User's Guide

DRV8317HEVM User's Guide

ABSTRACT

This document is provided with the DRV8317HEVM customer evaluation module (EVM) to evaluate the DRV8317 4.5-V to 20-V Three-Phase Smart Gate Driver. This User's Guide details the implementation of the EVM and shows how to set up and power the board with the LAUNCHXL-F280049C (C2000 Piccolo MCU F280049C LaunchPad™ development kit).

Note

The DRV8317HEVM comes automatically populated with and configured for the DRV8317H hardware device. It is also compatible for the DRV8317S variant, but the user will need to modify the board to make it compatible for the SPI variant (see Section 4.4).

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Trademarks

All trademarks are the property of their respective owners.

1 Cautions and Warnings

Observe the following cautions and warnings as printed on the EVM board.

HOT SURFACE:

Caution Hot Surface! Contact may cause burns. Do not touch. Please take the proper precautions when operating.

Regulatory

REACH:

A component in this module contains a REACH Restriction candidate.

Table 1-1. REACH Components

Component Name	Manufacturer	Part Number	Candidate Listed Chemical	Chemical Identity (CAS#)	Concentration
PCB terminal block - PT 1,5/ 5-5,0-H	Phoenix Contact	1935190	Lead	7439-92-1	~5%

2 Introduction

The DRV8317 is a 4.5-V to 20-V, 5-A peak integrated three-phase FET driver IC for motor drive applications. It provides three integrated half-bridges capable of directly driving a 3-phase Brushless-DC motor. The DRV8317 integrates multiple control interface options, low-side integrated current sense resistors and sense amplifiers, a 3.3-V 80-mA LDO regulator, and a variety of protection and control features. The device is available in the hardware variant (DRV8317H) and SPI variant (DRV8317S) Table 2-1.

Table 2-1. DRV8317x Device Variants

Device Name	Device Description
DRV8317H	Hardware variant
DRV8317S	SPI variant

The DRV8317HEVM can be interfaced with the TMS320F280049C microcontroller on the LAUNCHXL-F280049C LaunchPad in correspondence with the reference software to provide the algorithm to the DRV8317 to control the BLDC motor.

This document serves as a startup guide for the DRV8317HEVM + LAUNCHXL-F280049C BLDC motor control demo kit. It also is intended to help engineers design, implement, and validate reference hardware and software for the LaunchPad MCU and DRV8317. For step by step details on connecting the LAUNCHXL-F280049C + DRV8317HEVM, installing software, and running the project to spin a motor, refer to Section 5.

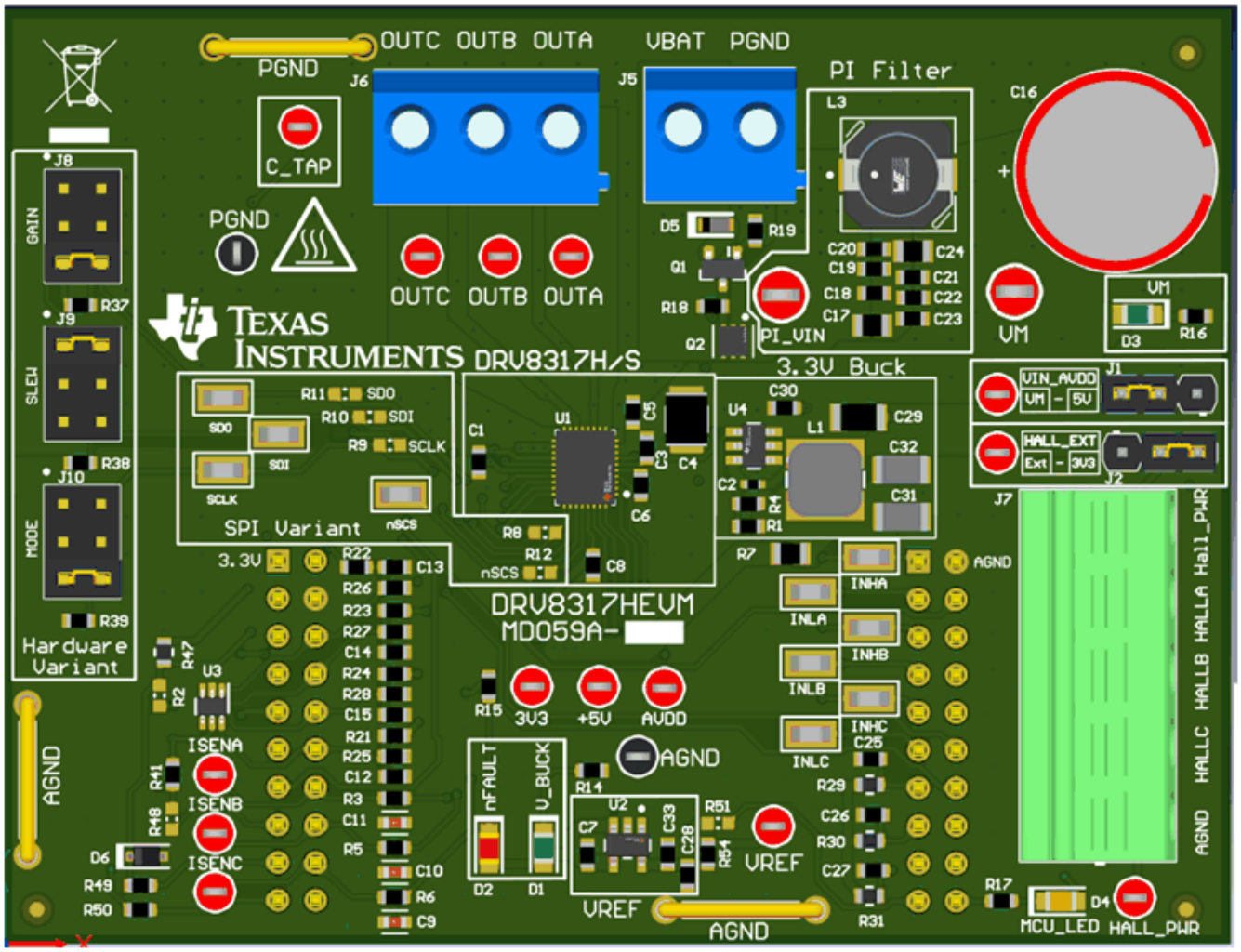

Figure 2-1. DRV8317HEVM PCB Layout

3 Quick Start Guide

The DRV8317HEVM requires a power supply with a recommended operating range from 4.5-V to 20-V. To setup and power the EVM, follow the sequence below:

1. Connect the power supply ground to the PGND of the 2-pin power connector J5 and the power supply positive terminal to the VBAT pin of J5. Ensure jumpers JP1, JP2, and JP3 of the LAUNCHXL-F280049C are populated to ensure that 3.3 V and 5 V are powered from the LaunchPad.
2. Connect the motor phases to OUTA, OUTB, and OUTC in the correct order. For sensored applications, connect the Hall sensors to the appropriate locations on the 5-pin connector J7 as shown in Figure 4-2. Select 3V3 or Ext on jumper J2 to choose the Hall power source voltage to be either from the 3.3 V on the board or from an external supply.
3. Mate the DRV8317HEVM onto the top half of the LAUNCHXL-F280049C (LaunchPad Headers J1/J3 and J2/J4) as shown in Figure 4-3. Make sure motor and power connectors face the same direction as the Micro-USB connector on the LaunchPad.
4. Connect a Micro-USB cable from the computer into the Micro USB connector on the top of the LAUNCHXL-F280049C.
5. Power on the DRV8317HEVM.

4 Hardware and Software Overview

4.1 Hardware Connections Overview – DRV8317HEVM + LAUNCHXL-F280049C

Figure 4-1 shows the major hardware blocks of the DRV8317HEVM. The DRV8317HEVM is designed for an input supply from 4.5-V to 20-V. The DRV8317 includes three integrated half-bridges that can drive up to 5-A peak current which can be used in conjunction with an external MCU for sensored or sensorless trapezoidal control, sinusoidal control, or Field-oriented control (FOC).

