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

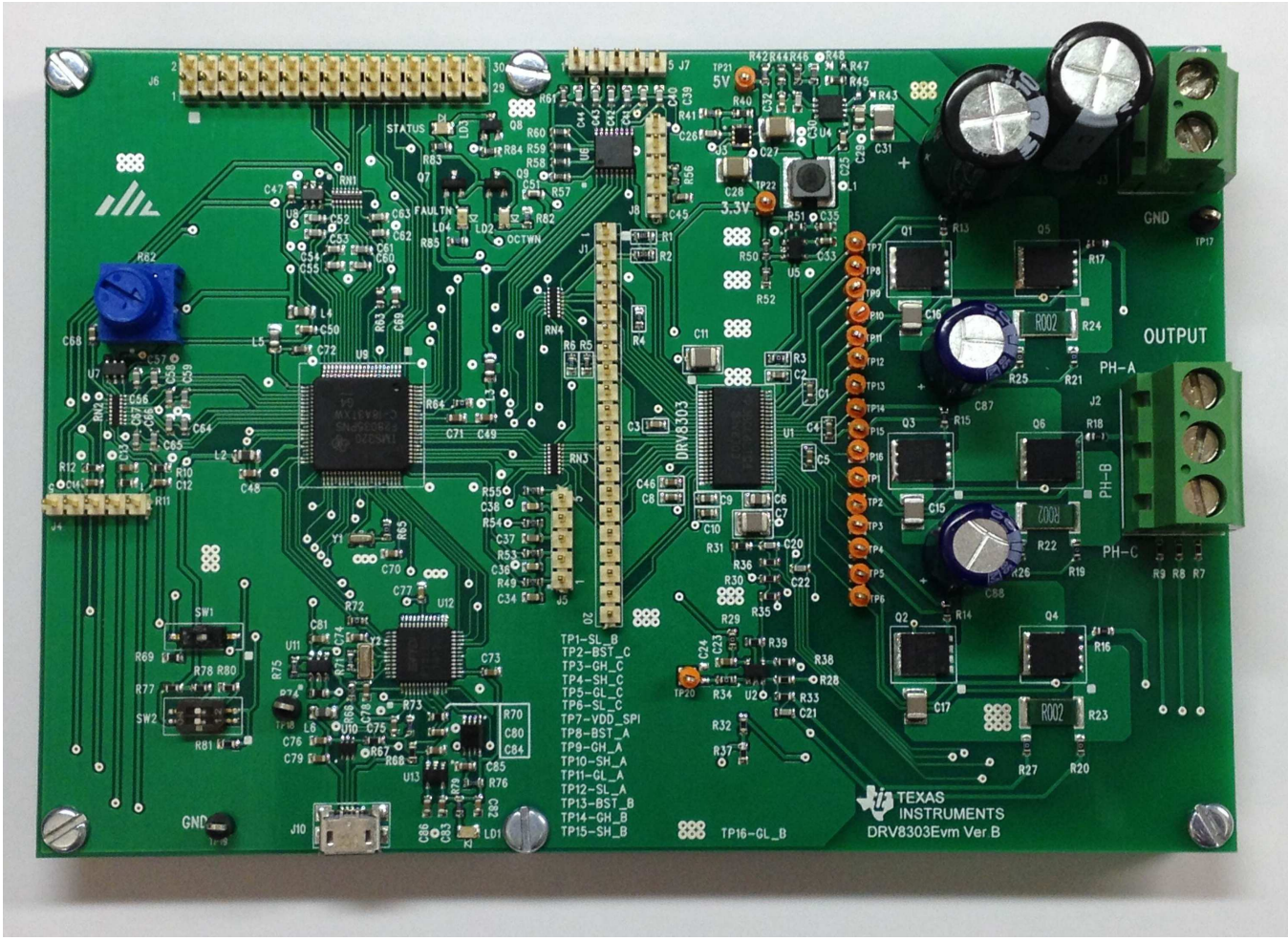


Figure 1. DRV8303EVM

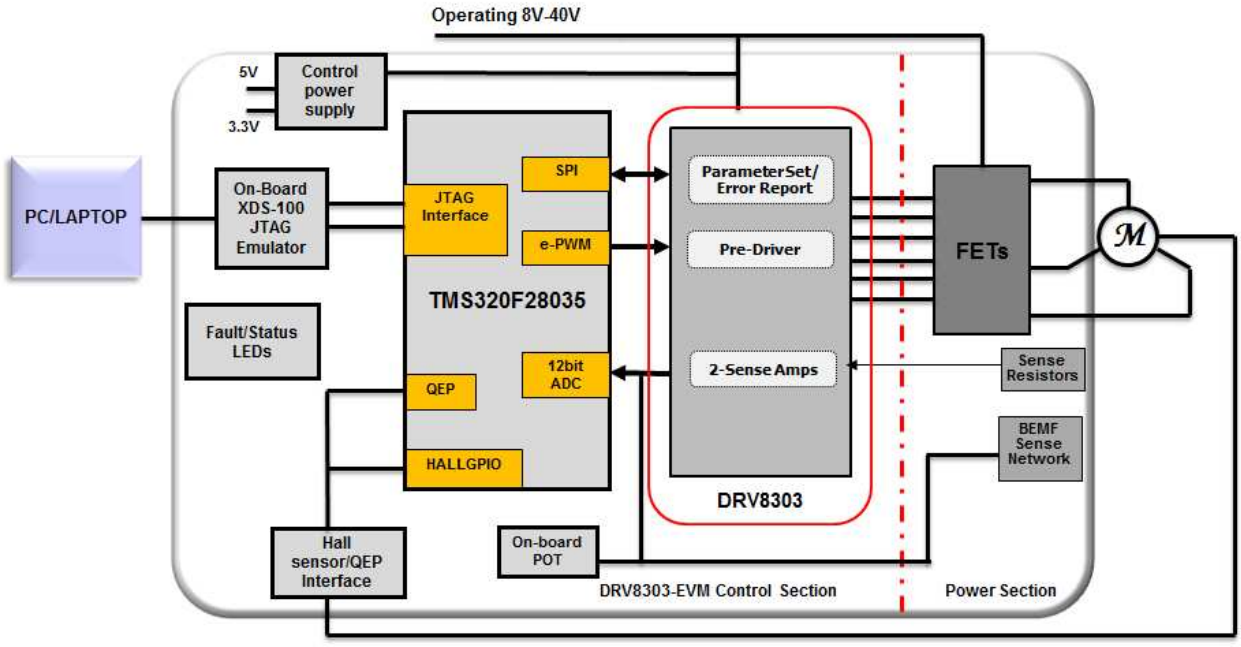
WARNING

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

