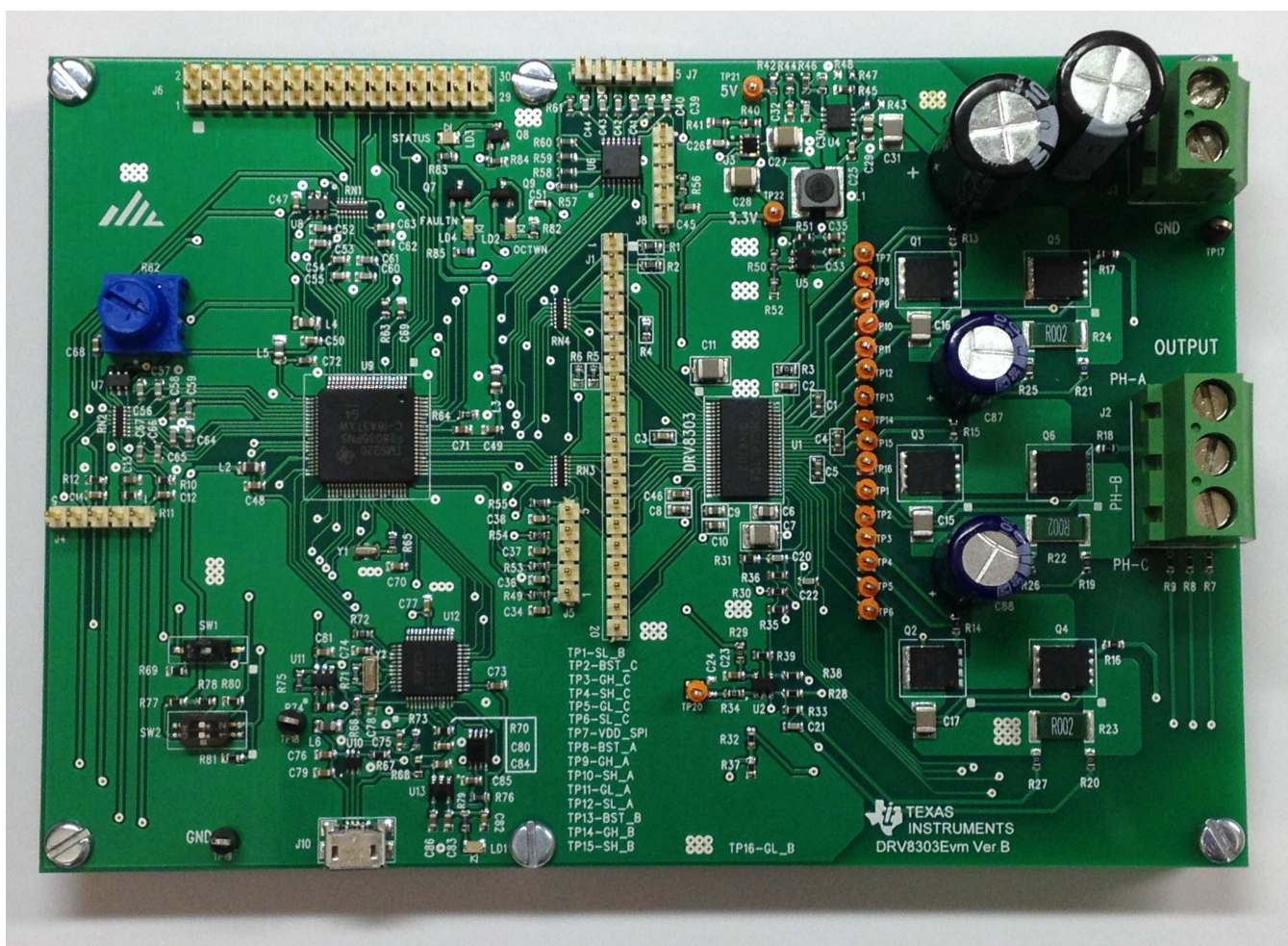


## DRV8303EVM User Guide

### 1 Introduction

The Medium Voltage Digital Motor Control (DMC) kit (see [Figure 1](#)), provides a great way to learn and experiment with digital control of medium-voltage, brushless motors to increase efficiency of operation. This user guide describes the kit contents and hardware details and explains the functions and locations of switches and connectors present on the board. This guide also explains steps required to run the DRV8303EVM using BLDC-InstaSpinGUI and motor control software projects supplied through control-SUITE. The kit has three-phase power stage, DRV8303 capable of driving three-phase brushless DC motors, and permanent magnet synchronous motors with following specification:

- 60-V DC max input voltage
- 20-A peak current per phase



**Figure 1. DRV8303EVM**

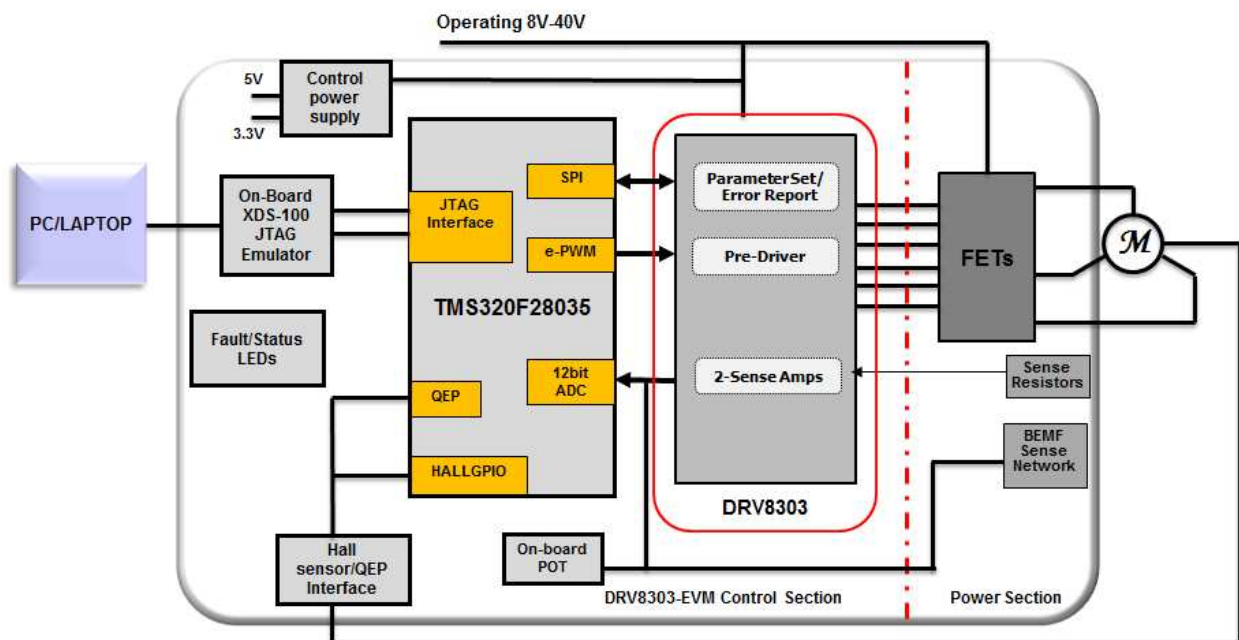
## **WARNING**

This EVM is meant to be operated only in a lab environment, and TI does not consider this EVM to be a finished end-product fit for general consumer use. This EVM must be used only by qualified engineers and technicians familiar with the risks associated with handling high voltage electrical and mechanical components, systems, and subsystems. This equipment operates at voltages and currents that can result in electrical shock, fire hazard, and personal injury, if not properly handled or applied. Equipment must be used with necessary caution and appropriate safeguards employed to avoid personal injury or property damage. The user has the responsibility to confirm that the voltages and isolation requirements are identified and understood prior to energizing the board or simulation, or both. When energized, do not touch the EVM or components connected to the EVM.

## 2 Hardware Block Diagram

Figure 2 illustrates a typical motor drive system running from a DC power supply. The DRV8303 motor control board has all the power and control blocks that constitute a typical motor drive system for a PMSM or BLDC motor.

**Figure 2. DRV8303EVM Kit Hardware Block Diagram**



## 3 Hardware Macro Blocks

The motor control board is separated into functional groups (referred to as macro blocks) that enable a complete motor drive system. The following list describes the macro blocks present on the board and their functions:

- TMS320F28035 controller block with a built-in non-isolated XDS100 JTAG emulator
- DC bus connection PVDD and GND terminals that connect to an external 8 to 60-V DC lab supply, making sure to observe correct polarity

- Micro-USB connector for serial communication with external PC or laptop to run GUI and download software to onboard MCU
- DRV8303 module that includes DRV8303 three-phase pre-driver as well as all of the necessary external passive components
- On-board control power supply of 5 V and 3.3 V
- Current sense, which is a low-side shunt current sensing on each half-bridge
- Quadrature encoder connections are available for an optional shaft encoder to interface to the QEP peripheral of the MCU
- Hall effect sensor connections are available for optional Hall effect sensors

