TI Spins Motors

DRV8312 Rev D. Hardware Quick Start Guide

Version 1.0.3 *Motor Solutions*

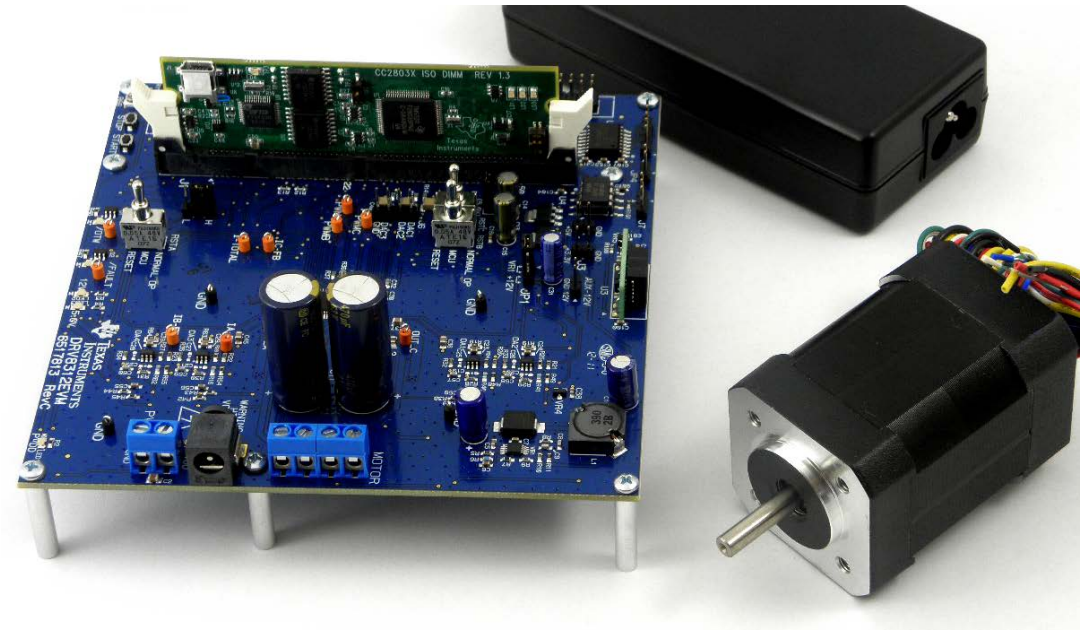


Fig 1: DRV8312 EVM with a controlCARD, NEMA17 BLDC/PMSM Motor, and Power Supply

Abstract

The Low Voltage, Low Current DRV8312 Motor Drive EVM (Figure 1), provides a great way to learn and experiment with digital control of sub 50 volt three phase motors to increase efficiency of operation. This document goes over the kit contents and hardware details, and explains the functions and locations of jumpers and connectors present on the board. This document supersedes all the documents available for the kit.

Version: 1.0.3

Revision History:

1.03	**July 11, 2013**	**Updated for TMDSCNCD28027F support (page 9)**
1.0.2	**March 21, 2013**	**Added Revision History**
1.0.1	**February 26, 2013**	**First release**

WARNING

This EVM is meant to be operated in a lab environment only and is not considered by TI to be a finished end-product fit for general consumer use

This EVM must be used only by qualified engineers and technicians familiar with 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/or 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. It is the user's responsibility to confirm that the voltages and isolation requirements are identified and understood, prior to energizing the board and or simulation. When energized, the EVM or components connected to the EVM should not be touched.

Table of Contents

Getting Familiar with the Kit

Kit Contents

The DRV8312 Motor Drive EVM is typically available as a kit with a specific MCU

- MCU controlCARD
- DRV8312 EVM with slot for the controlCARD
- BLDC/PMSM motor
- USB Cable
- 24V 2.5A AC/DC supply with universal wall plugs
- USB/DVD with CCStudio IDE, GUI, documentation, and link to project software distribution

The DRV8312EVM board can accept many of the TI MCU controlCARDs, but we recommend using the versions that ship with the kits that include JTAG emulator, USB to serial, and isolation on the controlCARD. It is recommended to always check for any updates to the GUI executable and source/binary through the software distribution tool of the MCU family you are evaluating.

