DRV830x Digital Motor Control Kit Quick Start Guide

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SPRUHX4

The DRV830x Digital Motor Control (DMC) Kit (DRV830x-HC-EVM), provides a great way to learn and experiment with digital control of Permanent Magnet Synchronous Motors (PMSM) and Brushless DC (BLDC) motors.

The DRV830x Digital Motor Control Kit contains:

- F28035 controlCARD
- Either a DRV8301-HC-EVM or DRV8302-HC-EVM DMC board with slot for the controlCARD
- USB Cable, USB Stick with Quick Start GUI, Guide, and links to install controlSUITE (which includes all documentation, PCB files, and source code) and CCStudio Integrated Development Environment

WARNING

This EVM should be used only by qualified engineers and technicians who are familiar with the risks associated with handling electrical and mechanical components, systems and subsystems. The EVM operates at voltages and currents that can result in electrical shock, fire hazard and/or personal injury if not properly handled or applied. Users must use the equipment with necessary caution and employ appropriate safeguards to avoid serious injury. Users must not touch any part of the EVM while energized.

Features of the DRV830x Motor Control Board:

- **Three-Phase Inverter Power Stage** capable of PMSM or BLDC motor control. 60V DC max input voltage and 60A maximum current in the configuration shipped.
- **Isolated SCI and CAN**, **Isolated JTAG on controlCARD**
- **Quadrature Encoder Interface**
- **Hall Sensor Input**
- **Four PWM DAC's** to observe the system variables on an oscilloscope.
- Hardware Developer's Package which includes schematics & bill of materials.
- Open source software available through **controlSUITE**

Hardware Overview

Below is a list of all the major functional blocks present on the board and a short description of its function, Fig 1, shows the location of these blocks on the motor control board and a few key connector locations.

- **ISO controlCARD socket**: controlCARD slot; controlCARD has built-in isolated XDS100 emulator.
- **DC Bus Power Entry**: Connect an external 8-60V DC power supply.
- **DRV830x**: DRV830x Three Phase Pre-Driver with Dual Current Shunt Amplifiers and Buck Converter as well as external passive components.
- **Current Sense**: Low-side shunt current sensing on each half-bridge and DC bus.
- **Quadrature Encoder**: Connections for an optional shaft encoder to interface to the MCU's QEP peripheral.
- **Hall Sensor Input**: Connections for Hall sensor feedback.

