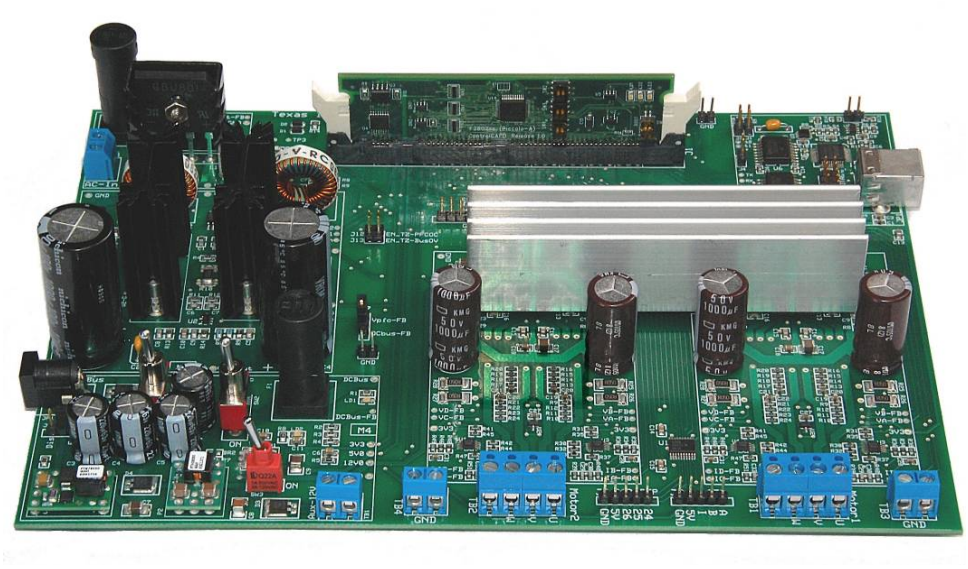
Multi-Axis DMC Kit Hardware Guide

Version 1.1 – July 2009



The **Multi-Axis Digital Motor Control** kit gives a great way to begin learning about digital motor control. This kit contains a motherboard that can accept any of the C2000 series controlCARDs. This board is divided into a Power Factor Correction (PFC) stage and two identical 3-phase inverter stages.

The Multi-Axis Digital Motor Control Kit contains:

- 1 - F28035 controlCARD
- 1 - Multi-Axis DMC board
- 1 - 24V Power Supply
- 1,2 - 24V BLDC motors – Anaheim Automation BLY172S-24V-4000 (controlled as a permanent magnet synchronous motor on this board)

Recommended Add-on components:

- Brake – Magtrol HB-16-2
- Coupler – Anaheim Automation CPL-HC075-5mm-5mm
- Quadrature Encoder

WARNING

This equipment may generate voltages and currents that can be injurious to humans, and must be used with caution. The user must employ appropriate safeguards to avoid serious injury.

Features of the Multi-Axis Digital Motor Control board:

- Sensorless space vector control of 2 motors using the Texas Instruments DRV8402 IPM module
    - Sinusoidal control of two PMSM motors
    - 24-36Vdc input (kit includes 24V motors and a 24V power supply)
    - 40W output from each inverter stage
    - 10KHz switching frequency per inverter stage
    - High precision low-side sensing using the C2000's high-performance ADC and Texas Instruments OPA2350 high speed op-amps.
    - QEP and CAP inputs available on board for speed and position measurement
- PFC provides current-shaping of the AC input and regulate the DCbus.
    - Two-phase interleaved topology
    - 13-16Vac input provides 24Vdc to the DCBus
    - Approximately 90% efficiency
    - 80W output continuous (40W without forced air flow through heatsink)
    - 100KHz switching frequency (200kHz effective when both phases are operating)
    - 50KHz PFC control loop frequency
    - Capable of phase shedding
- Closed-loop digital control with feedback using the C2000's on-chip PWM and ADC peripherals
- On-board isolated JTAG emulation
- Over-current and Over-voltage protection for the PFC stage and over-current protection for each rectifier section
- UART communication header available for host-control
- Hardware Developer's Package is available and includes schematics, bill of materials, Gerber files, etc.

Macro Blocks

Note that the Multi-Axis DMC kit is separated into several functional groups that are referred to as macro blocks. See below for a list of the various macros and what each is responsible for doing in the board.