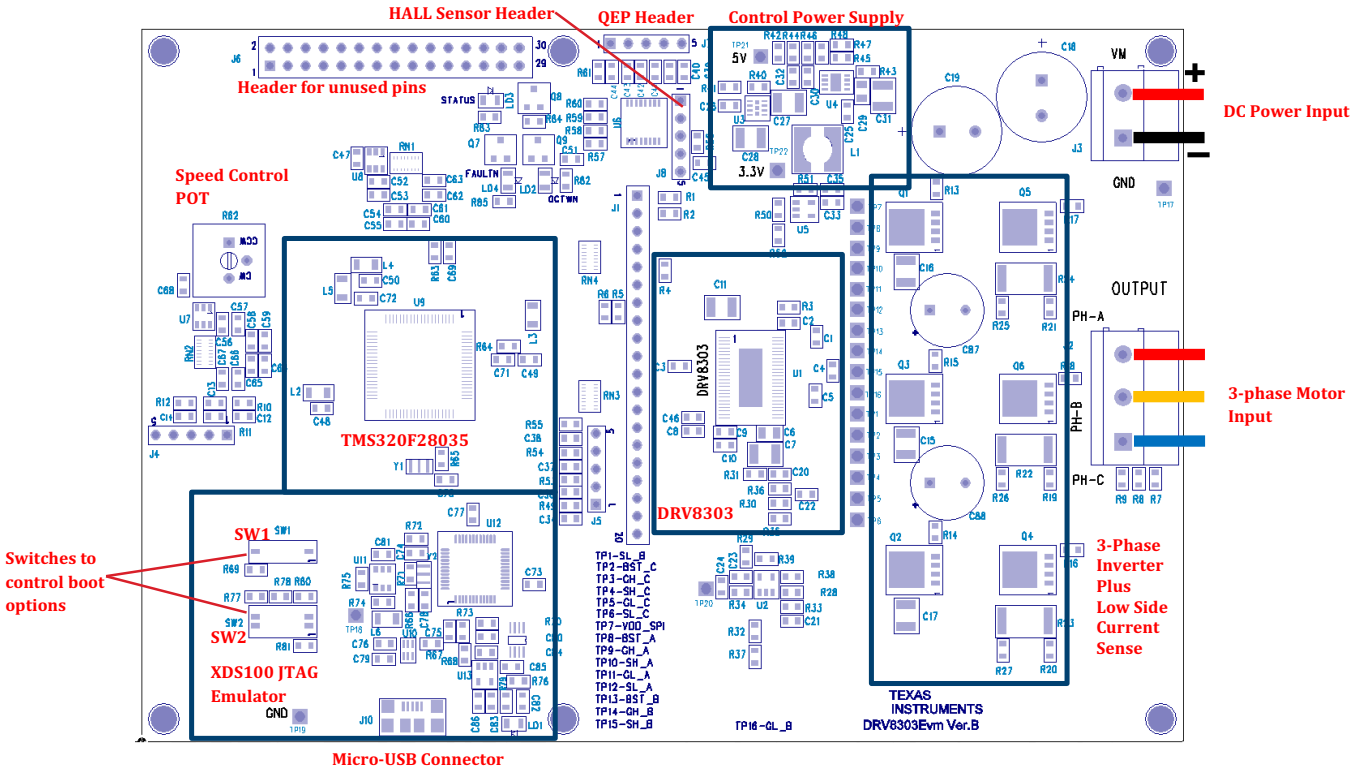


Figure 3. DRV8303EVM Kit Hardware Macro Blocks

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. 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. 