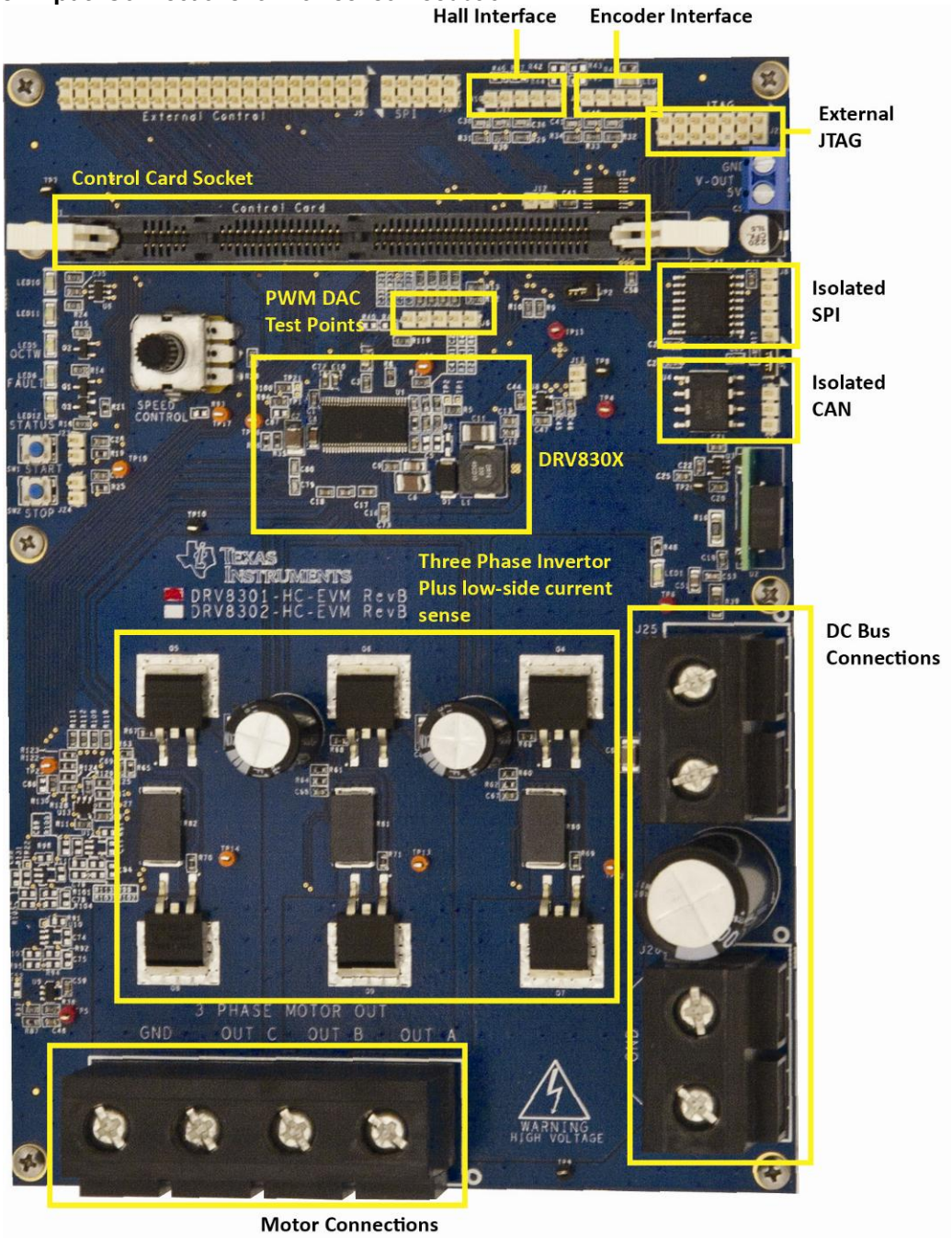

Fig1: DRV830x-HC-EVM Board Macros

Quick Start GUI

The kit comes with a GUI which provides a convenient way to evaluate the functionality of the DRV830x and the F28035 device without needing to learn and configure the underlying project software or install CCStudio. The interactive interface using knobs, sliders, buttons, textboxes and graphs enables easy demo of Sensorless Trapezoidal Commutation of BLDC motors.

Hardware Setup

Note: Do not apply power to board before you have verified these settings!

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

1) Make sure nothing is connected to the board, and no power is being supplied to the board.
2) Insert the Control card into the J1 controlCARD connector if not already populated.
4) Make sure the following jumpers & connector settings are valid on the DRV830x base board i.e.
    a. JP2 is installed
5) Make sure that the following switches are set as described below on the F28035 controlCARD to enable boot from flash and connection to the SCI
    a. SW3: OFF (UP) position
    b. SW2: Position 1 = ON (UP), Position 2 = ON (UP)
6) Connect a USB cable from J1 on the controlCARD to the host computer. LD4 on the controlCARD will light up indicating that the USB is powered. Windows will then search for a driver for the device. If the computer has CCSv4 or prior versions of it installed which supported XDS100 emulator, Windows should be able to find the driver successfully. If not you will be prompted to install the driver. **Installing driver for USB to serial**: Do not let Microsoft search for the driver, instead browse to the following location on the USB stick shipped with the kit <Drive Name:\Drivers>, windows should now be able to find the driver and will install it. If Windows still does not find the driver, you may have to 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 you can check if the installation was completed properly by browsing to ControlPanel-> System->Hardware->Device Manager and looking for USB Serial Port under Ports(COM&LPT). Make note of this port number.
7) Connect the motor you want to spin to the OUT A, OUT B and OUT C terminals on the board. The figure below shows settings required to run the GUI.

