Home Screen

Step 4. Read though and accept the license agreement to proceed with the installation (see Figure 16).

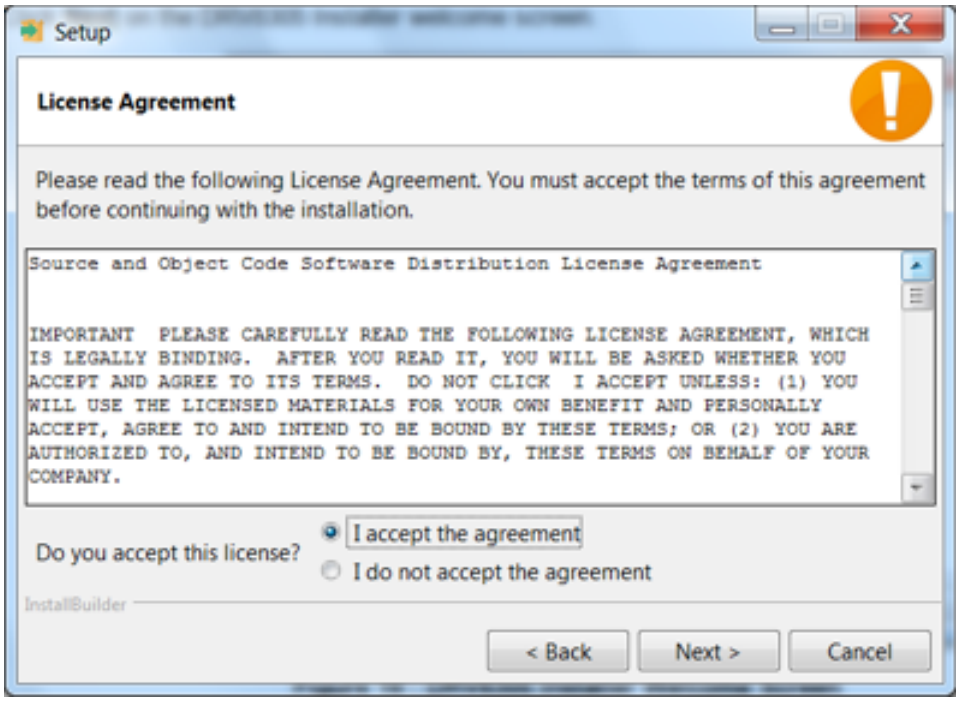

Figure 16. DRV835XX Software License Agreement

Step 5. Choose the destination location for the example CCS projects and the documentation (see Figure 17). This destination can be set to any location in the PC.

