User's Guide

DRV8251/AEVM User's Guide

ABSTRACT

This document is provided with the DRV82X1 family customer evaluation modules (EVM) as a supplement to the DRV8251, DRV8251A, DRV8231 and DRV8231A data sheets. This user's guide describes the hardware implementation of the EVM.

Hot surface. Contact may cause burns. Do not exceed limitations of the DRV devices:

4.5-V to 48-V operating supply voltage range • RDS(on), voltage, and current sense/regulation variants (external shunt resistor and integrated current mirror) – DRV8251: 4.5-V to 48-V, 450-mΩ, shunt – DRV8251A: 4.5-V to 48-V, 450-mΩ, mirror – DRV8231: 4.5-V to 33-V, 600-mΩ, shunt – DRV8231A: 4.5-V to 33-V, 600-mΩ, mirror • Keep the peak current below **1.6 A RMS** to avoid temperatures above **130°C** (at 25°C ambient temperature).

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1 PCB (Top and Assembly View)

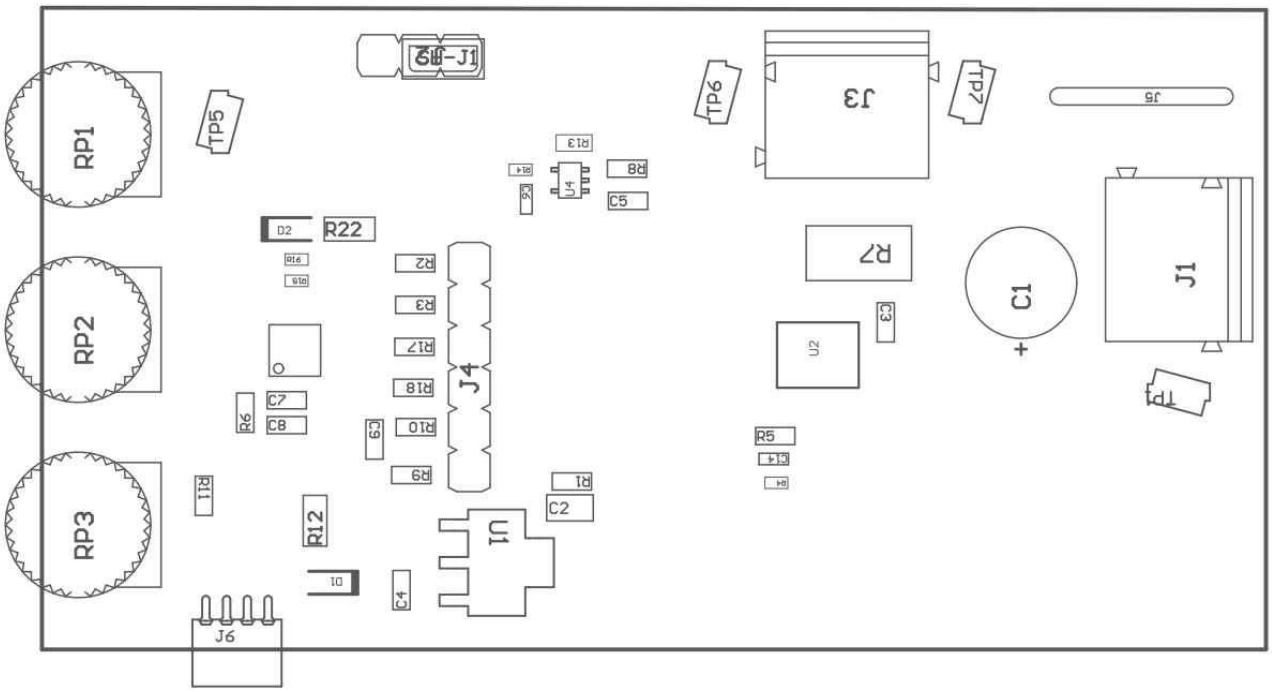

Figure 1-1. PCB Assembly View

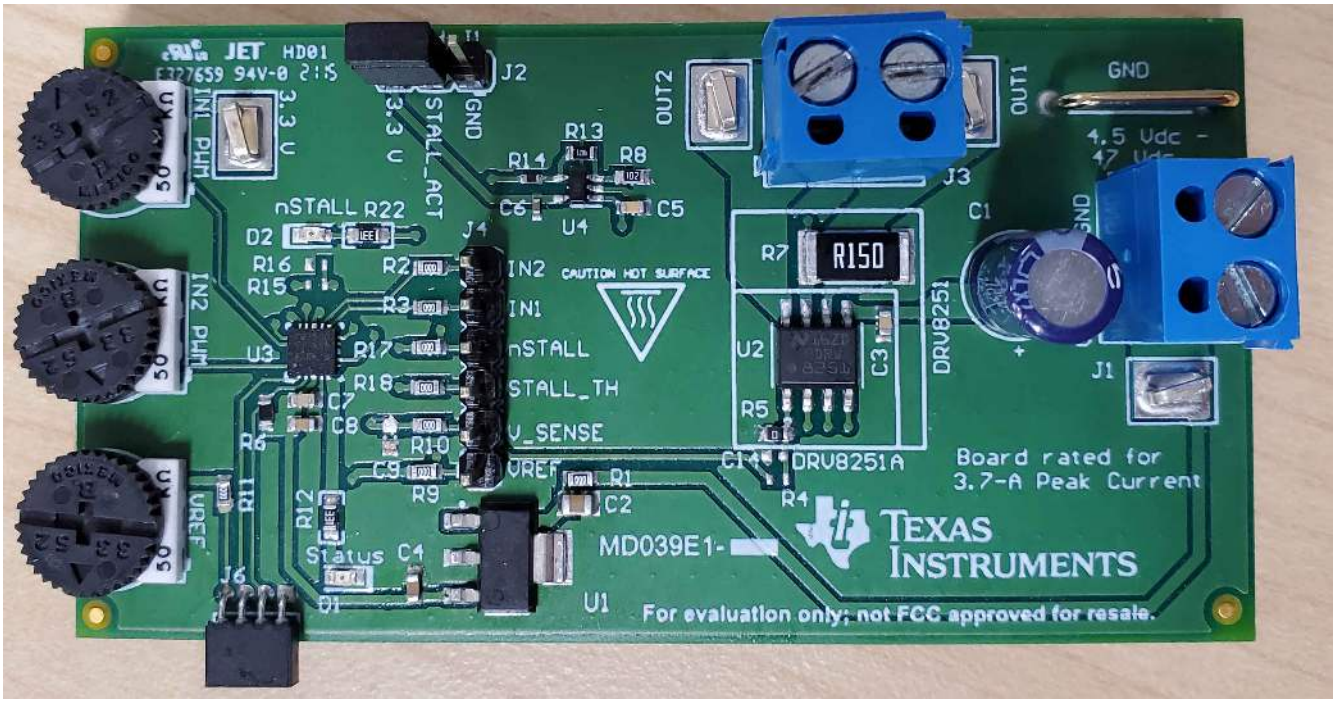

Figure 1-2. PCB Top 3-D View

2 Introduction

The MD039 is a complete solution for evaluating the DRV8251/DRV8251A/DRV231/DRV8231A H bridge motor drivers. It includes the necessary shunt resistors for the current regulation in the non a variants and the internal FETs needed for the current mirroring circuit in the A variants.

The EVM includes and MSP430 microcontroller that is preprogrammed tot ake input from three dedicated analog potentiometers for PWM (POT1) (POT2) speedcontrol as well as VREF (POT3) for current regulation and monitoring. The jumper for STALL_ACT allows for the selection of differetn stall detection features depending on the desired application.

The supply voltage can be externally powered to 48 V for the DRV8251x series and up to 33 V for the DRV8231X series. To expand beyond the included firmware capability, the MSP430 MCU can be reprogrammed through the eZ-FET™ emulation circuit found in most MSP430 Launchpads. We recommend the MSP-EXP430FR5969. Note that a four pin angled male header is required and must be soldered to J21 of this Launchpad from V+ pin to GND pin. We recommend a pin header with pin dimensions similar to 850-10-050-20-001000 (Digikey part number). The U1 MCU must be removed from the Launchpad.