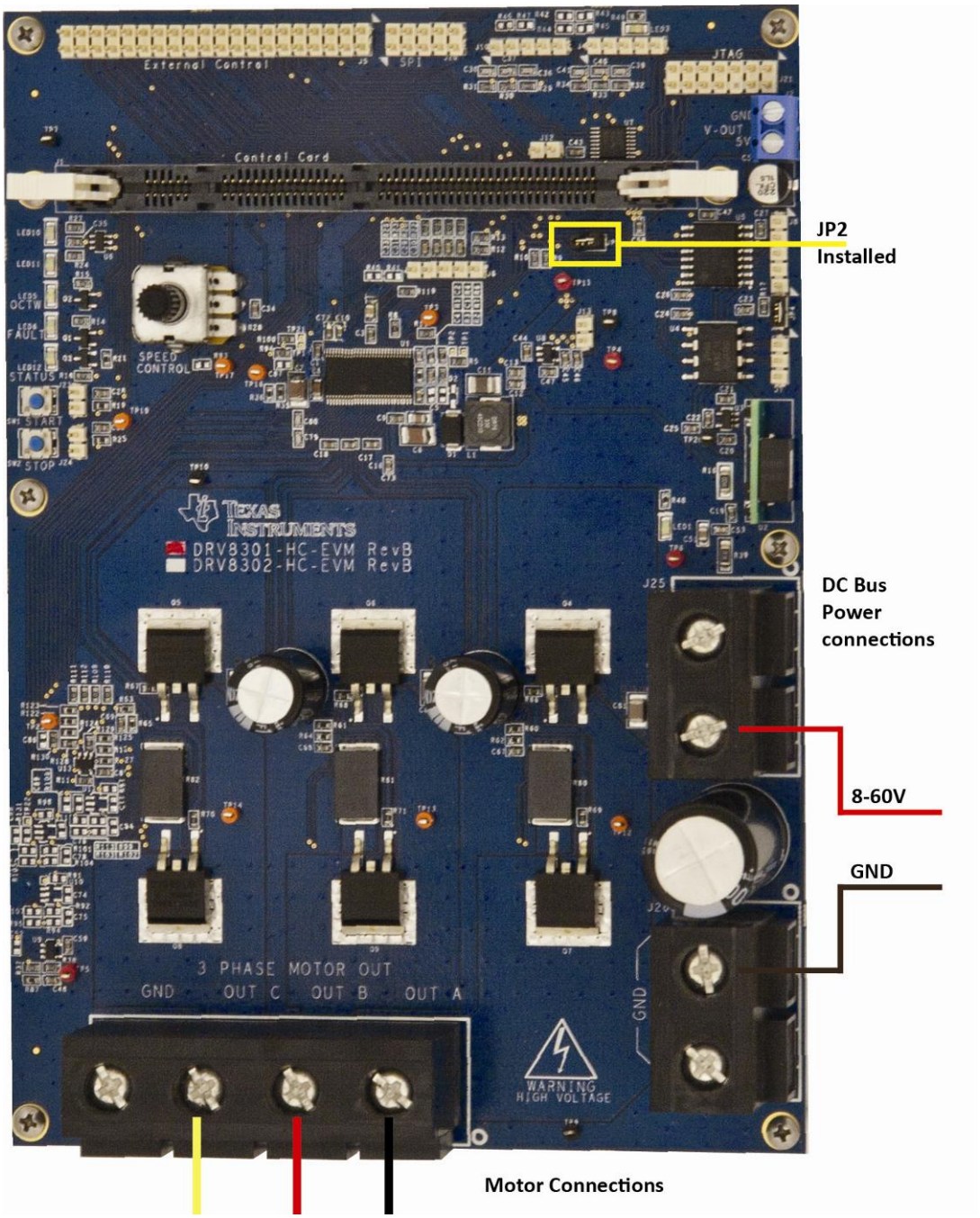

Fig2: DRV830x-HC-EVM Board Connections and Settings

8) Connect an 8-60V DC power supply at connectors J25 (PWR) and J26 (GND). .
9) Once the power is connected the board will power up and you will see that LED1 and LED3 on the DRV830x EVM base board are green (indicating power), LD1 on the controlCARD is green (also indicating power) and LD3 (Red) on the controlCARD is blinking slowly indicating that code is running.

Software Setup

The QSG GUI (InstaSPIN-BLDC_GUI_DRV83xx_v100.exe) can be located on the drive that is shipped with the kit or once controlSUITE is installed at the following location:

controlSUITE\development_kits\DRV8312-C2-KIT_vXXX\~GUI

The GUI requires Microsoft .NET framework 3.5 SP1 or higher to run. Please ensure that this software is installed prior to running this program.

