User's Guide
DRV8329AEVM User's Guide

TEXAS INSTRUMENTS

ABSTRACT

This document is provided with the DRV8329 customer evaluation module (EVM) as a supplement to the DRV8329 data sheet (DRV8329 4.5-V to 60-V 1000/2000mA 3-phase gate driver). This User's Guide details the implementation of the EVM and shows how to set up and power the board.

Note

The DRV8329AEVM comes automatically populated with and configured for the DRV8329A. It is also compatible for the DRV8329B variants (see Section 4.4.1), but the user will need to replace the DRV8329A with the DRV8329B for compatibility.

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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.

CAUTION:

Read the User's Guide before use.

HOT SURFACE:

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

2 Introduction

The DRV8329 is a 4.5-V to 60-V triple half-bridge gate driver IC for motor drive applications. It provides a bootstrap architecture to drive 3 high-side and 3 low-side N-channel MOSFETs with up to 1-A peak source and 2-A peak sink current and can support up to 100% PWM duty cycle inputs with a trickle charge pump. All variants are in compact QFN packages with hardware configurations and provide ultra-low sleep mode current. Additionally, variants offer a variety of optional features including a dead time pin, overcurrent level pin, driver shutoff pin, and integrated LDO capable of driving 3.3 V and 80 mA. A summary of the variants below can be seen in Table 2-1.

Table 2-1. DRV8329 device variant names and descriptions (default of EVM in bold)

Device Name	LDO Output	DRVOFF pin	DT pin and VDSLVL pin	PWM_MODE
DRV8329A	**3.3 V**	**Yes**	**Available**	**6x**
DRV8329B	3.3 V	Yes	Available	3x

The DRV8329AEVM can be interfaced with the TMS320F280049C microcontroller on the LAUNCHXL-F280049C LaunchPad in correspondence with the reference software to provide the algorithm to the DRV8329 to control the BLDC motor.

This document serves as a startup guide to supplement the DRV8329AEVM + 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 DRV8329. For step by step details on connecting the LAUNCHXL-F280049C + DRV8329AEVM, refer to Hardware Setup.
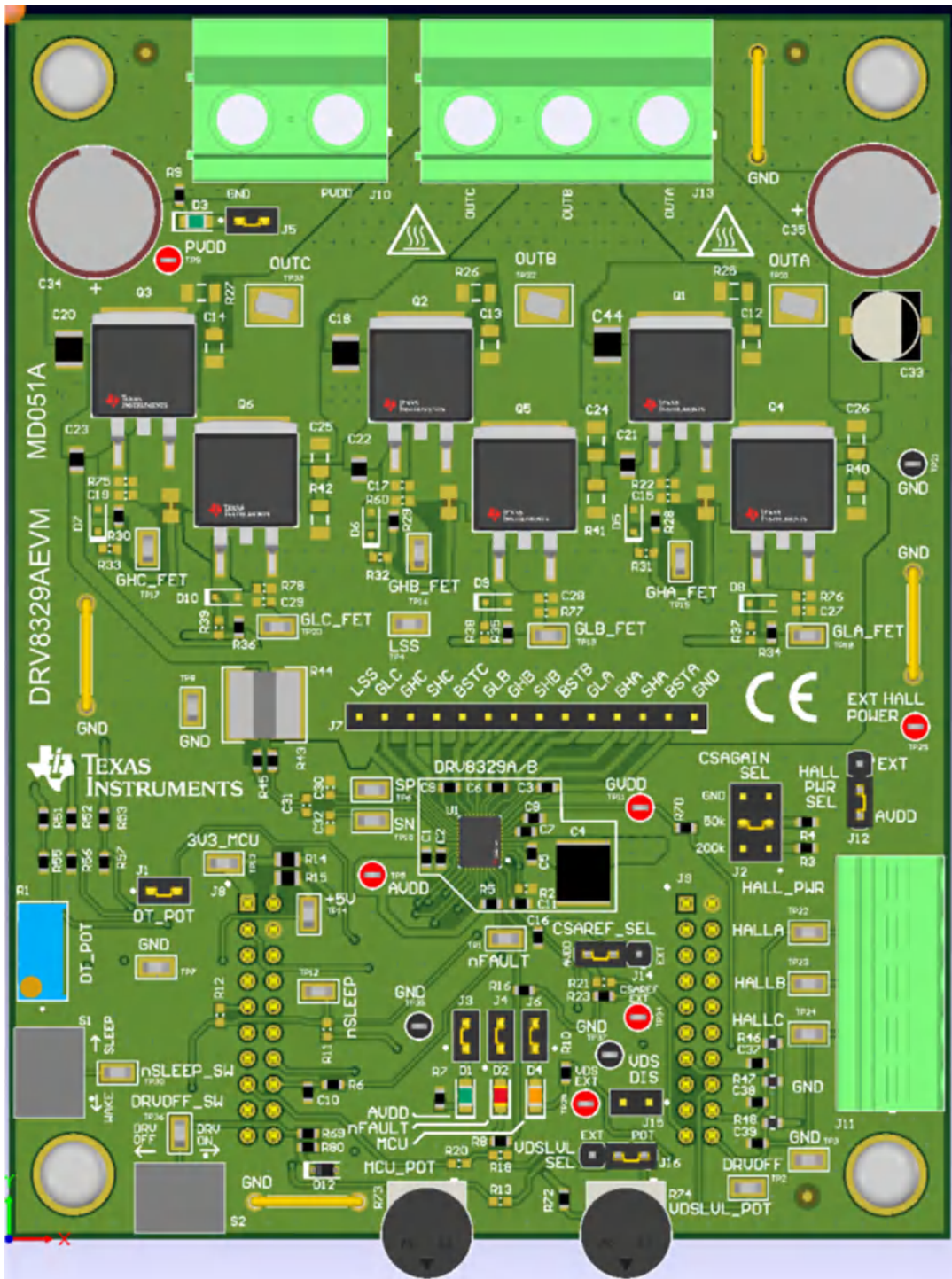
Figure 2-1. DRV8329AEVM PCB Layout

3 Quick Start Guide

The DRV8329AEVM requires a power supply with a recommended operating range from 4.5-V to 60-V. To setup and power the EVM, follow the sequence below:

1. Connect the power supply ground to the GND of the 2-pin power connector J10 and the power supply positive terminal to the PVDD pin of J10. Ensure jumpers JP1, JP2, and JP3 of the LAUNCHXL-F280049C are not populated (DNP) to ensure that the LaunchPad is powered by the DRV8329AEVM and the motor supply is isolated from the USB.
2. Connect the motor phases to OUTA, OUTB, and OUTC in the correct order to connector J13. For sensored applications, connect the Hall sensors to the appropriate locations on the 5-pin connector J11 as shown in Figure 4-2. Select AVDD or EXT on jumper J11 to choose the Hall power source voltage.
3. Mate the DRV8329AEVM onto the top half of the LAUNCHXL-F280049C (LaunchPad Headers J1/J3 and J2/J4) as shown in Figure 4-3. The motor and power connectors should face the same direction as the Micro-USB connector on the LaunchPad.
4. Place nSLEEP switch in WAKE position and DRVOFF in ON position.
5. Power on the DRV8329AEVM.
6. Connect a Micro-USB cable from the computer into the Micro USB connector on the top of the LAUNCHXL-F280049C as shown in Figure 4-4.