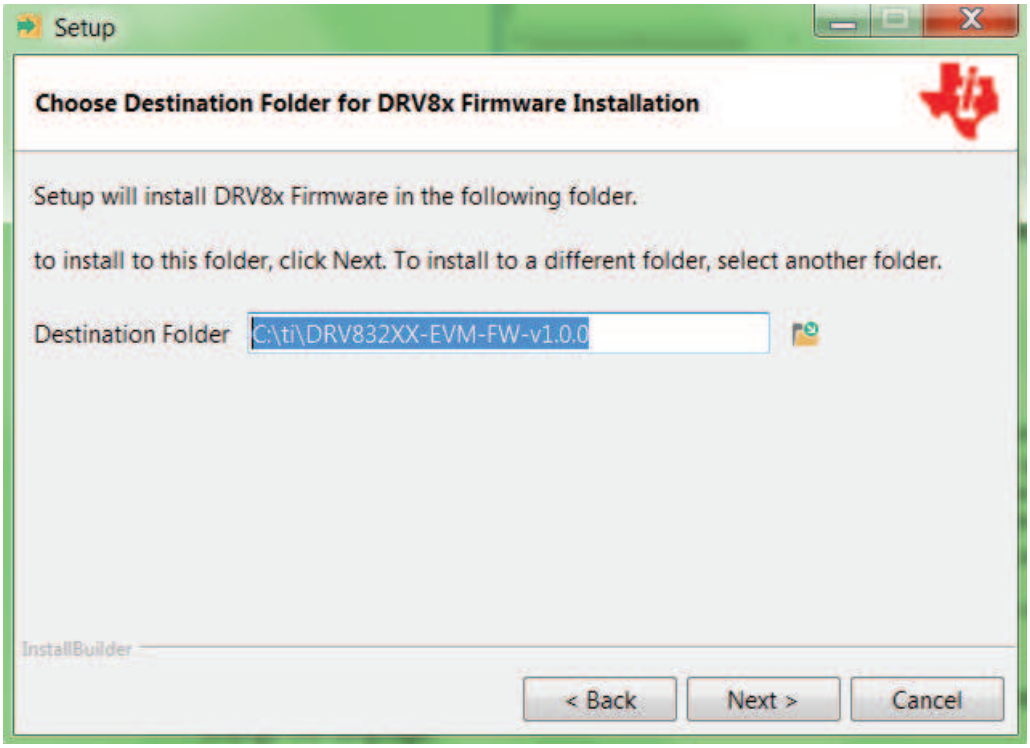

Figure 17. Setup Destination Folder

Step 6. Select each DRV8x components to Install (see Figure 18).

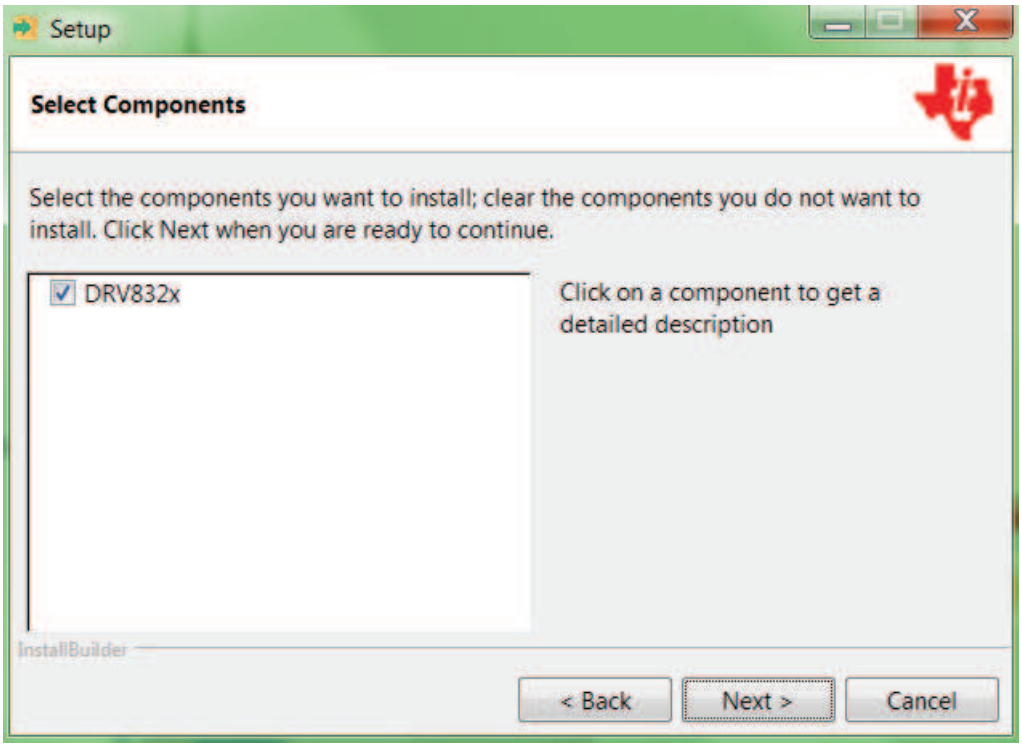

Figure 18. Select Setup Components

Step 7. Ensure all running instances of CCS are closed (see Figure 19).