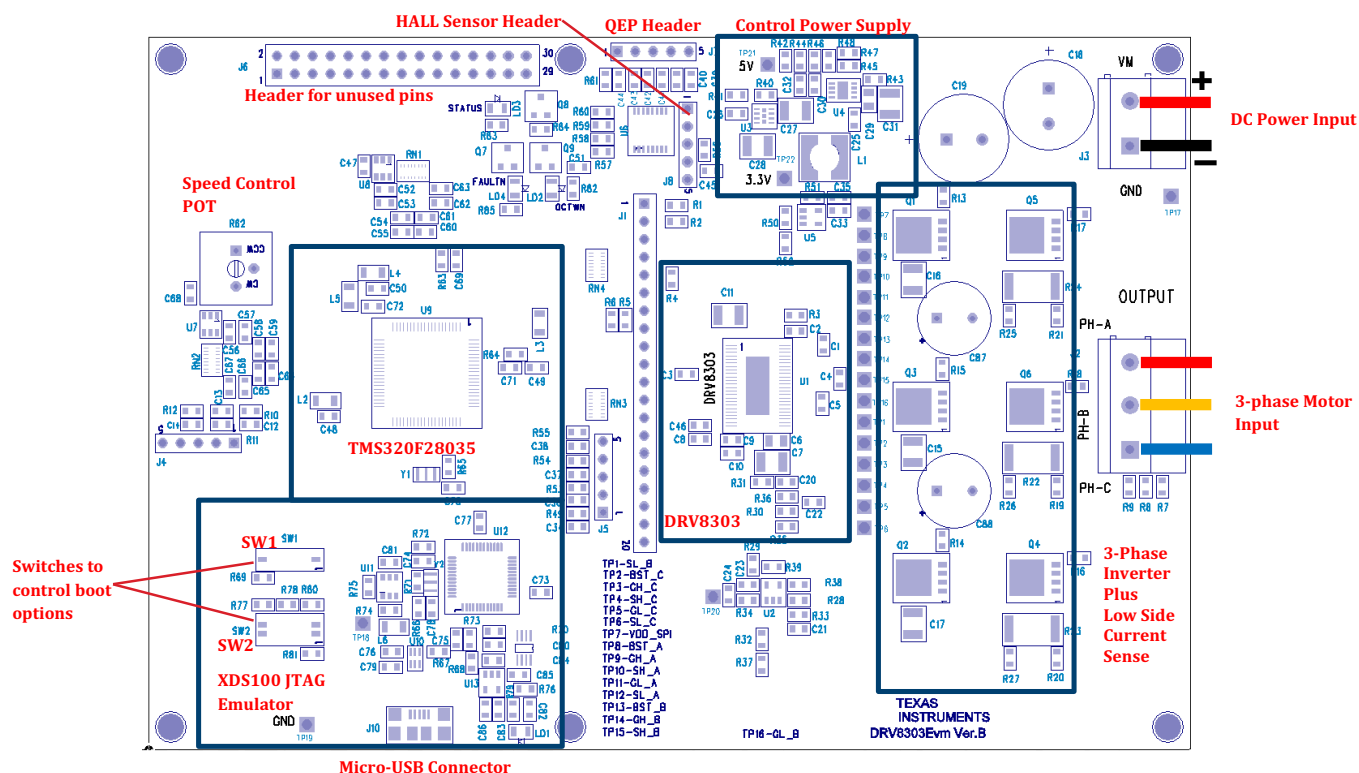


Figure 3. DRV8303EVM Kit Hardware Macro Blocks

## 4 Quick Start GUI

The InstaSPIN-BLDC GUI provides a convenient way to evaluate the functionality of the DRV8303 and the F28035 device, without needing to learn and configure the underlying project software, or install Code Composer Studio (CCS). The interactive interface uses knobs, sliders, buttons, text boxes, and graphs to enable an easy demonstration of sensor-less trapezoidal commutation of BLDC motors.

### 4.1 Hardware Setup

The kit ships with switch settings pre-selected for connecting with the GUI. However, the user must ensure that these settings are valid on the board.

**NOTE:** Do not apply power to the board before you have verified these settings.

1. Make sure nothing is connected to the board, and no power is supplied to the board.
2. Make sure that the following switches (SW1 and SW2) are set on the board as follows, to enable boot from flash and connection to the SCI.
  - (a) SW1: OFF (down) position



- (b) SW2: position one is ON (up) and position two is ON (up)
3. Connect a USB cable from J10 (on the board) to the host computer. LED1 on the board lights up indicating that the USB is powered. Windows® then searches for a driver for the device. Windows® should locate the driver successfully, if the computer has CCS version 5, or prior versions, installed which support XDS100 emulator. If the driver is not found, an installation prompt appears for the driver. For installing the driver for USB to serial, do not let Microsoft® search for the driver. Instead download the DRV8303EVM hardware and software folder from [Ti.com](http://ti.com). Browse to the following location in the folder <DRV8303EVM Hardware and Software\USB Driver\XDS100 Drivers v1.0>. Windows® should now be able to find and install the driver. If Windows® still does not find the driver, repeat the process and point to the location pointed out previously. You may have to reboot the computer for the drivers to come into effect. Once installed, check if the installation completed properly by browsing to control panel > system > hardware > device manager and look for USB serial port under ports (COM & LPT). Make note of this port number.  
Windows should
  4. Select the motor to spin and connect to the PH A, PH B, and PH C terminals on the board.
  5. Connect an 8 to 60-V DC power supply at connector J3 between VM and GND.
  6. Once the power is connected, the board powers up and LED3 (STATUS) on the DRV8303EVM board becomes green.