4 Hardware and Software Overview

4.1 Hardware Connections Overview – DRV8329AEVM + LAUNCHXL-F280049C

Figure 4-1 shows the major hardware blocks of the DRV8329AEVM. The DRV8329AEVM is designed for an input supply from 4.5-V to 60-V.
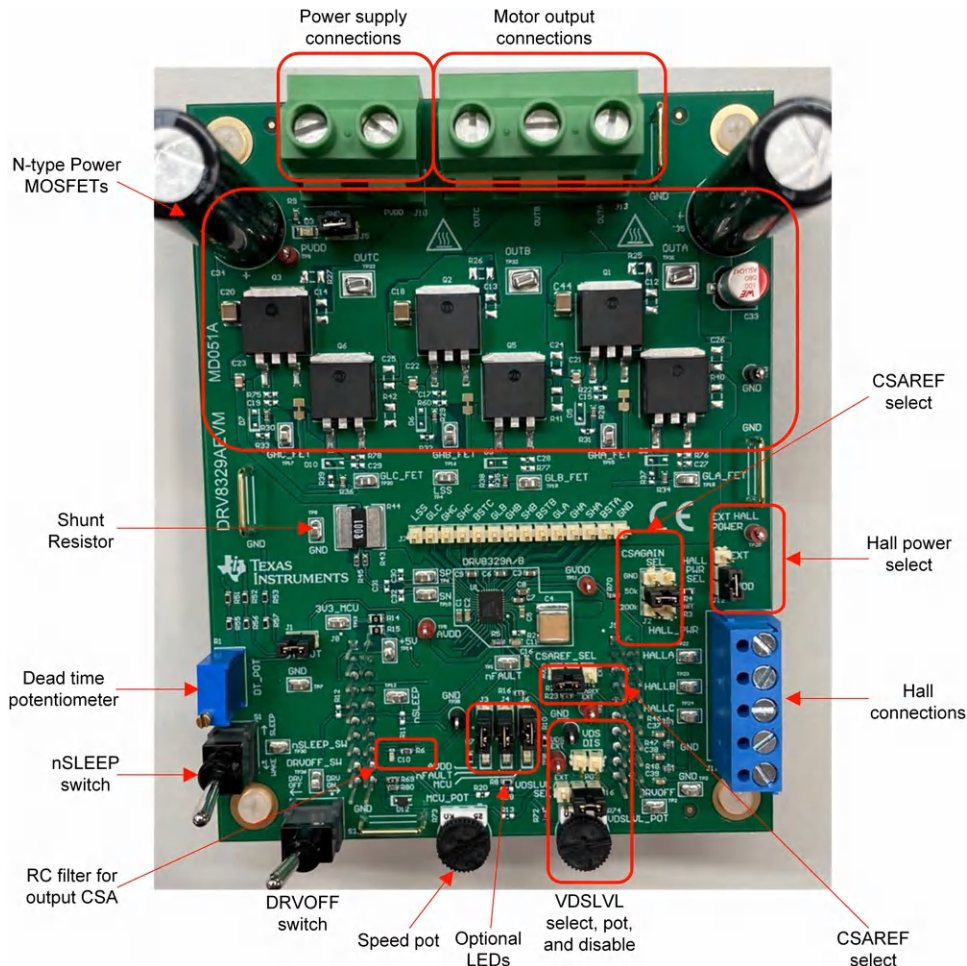
Figure 4-1. Major hardware blocks of the DRV8329AEVM

4.2 Connection Details

Figure 4-2 shows the power supply and motor connections made to the DRV8329AEVM in order to spin a 3-phase sensored or sensorless Brushless-DC motor.

A 4.5-V to 60-V power supply or battery is connected to the PVDD and GND terminals. The three phases of the BLDC motor connect directly to the OUTA, OUTB, and OUTC terminals of the screw terminal J13 provided on the DRV8329AEVM.

For sensored applications, to connect the Hall sensor outputs to the Hall connectors on the DRV8329AEVM, push down on the respective terminals to open the sockets and insert the Hall sensor wires into connector J11.
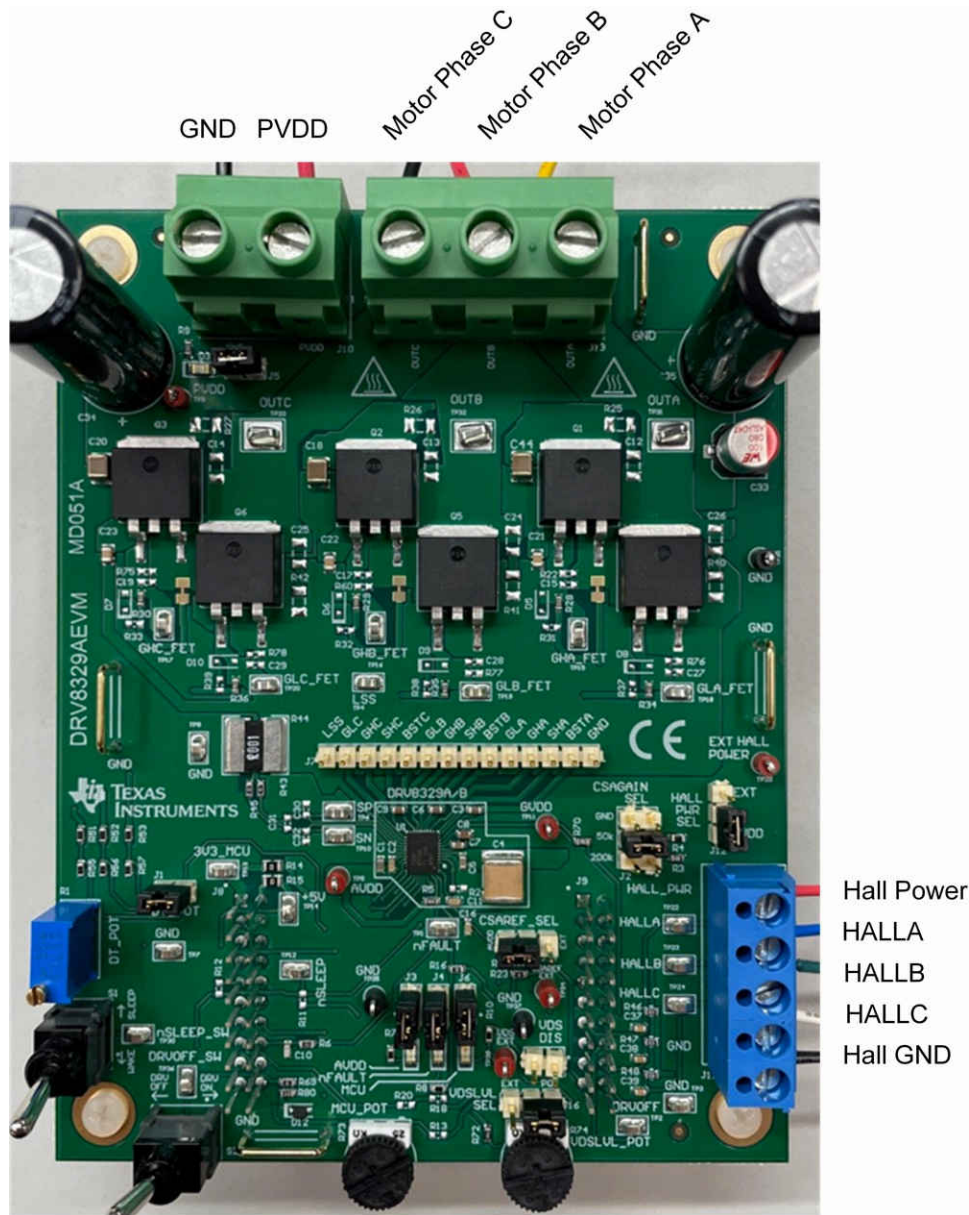
Figure 4-2. Connections from motor to DRV8329AEVM