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
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).

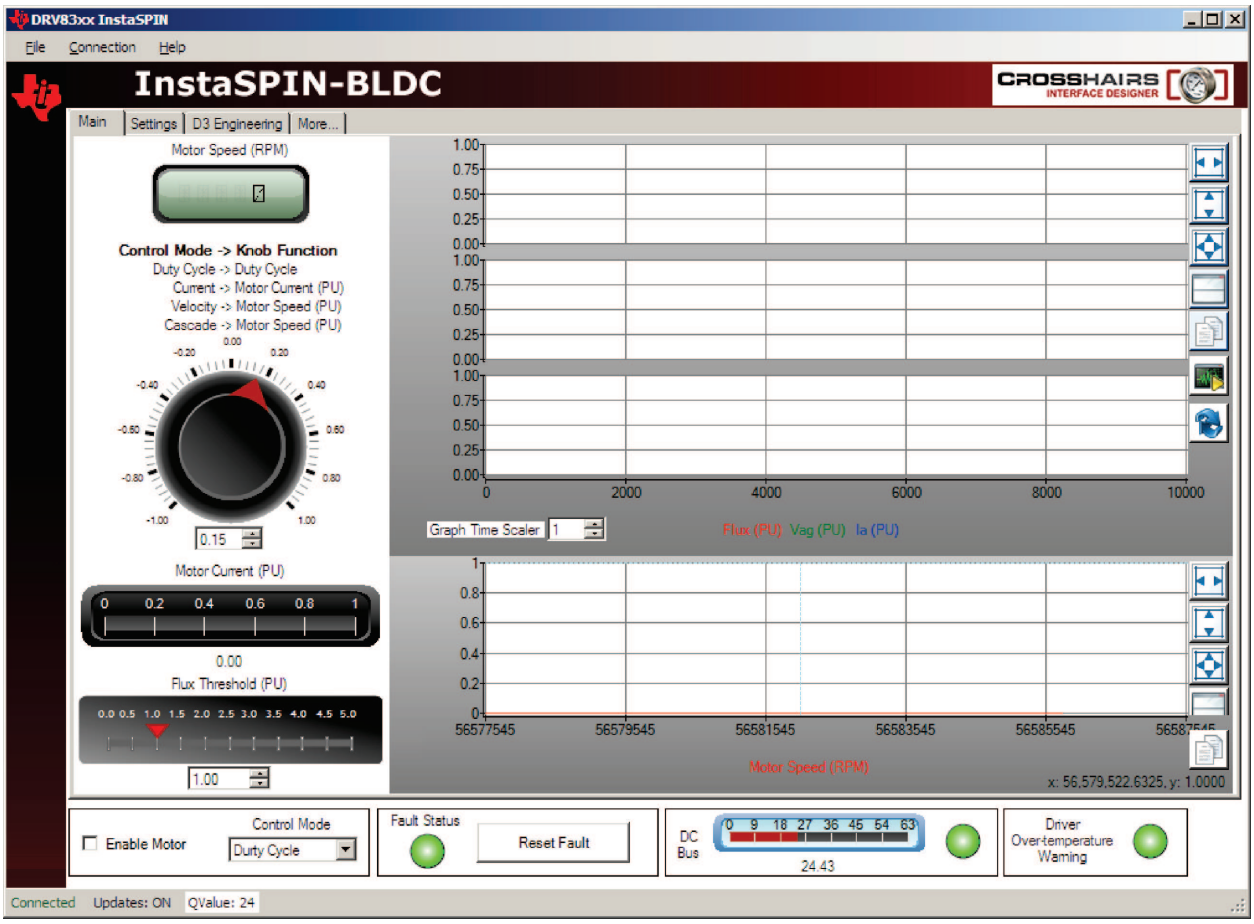


Figure 4. GUI Start-Up

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.