## 4.2 Software Setup

The QSG GUI (InstaSPIN-BLDC\_GUI\_DRV83xx\_v104.exe) can be located in the DRV8303EVM hardware and software folder from [Ti.com](http://ti.com). Download the folder and browse to <DRV8303EVM Hardware and Software\Application>. Once controlSUITE is installed, the GUI can also be found at the following location: controlSUITE\development\_kits\DRV830x-HC-C2-KIT\_v104\~GUI.

The GUI requires Microsoft® .NET framework 3.5 SP1, or higher, to run. Please ensure this software is installed before running this program. The kit ships with pre-flashed TMS320F28035 with the code that enables interface to this GUI.

The microcontroller flash image can be re-flashed using CCS, if needed. Use the following steps to re-flash the TMS320F28035 microcontroller with the .out file provided in the DRV8303EVM Hardware and Software Folder:

1. Download the latest version of Code Composer Studio from [Ti.com](http://ti.com)
2. Ensure that the following switches (SW1 and SW2) are both in the ON (up) position
3. Connect the micro-USB cable and appropriate power supply to the DRV8303EVM. (The VM power supply must be applied in order to power the JTAG programmer.)
4. Enable the power supply
5. Launch CCS and remove all other projects
6. Go to view > target configurations > user defined
7. Verify the proper target configuration is set as default, or create a new target configuration for your device
8. Skip the rest of this section, if your target configuration is already properly set up and set at the default
9. Go to target > new target configuration
10. For the filename, set "xds100v1-TMS320F28035.ccxml"
11. For a new target configuration, the typical connection type is "Texas Instruments XDS100v1 USB Emulator"
12. In the device section, select the TMS320F28035 device
13. Save configuration
14. Verify no targets are under the projects folder
15. Right click the desired target configuration and select launch target configuration
16. Go to target > connect target
17. Go to target > load program... > [Select the supplied .out file]
18. Terminate all. (Use the red square in the debug box)

19. The microcontroller is now flashed
20. Power cycle the board before connecting the GUI
21. Move the switch (SW1) back to the OFF position in order to connect to the GUI

