TI Spins Motors

Hardware Quick Start Guide

Abstract

This document discusses how to set up a motor drive platform using Texas Instruments' motor EVM kits, either F280049C controlCARD paired with TMDSHVMTRINSPIN kit or F280049C LaunchPad paired with BOOSTXL-DRV8320RS to evaluate the InstaSPIN-FOC algorithm with MotorControl SDK example projects.

Introduction

This section acts as a guide for evaluation of InstaSPIN enabled Piccolo controllers paired with various three-phase inverter hardware boards. The following topics will be presented:

1. Board introduction and hardware settings
2. Quick start guide for running a motor drive

Objectives Learned

- How to use F280049C controlCARD paired with TMDSHVMTRPFCKIT to evaluate InstaSPIN-FOC.
- Alternatively, how to use LAUNCHXL-F280049C paired with BOOSTXL-DRV8320 to evaluate InstaSPIN-FOC.

Overview

This document acts as a guide for your evaluation of an InstaSPIN enabled F28004xC controllers paired with various three-phase inverter hardware kits.

Supporting Kits:

- Piccolo InstaSPIN enabled controllers
    - TMDSCNCD280049C Piccolo F280049C controlCARD
        - PN: TMDSCNCD280049C
        - Includes on-card XDS100v2 JTAG (isolated)
        - [Piccolo F280049C controlCARD Information Guide](#)
    - LAUNCHXL_F280049C LaunchPad for InstaSPIN-FOC
        - PN: LAUNCHXL-F280049C
        - Includes on-card XDS110 JTAG (isolated)
        - [Piccolo F28004x Series LaunchPad Evaluation Kit Guide](#)

- 3-phase Inverters
    - High Voltage: hvmtrkit_r1p1 [Yellow PCB with black enclosure]
        - PN: TMDSHVMTRINSPIN
        - Also ships as the inverter board in TMDSHVMTRPFCKIT
        - Needs 180 to 100 Pin DIMM Adapter ([TMDSADAP180TO100](#)) to work with F280049C controlCARD.

TI Spins Motors

- o Low Voltage / Medium Current: boostxldrv820rs_reVA
  - PN: BOOSTXL-DRV8320RS
  - [BOOSTXL-DRV8320RS EVM User's Guide](#)

3-phase Inverter Board	Controller Board	Maximum Input Voltage	Maximum Current	PGA Support
TMDSHVMTRINSPIN	TMDSCNCD280049C+ TMDSADAP180TO100	265VAC/400VDC	15A	N/A
BOOSTXL-DRV8320RS	LAUNCHXL_F280049C	60VDC	10A	YES

Table 1: Hardware kit specifications and possible controller combinations

TI Spins Motors

Path to Success:

1 Always make sure you are using the latest version of MotorControl SDK
   a. http://www.ti.com/tool/download/C2000WARE-MOTORCONTROL-SDK
   b. MotorControl SDK contains all of the modules, drivers, example Code Composer Studio based InstaSPIN-FOC projects, and associated documentation.
   c. Detect and import example projects of MotorControl SDK by using Resource Explore in CCS. View MotorControl SDK Resource Explorer on the web, or Resource Explorer can also be opened by going to the menu View-> Resource Explorer in CCS.
   d. Read the solution documentation:
       I. C2000Ware Motor Control SDK Getting Started Guide.
       II. InstaSPIN-FOC Lab Projects User's Guide.
       III. C2000Ware MotorControl SDK InstaSPIN Universal GUI Quick Start Guide.
       IV. F28004xC InstaSPIN-FOC Technical Reference Manual (will be released on ti.com).
       V. InstaSPIN-FOC User's Guide (will be released on ti.com).

2 Always use the latest version of Code Composer Studio for example projects.

   a. The latest version of Code Composer Studio can be obtained at the following link: http://www.ti.com/ccstudio

   b. The latest C2000 compiler can be obtained at the following link:

      http://www.ti.com/tool/c2000-cgt

      Or update from CCS App Center. App Center can be opened by going to the menu View-> CCS App Center in CCS.

3 Evaluate with the InstaSPIN Universal GUI and TI controlCARD / LaunchPad.
   a. Follow GUI Quick Start Guide to set-up the hardware kits.
   b. Note that you will need to compile your specific .out for the GUI to work properly with your motor.
   c. Notes:
       I. Not all possible functionality is demonstrated through use of the GUI.
       II. Not all performance capability is enabled by the use of the GUI.
       III. The intention of this GUI is to demonstrate and evaluate general capability for a broad amount of applications, on specific hardware that is widely available from TI, with the intention of giving confidence for a more thorough evaluation.