- [Main] – controlCARD connection, jumper configurations, trip zones
- [M1] – Isolated USB Emulation
- [M2] – AC rectification
- [M3] – Power Factor Correction (PFC)
- [M4] – DC Power Entry
- [M5], [M6] – Motor Inverter stage

Boot Modes

	Boot from FLASH *	Boot from SCI
F2802x	SW1 on controlCARD- Position 1 = 1 Position 2 = 1	SW1 on controlCARD- Position 1 = 1 Position 2 = 0
F2803x	SW2 on controlCARD- Position 1 = 1 Position 2 = 1	SW2 on controlCARD- Position 1 = 1 Position 2 = 0
F280x	No jumper at [M1]-J1 No jumper at [M1]-J3	Jumper at [M1]-J1. No jumper at [M1]-J3
F283x	No jumper at [M1]-J1 No jumper at [M1]-J3	No jumper at [M1]-J1 Jumper at [M1]-J3

* Errata for Boot to FLASH mode on the Multi-Axis DMC board: Once code is flashed into the device, place boot jumpers as directed in the table above. Next, power cycle the board then connect a connected USB cable onto [M1]-JP1. This will force a proper reset and enable the C2000 device to boot from on-board flash.

Warning about low switching frequencies on the DRV8402:

From page 10 of the DRV8402 datasheet:
When the device 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 undervoltage 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 pull low and the device should self-protect itself. The motor's inductance and the inverter's bootstrap capacitance will allow the DRV8402 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.