Figure 4-3 and Figure 4-4 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 DRV8329AEVM to the J1/J3 and J2/J4 headers of the LaunchPad.
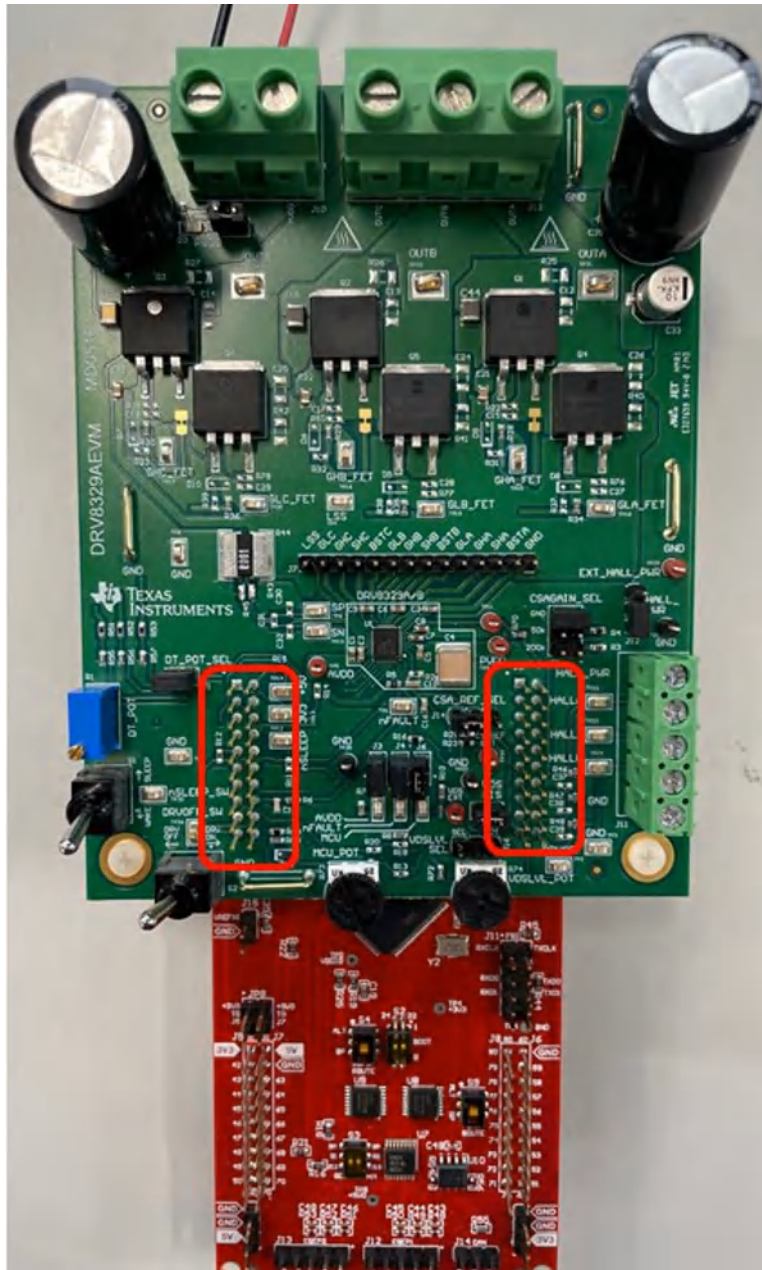
Figure 4-3. DRV8329AEVM on headers J1/J3 and J2/J4 of LaunchPad
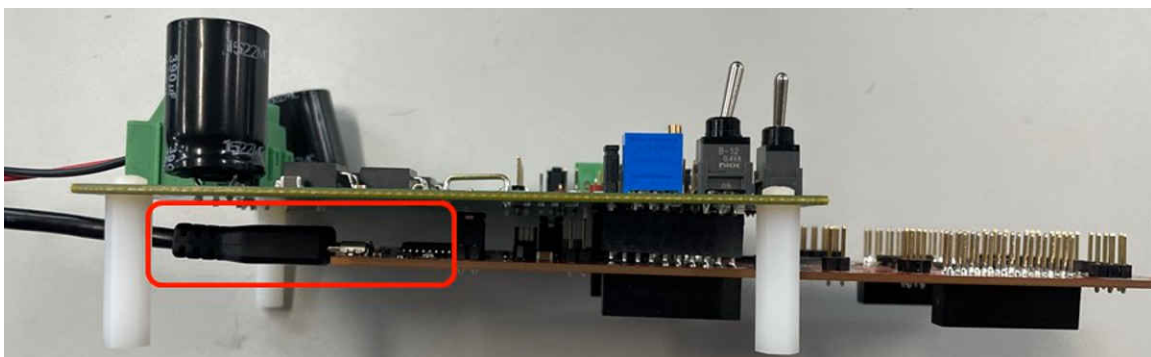
Figure 4-4. Micro-USB plugged into LaunchPad

4.3 LED Lights

There are LED indicators on both the LAUNCHXL-F280049C and DRV8329AEVM when power is provided and the micro USB cable is plugged in to the LaunchPad.

The DRV8329AEVM has 4 status LEDs on the board. By default, the PVDD and AVDD 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 4-5 shows the LED locations on the EVM. These LEDs all have removable jumpers to reduce power consumed by the EVM.

Table 4-1. Description of DRV8329AEVM LEDs (on during power up in bold)

Designator	Jumper	Name	Color	Description
D1	**J1**	**AVDD**	**Green**	**AVDD is outputting 3.3 V**
D2	J2	nFAULT	Red	Lights up when fault condition has occurred on DRV8329
D3	**J3**	**PVDD**	**Green**	**Power is supplied to the board**
D4	J4	MCU_LED	Orange	MCU debugging
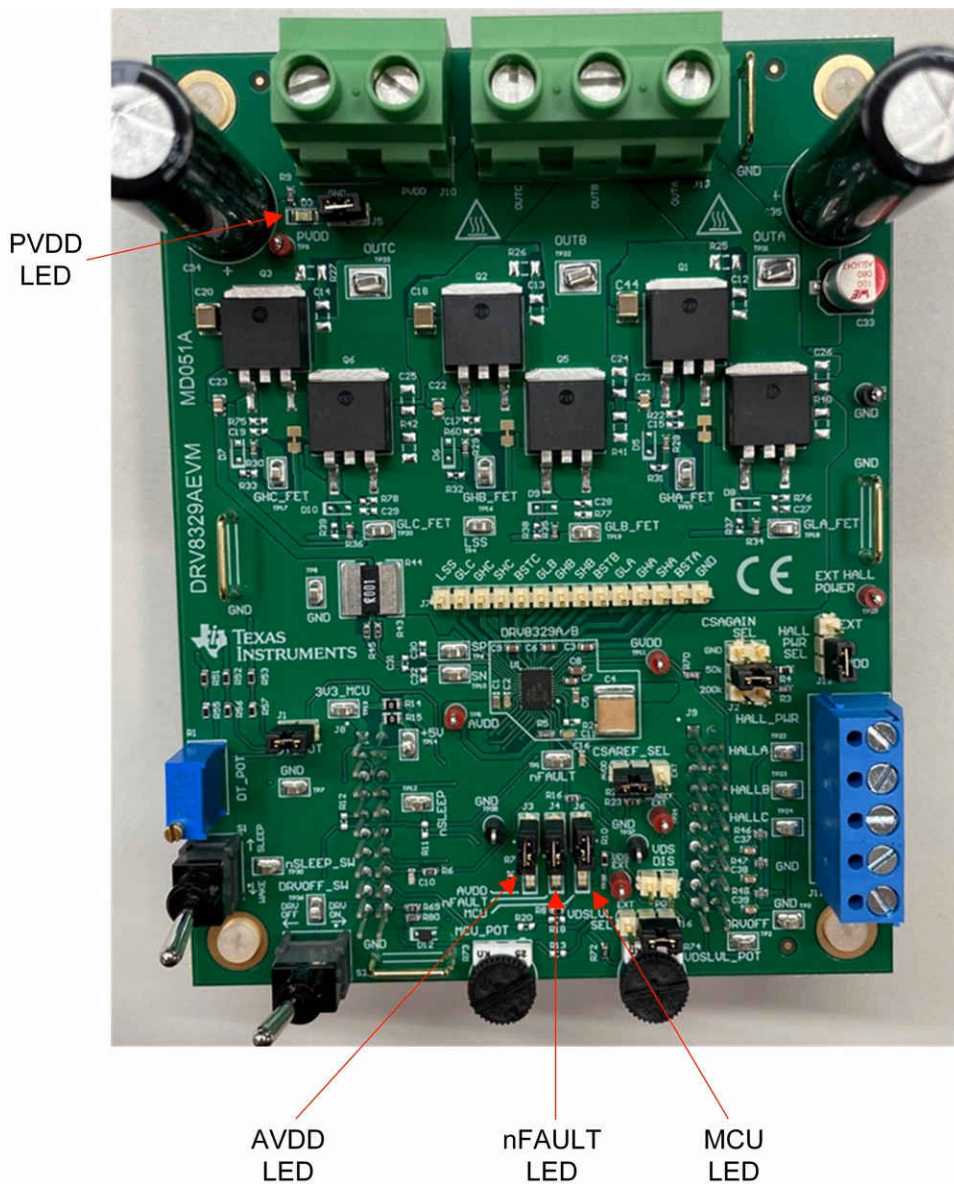
Figure 4-5. DRV8329AEVM LEDs

4.4 DRV8329AEVM Configurability

The DRV8329AEVM includes a variety of user-selectable jumpers and unpopulated components on the PCB to choose user settings and evaluate the DRV8329A, DRV8329B, DRV8329C, or DRV8329D 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 4-6.