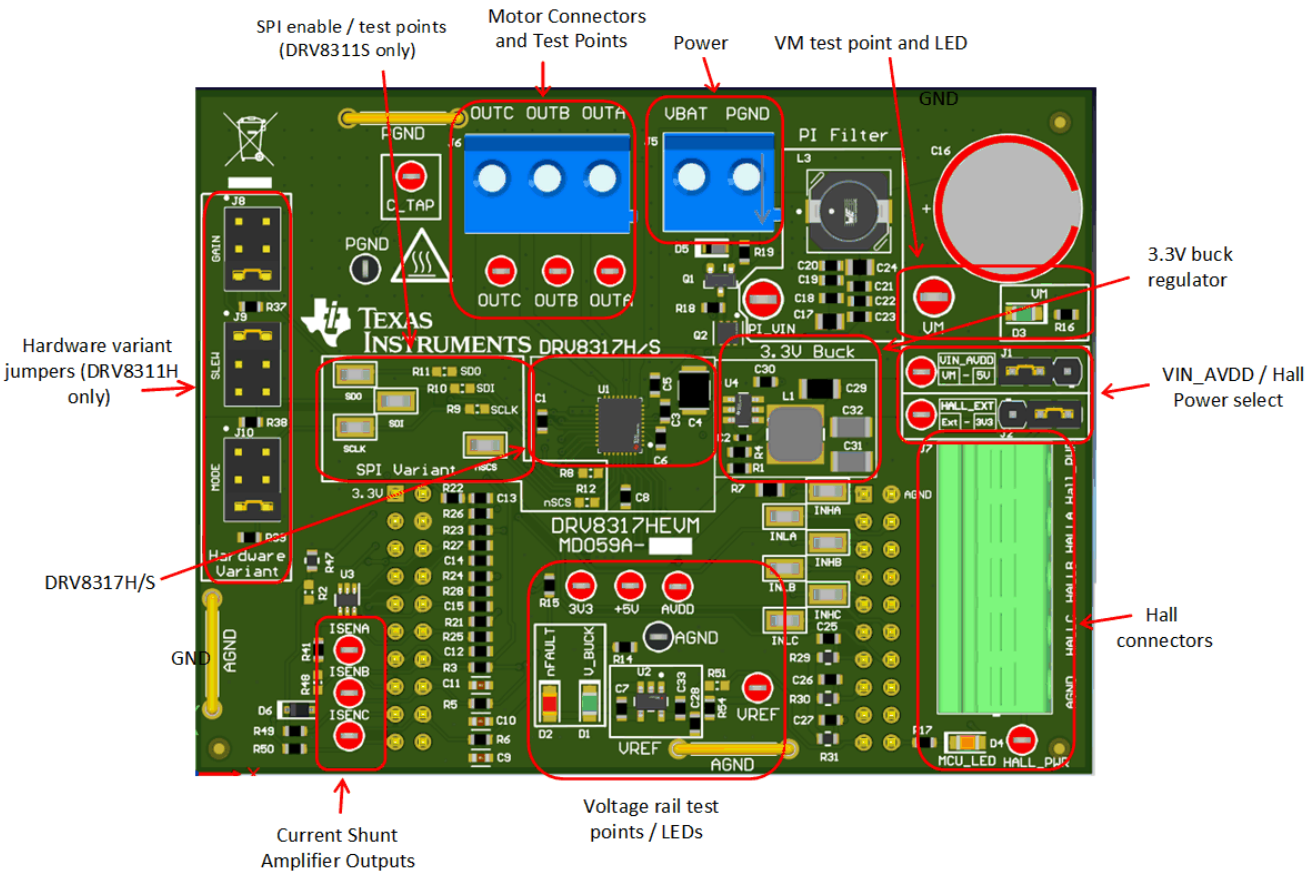

Figure 4-1. Major hardware blocks of the DRV8317HEVM

4.2 Connection Details

Figure 4-2 shows the power supply and motor connections made to the DRV8317HEVM in order to spin a 3-phase sensored or sensorless Brushless-DC motor.

A 4.5-V to 20-V power supply or battery is connected to the VBAT and GND terminals. The three phases of the BLDC motor connect directly to the OUTA, OUTB, and OUTC terminals of the screw terminal provided on the DRV8317HEVM.

For sensored applications, the Hall sensor outputs need to be connected to the respective Hall connector terminals on the DRV8317HEVM.

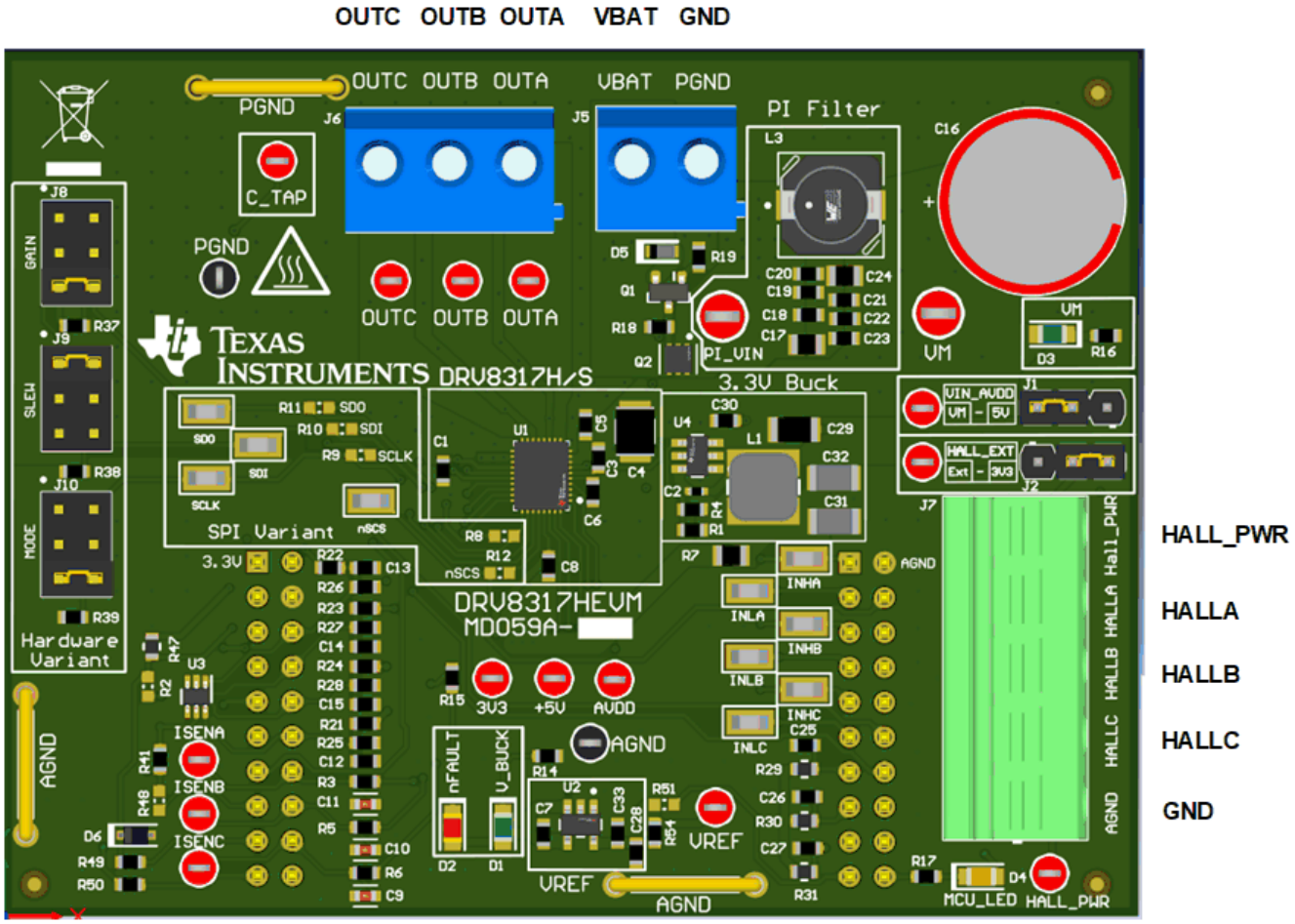

Figure 4-2. Connections from motor to DRV8317HEVM

Figure 4-3 shows where the Micro-USB cable is plugged in to the LAUNCHXL-F280049C to provide communication between the LaunchPad firmware and GUI as well as the correct installment of the DRV8317HEVM to the J1/J3 and J2/J4 headers of the LaunchPad.

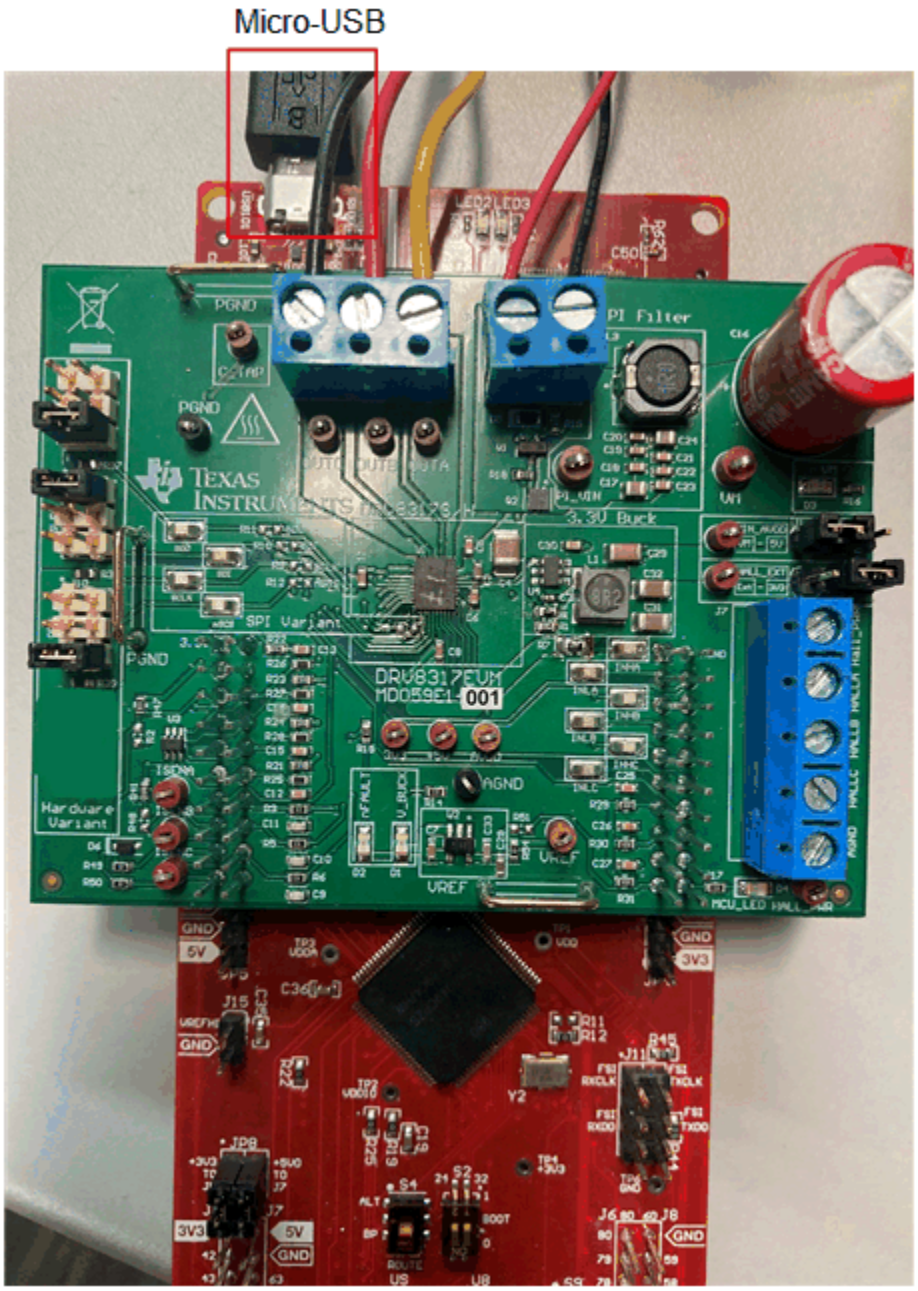

Figure 4-3. DRV8317HEVM on headers J1/J3 and J2/J4 of LaunchPad and Micro-USB plugged into LaunchPad

4.3 LED Lights

There are LED indicators on both the LAUNCHXL-F280049C and DRV8317HEVM when power is provided and the micro USB cable is plugged in to the LaunchPad.