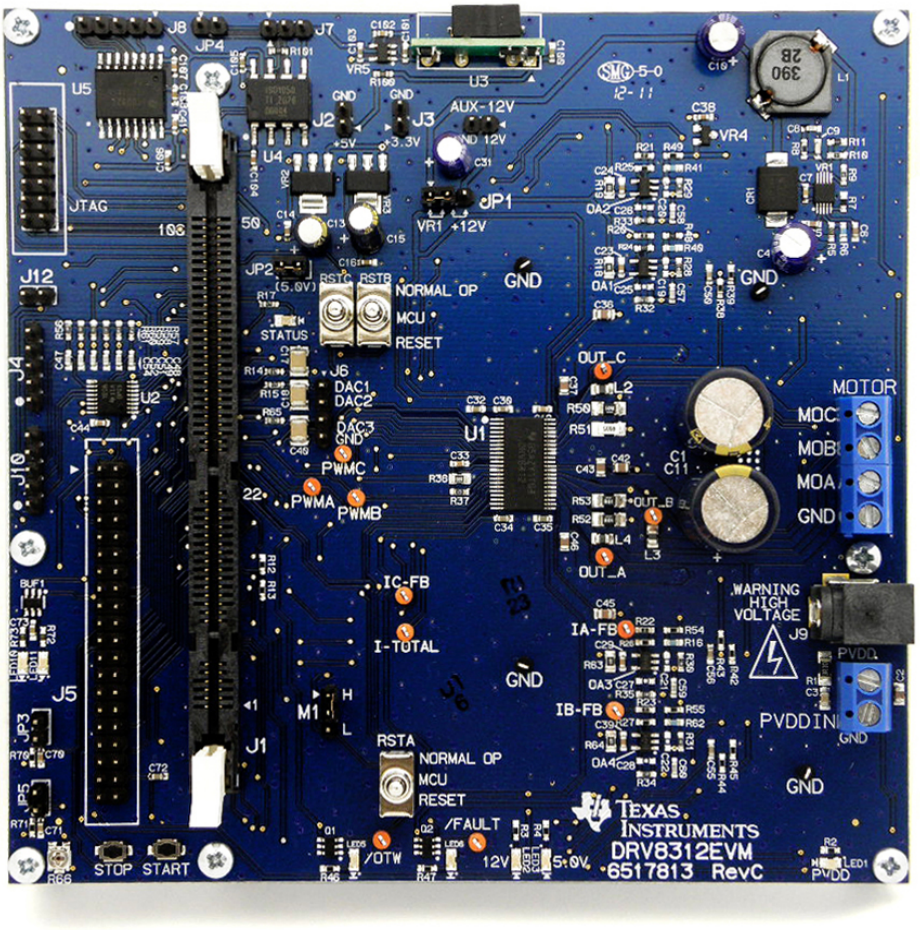


Fig 2: DRV8312 EVM

Board Features

The board has the following features

- **Three-Phase Power Stage, DRV8312** capable of driving 3-phase brushless DC motors and Permanent Magnet Synchronous Motors.
    - 52.5V DC max input voltage
    - 6.5A peak with a 3.5A max continuous output current per phase
    - Up to 500khz driver switching frequency
- 24V switching power supply with onboard regulation for powering other analog and digital circuitry
- Isolated CAN and SPI communication (will only work if MCU supports and SW is enabled)
- Quadrature Encoder Interface and Hall Sensor Interface available for speed and position measurement (only if MCU supports and SW is enabled)
- JTAG connector for external emulators
- High precision low-side current sensing using OPA365A high speed op-amps and Texas Instruments REF3025 high precision voltage reference chip
- Over current protection on the inverter stage, DRV8312
- Hardware Developer's Package that includes schematics and bill of materials
- Closed-loop digital control with feedback using the MCU's on-chip PWM/timer and ADC peripherals

Warning: about low switching frequencies on the DRV8312

When the DRV8312 runs at a low switching frequency (e.g. less than 20 kHz with 47 nF bootstrap capacitor), the bootstrap capacitor voltage might not be able to maintain a proper voltage level for the high-side gate driver. A bootstrap capacitor under voltage protection circuit (BST_UVP) will start under this circumstance to prevent the potential failure of the high-side MOSFET.

In this circumstance, both the FAULT and OTW pins should be pulled low and the device should self-protect itself. The motor's inductance and the inverter's bootstrap capacitance will allow the DRV8312 to run efficiently until approximately 10 kHz (with margin). Setting the PWM switching frequency below 10 kHz may cause issues on the inverter output and is not recommended. Please reference the datasheet.