Table 4-2. User-Selectable Jumpers

Id.	Setting Name	Description	Position	Function
A	nSLEEP switch	Places DRV8329 in sleep mode	S2 = Left	Sleep mode
			S2 = Right	**Operating mode**
B	Dead time potentiometer, jumper, & resistor	Jumper to enable dead time control from potentiometer and potentiometer used to set the resistance for DT pin.	**J1 = Populated**	**DT from pot is enabled**
			J1 = DNP	DT from pot is disabled
			R1 (CW = more DT, CCW = less DT)	**Sets dead time of gate driver outputs**
			R2	Fixed resistor for DT pin

Table 4-2. User-Selectable Jumpers (continued)

| Id.	Setting Name	Description	Position	Function
C	CSA input filter	Input filter to filter any Vsense switching transients at the current sense amplifier inputs.	**R45 = R43 = 0 ohm** C30, C31, C32 = DNP	CSA input filtering
D	Power stage MOSFETs and passive components	Optional passive components for tuning power stage, i.e. series gate resistors, RC snubbers, PVDD-GND capacitors, PVDD-LSS capacitors	**R28, R29, R30, R34, R35, R36 = 10 ohm**	**Series gate resistors (GHA, GHB, GHC, GLA, GLB, GLC)**
			R25/C12, R26/C13, R27/C14, R40/C26, R41/C24, R42/C25 = DNP	RC snubbers (HS FET A, HS FET B, HS FET C, LS FET A, LS FET B, LS FET C)
			C18, C20, C44 = 2.2uF	**PVDD-VDRAIN bypass capacitor**
			C21, C22, C23 = 0.01uF	**PVDD-LSS bypass capacitors**
G	CSA gain select	Selects the gain setting of the integrated CSA in V/V.	J2 = GND	CSAGAIN = 5 V/V
			J2 = 50 k	CSAGAIN = 10 V/V
			J2 = 200 k	**CSAGAIN = 20 V/V**
			J2 = DNP	CSAGAIN = 40 V/V
H	HALL_PWR select	Use J6 to supply Hall power from AVDD or external hall power.	**J11 = AVDD**	**Supplies AVDD to Hall power**
			J11 = EXT	Supply external hall power from EXT HALL POWER test point.
J	VDSLVL potentiometer, select and disable jumpers	Potentiometer to set VDSLVL between 0.1–2.5 V, VDSLVL_SEL to select voltage source, disable jumper to disable VDSLVL	**J16 = POT**	**VDSLVL set from potentiometer**
			J16 = EXT	VDSLVL set from VDS EXT test point
			J15 = Populated	VDSLVL is disabled (100 kΩ to GVDD)
			J15 = DNP	**VDSLVL is enabled**
			R74 (CCW = higher VDSLVL, CW = lower VDSLVL)	**Sets VDSLVL from 0.1 V– 2.5 V**
K	CSAREF select	Jumper to select CSA reference voltage from AVDD or an external reference source.	**J14 = AVDD**	**CSAREF = AVDD**
			J14 = EXT	CSAREF = CSAREF EXT test point
L	Speed pot	Sets speed of the motor when potentiometer is enabled in the GUI.	**R73 (CW = less speed, CCW = more speed)**	**Sets duty cycle from 0% to 100%.**
M	External CSA output filter	RC output filter to suppress high frequency transients of CSA output from current shunt.	R59 = 330 ohms, C31 = 470 pF	F**c** ~10 MHz
N	DRVOFF switch	Turns off the gate driver outputs.	**S2 = Down**	**Drivers are on**
			S2 = Up	Drivers are off (DRVOFF is enabled)
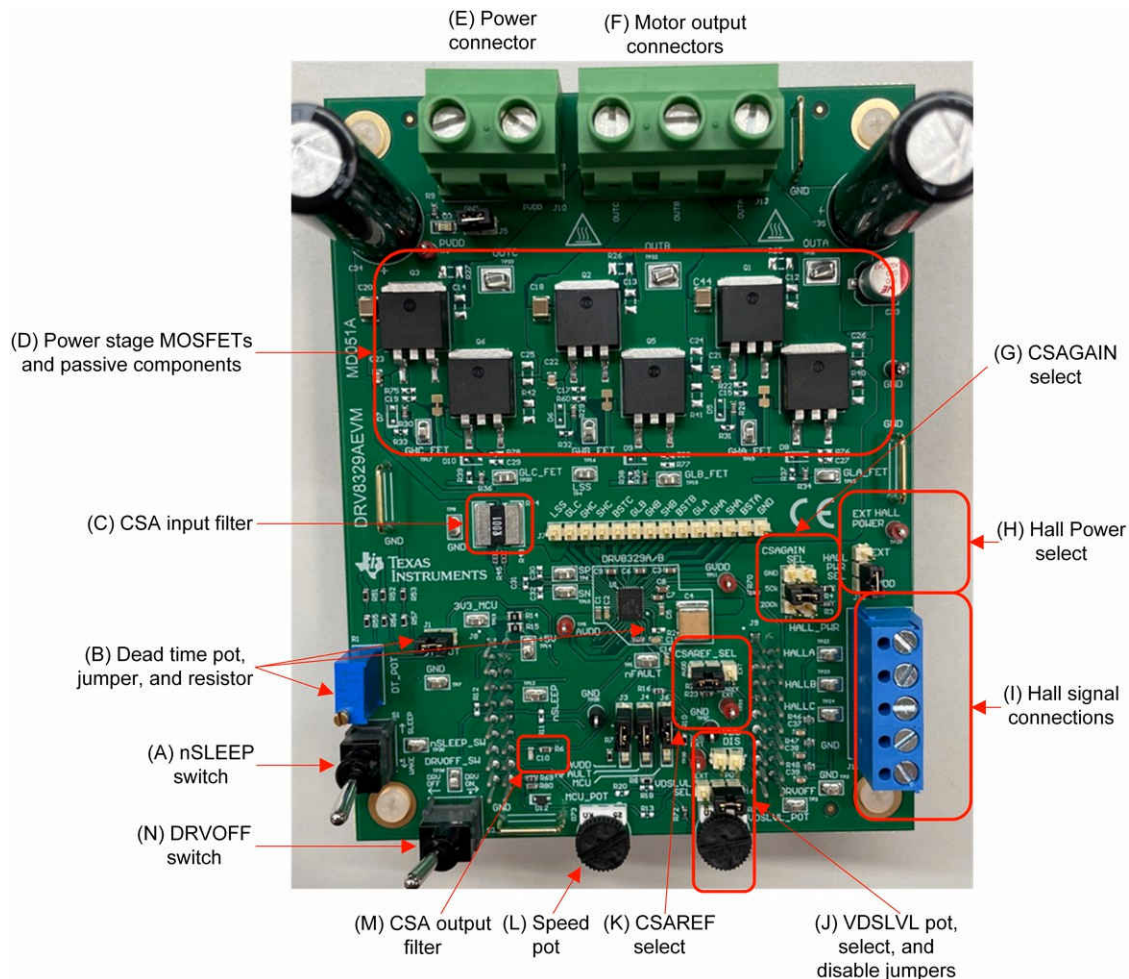
Figure 4-6. User-adjustable jumpers, resistors, and switches on DRV8329AEVM

4.4.1 DRV8329A/B Compatibility

The DRV8329AEVM default is the DRV8329A (Hardware variant), but can also be compatible with the DRV8329B. The main difference is that DRV8329A operates in 6x PWM mode and DRV8329B operates in 3x PWM mode. To use the DRV8329B, remove the DRV8329A from the EVM and replace with the DRV8329B. No extra hardware changes are required for 3x PWM operation.

4.5 Interfacing DRV8329AEVM and LAUNCHXL-F280049C LaunchPad

The DRV8329AEVM has 40 pins with different functions. These pins are interfaced with the LAUNCHXL-F280049C LaunchPad development kit and are mapped appropriately to receive the functionalities of the DRV8329 device. These 40 pins are grouped into 4 ports in respect to the LAUNCHXL-F280049C (J1 to J4). Table 4-3 and Table 4-4 list the interfacing of these ports of the DRV8329AEVM headers J3 and J4.

Table 4-3. Connections for Header J1 on DRV8329AEVM (DNP in bold)

J3 Pin Number	DRV8329AEVM Function	LAUNCHXL-F280049C Function	Description
1	**AVDD (DNP)**	+3.3 V	3.3 V LaunchPad Supply
2	+5 V	+5 V	5 V LaunchPad Supply
3	POT_MCU/NC_49C	PGA1/3/5_GND	Not used
4	GND	GND	GND connection
5	Not used	GPIO13/SCIBRX	Not used
6	VSENA	ADCINA5	Phase A Voltage Sense
7	Not used	GPIO40/SCIBTX	Not used

Table 4-3. Connections for Header J1 on DRV8329AEVM (DNP in bold) (continued)

J3 Pin Number	DRV8329AEVM Function	LAUNCHXL-F280049C Function	Description
8	VSENB	ADCINB0	Phase B Voltage Sense
9	**nSLEEP_DFLT**	NC	nSLEEP for internal use only.
10	VSENC	ADCINC2	Phase C Voltage Sense
11	**CTAP**	ADCINB3/VDAC	Center tap voltage sense.
12	VSENPVDD	ADCINB1	PVDD Bus Voltage Sense
13	Not used	SPIACLK	Not used
14	NC_MCU/POT_49C	ADCINB2	General Purpose pot for MCU (R90)
15	**nFAULT_DFLT**	ADCINC4	nFAULT for internal use only.
16	ISENA	ADCINC0	LSS current sense
17	Not used	GPIO37	Not used
18	Not used	ADCINA9	Not used
19	Not used	GPIO35	Not used
20	**VDSLVL/C_TAP**	ADCINA1/DACB_OUT	VDSLVL from DAC. C_TAP for internal use only.