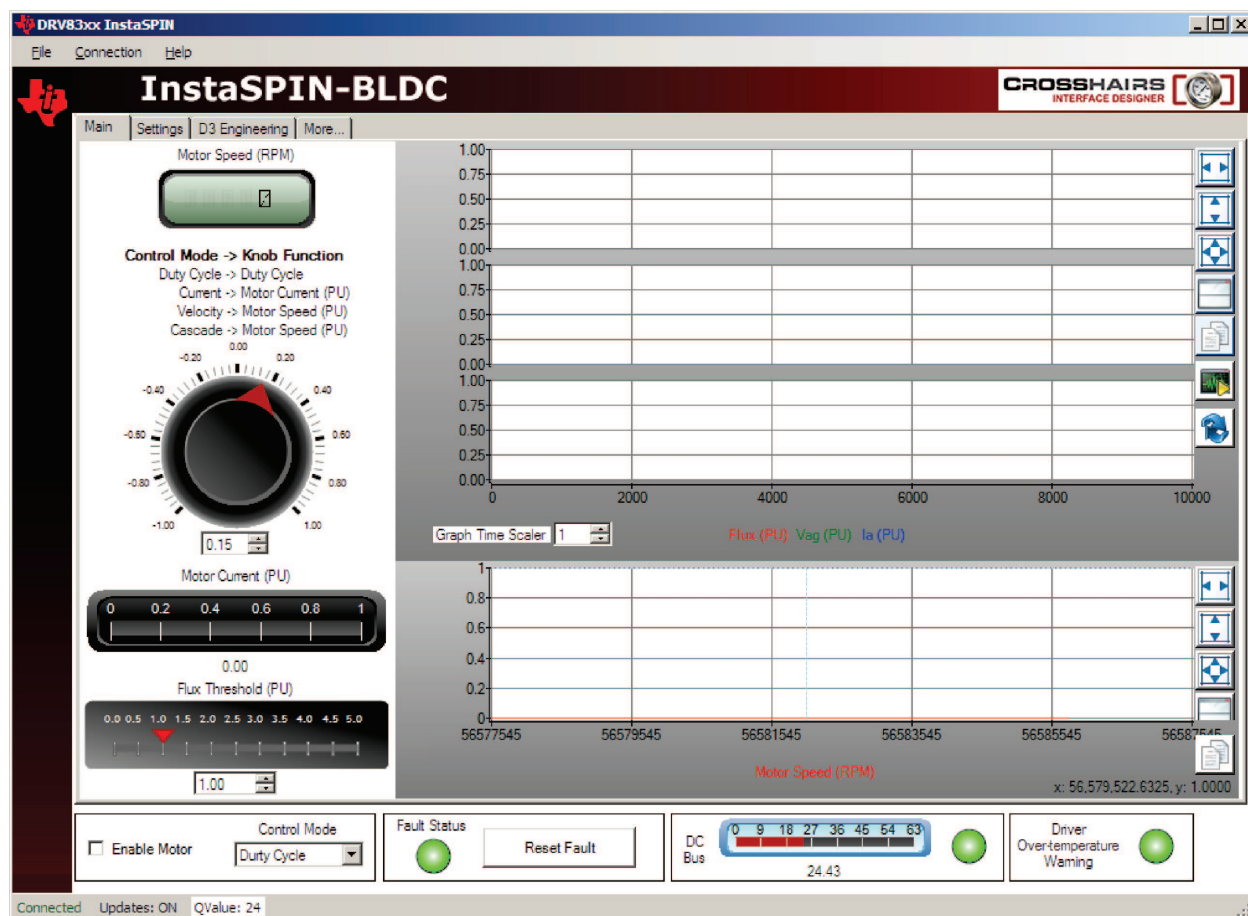
### 4.3 Running the GUI

#### 4.3.1 Switch and Connector Settings

Make sure both the switches and connector settings are set as described in [Section 4.1](#).

#### 4.3.2 Navigate to the GUI Window

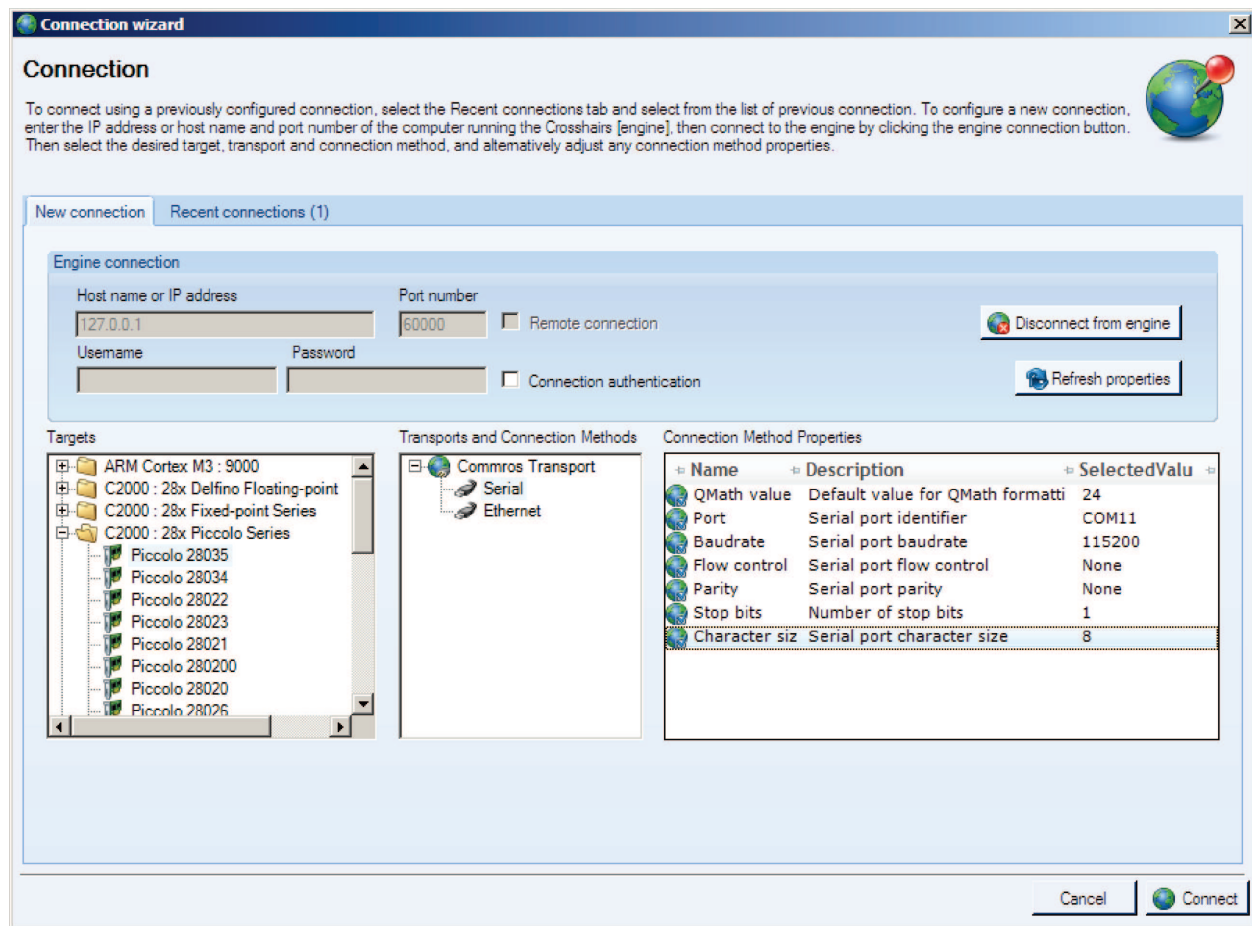
Browse to and double click on InstaSPIN-BLDC\_GUI\_DRV83xx\_v104.exe. The following GUI window should pop up (see [Figure 4](#)).