4 Follow the is##_<name> lab examples from MotorControl SDK and the Lab User's Guide to test with
   a. TI controlCARD / LaunchPad and its paired inverters.
   b. On your own control and inverter hardware to adapt and modify.

Set-up EVM Kits for Lab Exmples in Montrol Control SDK

1 High Voltage EVM Kit: TMDSCNCD280049C + TMDSADAP180TO100 + TMDSHVMTRINSPIN

   a. The latest content of F280049C controlCARD (TMDSCNCD280049C) can be obtained at the following link:
      http://www.ti.com/tool/TMDSCNCD280049C

      Figure 1 illustrates the location on the controlCARD of the components, set these switches on the F280049C controlCARD for connecting to High voltage kit as described in **Table 2**.

Switch	References	Position
S1	Boot Mode Switch	1-ON/UP, 2-ON/UP for Flash Mode
S1:A	Isolated emulation and UART communication enable switches	1-ON/UP, onboard emulator enabled 2-ON/UP, onboard ISO UART enabled
S2	GPIO10/GPIO35 Configuration Switches	ON/UP
S3	GPIO08/GPIO37 Configuration Switches	ON/DOWN
S4	JTAG/cJTAG Selection Switch	OFF/DOWN, on-board JTAG enabled
S5	GPIO24/GPIO25 Configuration Switches	1-ON/UP 2-ON/UP
S6	GPIO26/GPIO27 Configuration Switches	1-ON/DOWN 2-ON/DOWN
S7	PGA Filter Configuration Switches	ALL-ON/UP
S8	ADC VREFHI Control Switch for ADC modules	1-ON/LEFT 2-ON/LEFT

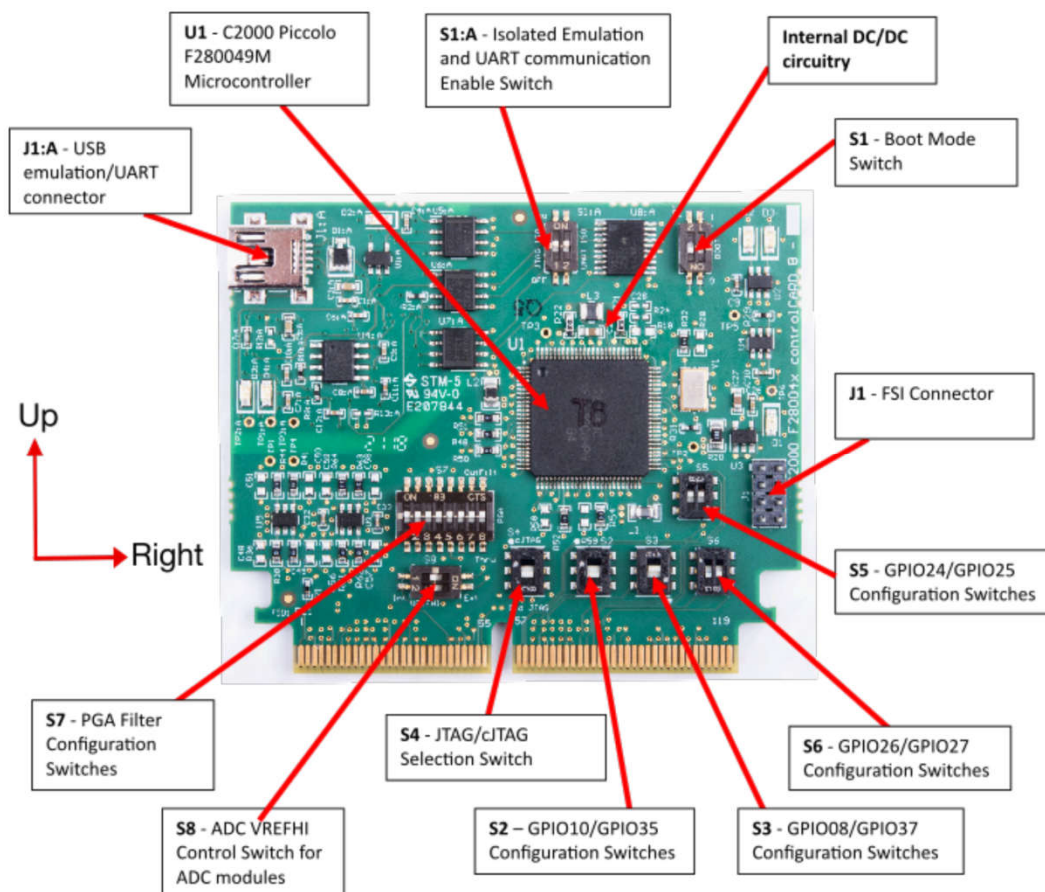**Table 2:** TMDSCNCD280049C Switches Setting