Table 4-4. Connections for Header J2 on DRV8329AEVM

J4 Pin Number	DRV8329AEVM Function	LAUNCHXL-F280049C Function	Description
1	INHA	GPIO10/PWM6A	PWM used to switch Phase A High-side FET
2	GND	GND	GND connection
3	INLA	GPIO11/PWM6B	PWM used to switch Phase A Low-side FET
4	MCU_LED	SPIASTE	Visual feedback for LaunchPad connection.
5	INHB	GPIO8/PWM5A	PWM used to switch Phase B High-side FET
6	**nFAULT_DFLT**	NC	nFAULT for internal use only.
7	INLB	GPIO9/PWM5B	PWM used to switch Phase B Low-side FET
8	Not used	NC	Not used
9	INHC	GPIO4/PWM3A	PWM used to switch Phase C High-side FET
10	Not used	XRSn	Not used
11	INLC	GPIO5/PWM3B	PWM used to switch Phase C Low-side FET
12	Not used	SPIASIMO	Not used
13	HALLA	GPIO58	Hall sensor A from motor
14	Not used	SPIASOMI	Not used
15	nSLEEP_49C	GPIO30	nSLEEP signal (active low)
16	DRVOFF	GPIO39	Active-high output to disable gate drivers
17	Not used	GPIO18*/XCLKOUT	Not used

Table 4-4. Connections for Header J2 on DRV8329AEVM (continued)

J4 Pin Number	DRV8329AEVM Function	LAUNCHXL-F280049C Function	Description
18	HALLB	GPIO23/LED4	Hall sensor B from motor
19	nFAULT_49C/CSAREF	GPIO25	nFAULT signal (active low)
20	HALLC	GPIO59	Hall sensor C from motor

Note

There are many resistors that are not populated for internal use only. Ensure the correct resistors are populated so every has signal has only signal path. If multiple signal paths are present, or no signal path is present, the device may not work as intended.

5 Hardware Setup

The hardware required to run the motor control is the LAUNCHXL-F280049C LaunchPad development kit, the DRV8329AEVM, a Micro-USB cable, and a power supply with a DC output from 4.5-V to 60-V. Follow these steps to set up the evaluation module:

1. Ensure all resistors, jumpers, and switches are set up accordingly.
2. Mate the DRV8329AEVM 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). Observe the correct orientation when placing DRV8329AEVM to the LAUNCHXL-F280049C. The motor and power connectors should face to the LaunchPad's Micro-USB connector.
3. Connect the three phases from the brushless-DC motor to the 3-pin connector J12 on DRV8329AEVM. Phases OUTA, OUTB, and OUTC are labeled in white silkscreen on the PCB top layer. If using a sensored algorithm on the LaunchPad development kit, connect Hall sensors to the 5-pin connector J10.
4. Connect the DC power supply to header J9. Observe the correct polarity PVDD and GND connections on the DRV8329AEVM connector J9.
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 DRV8329AEVM 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 DRV8329AEVM can implement sensored, sensorless, or Field-oriented control for commutating a 3-phase Brushless-DC motor. There are two GUIs to support DRV8329A (DRV8329A-EVM-GUI) and DRV8329B (DRV8329B-EVM-GUI) using sensored trapezoidal commutation with Hall sensor feedback. The GUIs allow for basic trapezoidal motor control functions such as acceleration, duty cycle control, PWM switching frequency, MCU dead time insertion, braking, and direction changes. The bus and phase voltage feedback circuits as well as the integrated CSA provide voltage and current feedback from the motor for over-current and motor voltage protection.

The following GUIs are available on the Gallery:

Table 6-1. DRV8329x EVM GUIs available

Variant	GUI
DRV8329A	https://dev.ti.com/gallery/view/BLDC/DRV8329A_EVM_GUI/ver/1.0.0/
DRV8329B	https://dev.ti.com/gallery/view/BLDC/DRV8329B_EVM_GUI/ver/1.0.0/

6.1 Connecting to the DRV8329AEVM-GUI

Follow the instructions in Section 5 and ensure the LAUNCHXL-F280049C is connected to the PC. Turned on the supply to power the DRV8329AEVM and LAUNCHXL-F280049C.

Access the Gallery and search for "DRV8329" as shown in Figure 6-1. Click on the GUI for the variant.
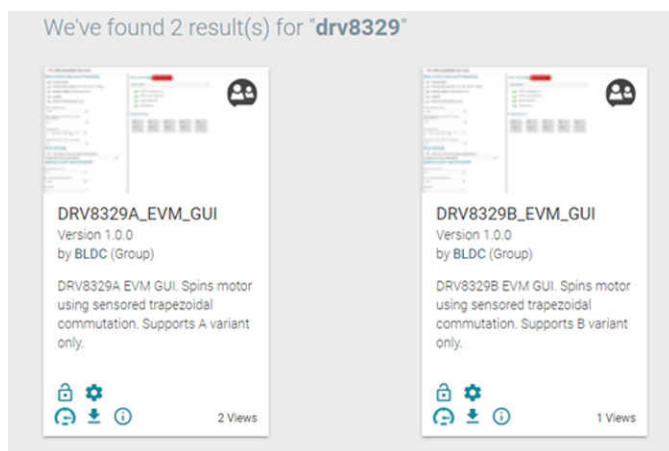

Figure 6-1. DRV8329A_EVM_GUI and DRV8329B_EVM_GUI on the Gallery

Accept the readme that appears. The GUI will detect the LAUNCHXL-F280049C and automatically download the program into the MCU. Once complete, the "Hardware Connected" message appears at the bottom left hand corner as shown in Figure 6-2.

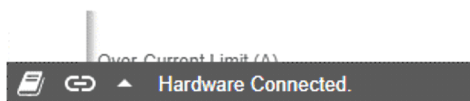**Figure 6-2. Hardware connected message**

The following defaults should appear as shown in Figure 6-3 when the GUI is connected:

- **Direction** – Enabled
- **PWM Frequency (Hz)** – 20000
- **MCU Dead Time (ns)** – 0
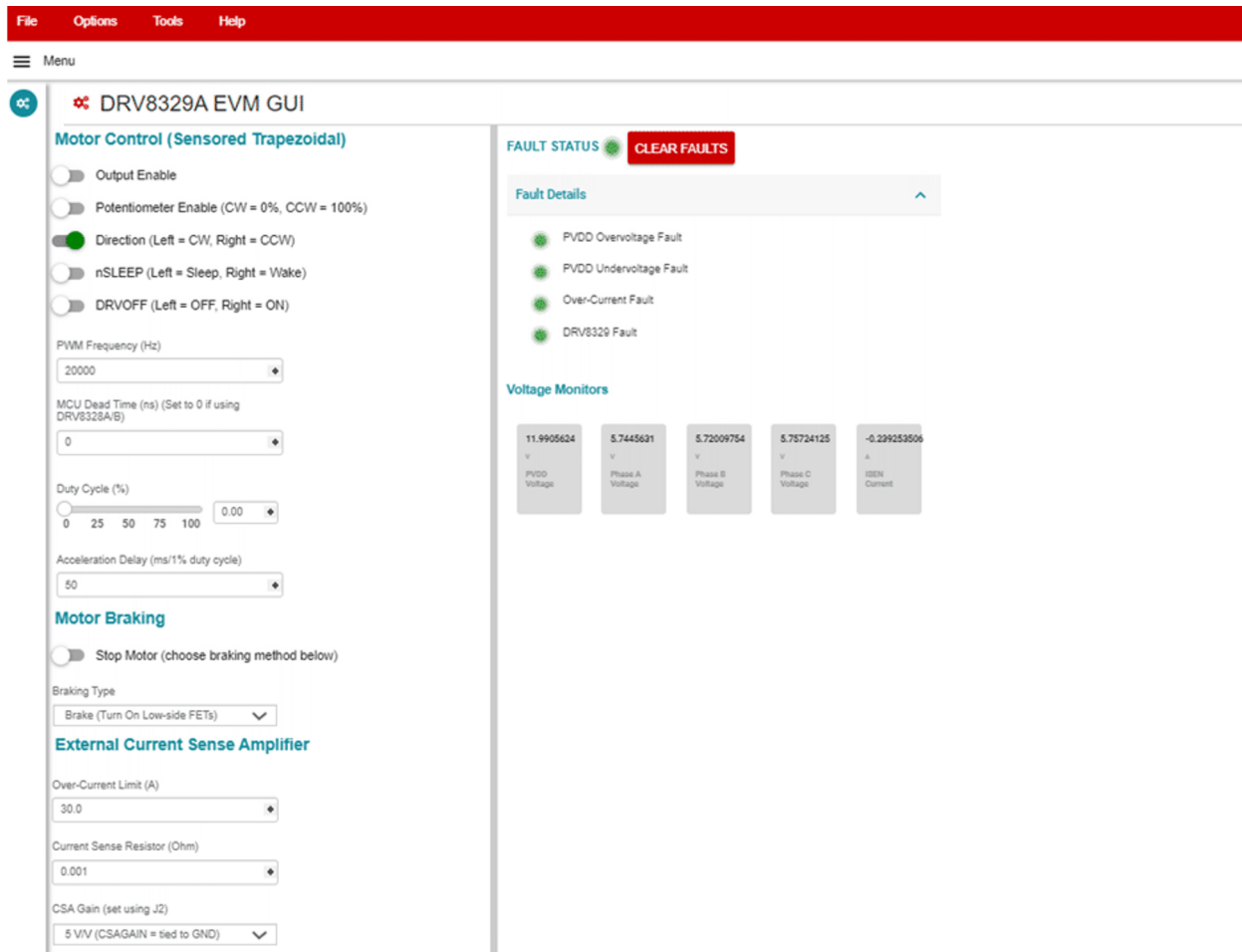- **Acceleration Delay (ms/1% duty cycle)** – 50