The DRV8317HEVM has 4 status LEDs on the board. By default, the VM and V_BUCK LEDs will light up when the board is powered on. The fault LED will light up when the driver reports a fault, and the MCU LED (tied to GPIO59) can be used for debugging and validation. Table 4-1 shows the LED descriptions, with the LEDs that are on during power up indicated in bold. Figure 4-4 shows the LED locations on the EVM.

Table 4-1. Description of DRV8317HEVM LEDs (on during power up in bold)

Designator	Name	Color	Description
D1	**V_BUCK**	**Green**	**on-board 3.3 V Buck is on**

Table 4-1. Description of DRV8317HEVM LEDs (on during power up in bold) (continued)

Designator	Name	Color	Description
D2	nFAULT	Red	Lights up when fault condition has occurred on the DRV8317
D3	**VM**	**Green**	**Power is supplied to the board**
D4	MCU_LED	Orange	MCU debugging

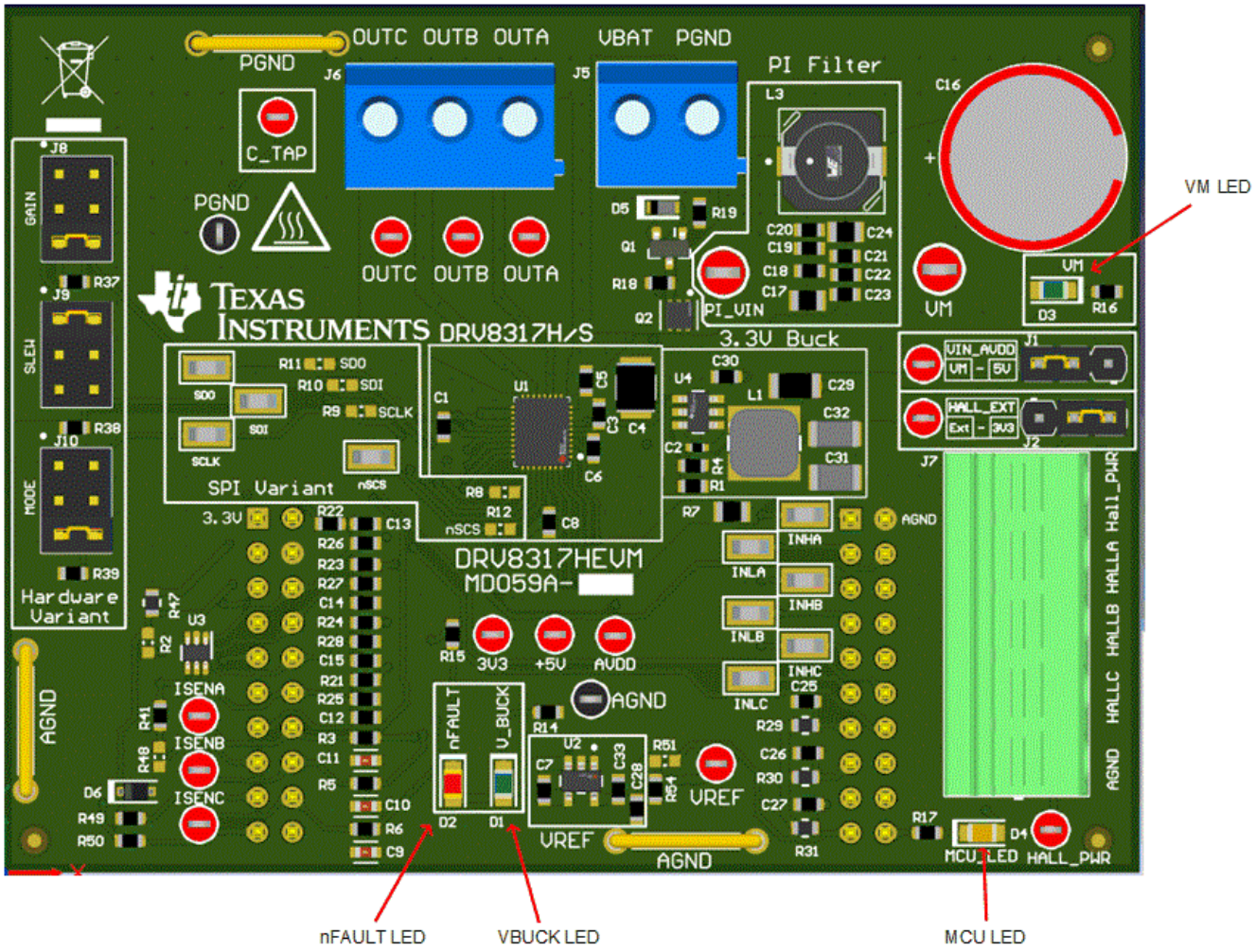

Figure 4-4. DRV8317HEVM LEDs

4.4 DRV8317HEVM Configurability – Jumpers and Resistors

The DRV8317HEVM includes a variety of user-selectable jumpers and unpopulated components on the PCB to choose user settings and evaluate the DRV8317H or the DRV8317S device. A summary of those selectable settings is listed in Table 4-2 (defaults in bold), and can be seen on the board in Figure 4-5. Section 4.4.2 describes the changes that need to be made to the board in order to use the SPI variant as the main motor driver IC.

Table 4-2. Description of user selectable settings on DRV8317HEVM (H variant defaults in bold)

Id.	Setting Name	Description	Position	Function
A	GAIN select	(DRV8317H only) Use J8 to select desired gain settings. DNP jumper if DRV8317H is not used.	**J8 = Bottom**	**0.25 V/A**
			J8 = Middle	0.5 V/A
			J8 = No Jumper	1 V/A
			J8 = Top	2 V/A

Table 4-2. Description of user selectable settings on DRV8317HEVM (H variant defaults in bold) (continued)

Id.	Setting Name	Description	Position	Function
B	SLEW select	(DRV8317H only) Use J9 jumper to select desired slew rate settings. DNP jumper if DRV8317H is not used.	J9 = Bottom	25 V/us
			J9 = Middle	50 V/us
			J9 = No Jumper	125 V/us
			J9 = Top	**200 V/us**
C	MODE select	(DRV8317H only) Use J10 jumper to select desired PWM mode. DNP jumper if DRV8317H is not used.	**J10 = Bottom**	**6x PWM mode**
			J10 = Middle	6x direct PWM mode
			J10 = No Jumper	3x PWM mode
			J10 = Top	3x direct PWM mode
D	Power LaunchPad from buck	0-ohm R13 resistor on bottom of board used to supply power from buck to LaunchPad. DNP if powering LaunchPad externally. See Section 4.4.3 on MCU Power		**See Section 4.4.3 on MCU power options**
E	Supply 5 V from LaunchPad	0-ohm R36 resistor on bottom of the board Supplies 5 V from the F280049C LaunchPad boost converter.	**R36 is populated**	**Supply 5 V from LaunchPad**
			R36 is DNP	Supply 5 V externally (if desired) from the+5V test point
F	Supply 3.3 V from buck	0-ohm R7 resistor connects buck 3.3 V voltage to supply main 3.3 V.	**R7 is populated**	**Connects buck output to supply 3.3 V rail**
			R7 is DNP	Supply 3.3 V externally from the 3V3 test point
G	VIN_AVDD select	Use J1 to supply VIN_AVDD voltage from either VM or 5 V.	**J1 = Left**	**VIN_AVDD supplied from VM**
			J1 = Right	VIN_AVDD supplied from 5 V
H	HALL_EXT select	Use J2 to supply Hall power externally or from 3.3 V	J2 = Left	Hall power supplied externally from the HALL PWR test point
			J2 = Right	**Hall power supplied from 3V3**
I	SPI variant connections	Populate specific resistors to properly use the Hardware or SPI variant	SPI variant: Populate R9, R10, R11, and R12	
J	VREF connection	0-ohm R54 resistor supplies CSA REF from on-board VREF	**R54 is populated**	**CSA REF is supplied from on-board VREF voltage**
			R54 is not populated	CSA REF needs to be supplied externally through VREF test pin

Table 4-2. Description of user selectable settings on DRV8317HEVM (H variant defaults in bold) (continued)

Id.	Setting Name	Description	Position	Function
K	CSA output filtering	C9-11 and R3, 5, and 6 are used for RC filtering	**C9-11 and R3, 5, and 6 populated**	**RC filter for CSA outputs**
			C9-11 and R3, 5, and 6 not populated	No RC filter for CSA outputs