Figure 1: Key components on the F280049C controlCARD

b. The latest content of 180 to 100 Pin DIMM Adapter (TMDSADAP180TO100) can be obtained at the following link:
http://www.ti.com/tool/tmdsadap180to100

Figure 2 illustrates the location on the adapter board of the components, set these switches on the adapter board for connecting to High voltage kit as described in **Table 3**.

Switches	References	Position
S1	Selects whether controlCARD pins 30 and 33 are routed to HSEC58 or HSEC89	OFF/RIGHT
S2	Selects whether controlCARD pins 80 and 83 are routed to HSEC60 or HSEC91	ON/LEFT
S3	Selects whether controlCARD pins 31 and 84 are routed to HSEC62 or HSEC93	ON/LEFT
S4	Selects whether controlCARD pins 34 and 81 are routed to HSEC64 or HSEC95	OFF/RIGHT

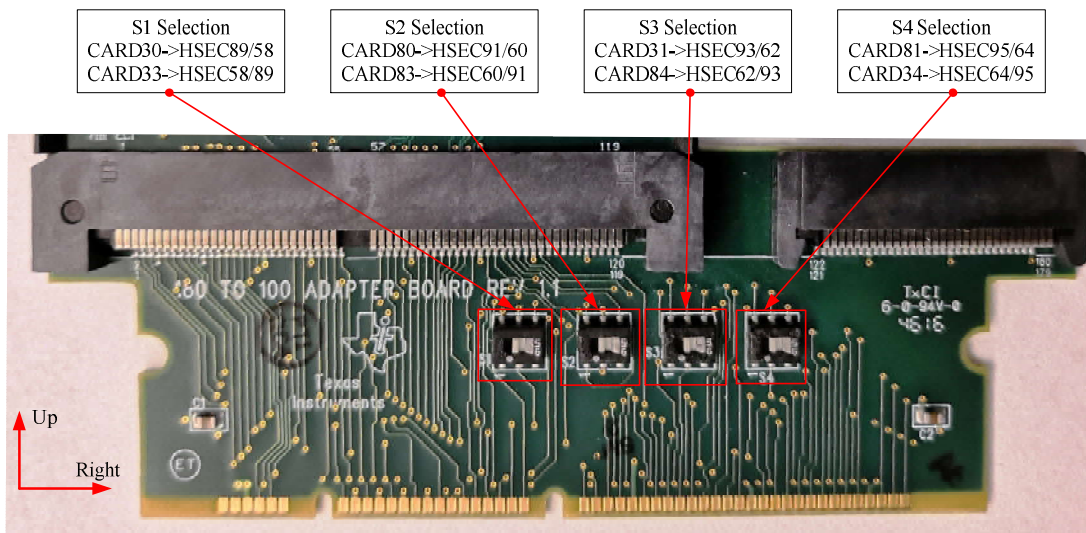**Table 3**: TMDSADAP180TO100 switches Setting

Figure 2: Routing switches on the TMDSADAP180TO100 adapter card

c. The latest content of High Voltage Motor Control Kit (TMDSHVMTRINSPIN) can be obtained at the following link:
http://www.ti.com/tool/tmdshvmtrinspin

The board has the following features for motor control:

- 3-Phase Inverter Stage to control high voltage motors.
    - 350V DC max input voltage
    - 1KW*/1.5KW* maximum load (for loads > 150W, the fan** attached to the IPM heat sink must be used)
    - Sensorless and sensored field oriented control of synchronous and asynchronous motors

- AC Rectifier stage rated for delivering up to 750W* power. This stage can be used to either generate the DC Bus voltage for the inverter directly or provide input for the Power Factor Correction stage present on the board.
    - 85-132VAC/ 170-250VAC input
    - 750W max power rating
- Aux Power Supply Module can generate 15V and 5V DC from rectified AC voltage or the PFC output (input Max voltage 400V).