Figure 6-3. DRV8329A_EVM_GUI defaults when connected

6.2 DRV8329x EVM GUI Quick Start Guide

1. Click on the "Output Enable" switch.
2. Enter the PWM frequency in Hz using the "PWM Frequency (Hz)" text box. Press Enter.
3. Adjust the MCU dead time and Acceleration Delay values. You may also use the DT potentiometer to insert dead time from the DRV8329 rather than the MCU by setting the dead time potentiometer resistance, enabling the DT_POT jumper, and setting the MCU dead time to 0 ns.
4. To control the motor speed using the speed potentiometer, turn the potentiometer all the way counterclockwise to set to 0% speed. Click on the "Potentiometer Enable" switch. To not use the potentiometer to control the motor speed, skip this step.
5. Adjust the "Duty Cycle" slider or enter the duty cycle in the number box to control the speed of the motor from 0% to 100%.
6. Use the "Direction" switch to switch the direction of the motor.
7. Use the drop-down menu in "Motor Braking" to determine the motor braking type. Click on "Stop Motor" to stop the method with the selected braking type.
8. If R58 is populated and R11 is not populated, use the nSLEEP switch to put the driver into a low-power sleep mode.
9. If R69 is populated, use the DRVOFF switch to shut off the gate drivers and Hi-Z the gate driver outputs.

6.3 Using the DRV8329x EVM GUI

The GUI offers the following features:

<u>MOTOR CONTROL SETTINGS</u>

• **Output Enable** – Global enable flag to run the motor at the selected duty cycle.

- **Potentiometer Enable** – Enables potentiometer R90 to control the duty cycle of the motor. Duty cycle is updated in the Duty Cycle slider in real time. Turn all the way clockwise for 0% duty cycle, all the way counterclockwise for 100% duty cycle.
- **Direction** – Sets direction of the motor. When enabled, motor spins counterclockwise. When disabled, motor spins clockwise. When the direction is changed, the motor will coast to a stop, wait 1 second, then accelerate to the duty cycle in the opposite direction.
- **nSLEEP** – Places the DRV8329 in a low-power sleep mode. nSLEEP toggle switch only works when resistor R26 is populated and resistor R75 is DNP.
- **DRVOFF** – Disables all gate drivers in Hi-Z state.
- **PWM Frequency –** Sets the PWM switching frequency of the motor in Hz.
- **MCU Dead Time** – Sets the MCU deadband time for the PWM inputs in nanoseconds.
- **Duty Cycle** – Sets the duty cycle of the motor when potentiometer is disabled.
- **Acceleration Delay –** Sets the acceleration and deceleration ramp rate in ms per 1% duty cycle.

MOTOR BRAKING SETTINGS

- **Stop Motor** – Stops the motor when toggled according to the braking method in the drop-down menu. The two methods are brake (turn on all low-side MOSFETs) and coast (float all MOSFETs).

CSA SETTINGS

- **Over-current Limit –** Sets the overcurrent limit in amps. If ISEN is measured to be over the overcurrent limit, Over-Current fault is triggered.
- **Current Sense Resistor** – Sets the resistor value in ohms for the shunt resistor onboard the EVM. Default resistor populated is 0.001 ohm.
- **CSA Gain** – Gain of the integrated CSA on the EVM. Set the CSA gain setting to match the CSAGAIN setting on J2 of the EVM so the firmware can calculate the ISEN current correctly.

FAULT STATUS BITS

- **Fault Status –** Logical "or" of all faults. When a fault occurs, Output Enable is turned off, Duty Cycle is set to 0%, and the corresponding fault status LED is lit.
- **PVDD Overvoltage Fault –** PVDD is over 60 V. Configurable through firmware.
- **PVDD Undervoltage Fault –** PVDD is under 4.5 V. Configurable through firmware.
- **Over-Current –** Measured LSS current is over the Over-Current threshold.
- **DRV8329 Fault –** Fault indicated by the DRV8329. See DRV8329 datasheet.
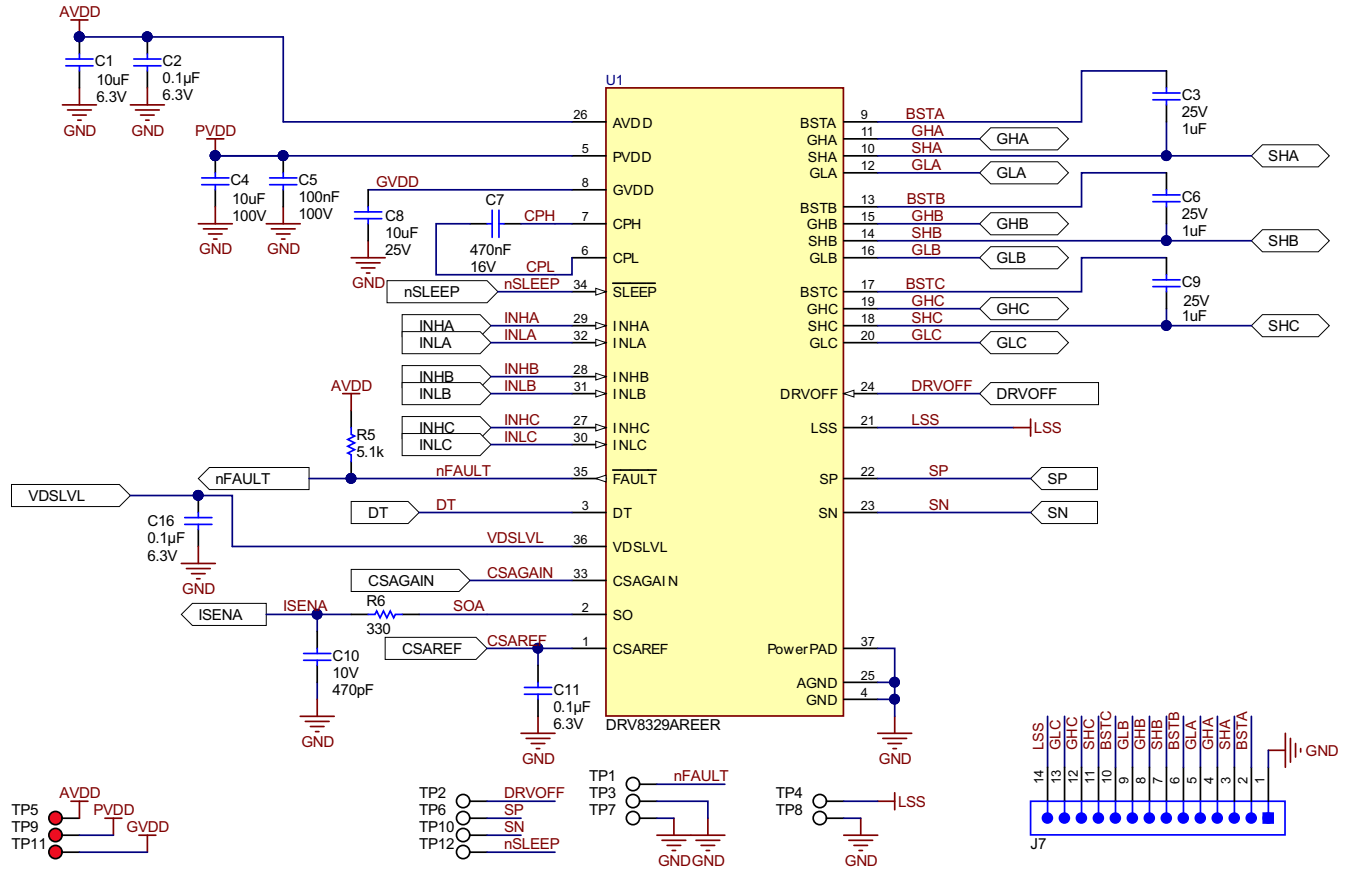
7 Schematics
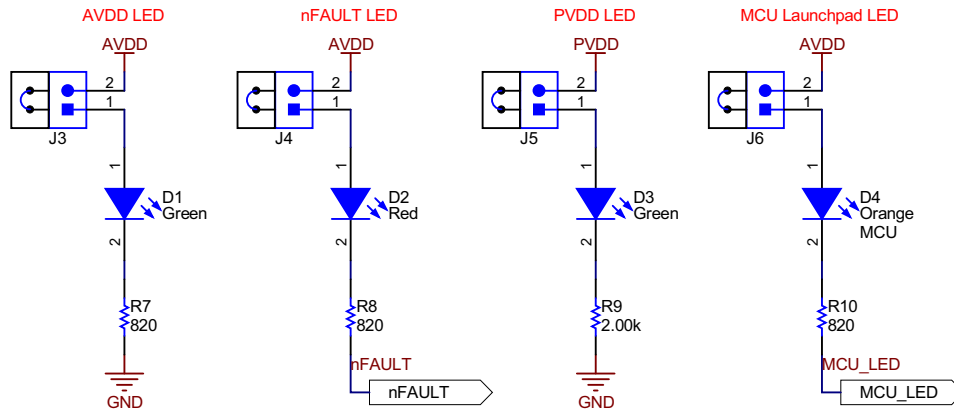
7.1 DRV8329A/B