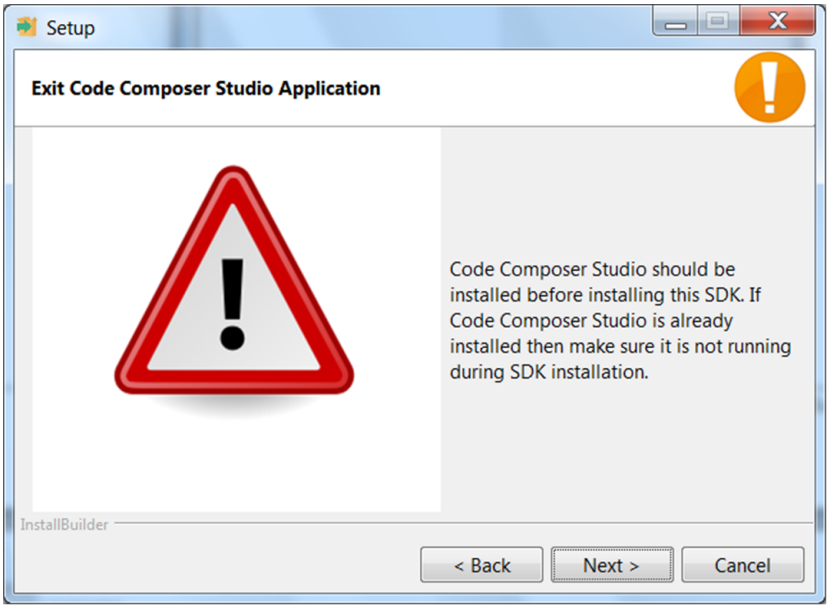

Figure 19. Warning Message to Close CCS

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 20).

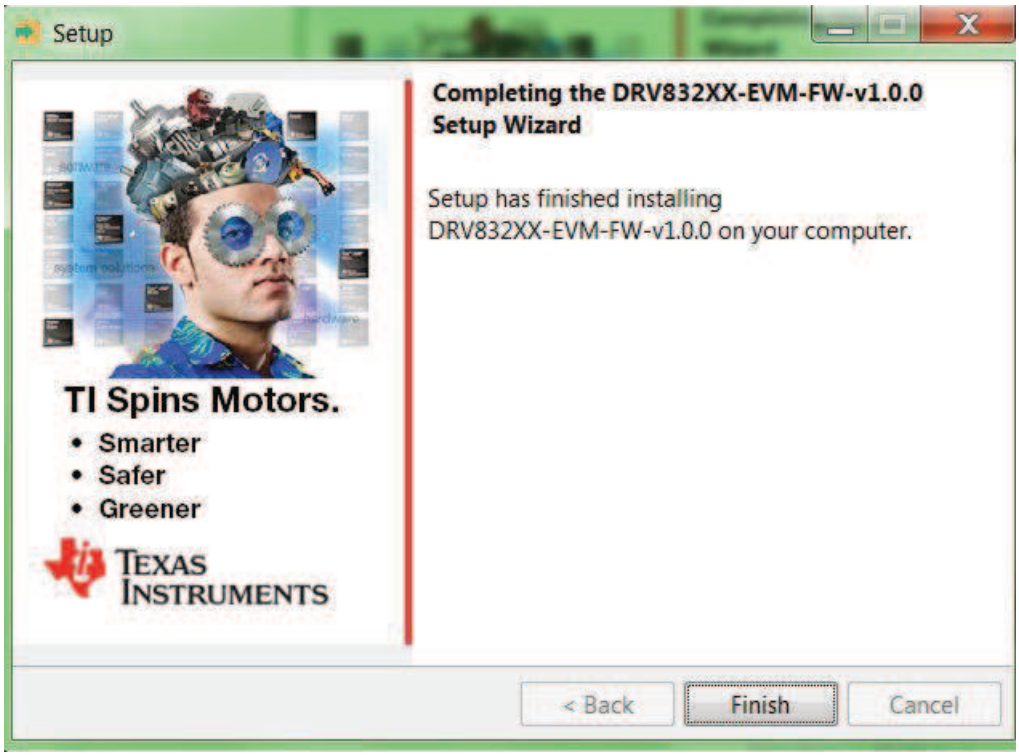

Figure 20. Firmware Setup Complete

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 21).