Hardware Overview

The example projects made available with the kit are typically done using the supplied 24V power supply, but many of the examples will work with an externally supplied laboratory power supply. The DRV8312 EVM has all the power and control blocks that constitute a typical motor drive system for a three phase system: Communications + Control + Feedback + Feedforward + Drive

Macro Blocks

The motor control board is separated into functional groups that enable a complete motor drive system, these are referred to as macro blocks. Following is a list of the macro blocks present on the board and their functions:

- controlCARD socket – Socket for a controlCARD (preferably using built-in emulation).
- DC Bus Connection
    - J9 power entry jack - Connect the supplied +24V power supply here.
    - "PVDD/GND" Terminals – Connect an external lab supply here making sure to observe correct polarity.

- Aux-12V Control Power Entry – Connectors to optionally provide and external 12V supply for logic and gate drive power. The 12V supply can also be regulated on board from the DC bus depending on the setting of JP1. Set to position “VR1” to use on board regulator. Set to position “+12V” to use external regulator.
- DRV8312 – This module includes the DRV8312 Three Phase PWM Motor Driver as well as all of the necessary external passive components.
- Current Sense – Low-side shunt current sensing on each half-bridge.
- Reset Switch – Individual reset for each half-bridge. Reset can be forced manually from the 3-position switch or through a GPIO from the MCU. Setting switch in the down position, “RESET” will disable the half-bridge outputs. Setting the switch in the middle position will allow control through a GPIO on the MCU. Setting the switch in the up position, “NORMAL OP”, will disable control from the MCU and enable the half-bridge outputs.
- Mode Jumper “M1” – DRV8312 mode can be set to select between cycle-by-cycle current limit or latched over-current.
- Quadrature Encoder Connections – Connections are available for an optional shaft encoder to interface to the MCU’s QEP peripheral.
- Hall Effect Sensor Connections – Connections are available for optional Hall Effect Sensors.

Fig 3, illustrates the position of these macro blocks on the board. The use of a macro block approach, for different power stages enables easy debug and testing of one stage at a time. Banana jack connectors can be used to interconnect the power line of these power stages / blocks to construct a complete system. All the PWM’s and ADC signals which are the actuation and sense signals have designated test points on the board, which makes it easy for an application developer to try out new algorithms and strategies.

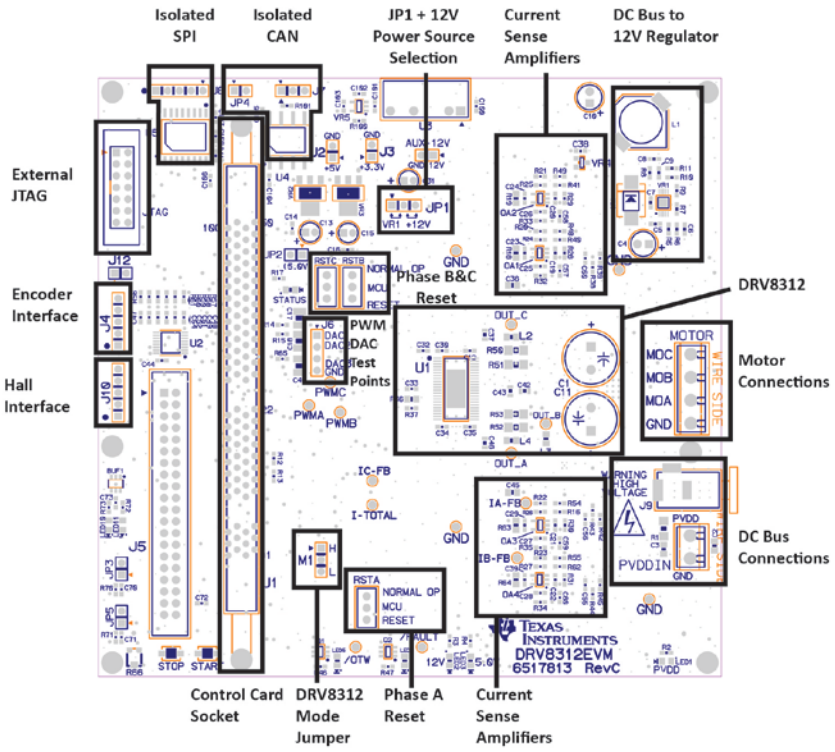


Fig3: DRV8312-EVM Board Macros

Powering the Board

The board is separated into two power domains*, the low voltage Controller Power domain that powers the controller and the logic circuit present on the board, and the medium voltage power delivery line that is used to carry the medium voltage and current like the DC power for the Inverter also referred to as DC Bus.