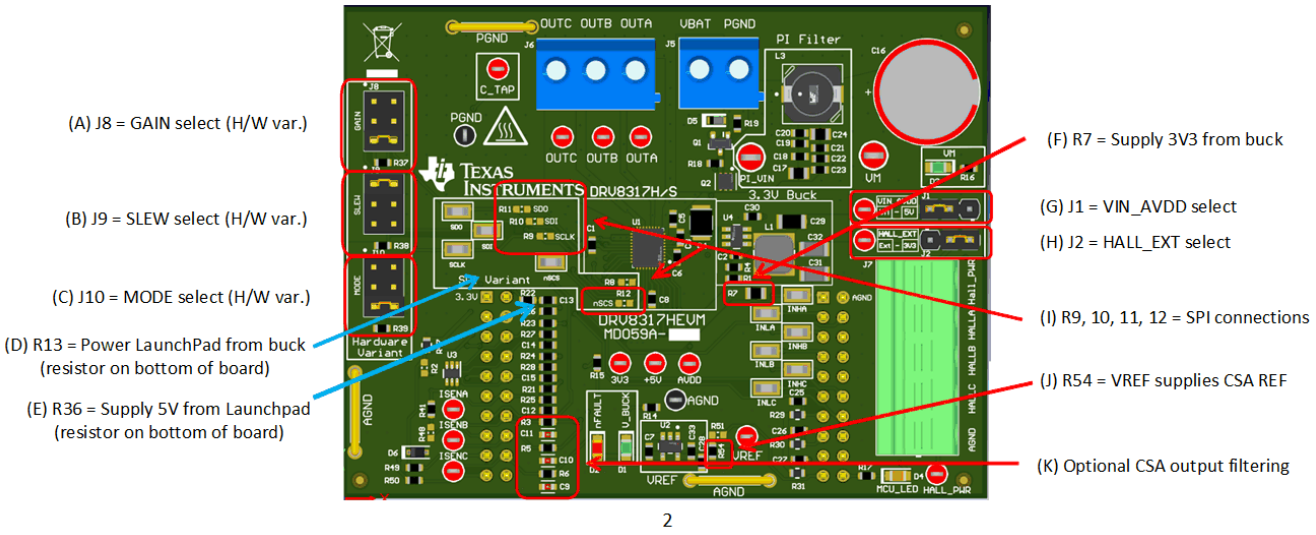

Figure 4-5. User-selectable jumpers and DNP components on DRV8317HEVM

4.4.1 DRV8317H Compatibility

The DRV8317HEVM default is the DRV8317H (Hardware variant), which can be used to spin a 3-phase Brushless-DC motor with selectable modes configured with hardware settings as shown in Table 4-3.

When using the DRV8317H, resistors R8, R9, R10, R11, and R12 must be left unpopulated. This allows the user to select settings using the MODE, SLEW, and GAIN pins by using jumpers on J10, J9, and J8. An outline of the various hardware selectable settings can be found below.

Note

In order to change the hardware settings for the GAIN, MODE, or SLEW using the appropriate jumpers, the device must first be powered off or put into sleep mode in order for the new hardware settings to take affect.

Table 4-3. Description of Hardware settings for DRV8317H

Setting	Jumper Position	Description
MODE	J10 = Top	3x direct PWM Mode
	J10 = No Jumper	3x PWM Mode
	J10 = Middle	6x direct PWM Mode
	J10 = Bottom	6x PWM Mode
SLEW	J9 = Top	200 V/µs
	J9 = No Jumper	125 V/µs
	J9 = Middle	50 V/µs
	J9 = Bottom	25 V/µs

Table 4-3. Description of Hardware settings for DRV8317H (continued)

Setting	Jumper Position	Description
GAIN	J8 = Top	2 V/A
	J8 = No Jumper	1 V/A
	J8 = Middle	0. 5 V/A
	J8 = Bottom	0.25 V/A

4.4.2 DRV8317S Compatibility

The DRV8317HEVM is compatible with the DRV8317S (SPI variant) to spin a 3-phase Brushless-DC motor. The DRV8317S replaces the hardware settings (MODE, SLEW, and GAIN) with 4 SPI signals: SDI, SDO, SCLK, and nSCS.

When using the DRV8317S, the DRV8317S variant IC needs to be soldered onto U1 in place of the DRV8317H, and resistors R9, R10, R11, and R12 must be populated with 0-ohm resistors. Additionally, the jumpers must be removed from J8, J9, and J10. This properly connects the SPI signals to the correct pins on the device.

4.4.3 MCU Power Options

The DRV8317HEVM has several options for powering the LAUNCHXL-F280049C or an external MCU. Table 4-4 provides a description of the various MCU power options.

Table 4-4. MCU power options

LAUNCHXL-F280049C connections	DRV8317HEVM connections	Result
JP1, JP2, and JP3 are populated	R13 and R7 are populated	F280049C MCU is powered both from the USB of the LaunchPad and the 3V3 rail of the EVM's buck regulator.
JP1, JP2, and JP3 are populated	R13 is populated, R7 is not populated, no external 3V3 supplied to EVM	MCU is powered from the USB of the LaunchPad, and the LaunchPad will supply 3V3 to the EVM.
JP1, JP2, and JP3 are populated	R13 is populated, R7 is not populated, external 3V3 supplied to EVM through the 3V3 test point	MCU is powered both from the USB of the LaunchPad and from the external 3V3 supplied to the EVM
JP1, JP2, and JP3 are populated	R13 is not populated	MCU is powered from USB power supply
JP3 is populated, JP1 and JP2 are not populated	R13 and R7 are populated	MCU is powered completely from the 3V3 of the buck of the EVM
JP3 is populated, JP1 and JP2 are not populated	R13 is populated, R7 is not populated, external 3V3 supplied to EVM through the 3V3 test point	MCU is powered completely from the external 3V3 supplied to the EVM

4.4.4 Interfacing DRV8317HEVM and LAUNCHXL-F280049C LaunchPad

The DRV8317HEVM has 40 pins with different functions. These pins are interfaced with the LAUNCHXLF280049C LaunchPad development kit and are mapped appropriately to receive the functionalities of the DRV8317H device. These 40 pins are grouped into 4 ports in respect to the LAUNCHXL-F280049C (J1 to J4). Table 4-5 and Table 4-6 list the interfacing of these ports of the DRV8317HEVM headers J3 and J4.

Table 4-5. Connections for Header J3 on DRV8317HEVM (DNP in bold)

J3 Pin Number	DRV8317HEVM Function	LAUNCHXL-F280049C Function	Description
1	3V3	+3.3 V	3.3 V LaunchPad Supply
2	5 V supply	+5 V	5 V Boost from LaunchPad
3	Not used	PGA1/3/5_GND	Not used
4	AGND	GND	GND connection

Table 4-5. Connections for Header J3 on DRV8317HEVM (DNP in bold) (continued)

J3 Pin Number	DRV8317HEVM Function	LAUNCHXL-F280049C Function	Description
5	Not used	GPIO13/SCIBRX	Not used
6	VSENA	ADCINA5	Phase A Voltage Sense
7	HALLC	GPIO40/SCIBTX	Hall sensor C from motor
8	VSENB	ADCINB0	Phase B Voltage Sense
9	**nSLEEP (DNP)**	NC	For internal use only
10	VSENC	ADCINC2	Phase C Voltage Sense
11	Not used	ADCINB3/VDAC	Not used
12	VSENVM	ADCINB1	VM Bus Voltage Sense
13	SCLK	SPIACLK	SPI Clock (DRV8317S only)
14	ISENA	ADCINB2	Phase A low side Current Sense
15	**nFAULT (DNP)**	ADCINC4	For internal use only
16	ISENB	ADCINC0	Phase B low side Current Sense
17	nSLEEP	GPIO37	Active-low input to sleep pin
18	ISENC	ADCINA9	Phase C low side Current Sense
19	nFAULT	GPIO35	Active-low output from fault pin
20	C_TAP	ADCINA1	ADC for Center Tap sensing

Table 4-6. Connections for Header J4 on DRV8317HEVM

J4 Pin Number	DRV8317HEVM Function	LAUNCHXL-F280049C Function	Description
1	INHA	GPIO10/PWM6A	PWM used to switch High-side FET of Phase A
2	AGND	GND	GND connection
3	INLA	GPIO11/PWM6B	PWM used to switch Low-side FET of Phase A
4	nSCS	SPIASTE	SPI active-low chip select (DRV8317S only)
5	INHB	GPIO8/PWM5A	PWM used to switch High-side FET of Phase B
6	Not used	NC	Not used
7	INLB	GPIO9/PWM5B	PWM used to switch Low-side FET of Phase B
8	Not used	NC	Not used
9	INHC	GPIO4/PWM3A	PWM used to switch High-side FET of Phase
10	Not used	XRSn	Not used
11	INLC	GPIO5/PWM3B	PWM used to switch Low-side FET of Phase C
12	SDI	SPIASIMO	SPI data input
13	HALLA	GPIO58	HALL sensor A from motor
14	SDO	SPIASOMI	SPI data output (DRV8317S only)
15	HALLB	GPIO30	HALL sensor B from motor
16	Not used	GPIO39	Not used

Table 4-6. Connections for Header J4 on DRV8317HEVM (continued)

J4 Pin Number	DRV8317HEVM Function	LAUNCHXL-F280049C Function	Description
17	Not used	GPIO18/XCLKOUT (not connected)	Not used
18	Not used	GPIO23/LED4	LED reserved on LaunchPad
19	**CSA_REF (DNP)**	GPIO25	For internal use only
20	MCU_LED	GPIO59	Visual feedback for LaunchPad connection

5 Hardware Setup

The hardware required to run the motor control is the LAUNCHXL-F280049C LaunchPad development kit, the DRV8317HEVM, a Micro-USB cable, and a power supply with a DC output from 4.5-V to 20-V. Follow these steps to set up the evaluation module:

1. Check that all resistors or jumpers are set up accordingly according to the device variant used. The DRV8317HEVM by default is populated with and configured for the DRV8317H (hardware variant). If using the DRV8317S, please populate the resistors mentioned in row I of Table 4-2 to configure the board for the proper device variant.
2. Mate the DRV8317HEVM board to the top half of the LAUNCHXL-F280049C LaunchPad development kit (mates to J1/J3 and J2/J4 of LaunchPad, as in Figure 4-3).

   Note

   Observe the correct orientation when placing DRV8317HEVM to the LAUNCHXL-F280049C. The motor and power connectors will face to the LaunchPad's Micro-USB connector.
3. Connect the three phases from the brushless-DC motor to the 3-pin connector J6 on DRV8317HEVM. Phases OUTA, OUTB, and OUTC are labeled in white silkscreen on the PCB top layer.