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

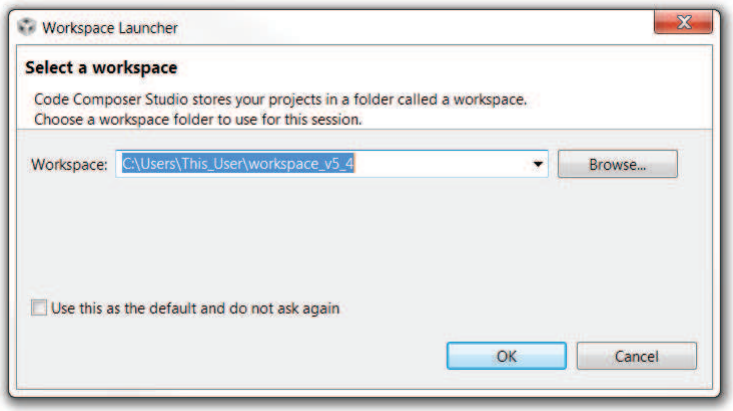

Figure 21. Workspace Launcher

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 22).

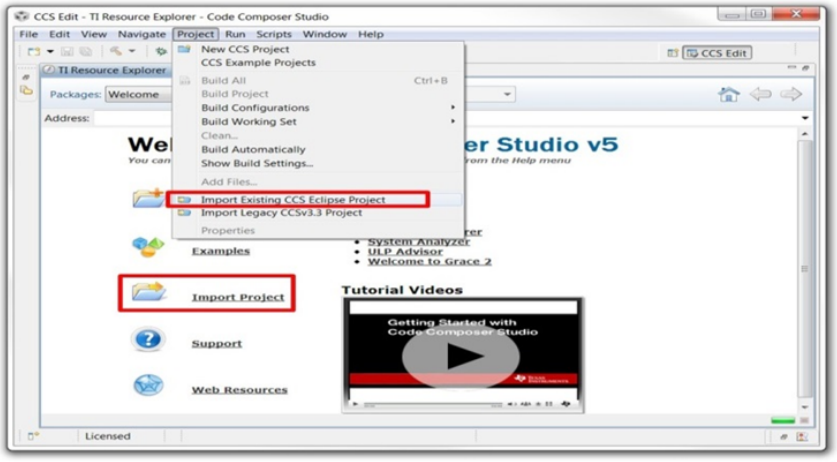

Figure 22. Importing Existing Projects

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\DRV835XX-V1.0 (see Figure 23). 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 23.

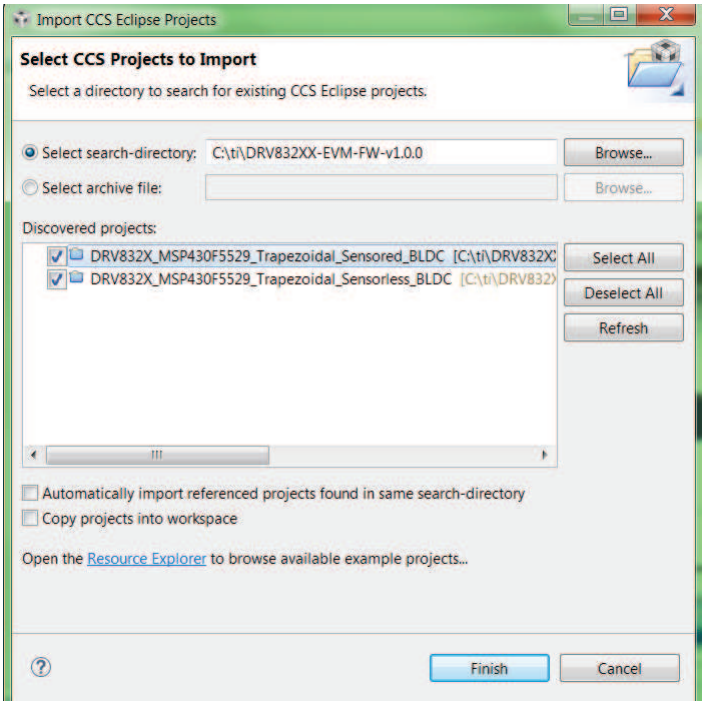

Figure 23. Selecting Existing Projects

When the projects are imported to the workspace, the project should appear in the *Project Explorer* window as shown in Figure 24.