**Figure 4. GUI Start-Up**

#### 4.3.3 Connect to DRV8303EVM

The GUI should auto-detect and connect to your DRV8303EVM. If auto-connect fails, set up the connection manually. Access the connection wizard through the connection menu. Click on "connect to engine" to view a list of available targets. Now, set up the connection wizard dialog to match [Figure 5](#) by selecting Piccolo 28035 from the target list and serial for connection method. Use the correct COM port number for your system. Find the COM port number by going to control panel > system > hardware tab > device manager > ports(COM & LPT) and look for the port that is described as USB serial port or a similar name. Select connect when done.



**Figure 5. GUI Setup Connection**

#### 4.3.4 Image Correction

If an incorrect image is flashed on the controller, the connection fails. In this case, TI recommends re-flashing the controller with the correct image.

#### 4.3.5 Common Controls and Board Status Indicators

Common controls and board status indicators are located at the bottom of the screen and include:

- Enable motor check box: The enable motor check box starts or stops the motor from running.
- Control mode drop-down box: Allows the selection of four different control modes.
  - Duty cycle: The motor is commutated using the sensor-less algorithm, but is driven in an open-loop duty cycle mode.
  - Current: The motor is commutated using the sensor-less algorithm, and the current (torque) is regulated using a PI controller. (Note: An unloaded motor rapidly accelerates to a very high speed in this mode.)
  - Velocity: The motor is commutated using the sensor-less algorithm, and the motor speed is regulated using a PI controller. The output of the speed controller is a PWM duty cycle.
  - Cascade: The motor is commutated using the sensor-less algorithm, and the motor speed is regulated using a PI controller. The output of the speed controller is a motor current command, which is regulated by a lower level current PI controller.
- Fault status: The on-screen LED turns red whenever there is a fault signaled by the DRV8303. To reset this fault, ensure enable motor check box is unchecked and push the reset fault button

- DC bus voltage: The measured DC bus voltage displays both digitally and graphically. The on-screen LED has three states, which depend on whether the DC bus is in or out of range:
  - Yellow: DC bus is less than the minimum value.
  - Green: DC bus is within limits.
  - Red: DC bus is more than the maximum value.
- Driver over-temperature warning: The state of the DRV830x OCTWn pin displays using an on-screen LED. The LED has two states:
  - Yellow: The DRV830x device temperature exceeds 130°C.
  - Green: The DRV830x device temperature is lower than 130°C.