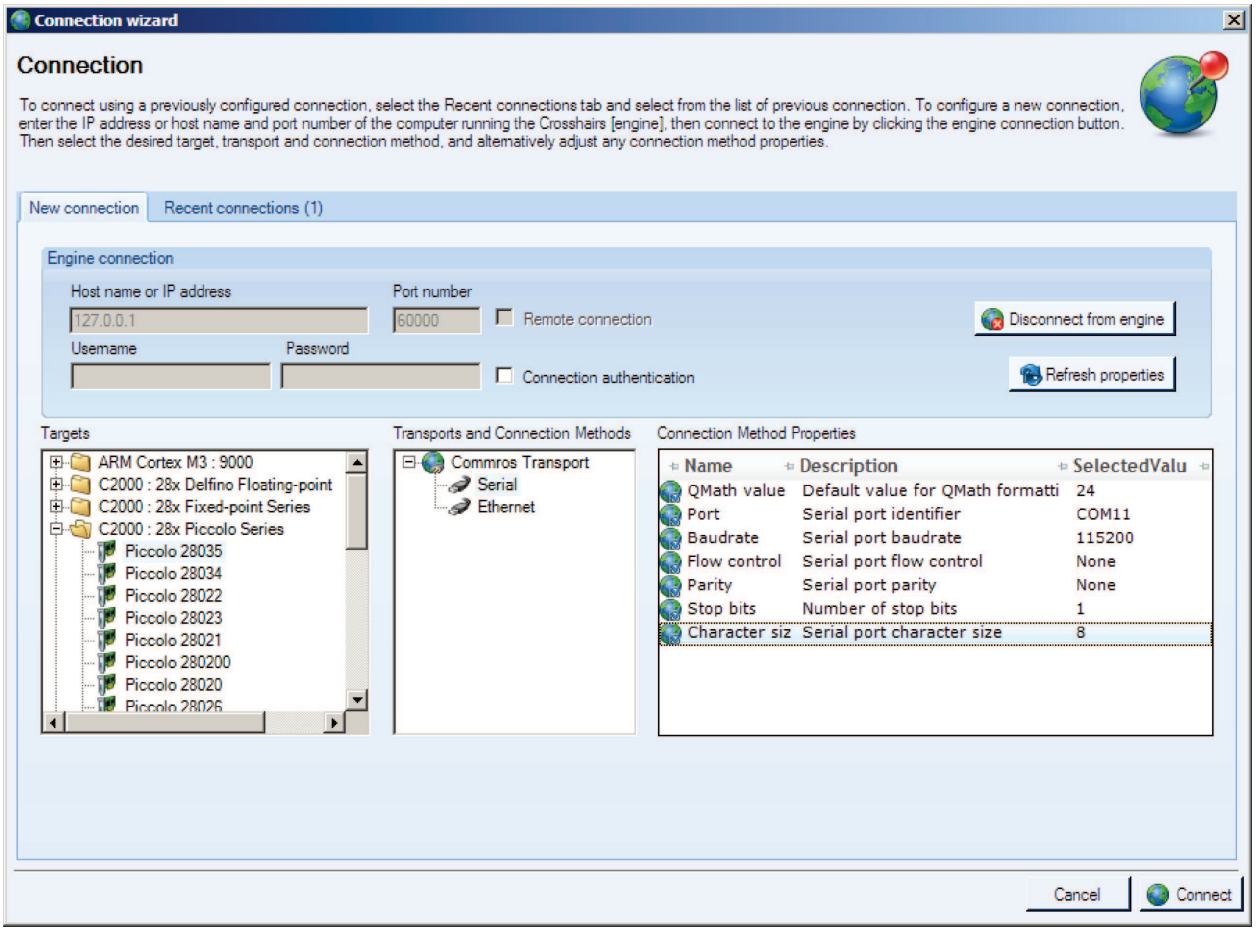


Figure 5. GUI Setup Connection

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.