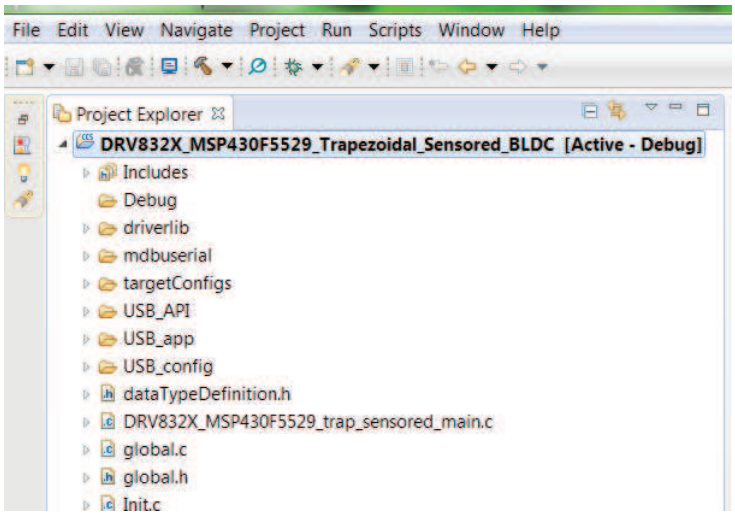

Figure 24. DRV835x Project Explorer

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.

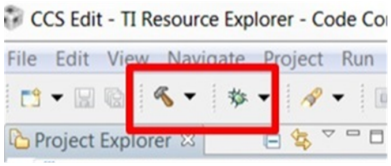

Figure 25. Build Project Files Buttons

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 26. Click the red stop button ((see Figure 26) to disconnect the MSP-FET430UIF from.

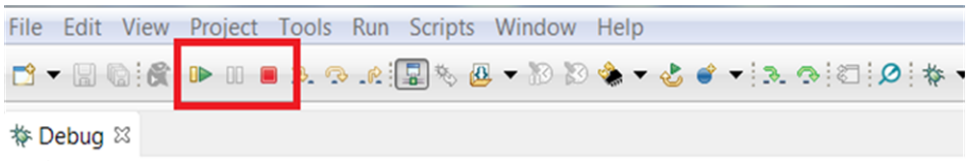

Figure 26. Execute Buttons

A new window appears showing loading of the program on MSP430 hardware (see Figure 27).

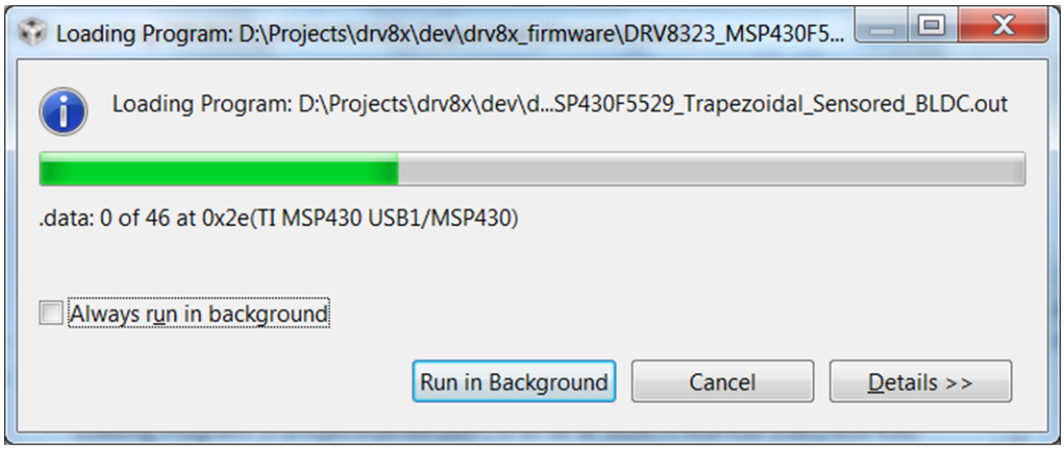

Figure 27. Flashing Firmware

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.