*All the power rating tests for the power stages have been performed at room temperature. The motor stage is rated for 1KW with the usage of DC Fan and heat sink shipped with the board. Operation up till 1.5KW is possible with a combination of more airflow and a different heat sink. For high power tests a high voltage external power supply was used (PFC and AC power stage was not used as these stages are rated for 750W).

** Make sure that the DC Fan shipped with the kit is connected to the DC Fan Jumper [Main]-J17 when operating the motor under load > 150W.

⚠️ **Note that the ground planes of both the power domains are the same, hence proper isolation requirements must be met before connecting any test equipment with the board.**

- **Do NOT use the onboard XDS100 emulator since the F280049C controlCARD has its own onboard emulation.**
- **Populate jumper M3-J5 to disable onboard emulation on HVKIT.**

Hardware Developer's Package that includes schematics and bill of materials is available through the MotorControl SDK.

Figure 4 illustrates the location of these connections on the board with help of a board image. **Table 4** shows the connections that need to be set for motor control and **Figure 3** shows the connections for motor control on the board if using AC power input.

Switches	References	Position
[Main]-BS1	Banana Jack for Output from AC Rectifier	Connect BS1 to BS5 using a line by pass PFC
[Main]-BS5	Banana Jack for input of DC bus voltage for the inverter	
[Main] J1	The DIMM socket to populate the controlCARD	Populated controlCard on J1
[Main] J2	Jumper connected to Bridge position: the aux power supply module sources power from the AC rectifier bridge output. Jumper connected to PFC position: the aux power supply module sources power from the output of the PFC stage.	Connect jumper to Bridge position
[Main] J3,J4,J5	Select the sourcing 15V, 5V and 3.3V power respectively for the board from the 15V DC Power supply.	Populated jumpers on J3, J4, and J5.
[Main] J7	Select the over current protection threshold source	Populated jumper on J7
[Main] J8	Enable/disable the IPM overcurrent protection	Populated jumper on J8
[Main] J9	JTAG TRSTn disconnect jumper, populating the jumper enables JTAG connection to the microcontroller. The jumpers needs to be unpopulated when no JTAG connection is required such as when booting from FLASH	Unpopulated jumper on J9
[M3]-J5	On-board emulation disable jumper: Place a jumper here to disable the on-board emulator and give access to the external interface.	Populated jumper on J5

Table 4: TMDSHVMTRINSPIN Jumpers and Connectors Setting

TI Spins Motors

High Voltage Kit Setup Instructions

- Install the Jumpers [Main]-J3, J4, and J5 for 3.3V, 5V and 15V power rails.
- [M3] - J5 is populated and [Main] - J9 is not populated for using isolated JTAG emulation on F280049C controlCARD
- Install jumpers [Main]-J7 between pins 2-3 (pins furthest from the DIMM socket) and [Main]-J8 to enable over-current protection.
- Place the TMDSADAP180TO100 adapter card with F280049C controlCARD in the connector slot of [Main]-J1. Push vertically down using even pressure from both ends of the card until the clips snap and lock.
- Ensure that [M6]-SW1 is in the "Off" position. Connect 15V DC power supply to [M6]-JP1.
- Turn on [M6]-SW1. Now [M6]-LD1 should turn on. Notice the control card LED would light up as well indicating the control card is receiving power from the board.
- Note that the motor should be connected to the [M5]-TB3 terminals after you finish with the first incremental build step.
- Note the DC Bus power should only be applied when instructed to do so. The two options to get DC Bus power are discussed below,
  - To use DC power supply, set the power supply output to zero and connect [Main]-BS5 and BS6 to DC power supply and ground respectively.
  - To use AC Mains Power, Connect [Main]-BS1 and BS5 to each other using banana plug cord. Now connect one end of the AC power cord to [Main]-P1.The other end need to be connected to output of a variac. Make sure that the variac output is set to zero and it is connected to the wall supply through an isolator.