The kit ships with a F28035 controlCARD which is pre-flashed with the code that enables interface to this GUI. The flash image can be re-flashed using CCS if needed.

Running the GUI

1) Make sure all the jumper and connector settings are as described in the Hardware setup section.
2) Browse to and double click on BLDC_Int_GUI_DRV83xxv*.*.exe The GUI window should pop up (Fig 3).
3) The GUI should auto-detect and connect to your DRV830x-HC-EVM. If auto-connect fails you will need to set up the connection manually. The Connection Wizard is accessed through the Connection menu. Click on "Connect to engine" to view a list of available targets. Now setup the Connection Wizard Dialog to match Fig 4. Select *Piccolo 28035* from the Target list and *Serial* for connection method. You will need to determine the correct COM port number for your system. This can be found by going to *Control Panel->System->Hardware tab->Device Manager->Ports(COM & LPT).* And look for the one which is described as USB Serial Port or similar. Hit Connect once done.

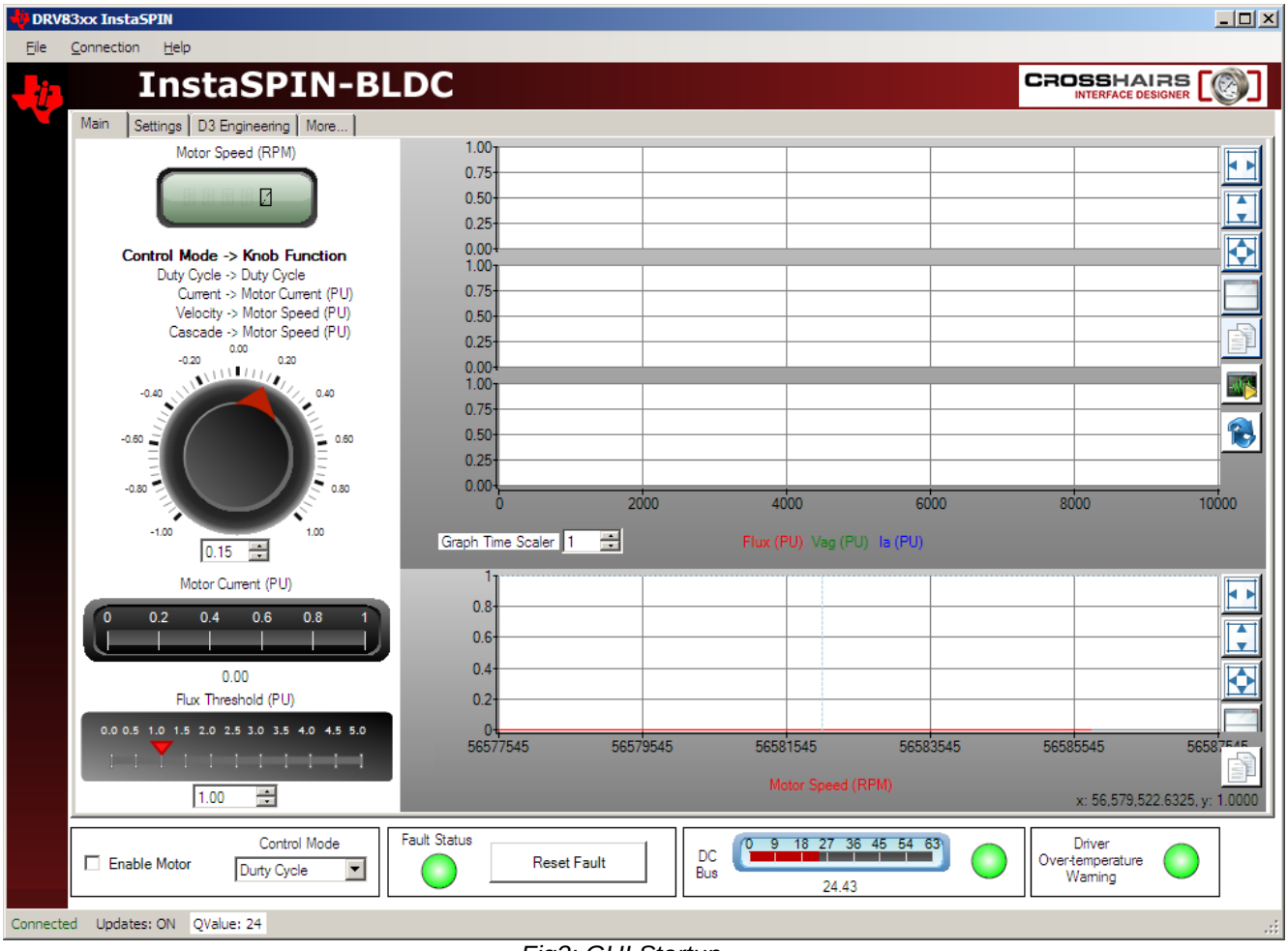

Fig3: GUI Startup

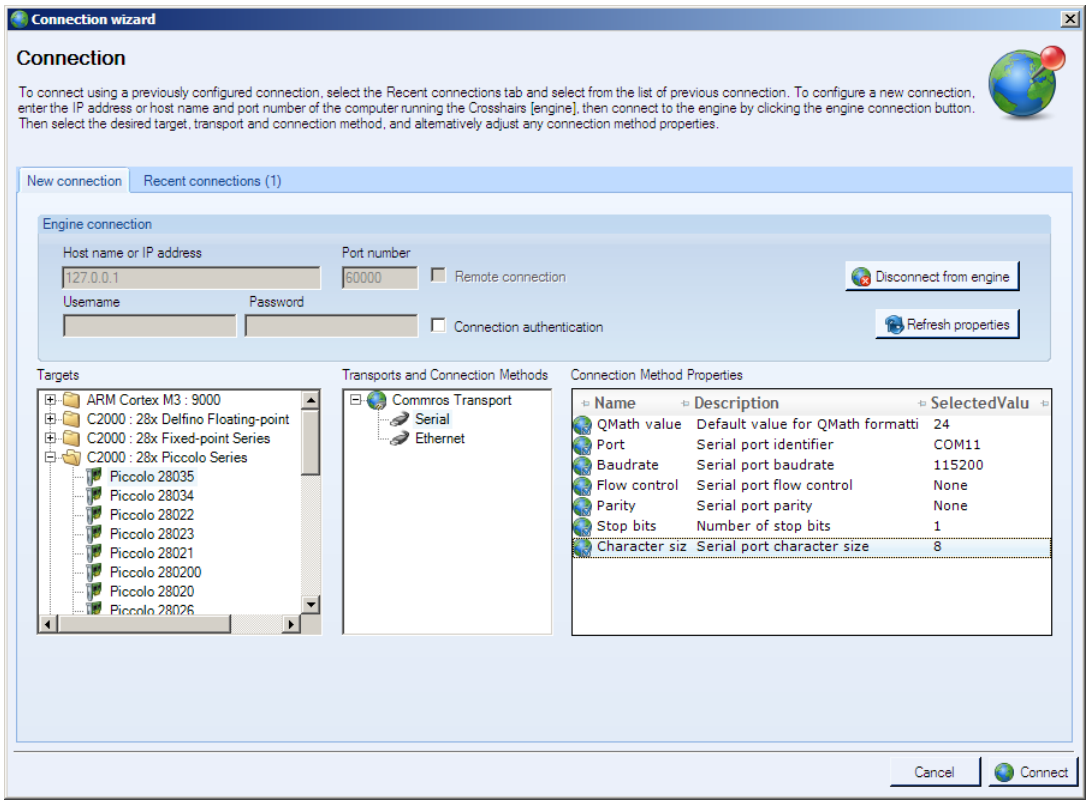

Fig4: GUI Setup Connections

4) If an incorrect image is flashed on the controlCARD, the connection will fail. In this case it is recommended to reflash the controlCARD with the correct image.