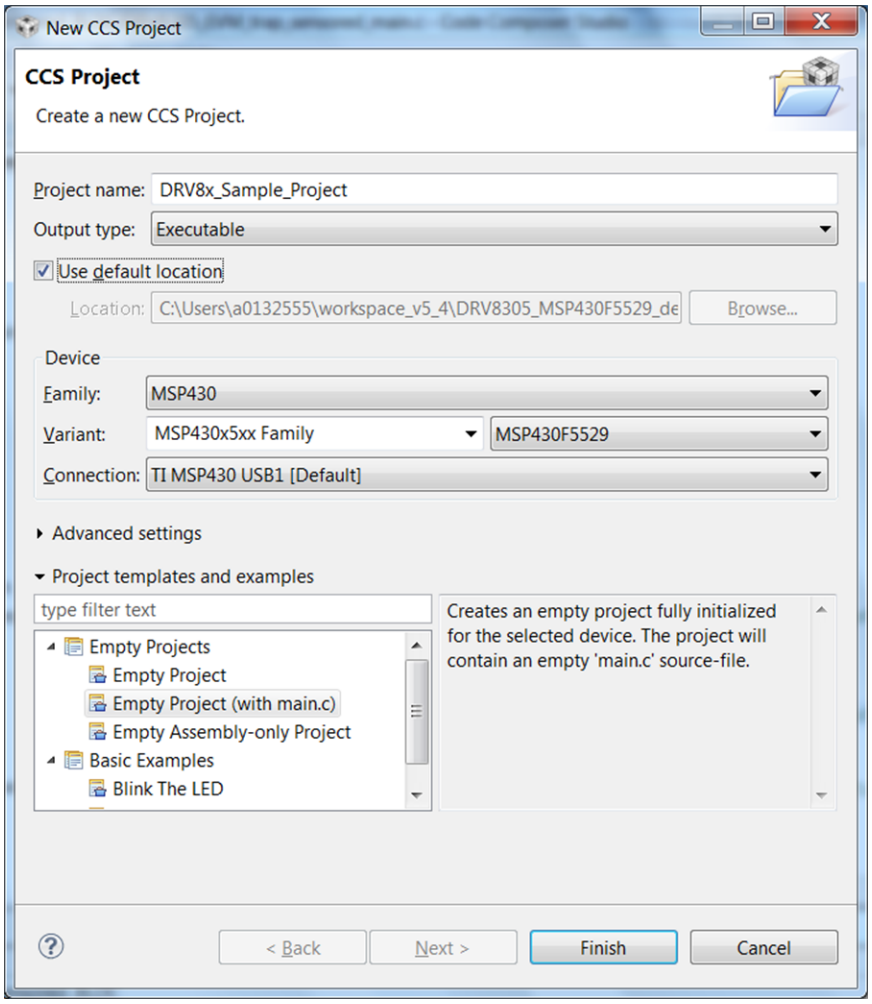

Figure 28. New CCS Project

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 29 and Figure 30 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.