⚠️ **WARNING:**

- **Always use caution when using the EVM electronics due to presence of high voltages.**
- **DC bus Capacitors would remain charged for a long time after the mains supply is disconnected. Use caution!**
- **The user must not touch any part of the board or components connected to the board while energized.**
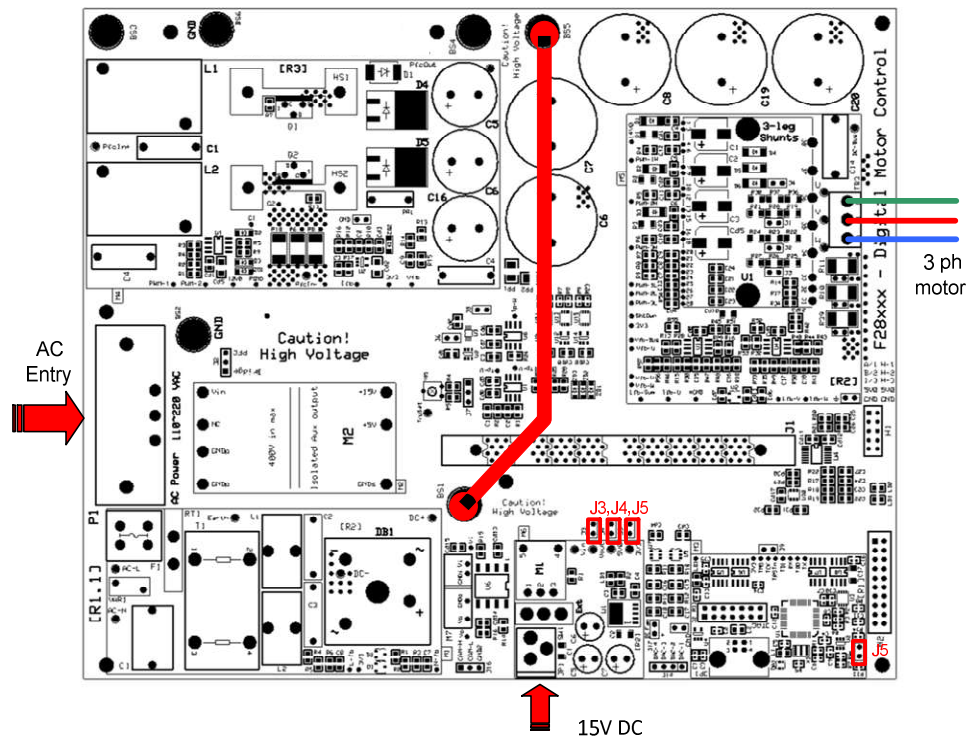
TI Spins Motors

Figure 3: Using AC Power to generate DC Bus Power for High Voltage Kit
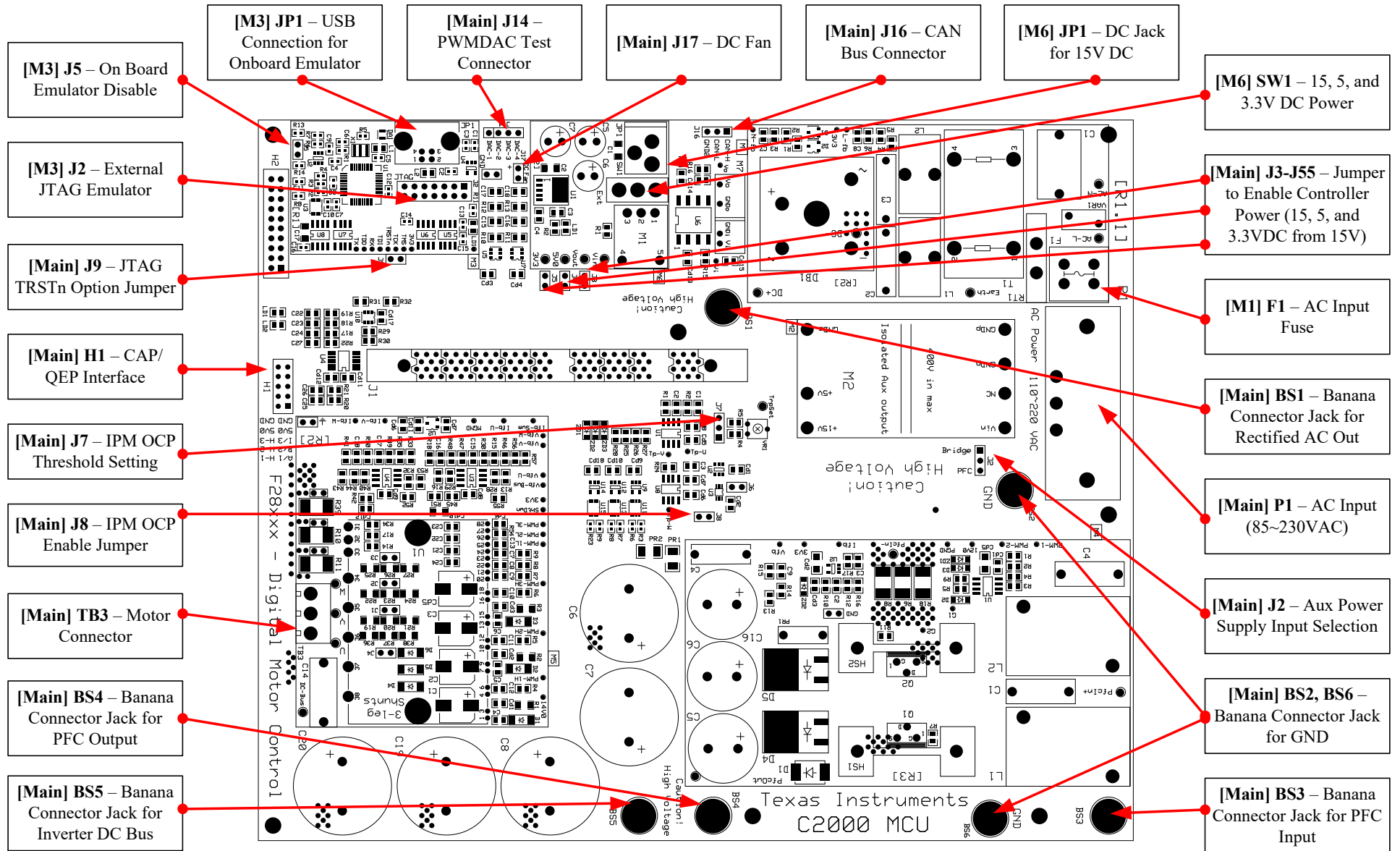
8