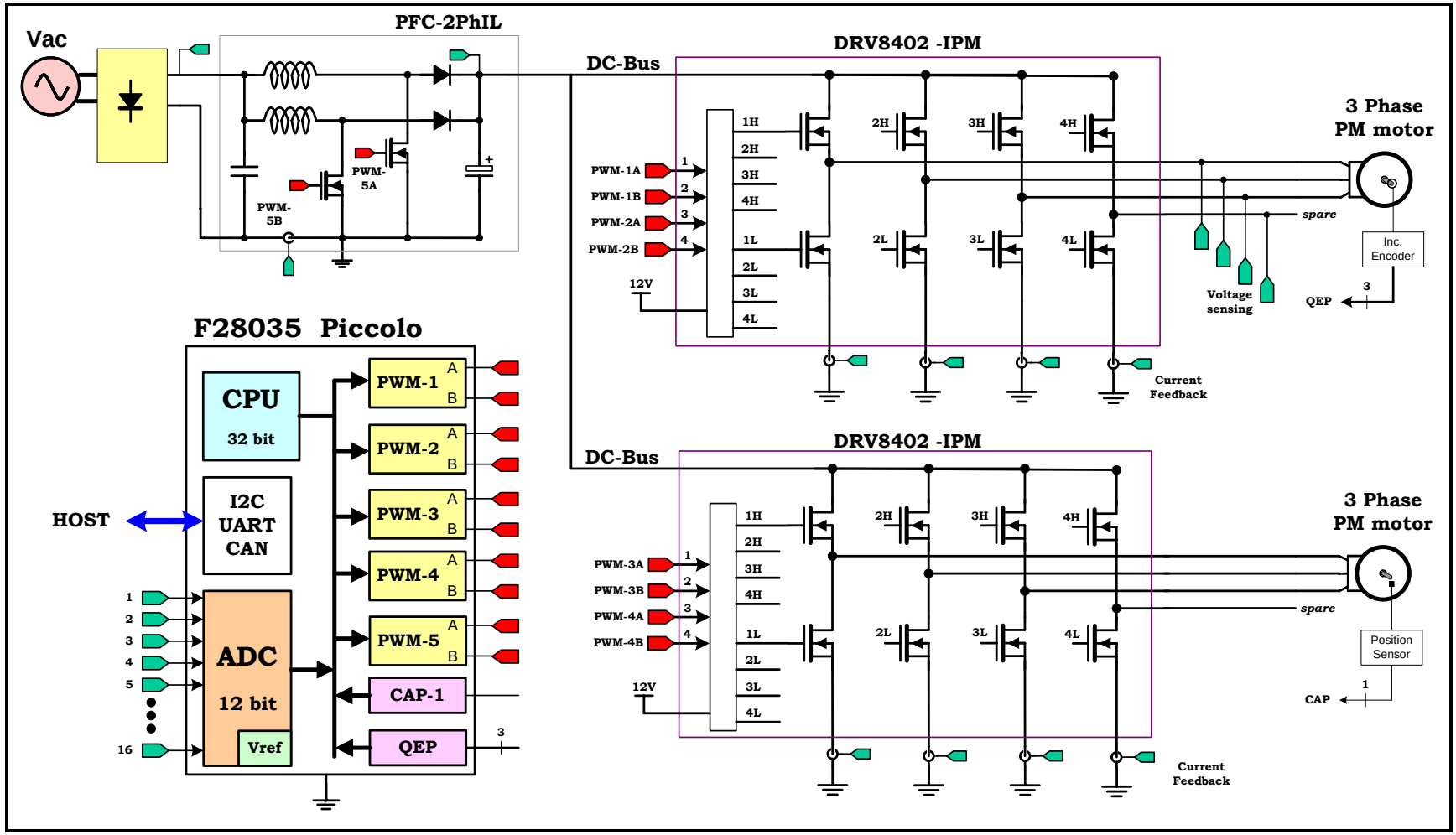


Figure 1: Multi-Axis with F28035 Block Diagram

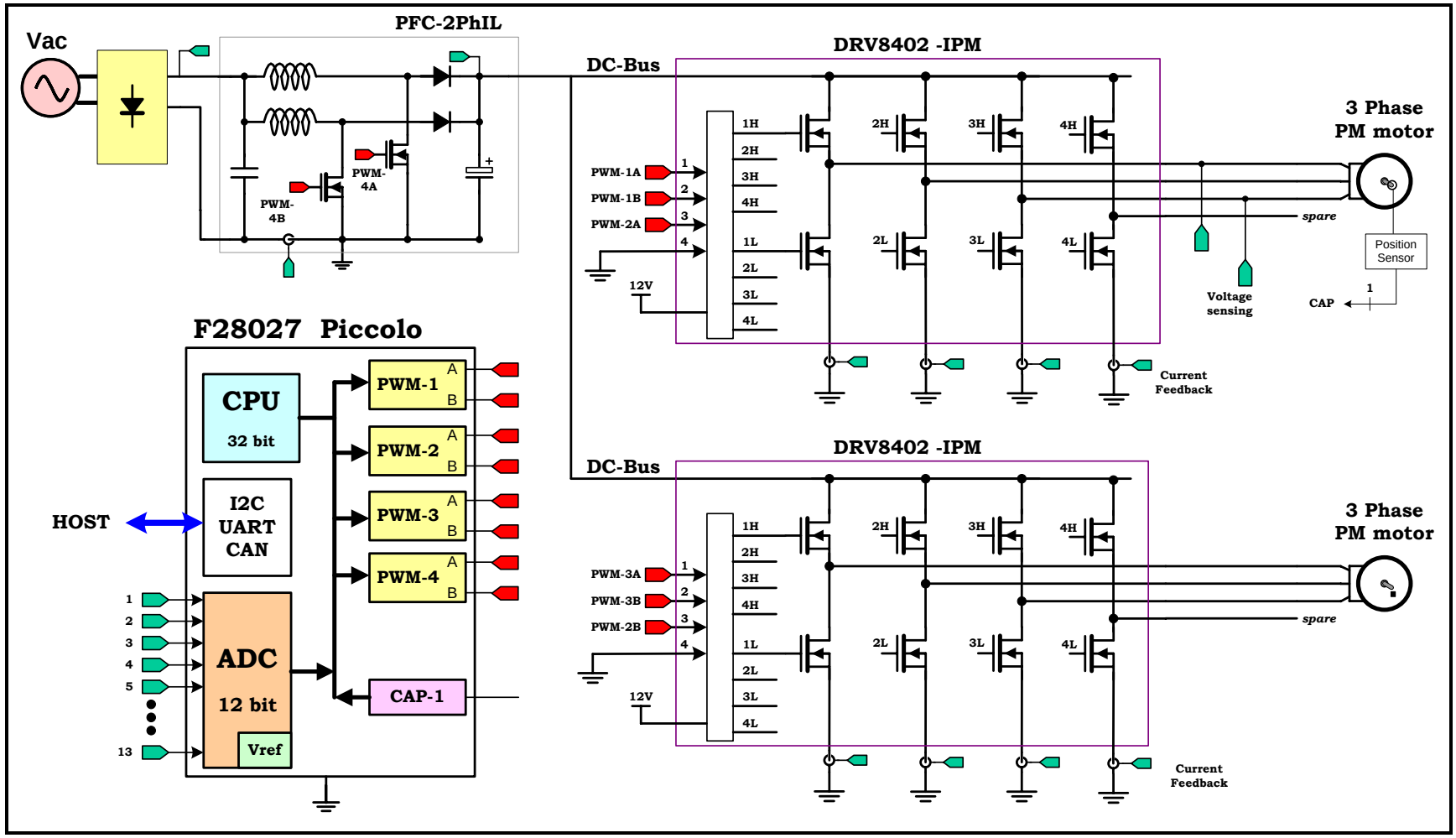
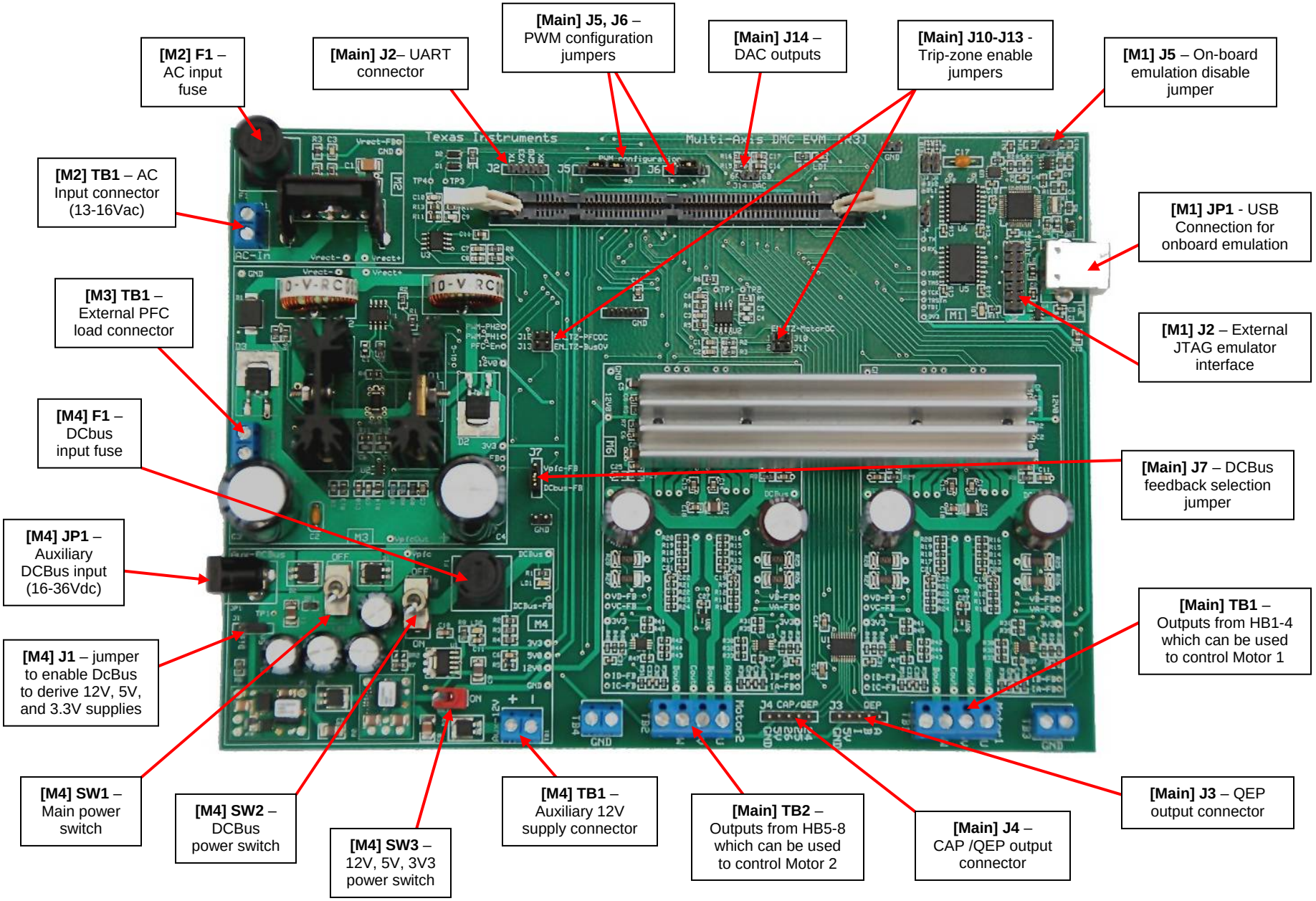


Figure 2: Multi-Axis with F28027 Block Diagram

Below is an image showing the major features of the board. The board is split into several sections called macros. For example, macro [M1] is located in the upper-right hand corner of the board and is responsible for providing isolated USB emulation.