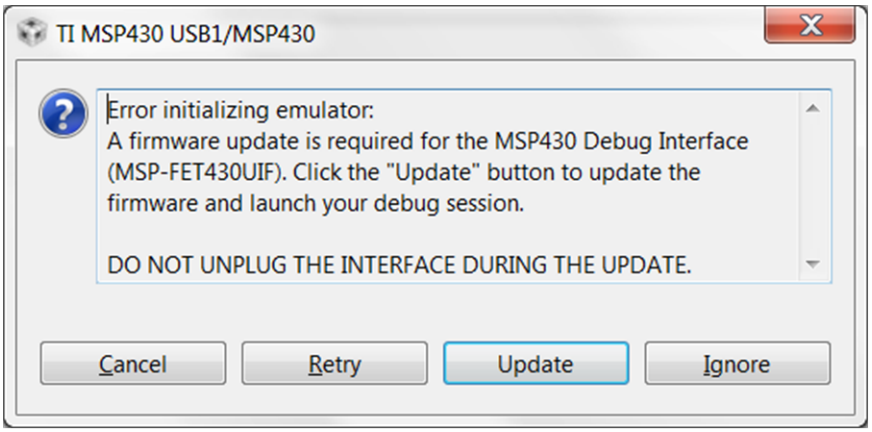

Figure 29. Error Initializing Emulator

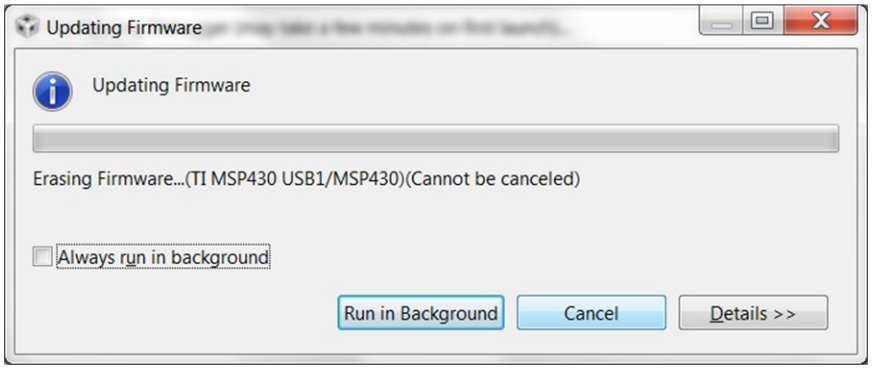

Figure 30. Updating LaunchPad development kit Firmware

4 GUI Application

4.1 Installation

Follow these steps to install the GUI application:

Step 1. Download and run the Setup_DRV8350x-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)

This driver is automatically installed during the GUI installation process. Click the *Install* button when the window shown in Figure 31 appears during the GUI installation. If this pop-up does not appear, then the drivers are already installed.

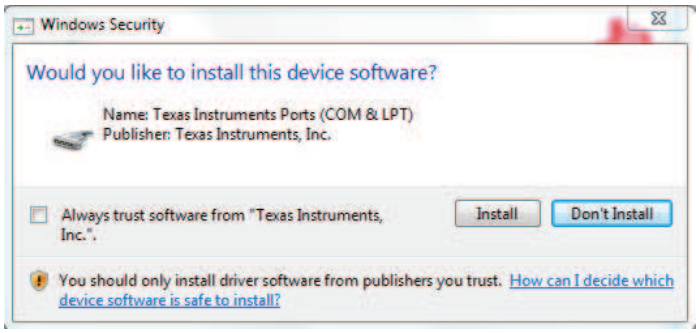

Figure 31. TI MSP430 USB Installer

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\DRV835X-EVM\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 the MSP430F5529, the DRV8350x-EVM , a Micro-USB cable, and a power supply with a DC output from 12 to 95 V. Follow these steps to start up the module:

Step 1. Connect the three phases from the brushless DC motor to the Motor connector on the DRV8350x-EVM. MOTA, MOTB, and MOTC are labeled in white silkscreen on the PCB top layer.

NOTE: If using the sensored firmware on the MSP430F5529, connect a brushless DC motor Hall sensor inputs to hall sensor header and solder the unpopulated R82, R84, and R86 0 ohm resistors. If using sensorless firmware, this header can be left unconnected.

NOTE: If using 1x PWM Mode with the **sensored firmware** the hall sensor 0 ohm resistors must be populated.

Step 2. Connect the DC power supply to the power connector.

NOTE: Observe the correct polarity of +VM and GND connections on the DRV8350x-EVM connection

Step 3. Connect a Micro-USB cable to the EVM's USB port.

Step 4. Turn on the power supply and power up the PCB.

4.3 Launching DRV835X-EVM EVM GUI

The DRV8350X-EVM GUI works with the two different DRV8350x-EVM to facilitate control of brushless DC motors. The DRV8350X-EVM 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 DRV8350X-EVM 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 DRV8350X-EVM folder.

The *Device Launch* page is displayed to launch one of the 2 device variants (DRV8350S, DRV8350H). Click on one of the *Launch* buttons to launch next either the **DRV8350S** or **DRV8350H** labels.

For a guide on the different attributes of the DRV8350X-EVM EVM GUI, refer to the *DRV835X-EVM GUI User's Guide*.

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