1) **Controller Power** comprises of the 12V, 5V and 3.3V that the board uses to power the controller and the logic and sensing circuit present on the board. This power can be sourced from two places:

Jumper JP1 selects between the two

(i) +12V **DC control power entry:** Connect an external bench supply with 1A current limit here

(ii) **On board regulator, VR1:** +12V is regulated from DC bus power via an on-board buck regulator.

2) **DC Bus Power** is the medium voltage line – up to 52.5V - that provides the voltage to the inverter stage to generate 3 phases to control the motor(s). Connect supplied 24V regulator to J9.

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 done 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 controlCARD connector if not already populated.

Special Notes Regarding controlCARD Use

- Make sure switches are set properly on the controlCARD according to the appropriate qsg_hw_cncd280xxx.pdf
- Special notes for using controlCARDs with this motor drive board
  - None

3. Make sure the following DRV8312 board jumpers & connector settings are valid i.e.
   a. JP1 is in the "VR1" position
   b. M1 is in the "H" position
   c. RSTA, RSTB and RSTC are in the middle "MCU" position
      i. It is common for these to be accidentally bumped out of position. If not in the middle position control will be impossible.
4. Connect your PC to the kit
   a. controlCARDs with on-card XDS100 USB-JTAG:
      i. connect USB cable from computer to USB connector on control card
   b. controlCARDs without on-card USB-JTAG
      i. connect USB cable from computer to external emulator, and emulator to 14-pin JTAG header (JTAG in upper left corner)
5. Connect the motor you want to spin to the "MOTOR" terminal block as shown below. The order is not important. If ground is available with your motor it should also be used.
6. Connect the included power supply to J9

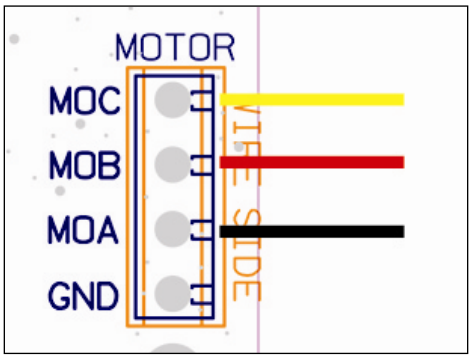


Fig4: DRV8312-EVM Motor Connections

Hardware Resource Mapping

Resource Allocation

The Fig 5 shows the various stages of the board in a block diagram format and illustrates the major connections and feedback values that are being mapped to the MCU. Table 2, below lists these resources.