TI Spins Motors

Figure 4: High Voltage Motor Control and PFC Kit Jumpers and Connectors Diagram

Labels around the diagram:

- **[M3] J5** – On Board Emulator Disable
- **[M3] J2** – External JTAG Emulator
- **[Main] J9** – JTAG TRSTn Option Jumper
- **[Main] H1** – CAP/ QEP Interface
- **[Main] J7** – IPM OCP Threshold Setting
- **[Main] J8** – IPM OCP Enable Jumper
- **[Main] TB3** – Motor Connector
- **[Main] BS4** – Banana Connector Jack for PFC Output
- **[Main] BS5** – Banana Connector Jack for Inverter DC Bus
- **[M3] JP1** – USB Connection for Onboard Emulator
- **[Main] J14** – PWMDAC Test Connector
- **[Main] J17** – DC Fan
- **[Main] J16** – CAN Bus Connector
- **[M6] JP1** – DC Jack for 15V DC
- **[M6] SW1** – 15, 5, and 3.3V DC Power
- **[Main] J3-J55** – Jumper to Enable Controller Power (15, 5, and 3.3VDC from 15V)
- **[M1] F1** – AC Input Fuse
- **[Main] BS1** – Banana Connector Jack for Rectified AC Out
- **[Main] P1** – AC Input (85~230VAC)
- **[Main] J2** – Aux Power Supply Input Selection
- **[Main] BS2, BS6** – Banana Connector Jack for GND
- **[Main] BS3** – Banana Connector Jack for PFC Input

2 Low Voltage EVM Kit: LAUNCHXL-F280049C + BOOSTXL-DRV8320RS

a. The latest content of F280049C LaunchPad Development Kit (LAUNCHXL-F280049C) can be obtained at the following link:
http://www.ti.com/tool/LAUNCHXL-F280049C