   Note

   If using a sensored algorithm on the LaunchPad development kit, connect Hall sensors to the 5-pin connector J7.
4. Connect the DC power supply to header J5.

   Note

   Observe the correct polarity for the VBAT and GND connections on the DRV8317HEVM connector J5.
5. Connect a Micro-USB cable to the LaunchPad development kit and computer.
6. Turn on the power supply and power up the PCB.

If using the DRV8317HEVM with an external microcontroller, make the connections needed on the male headers on the top of the board or female connectors on the bottom side of the board.

6 Firmware and GUI Application

The DRV8317HEVM can implement sensored, sensorless, or Field-oriented control for commutating a 3-phase Brushless-DC motor. The supported firmware is a sensorless Field-oriented control algorithm adapted from Texas Instruments' MotorControl SDK Library of motor solutions. The firmware includes motor identification and a sensorless FOC algorithm to spin the motor. The firmware uses the DRV8317HEVM InstaSPIN Universal GUI to run the algorithm and includes tabs to read from and write to the DRV8317 SPI registers (DRV8317S only).

The steps below will describe how to identify useful motor parameters, spin the motor, and work with the DRV8317S SPI registers. For more information on more advanced features of the C2000 InstaSPIN Universal GUI such as torque and speed control, MTPA, or Field-weakening, consult the MotorControl SDK InstaSPIN Lab Guide (in the MotorControl Software Development Kit tool page) and InstaSPIN-FOC and InstaSPIN-MOTION User's Guide.

6.1 C2000 InstaSPIN Universal GUI

1. Follow the instructions in Section 5 and ensure the LAUNCHXL-F280049C is connected to the PC and the power supply is turned on to the DRV8317HEVM PCB.
2. Search for the *GUI Composer Galllery* through https://dev.ti.com/gallery/search/DRV8317xevm. You will need to login with a myTI account in order to access the GUI.
3. Accept the readme if the readme message pops up.
4. Select the "InstaSPOIN-FOC" tab at the top right hand corner to go to the main page of the GUI. Check the bottom left corner of the GUI to see if the GUI flashes the algorithm to the MCU as shown in Figure 6-1. Once the device has completed flashing the algorithm, it should show "Hardware Connected" in the bottom left corner.

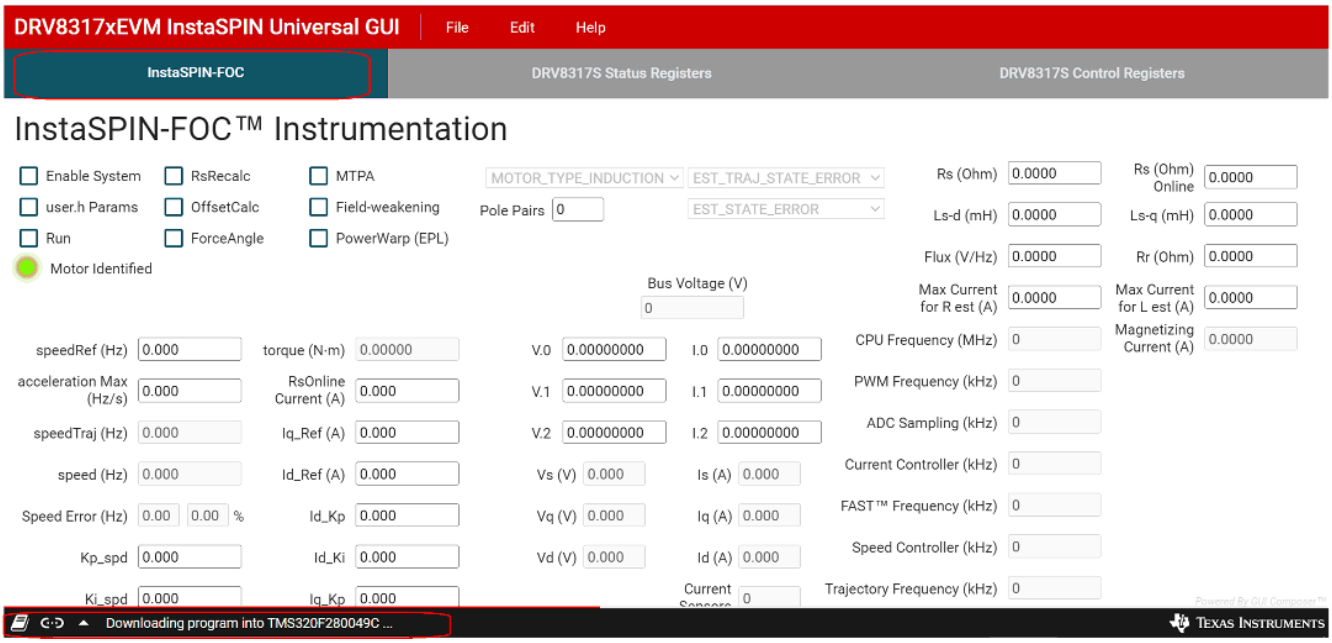

Figure 6-1. C2000 InstaSPIN Universal GUI Downloading Program

6.2 Motor Identification

1. Check the "Enable System" box to enable the InstaSPIN algorithm and run preset calibrations. Wait for the "OffsetCalc" button to uncheck automatically to finish calibrating board offsets.
2. Check the "Run" box to begin the motor identification algorithm as shown in Figure 6-2. The motor will begin to spin and stop as it goes through many states to calculate and identify useful motor parameters for sensorless Field-oriented control. This should take no more than a few minutes.
3. Once the motor identification process is complete, the "Motor Identified" indicator will light up, the "Run" box will be automatically unchecked, and the values Rs, Rs Online, Ls-d, Ls-q, Flux, and Rr will update for that motor as shown in Figure 6-3. These values will be automatically used for Field-oriented control.