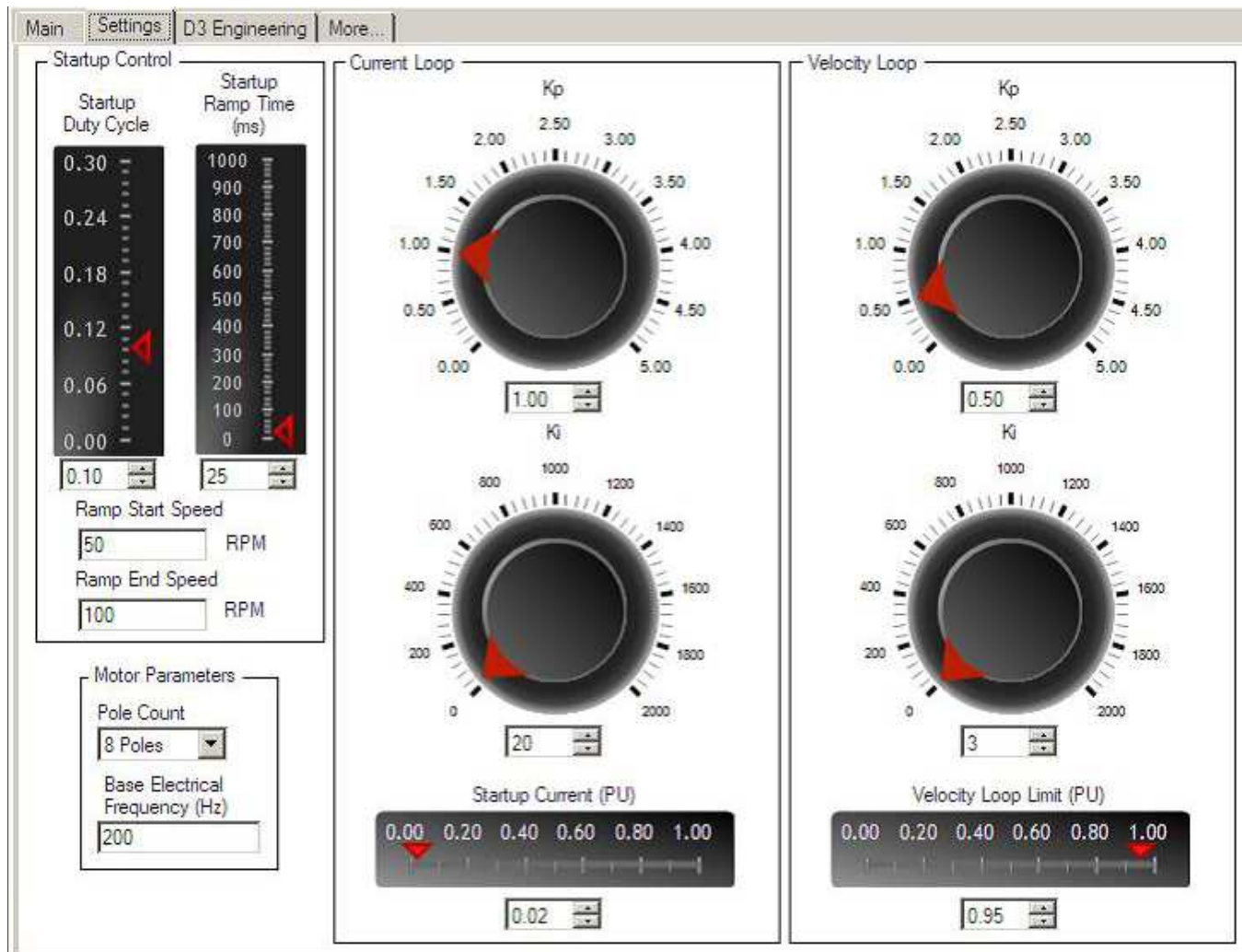


**Figure 6. GUI Common Controls**

#### 4.3.6 Main GUI Tab Controls

The main GUI tab contains controls that vary the motor set points and view various feedbacks.

- The setpoint knob has a separate function for each control mode.
  - Duty cycle: The knob adjusts the PWM duty cycle to the motor.
  - Current: The knob adjusts the per-unit (PU) commanded current through the motor. Note: The DRV830x-HC-EVMs have a measurable current range of  $\pm 82.5$  A which is normalized to a  $\pm 1.0$  PU scale.
  - Velocity: The knob adjusts the PU motor-commanded speed.
  - Cascade: The knob adjusts the PU motor-commanded speed.
- The actual motor speed (RPM) is displayed through a digital display.
- The actual motor current (PU) is displayed using a linear gauge. The current increases with motor load.
- The four graphs on the right display commutation and speed related data. Adjust the time scale of the top three graphs by incrementing or decrementing the graph time scalar.
  - Top graph: Displays the per-unit (PU) integrated motor flux
  - Second graph: Displays the PU Phase-A BEMF waveform
  - Third graph: Displays the PU Phase-A current waveform
  - Fourth graph: Displays the motor speed in RPM; this graph runs in a continuous strip chart mode and is not affected by the graph time scalar
- The flux threshold slider adjusts the commutation point of the motor.
- The settings tab contains parameters affecting motor start-up and control loop tuning.