Figure 7-1. DRV8329A/B schematic

7.2 Status LEDs

Figure 7-2. Status LEDs schematic
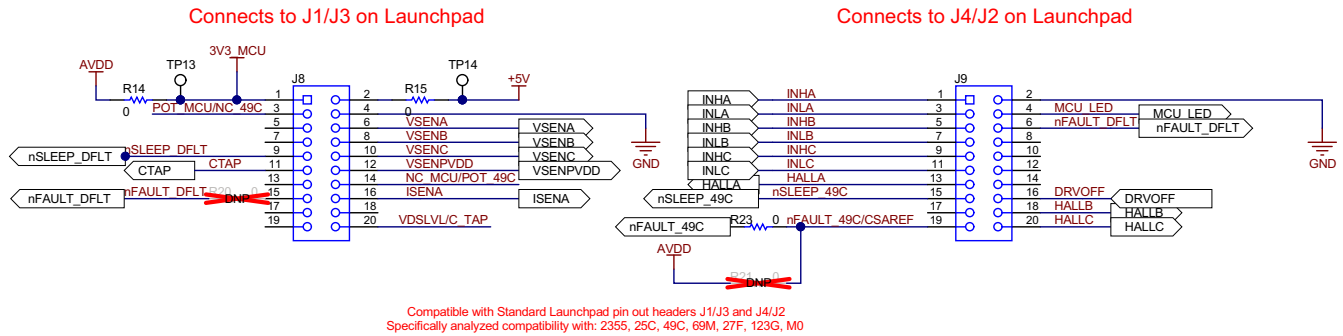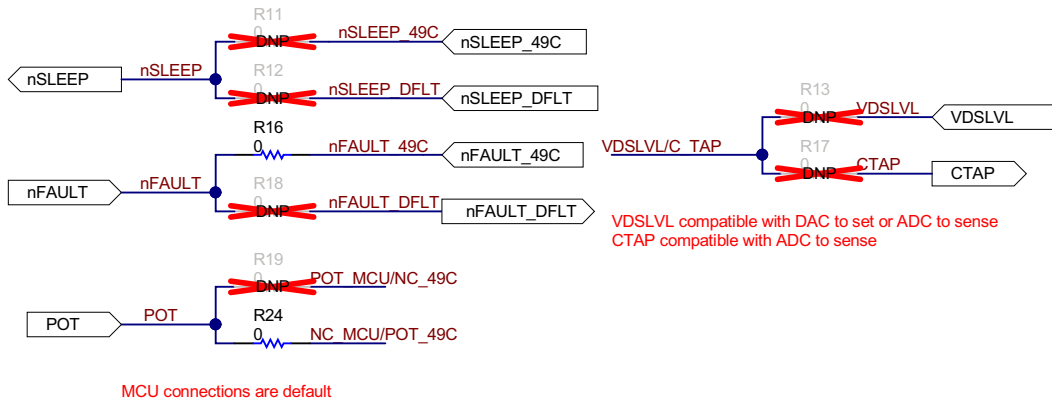
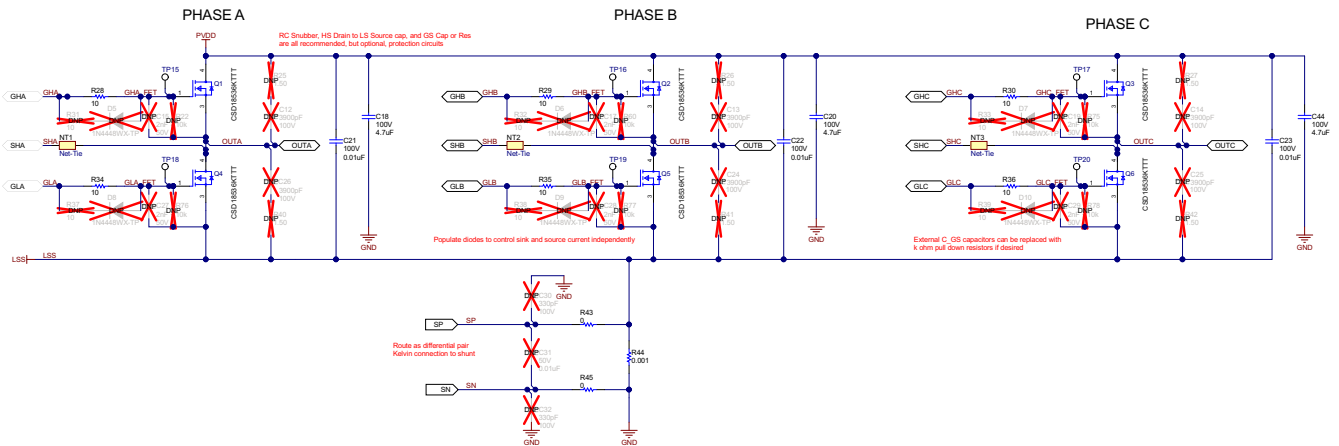## 7.5 Main Supply Input
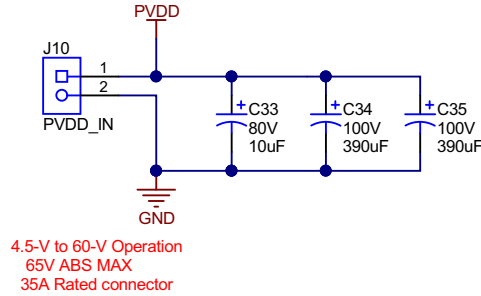
Figure 7-6. Main supply input schematic

7.6 Hall Sensor and Hall Power selection
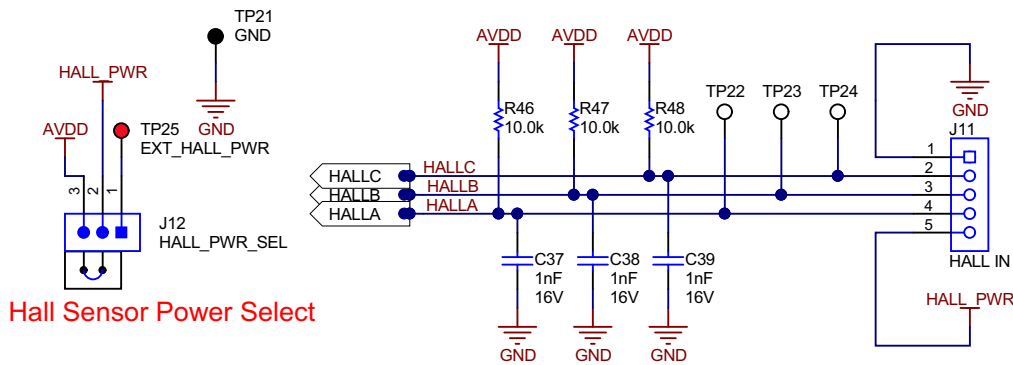
Figure 7-7. Hall Sensor and Hall Power selection schematic