5) At the bottom of the screen are some common controls and board status indicators:

- **Enable Motor Check Box**: The Enable Motor check box is used to start or stop 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 sensorless algorithm but is driven in an open-loop duty cycle mode.
    - **Current:** The motor is commutated using the sensorless algorithm while the current (torque) is regulated using a PI controller. (Note: An unloaded motor will rapidly accelerate to a very high speed in this mode.)
    - **Velocity:** The motor is commutated using the sensorless algorithm while 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 sensorless algorithm while 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 will turn red whenever there is a fault signaled by the DRV830x. 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 is displayed both digitally and graphically. The on-screen LED can take three states depending on whether the DC bus is in or out of range.
    - **Yellow**: DC bus is below the minimum value
    - **Green:** DC bus is within limits

- **Red**: DC bus is above the maximum value

- **Driver Over-Temperature Warning:** The state of the DRV830x OCTWn pin is displayed using an on-screen LED. The LED can take two states:
  - **Yellow:** The DRV830x device temperature exceeds 130°C
  - **Green:** The DRV830x device temperature is below 130°C

Fig 5: Common Controls

6) The **Main** GUI tab contains controls to vary the motor setpoint or view various feedbacks.
   - The **Setpoint Knob** takes on 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 measureable current range of +/-82.5A which is normalized to a +/-1.0 per-unit (PU) scale.
     - **Velocity**: The knob adjusts the per-unit (PU) motor commanded speed.
     - **Cascade**: The knob adjusts the per-unit (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 should increase with motor load.
   - The four graphs on the right display commutation and speed related data. The time scale of the top three graphs can be adjusted by incrementing/decrementing the **Graph Time Scaler**
     - Top Graph: Displays the per-unit (PU) integrated motor flux.
     - Second Graph: Displays the per-unit (PU) Phase A BEMF waveform.
     - Third Graph: Displays the per-unit (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 Scaler**.
   - The **Flux Threshold** slider is used to adjust the motor's commutation point.
7) The **Settings** tab contains parameters affecting motor startup and control loop tuning.