**Figure 7. Settings Tab**

- Start-up control: These parameters control how the motor initially ramps up under forced commutation. The motor must spin and generate some BEMF in order for the sensor-less algorithm to latch on and take over commutation.
  - Start-up duty cycle: Sets the constant PWM duty cycle given to the motor during the forced commutation ramp-up phase
  - Start-up ramp time: Sets the time taken to complete the forced commutation ramp-up phase
  - Ramp start speed: Sets the initial speed for the forced commutation ramp-up phase
  - Ramp end speed: Sets the final speed for the forced commutation ramp-up phase
- Motor parameters
  - Pole count: Choose the number of poles for the motor under test.
  - Base electrical frequency: Sets the scaling of per-unit (PU) speed to motor electrical speed. Use this equation for the settings shown prior:
 
$$200 \text{ Hz} \times \frac{1 \text{ Mechanical\_rev}}{\frac{8 \text{ poles}}{2} \text{ Electrical\_rev}} \times \frac{60 \text{ s}}{1 \text{ min}} = 3000 \text{ RPM} = 1 \text{ PU}$$
- Current loop: These parameters are associated with the current control loop and are only active when control mode is set to current or cascade. Current and cascade are the only modes which make use of the current loop.



- Kp: Sets the proportional gain for the current controller
- Ki: Sets the integral gain for the current controller
- Start-up current: When current control is active the motor is driven with constant current rather than a constant duty cycle during the forced commutation ramp up phase. This slider sets the current for this phase
- Velocity loop: These parameters are associated with the velocity control loop. These parameters are only active when control mode is set to velocity or cascade. Velocity and cascade are the only modes which make use of the velocity loop.
  - Kp: Sets the proportional gain for the velocity controller
  - Ki: Sets the integral gain for the velocity controller
  - Velocity loop limit
    - In velocity control mode, the velocity loop limit slider sets the maximum PWM duty cycle to the motor
    - In cascade control mode, the velocity loop limit slider sets the maximum current to the motor

#### 4.4 Shutting Down

When finished evaluating, uncheck the enable motor check box to stop the motor. When the motor comes to a full stop, the GUI can be closed. Now, turn off the DC power supply.

### **WARNING**

**Because the capacitors are charged, the VM may remain on for a couple of seconds, do not touch any parts on the board immediately after shutdown.**

## 5 Evaluation of Motor Control Software Projects through CCS

The hardware resource mapping for TMS320F28035 controller inside DRV8303EVM kit is exactly similar to DRV8301-HC-C2-KIT. All the motor-control software projects supplied through controlSuite for DRV8301EVM can be directly ported to DRV8303EVM without any modifications.

The following projects are currently available for the DRV8301-HC-C2-kit at controlSUITE\development\_kits\DRV830x-HC-C2-KIT\_v104.

- PM\_Sensorless: Sensorless field oriented control of permanent magnet motor
- BLDC\_Int: Sensorless trapezoidal control of BLDC motors based on BEMF integration

### 5.1 Motor Control Experiment HW Setup Instructions

Follow the hardware setup instructions described previously in [Section 4](#). except for the following change in the SW1 setting. In order to enable JTAG connection, keep the switch SW1: ON (up) position.

### 5.2 Motor Control Experiment SW Setup Instructions

In order to build and run the prior projects using CCS, please refer to [software setup](#) for DRV8301-HC-C2-Kit projects.

### 5.3 Additional Resources

For more information, download and install [controlSUITE](#).

After controlSUITE install view:

- DRV830x-HC-EVM How to Run Guide: HW and CCS setup required for using projects  
controlSUITE\development\_kits \DRV830x-HC-EVMv\*.\*\~Docs

- All the projects for different motors can be found at controlSUITE\development\_kits \DRV830x-HC-EVMv\*.\*\PM\_Sensorless controlSUITE\development\_kits \DRV830x-HC-EVMv\*.\*\BLDC\_Int
- C2000 source code for the GUI project can be found at controlSUITE\development\_kits \DRV830x-HC-EVMv\*.\*\GUI\_project
- Crosshairs embedded GUI .exe and project files can be found at controlSUITE\development\_kits \DRV830x-HC-EVMv\*.\*\~GUI

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As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

### General Statement for EVMs including a radio

*User Power/Frequency Use Obligations:* This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

### 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

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**

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.

### **For EVMs annotated as IC – INDUSTRY CANADA Compliant**

This Class A or B digital apparatus complies with Canadian ICES-003.

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

### **Concerning EVMs including radio transmitters**

This device complies with Industry Canada licence-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.

### **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.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

### **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.

### **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.



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**This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan**

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product 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 this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

**Texas Instruments Japan Limited**  
**(address) 24-1, Nishi-Shinjuku 6 chome, Shinjuku-ku, Tokyo, Japan**

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**For Feasibility Evaluation Only, in Laboratory/Development Environments.** Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure 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.
3. Since the EVM is not a completed product, it may not meet all applicable regulatory and safety compliance standards (such as UL, CSA, VDE, CE, RoHS and WEEE) which may normally be associated with similar items. You assume full responsibility to determine and/or assure compliance with any such standards and related certifications as may be applicable. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

**Certain Instructions.** It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

**Agreement to Defend, Indemnify and Hold Harmless.** You agree to 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 use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

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