7.7 Connectors, Selectors, and Analog Control Interface
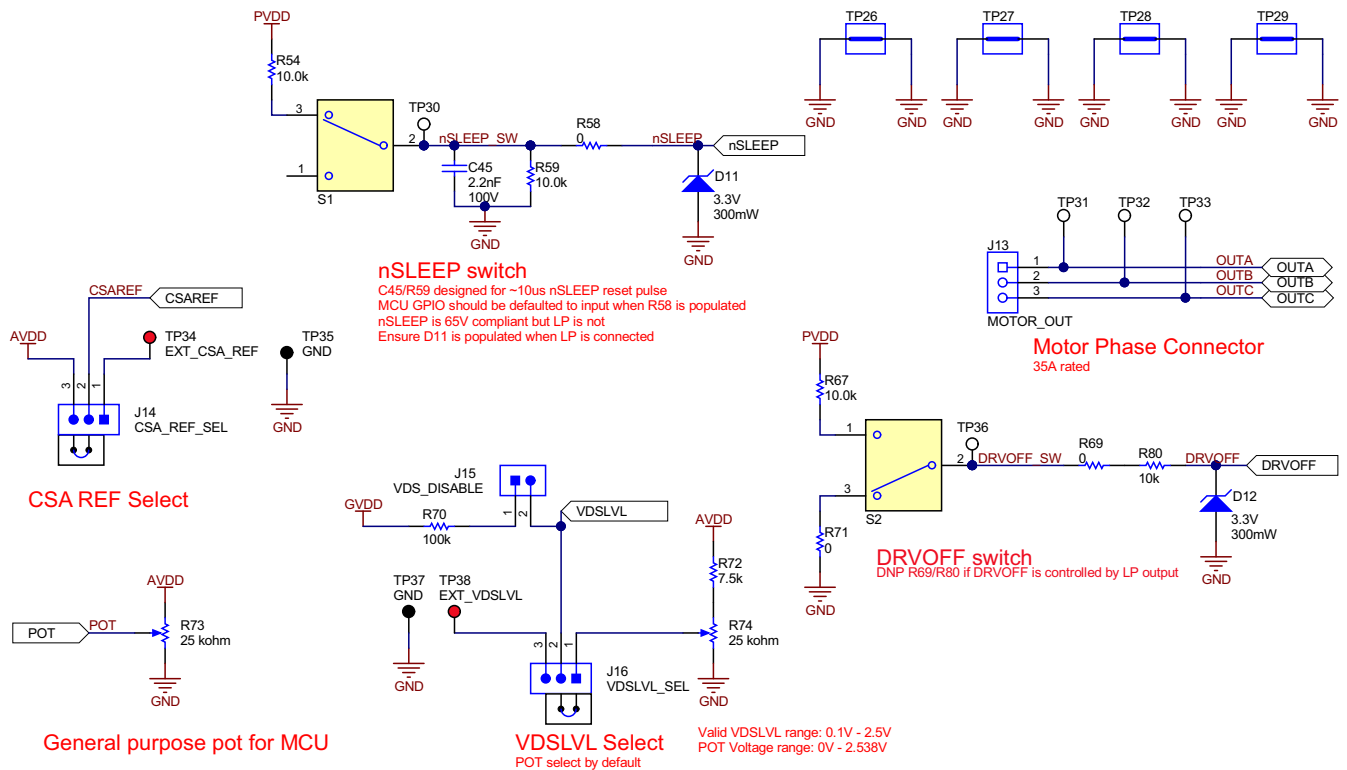
Figure 7-8. Connectors, Selectors, and Analog Control Interface schematic

7.8 Dead Time and CSA Gain Selection
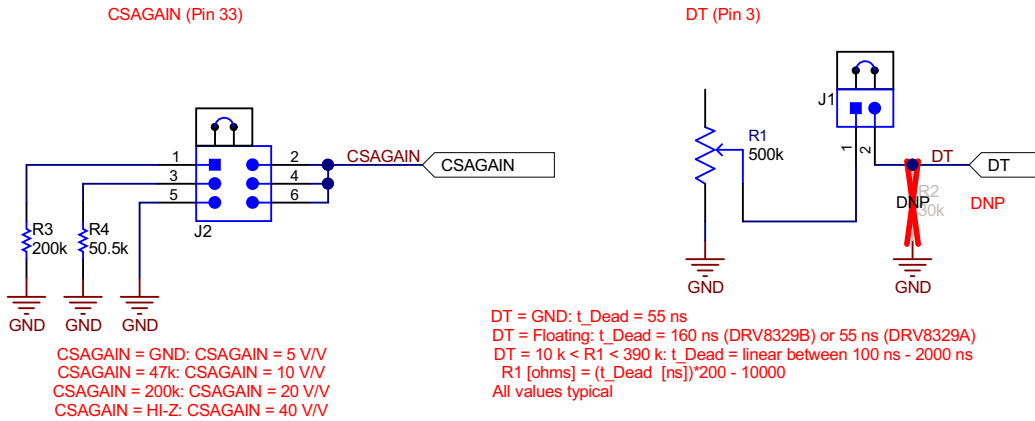
Figure 7-9. Dead time and CSA gain selection schematic

7.9 Voltage Sense and Protection
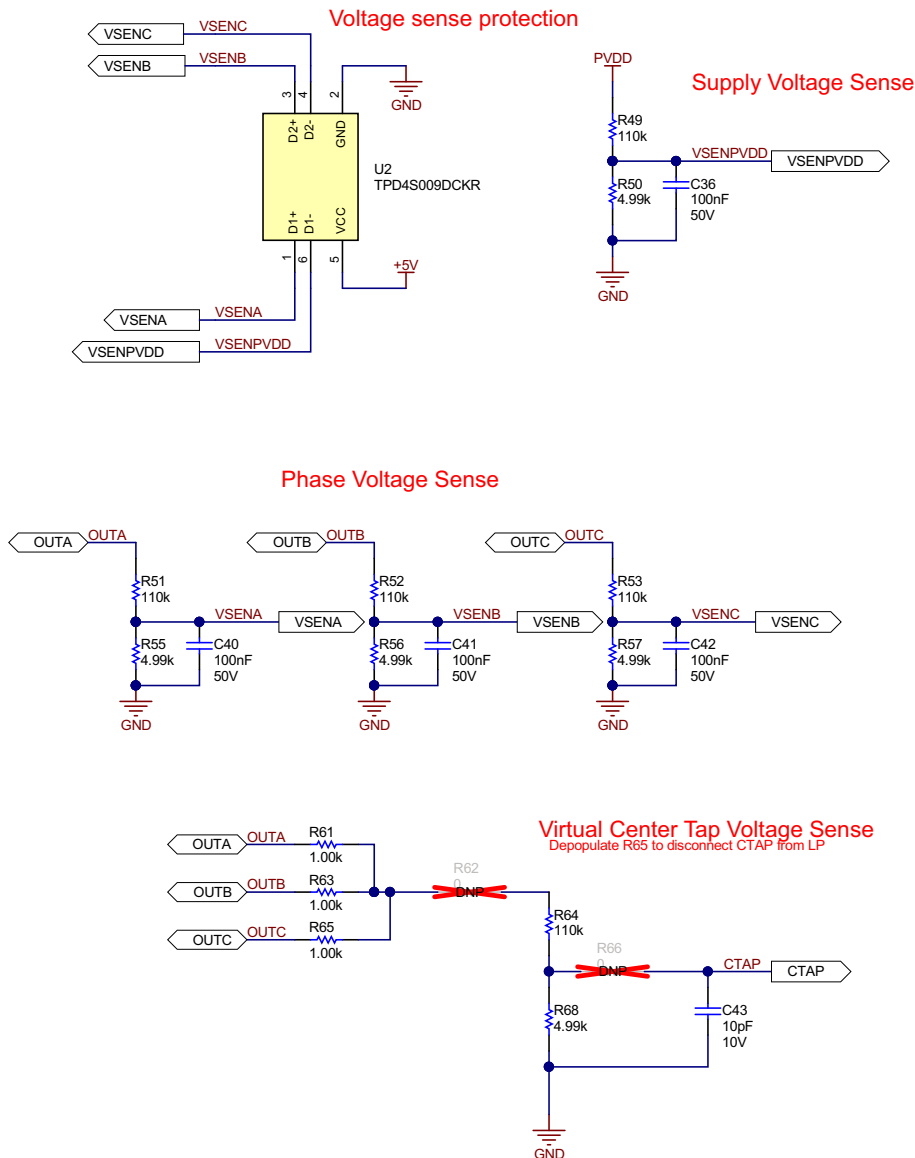
Figure 7-10. Voltage Sense and Protection schematic

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

Changes from Revision * (March 2022) to Revision A (August 2022)   **Page**

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

   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*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   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

Evaluation Kits 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 shall operate the Evaluation Kit within TI's recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI's recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI's instructions for electrical ratings of interface circuits such as input, output and electrical loads.

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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けて

いないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの

措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用 いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。 上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・イ

ンスツルメンツ株式会社

東京都新宿区西新宿６丁目２４番１号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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.

6.   *Disclaimers:*

    6.1   EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

    6.2   EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7.   *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations.* IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

IMPORTANT NOTICE AND DISCLAIMER