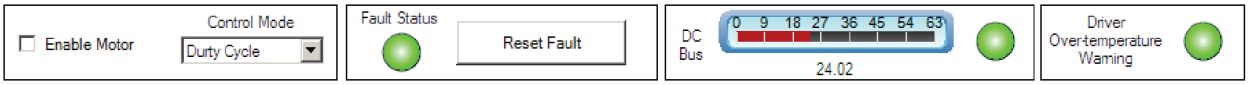


Figure 6. GUI Common Controls

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 ±82.5 A which is normalized to a ±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.

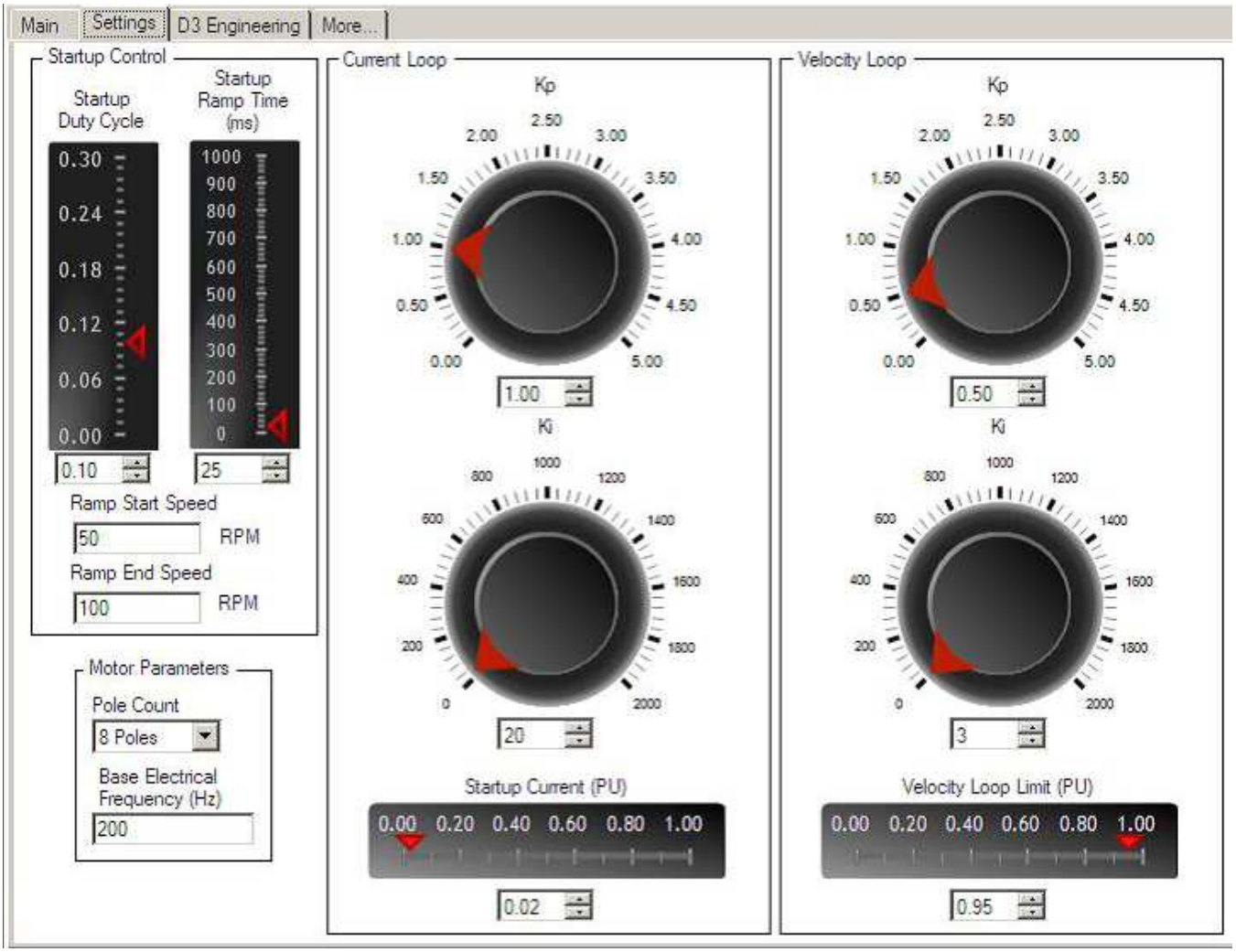


Figure 7. Settings Tab

- 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:

$$200\ \text{Hz}\ X\frac{1\,\text{Mechanical\_rev}}{\frac{8\ \text{poles}}{2}\,\text{Electrical\_rev}}\times\frac{60\ \text{s}}{1\,\text{min}}=3000\ \text{RPM}=1\,\text{PU}$$

- 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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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

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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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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:*

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