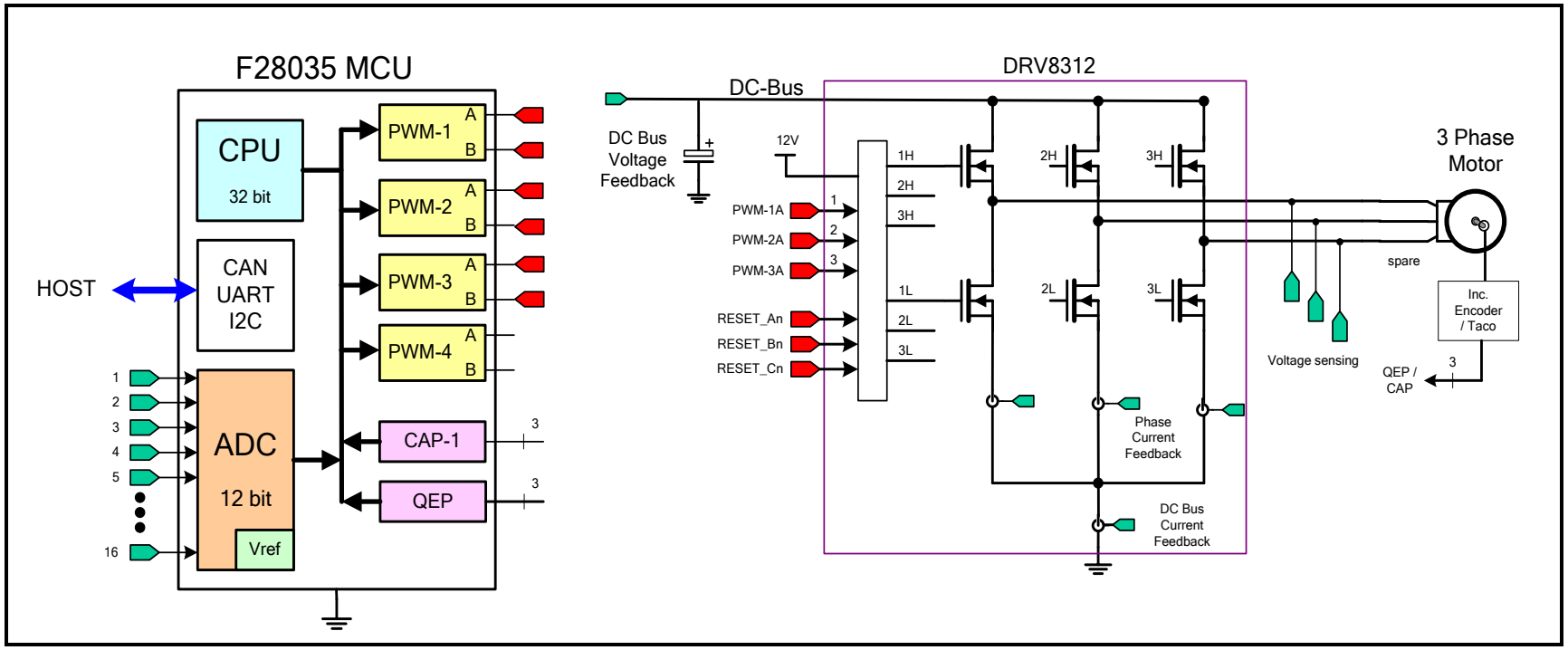
J1 Pin no.	GPIO	Signal Name	Function
23	GPIO-00	PWM_A	DRV Phase A PWM input

73	GPIO-01	RESET_A	DRV Phase A RESETn input
24	GPIO-02	PWM_B	DRV Phase B PWM input
74	GPIO-03	RESET_B	DRV Phase B RESETn input
25	GPIO-04	PWM_C	DRV Phase C PWM input
75	GPIO-05	RESET_C	DRV Phase C RESETn input
76	GPIO-07	STOP	Push button input
28	GPIO-08	DAC_PWM3	PWM DAC
78	GPIO-09	START	Push button input
29	GPIO-10	DAC_PWM1	PWM DAC
79	GPIO-11	DAC_PWM2	PWM DAC
33	GPIO-12	LED-1	User LED
83	GPIO-13	OTWn	Over-temperature warning
84	GPIO-14	FAULTn	Over-current fault
34	GPIO-15	LED-2	User LED
38	GPIO-16	SPI-SIMO	Isolated SPI Interface
88	GPIO-17	SPI-SOMI	Isolated SPI Interface
39	GPIO-18	SPI-CLK	Isolated SPI Interface
89	GPIO-19	SPI-STE	Isolated SPI Interface
40	GPIO-20	QEPA	Encoder A
90	GPIO-21	QEPB	Encoder B
41	GPIO-22	STATUS	User LED
91	GPIO-23	QEPI	Encoder Index
35	GPIO-24	CAP1	Hall input 1
85	GPIO-25	CAP2	Hall input 2
36	GPIO-26	CAP3	Hall input 3
44	GPIO-30	CAN-RX	Isolated CAN Interface

94	GPIO-31	CAN-TX	Isolated CAN Interface
59	ADC-A1	IA-FB	Current sense phase A
61	ADC-A2	I-TOTAL	DC Bus current sense
63	ADC-A3	IC-FB	Current sense phase C
67	ADC-A5	IC-FB	Current sense phase C
71	ADC-A7	ADC-Vhb2	Phase Voltage sense B
7	ADC-B0	TSI	Tach/Pot input
9	ADC-B1	IB-FB	Current sense phase B
11	ADC-B2	VDCBUS	DC Bus voltage sense
13	ADC-B3	IA-FB	Current sense phase A
15	ADC-B4	ADC-Vhb3	Phase Voltage sense C
17	ADC-B5	IB-FB	Current sense phase B
21	ADC-B7	ADC-Vhb1	Phase Voltage sense A

Table 2: GPIO and ADC resource allocation

Standard Signal Mapping from MCU to 3PH Inverter



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