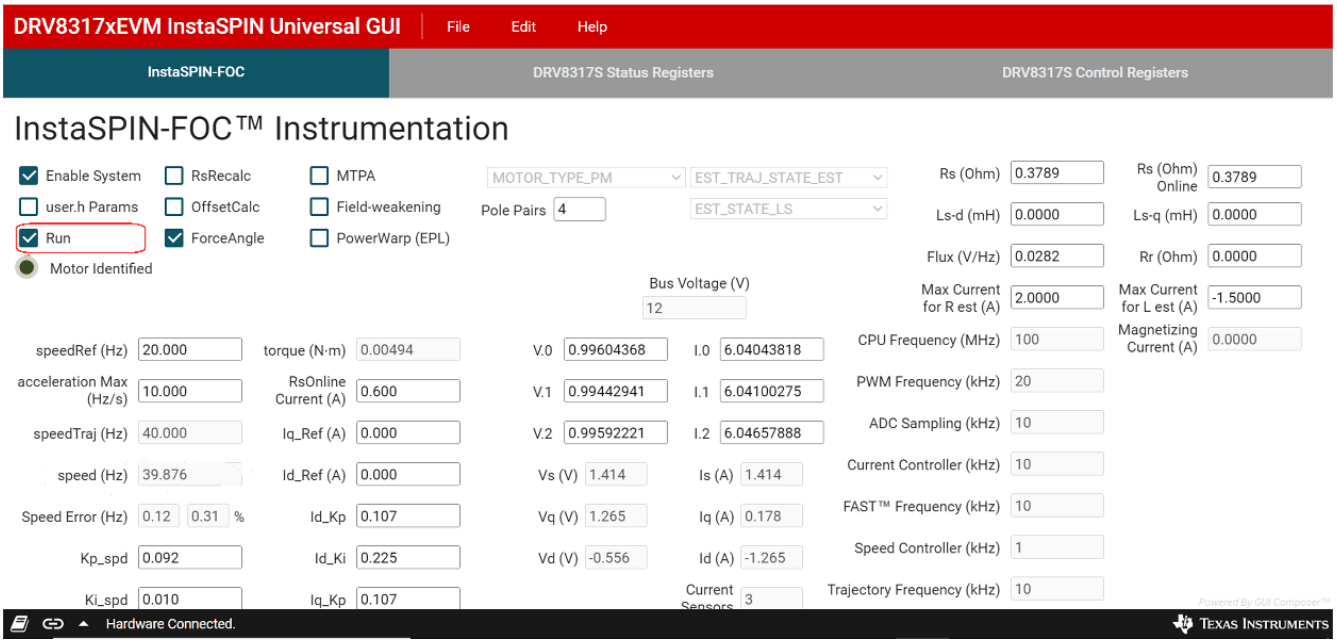

Figure 6-2. C2000 InstaSPIN Universal GUI Running motor identification

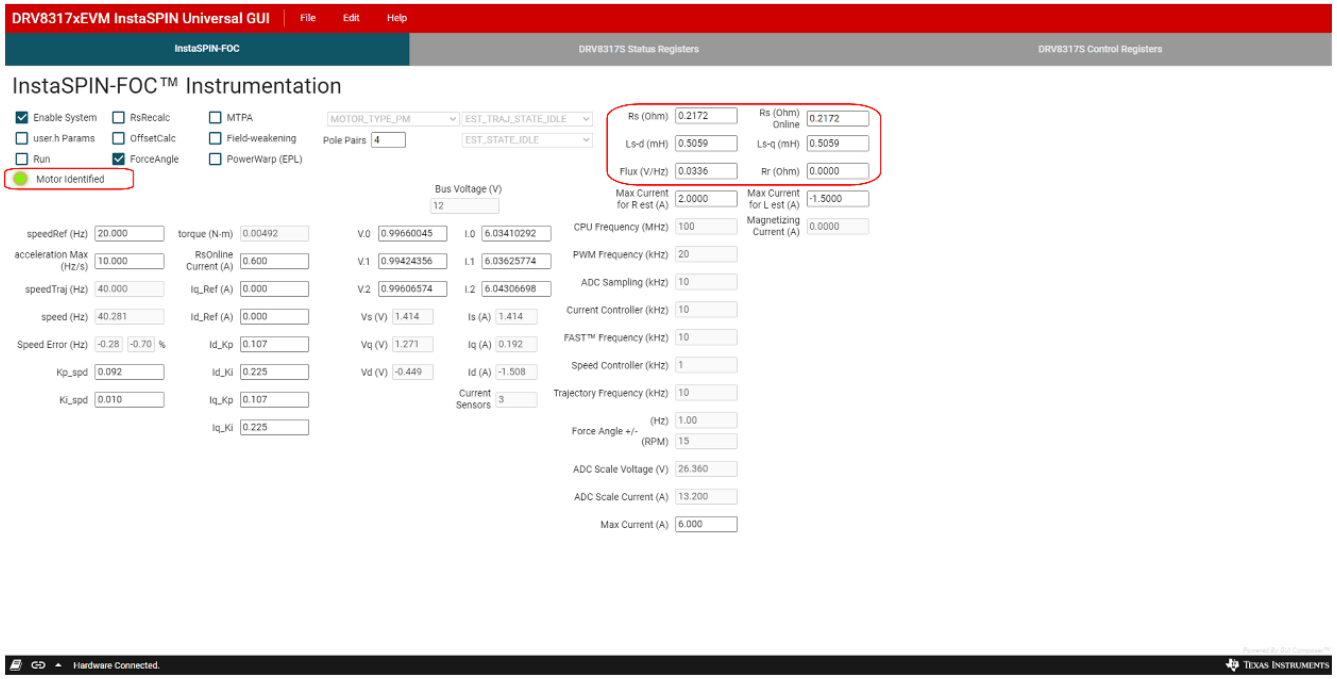

Figure 6-3. Motor identification complete using the DRV8317HEVM InstaSPIN GUI

6.3 Sensorless-FOC Commutation

1. To spin the motor with sensorless FOC, check the “Run” box again. The motor will spin with sinusoidal current at the speedRef (Hz) value in the GUI, which is automatically set to 20.0 Hz. Use the speedRef (Hz) input to change the current speed of the motor as shown in Figure 6-4. The GUI automatically calculates the current reference speed using the variable speed (Hz) and compares it to the trajectory speed variable speedTraj (Hz) to calculate the Speed Error (Hz) as a percentage.

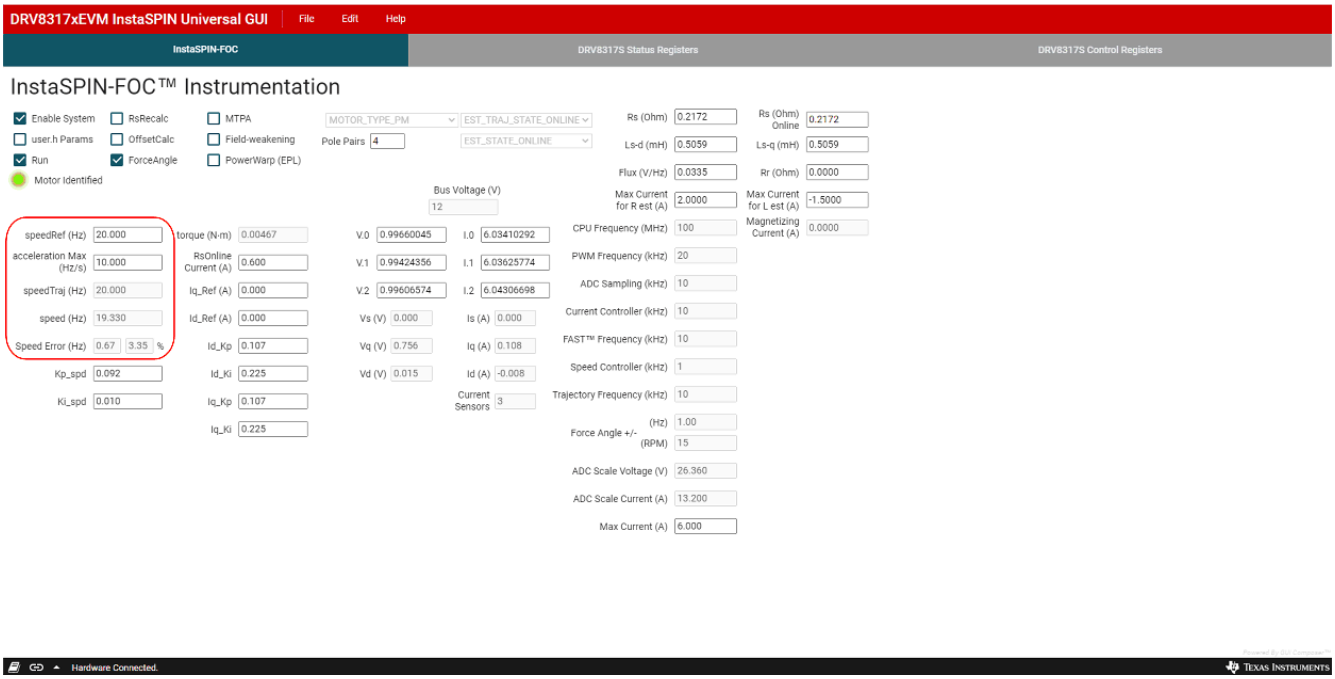

Figure 6-4. Sensorless-FOC commutation using the DRV8317HEVM InstaSPIN GUI

6.4 Torque Control, Speed Control, and Advanced Modulation Techniques

To implement more advanced modulation techniques such as torque control, speed control, and algorithms such as MTPA, Field-weakening, and PowerWarp (EPL) using the DRV8317HEVM InstaSPIN Universal GUI, please consult the MotorControl SDK InstaSPIN Lab Guide found in MotorControl SDK.

This document contains detailed lab overviews of how to implement each advanced modulation technique when using sensorless FOC to spin the BLDC motor in Code Composer Studio. In order to use the project with the GUI, the user must build and compile the project in CCS, and import the .out binary file for that project into the GUI properties through GUI Composer. More information can be found in the README when the GUI is first opened.

6.5 SPI Communication (DRV8317S only)

The DRV8317HEVM InstaSPIN_Universal_GUI includes two SPI register tabs for the DRV8317S device variant: Status Registers and Control Registers.

1. Click on the “DRV8317S Control Registers” tab to access the DRV8317S Control Registers as shown in Figure 6-5.
2. Choose the desired settings by selecting from the drop-down menus for each setting. Clicking a setting description selects the bits required for that control register setting. Consult the DRV8317 datasheet (in the *DRV8317 Registers* section) for detailed definitions of settings.
3. Click on “Write” to write to all control registers in the device with the configured settings.
4. To read all status and control registers in the device, click on “Read”. The statuses and settings will auto-populate in the DRV8317S Status Registers and Control Registers.
5. Alternatively, to write data to a specific address, input the address and data in decimal into the address and data inputs above the “Manual Write” box. Click on the “Manual Write” box to write the data to that address. To read data from a specific address, input the address in decimal into the address above the “Manual Read” box. Click on the “Manual Write” box to read the data from that address.