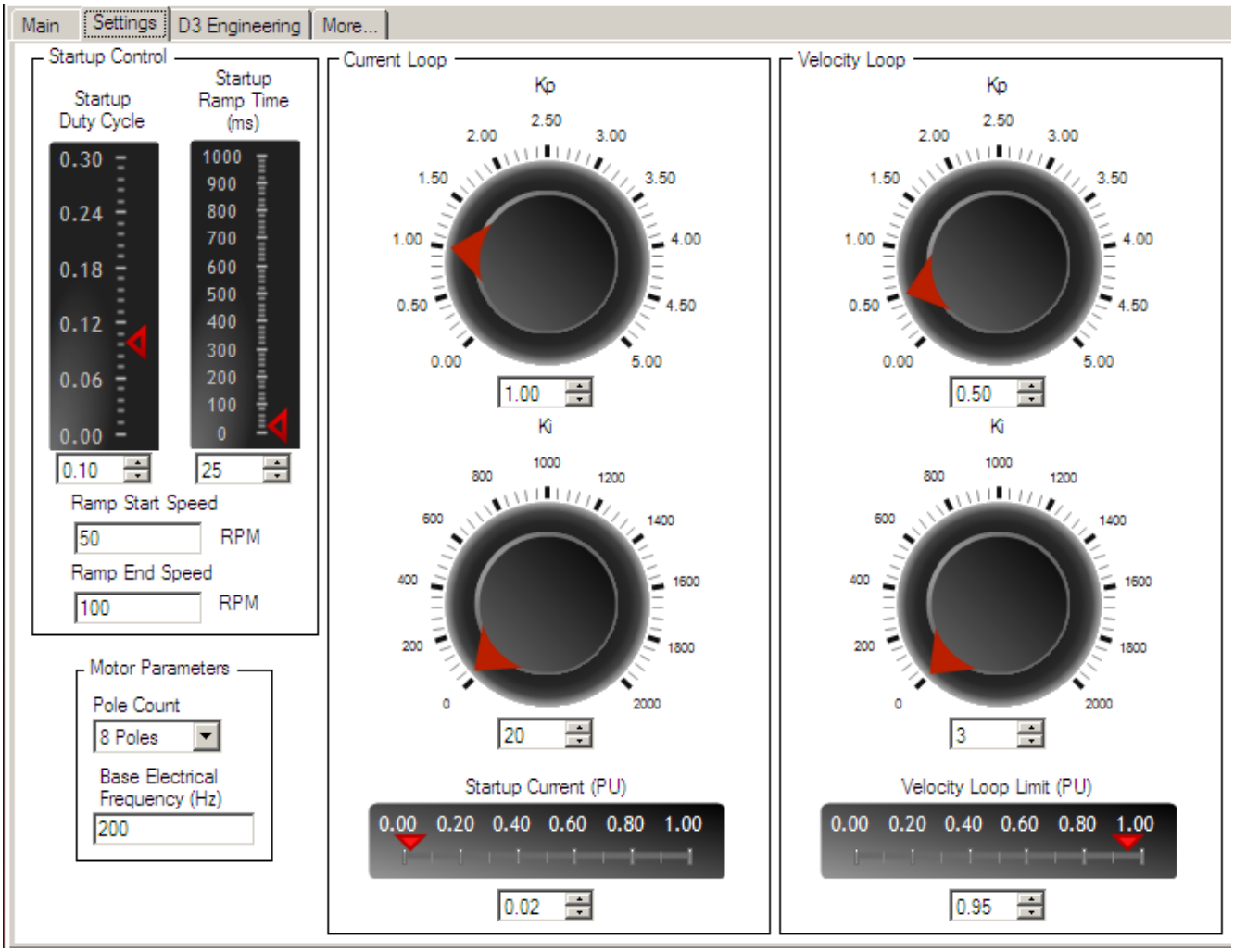

Fig 6: Setup Tab

- **Startup Control**: These parameters control how the motor initially ramps up under forced commutation. It is necessary to get the motor spinning and generating some BEMF in order for the sensorless algorithm to latch on and take over commutation.
  - **Startup Duty Cycle**: Sets the constant PWM duty cycle given to the motor during the forced commutation ramp up phase.
  - **Startup 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. For the settings shown above:

$$200Hz * \frac{1 mechanical\_rev}{\frac{8 poles}{2} electrical\_rev} * \frac{60\sec}{1\min} = 3000 RPM \Rightarrow 1.0 PU$$

- **Current Loop**: Contains parameters associated with the current control loop. These parameters are only active when Control Mode is set to Current or Cascade. Those 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.
  - **Startup 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**: Contains parameters associated with the velocity control loop. These parameters are only active when Control Mode is set to Velocity or Cascade. Those 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**
    i. In Velocity Control Mode the Velocity Loop Limit Slider sets the maximum PWM duty cycle to the motor.
    ii. In Cascade Control Mode the Velocity Loop Limit Slider sets the maximum current to the motor.

Shutting Down

1) Once finished evaluating, uncheck the Enable Motor check box to stop the motor. Once the motor comes to a full stop the GUI can be closed. Now turn off the DC power supply. As the capacitors are charged the PVDD LED (LED1) may remain ON for a couple of seconds. Do not touch the board unless this LED goes OFF.
2) All future updates/enhancements to the GUI and/or Flash image will be made available through controlSUITE.
3) Please note that the Flash image is meant for quick demonstration purpose only. For a more detailed explanation and understanding on the control algorithm being used and tradeoffs, refer to the build-level projects under

   controlSUITE\development_kits\DRV830x-HC-C2-KIT_v*.*

References

The GUI and corresponding C2000 code were developed by D3 Engineering. The GUI was created using Crosshairs Interface Designer from Crosshairs Embedded. There are links to each of the companies' web sites within the GUI. There is also information for downloading Crosshairs Interface Designer so that you can modify the GUI that comes with this kit. The More… tab gives a brief overview of the Interface Designer software.

www.crosshairsembedded.com
www.d3engineering.com

For more information please refer to the following:

- Download and Install ControlSUITE
  www.ti.com/controlSUITE

After controlSUITE install

- DRV830x-HC-EVM HW Reference Guide: provides detailed information on the DRV830x-HC-EVM hardware.
  controlSUITE\development_kits\DRV830x-HC-EVMv*.*\~Docs
- DRV830x-HC-EVM-HWdevPkg: files related to the hardware (schematics, BOM, Gerber files, PCB, etc).
  controlSUITE\development_kits \DRV830x-HC-EVMv*.*\~DRV830x-HC-EVM_HWdevPkg\
- DRV830x-HC-EVM How to Run Guide: HW and CCStudio 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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