The following table shows the various connections available on the board, and is split up by the macro they each connection is included in:

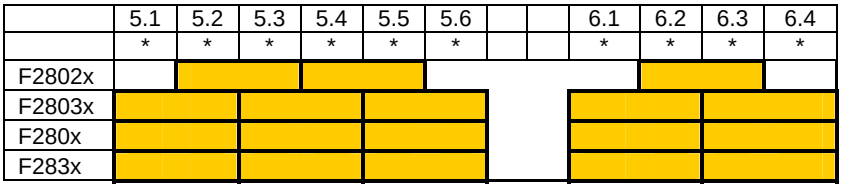
[Main] J2	UART connector: allows the F28x device to be controlled via a host. On the C2000 serial cable found in many C2000 kits, the red wire goes to RX. If the board is running off an AC supply, the supply must be isolated for the UART connection to be safe for the host.
[Main] J3	QEP connector: connects with a 0-5V QEP sensor to gather information on a motor's speed and position. Not accessible by the F28027 controlCARD.
[Main] J4	CAP/QEP connector: connects with a 0-5V sensor to gather information on a motor's speed and position. Only CAP1 (labeled "24") is accessible to the F28027 and F28035 controlCARDs.
[Main] J5 & J6	PWM configuration jumpers: See table below for how to configure jumpers  If the F2802x configuration is used, a wire should be used to connect PWM-A to PWM-D for both [M5] and [M6].
[Main] J7	DCbus feedback jumper setting: • DCBus-FB - If using an auxiliary power supply plugged into [M4]JP1 • Vpfc-FB – If power supply is coming from [M2]TB1
[Main] J10-J13	Trip-zone enable jumpers: Enable/Disables trip-zone connection on the F280x or F283x devices. For the F2802x or F2803x devices many of the PWM-trips can also be generated from the on-chip comparator peripherals.
[Main] J14	DAC outputs: Gives voltage outputs that result from a PWM being attached to a first-order low-pass filter PWM6A is attached to "6A". PWM6B is attached to "6B"
[Main] TB1	Inverter output 1: This block gives access to the outputs of [M5], the first of the two DRV8402 inverter chips. U, V, and W should attach to motor 1.
[Main] TB2	Inverter output 2: This block gives access to the outputs of [M6], the second of the two DRV8402 inverter chips U, V, and W should attach to motor 2.
[M1] J2	External JTAG interface: this connector gives access to the JTAG emulation pins. If external emulation is desired, place a jumper across [M1] J5 and connect the emulator to the board. To power the emulation logic a USB connector will still need to be connected to [M1] JP1.
[M1] J5	On-board emulation disable jumper: Place a jumper here to disable the on-board emulator and give access to the external interface
[M1] JP1	USB connection for on-board emulation
[M2] F1	Fuse for the AC input (8A fast acting)
[M2] TB1	AC input connector (13-16 Vac)
[M3] TB1	External PFC load connector – If the PFC section will be inspected without the inverter stages being operation an external load will be necessary
[M4] F1	DCBus input fuse (6.3A fast acting)
[M4] J1	Jumper that will allow the 12V, 5V and 3.3V supplies to be generated from the DCBus. If a jumper is not placed at the "Enable" position an external source should be connected to [M4]TB1. If in the "enabled" position, the DCBus absolute maximum should be +36V.
[M4] JP1	Auxiliary DCBus Power Supply: This connector should be used to power the DCBus if PFC is not enabled/desired. 16-48Vdc (36Vdc max if [M4]J1 is in the "enabled" position)
[M4] SW1	Main Power Switch: Allows the DCBus input ([M4]JP1 or from PFC stage) to flow to [M4]SW2 and [M4] J1
[M4] SW2	DCBus Power Switch: Allows the DCBus input to flow to inverter macro blocks [M5] and [M6]
[M4] SW3	12V Power Switch: Allows 12V, 5V and 3.3V to flow to be generated and flow to the rest of the board.
[M4] TB1	Auxiliary 12V Power Supply: Connect an auxiliary 12V supply to this terminal block to allow the controlCARD, etc to be isolated from the DCBus for safety during testing.

Table 1: Key features explanation