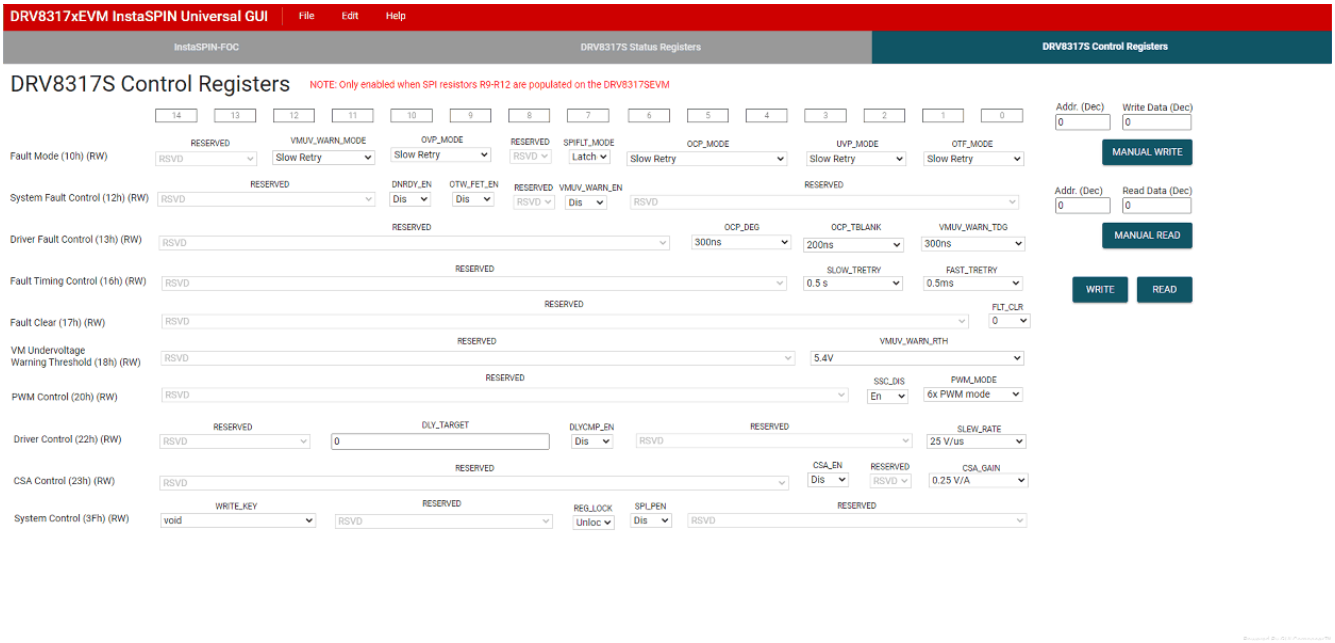

Figure 6-5. DRV8317HEVM InstaSPIN GUI SPI Control Registers

7 Schematics

7.1 Main Supply

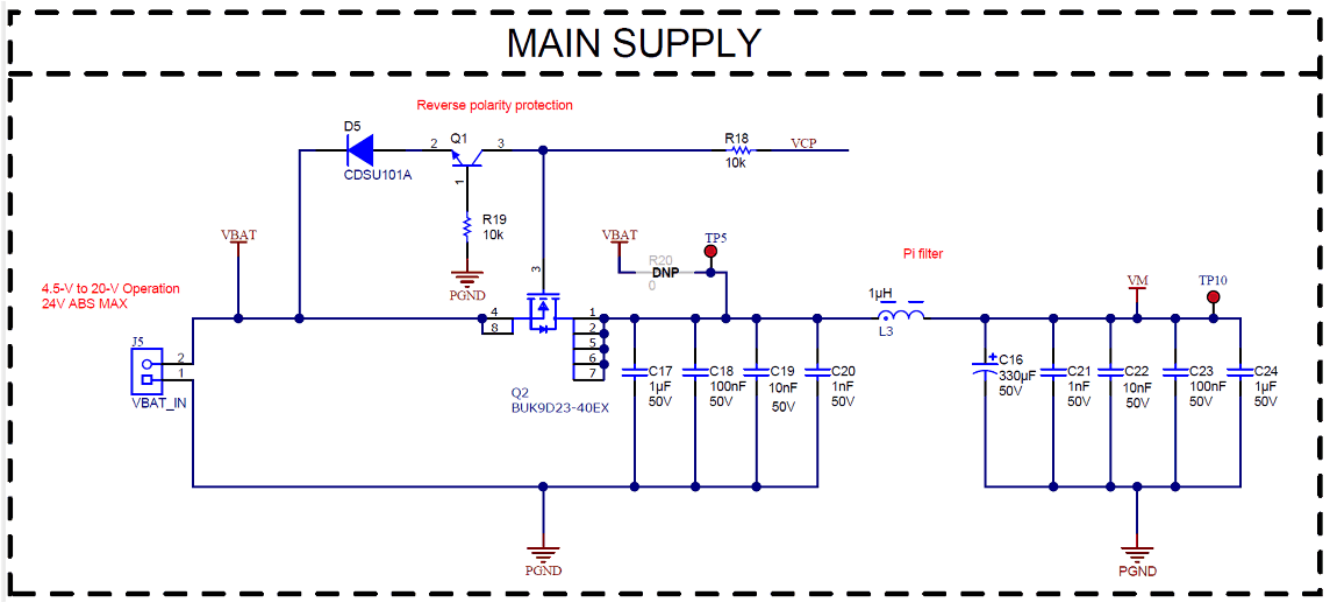

Figure 7-1. Main Supply schematic

7.2 DRV8317H/S

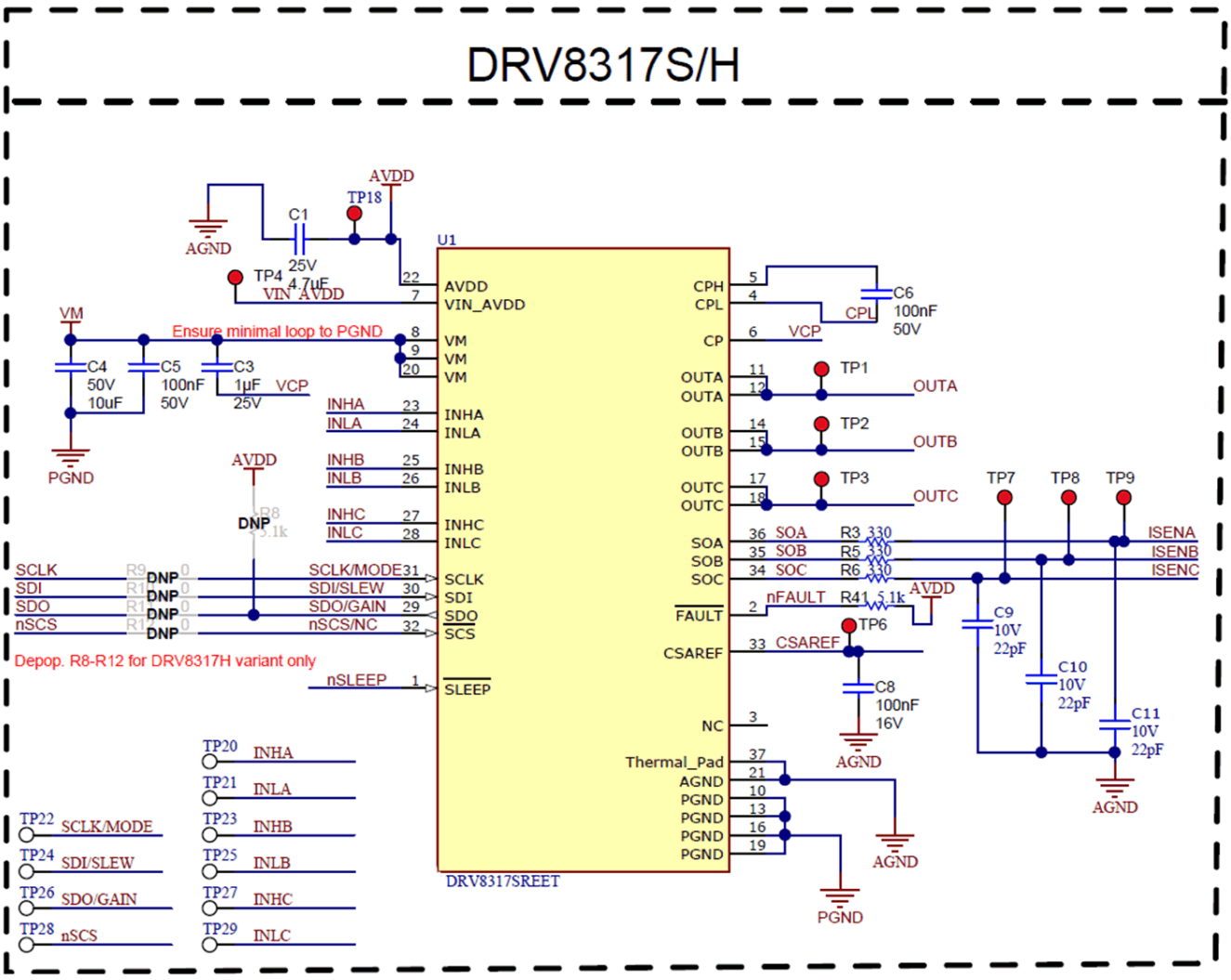

Figure 7-2. DRV8317H/S schematic

7.3 3.3V Buck Regulator and VREF

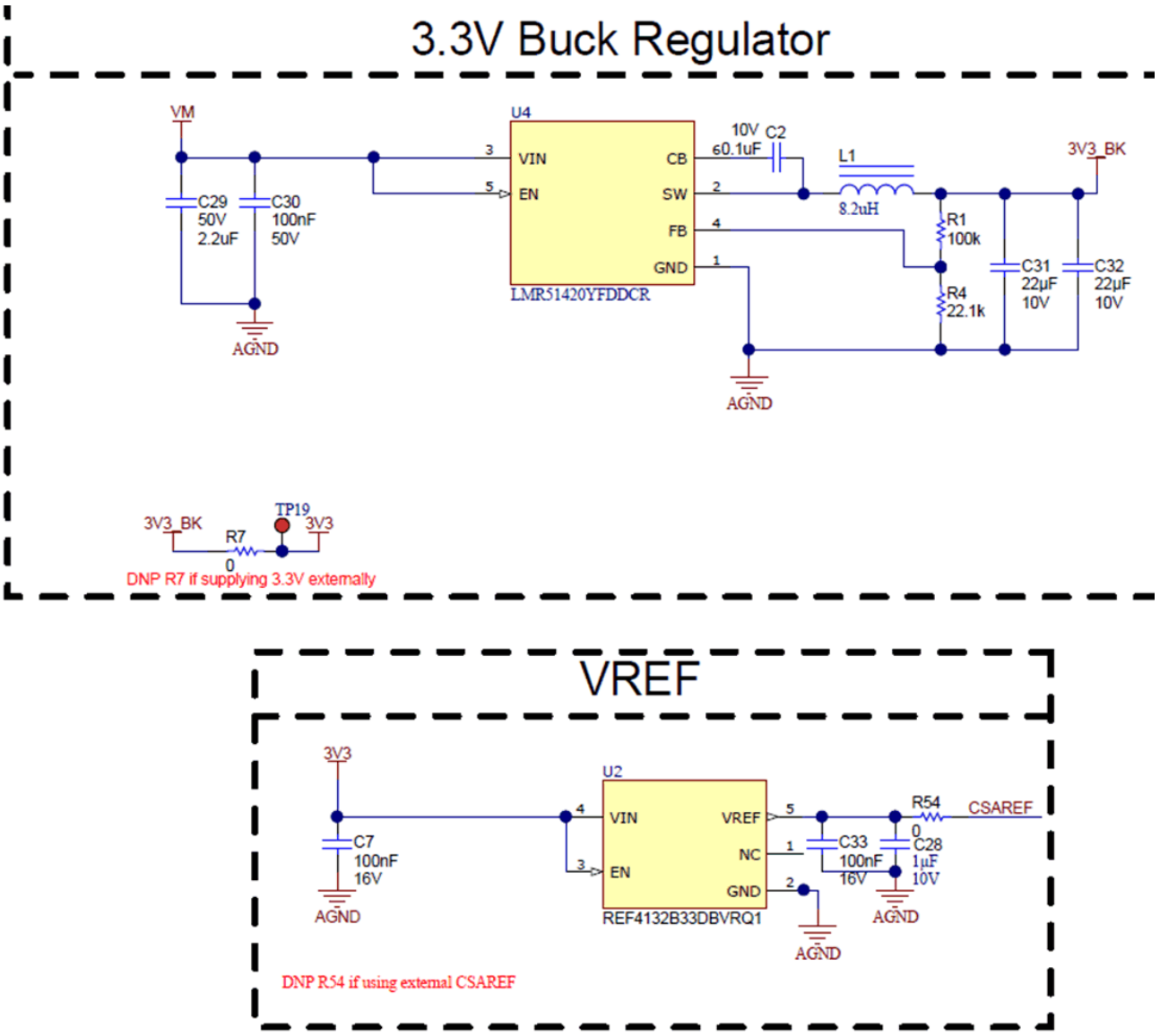

Figure 7-3. 3.3V Buck Regulator and VREF schematic

7.4

7.5 LaunchPad Connections

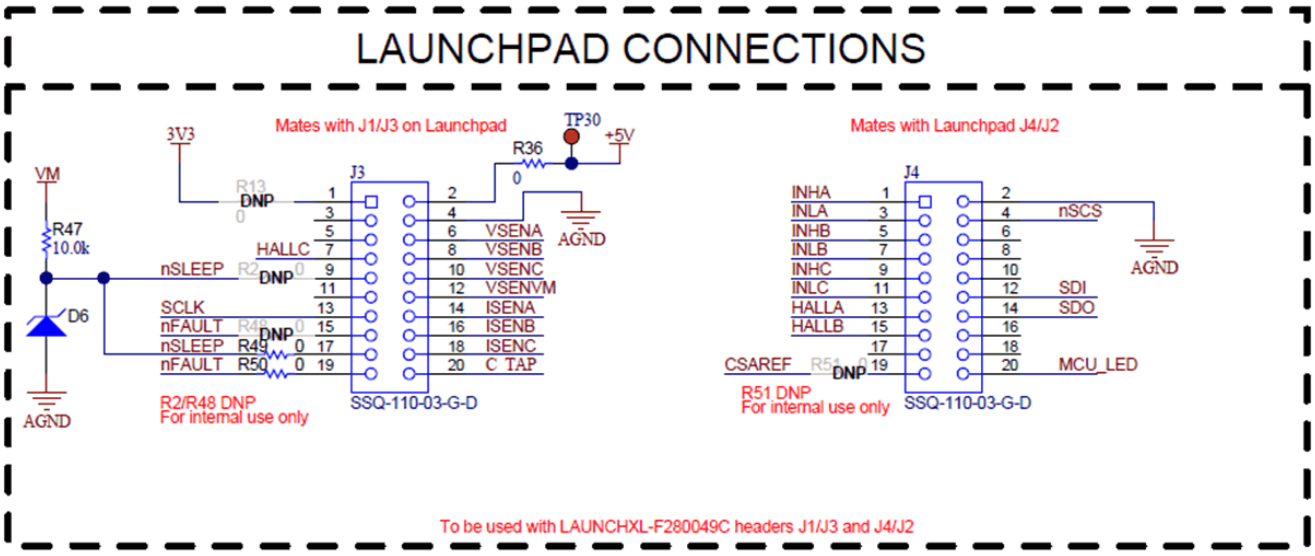

Figure 7-4. LaunchPad Connections schematic

7.6 Connectors & Interface

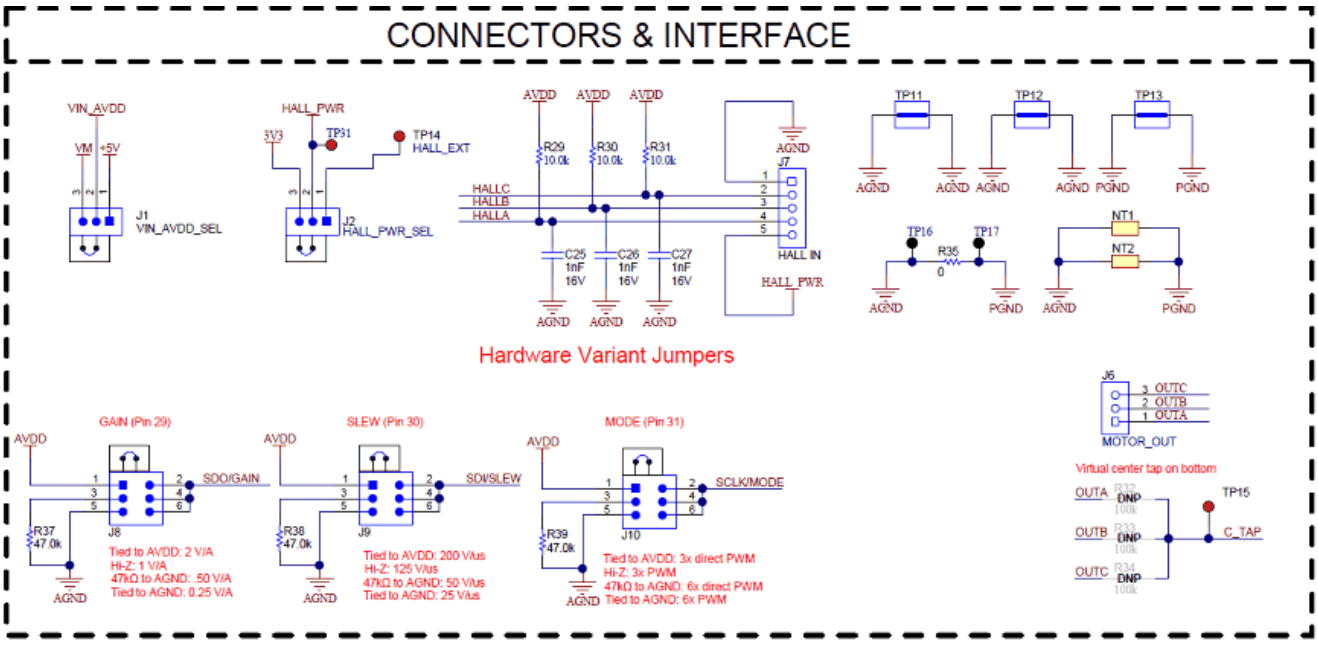

Figure 7-5. Connectors & Interface schematic

7.7 Status LEDs, Voltage Sense, and Protection

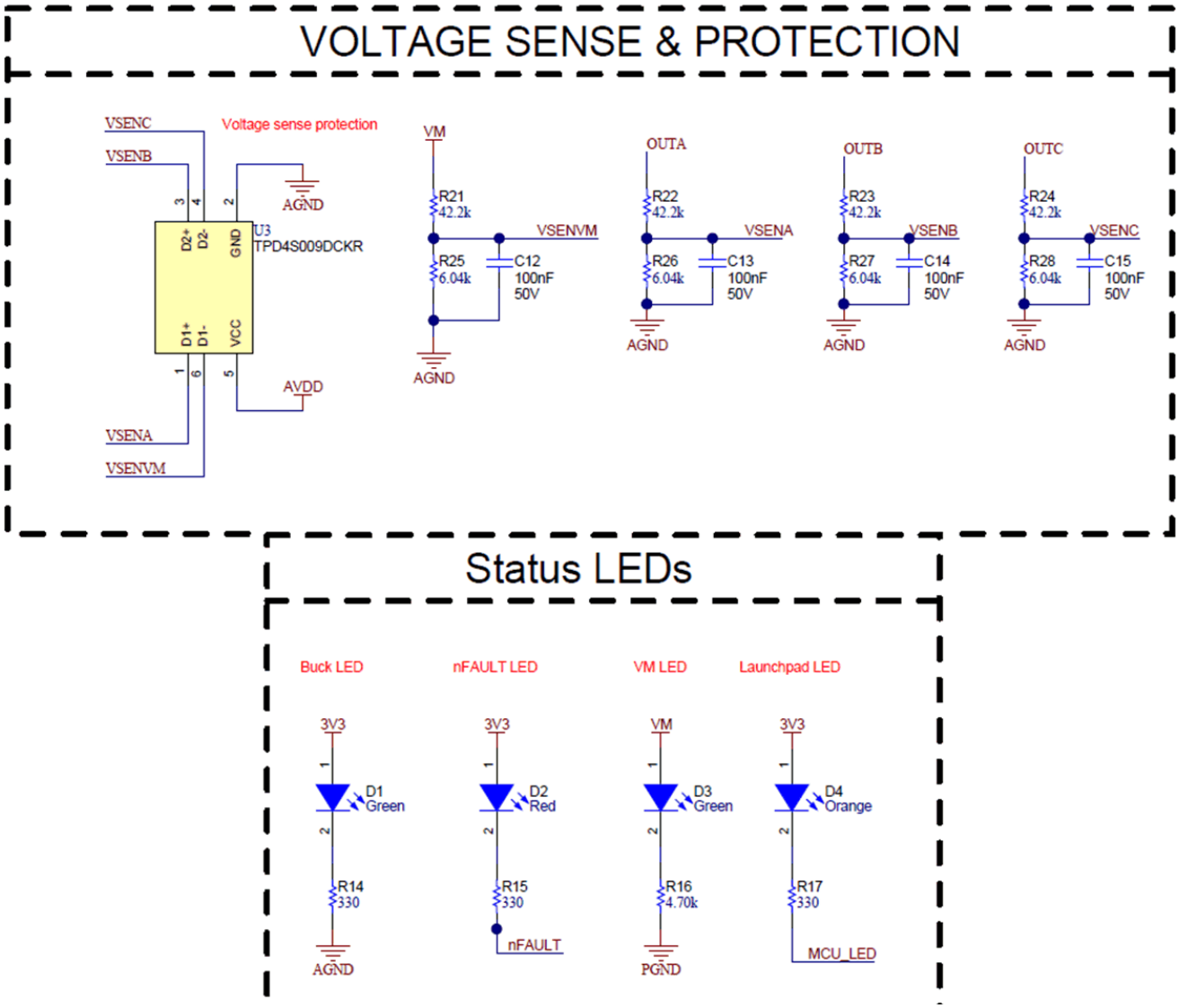

Figure 7-6. Status LEDs, Voltage Sense, and Protection schematic

8 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

DATE	REVISION	NOTES
December 2022	*	Initial Release

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   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

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   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

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NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

3.1.1 *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: 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 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. 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

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
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 to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

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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3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

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:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

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