Figure 5 illustrates the key features of the F280049C LaunchPad of the components, set these switches on the F280049C LaunchPad for connecting to DRV8320RS BoosterPack as described in **Table 5**. Refer to the C2000™ Piccolo™ F28004x Series LaunchPad™ Development Kit User's Guide (http://www.ti.com/lit/ug/spruii7/spruii7.pdf) to set up the hardware.
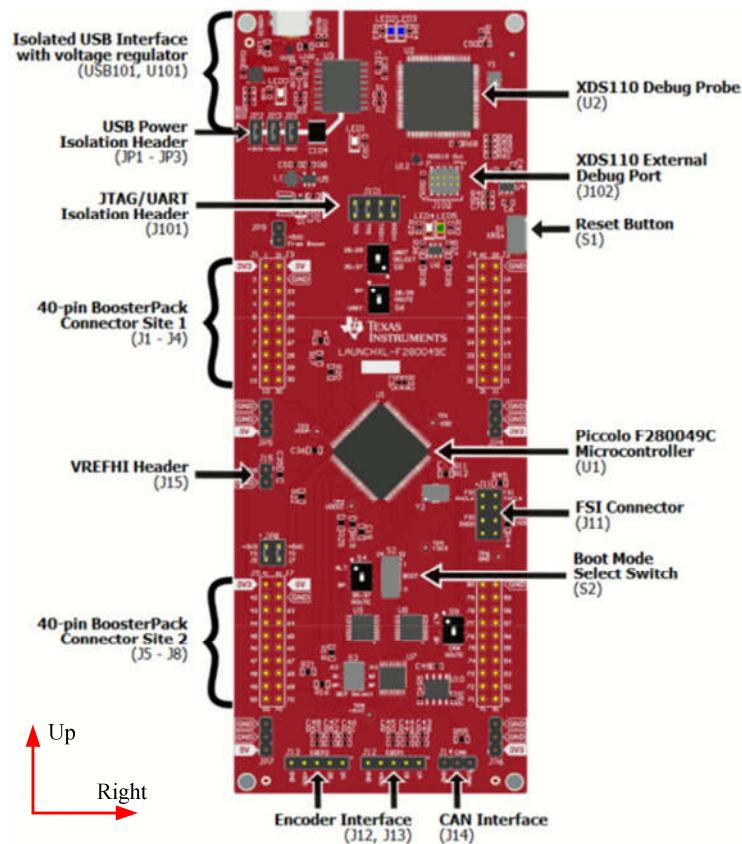

Figure 5: Piccolo F280049C LaunchPad Development Kit

Switches/Jumpers	References	Position
S2	Boot Mode Select. Boot from Flash (default).	OFF/LEFT OFF/LEFT
S6	SCIA to virtual COM port	OFF/DOWN
JP8	Connect 3.3V to J5, 5V to J7	Populated two jumpers on JP8

Table 5: F280049C LaunchPad Jumpers and Switches Setting

b. The latest content of DRV8320RS BoosterPack (BOOSTXL-DRV8320RS) can be obtained at the following link:
http://www.ti.com/tool/BOOSTXL-DRV8320RS

Figure 6 shows the power and motor phase connectors, the board support a DC power supply from 6 to 54 V from a battery or a DC voltage source. There is no any switch and jumper setting on the BOOSTXL-DRV8320RS board. Refer to the BOOSTXL-DRV8320RS EVM User's Guide (http://www.ti.com/lit/ug/spruij3/spruij3.pdf) to set up the hardware.

NOTE:

- To determine orientation of the DRV8320RS BoosterPack ensure that the power and ground pins line up
  with the LaunchPad.
- Site 1 (J1-J4) and Site 2 (J5-J8) of the F280049C LaunchPad are supported connecting to one DRV8320RS BoosterPack board separately for single motor control, or two boards for dual motor by software. Set the definition in user.h for selecting the Site 1 or Site 2.
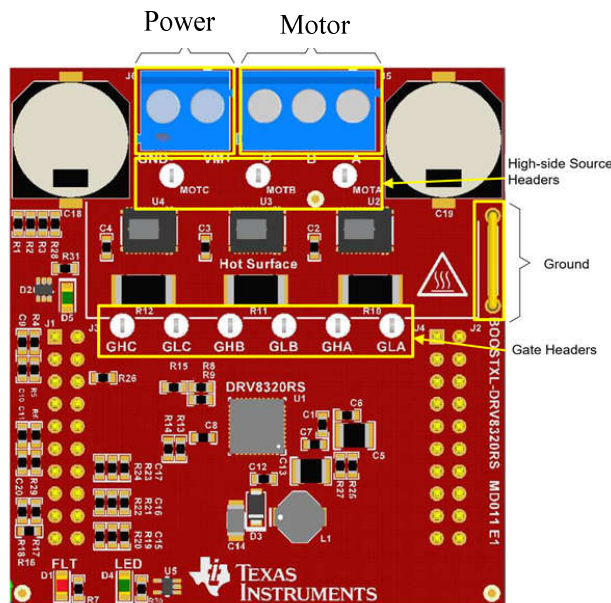

Figure 6: Power and motor connections