3 Power Connectors and Coding

The DRV8251/AEVM uses a single header for power entry to the EVM board. Only a single power supply rail is necessary since an onboard 3.3-V regulator provides power to the MSP430. The minimum recommended VM voltage for the EVM is 4.5 V and the maximum depends on the specific device installed (see reference section). For complete voltage range information of the driver itself, refer to the device.

As previously mentioned, the MSP430 comes preprogrammed to control basic DC motor operation. If changing the firmware via the external eZ-FET™ emulation tool, do not supply power to the VM connector on the EVM. The eZ-FET™ board provides the necessary power during programming when connected to the J6 connector. Note that a four-pin angled male header is required and must be soldered to J21 of this Launchpad from V+ pin to GND pin shown in image below. We recommend a pin header with pin dimensions similar to the Digikey part number 850-10-050-20-001000. The U1 MCU must be removed from the Launchpad.

3.1 Programming EVM

This section outlines the procedure for programming the EVM with a custom firmware. Out of the box, the DRV8251/DRV8251A EVMs will come programmed so no programming is required from the user. However, the information in this section only applies if the user wants to flash a custom program to the MSP430FR2100 MCU. If you are interested in viewing the source firmware files, go to the tool product page and download the firmware files.

To flash a custom firmware you will need the following components:

1. Code Composer Studio (CCS)
2. DRV8251/DRV8251AEVM
3. MSP430FR5969 LaunchPad
4. Mini USB to USB cable

Follow these steps in order to flash a custom firmware to the EVM MCU

1. Open Code Composer Studio. If you are new to CCS, visit this link to view the user's manual. Alternative, you can visit dev.ti.com/tirex to view code examples for any of the TI MCUs.
2. Connect the power supply cables to the EVM, connect USB cable to the LaunchPad (LP) and the computer, connect the launch pad to the EVM via the J21 connector on the LP and J6 on the EVM, make sure that there are jumpers on "TST", "RST", "V+", and "GND" on J13 on the LP. Your set-up should look as the picture below:

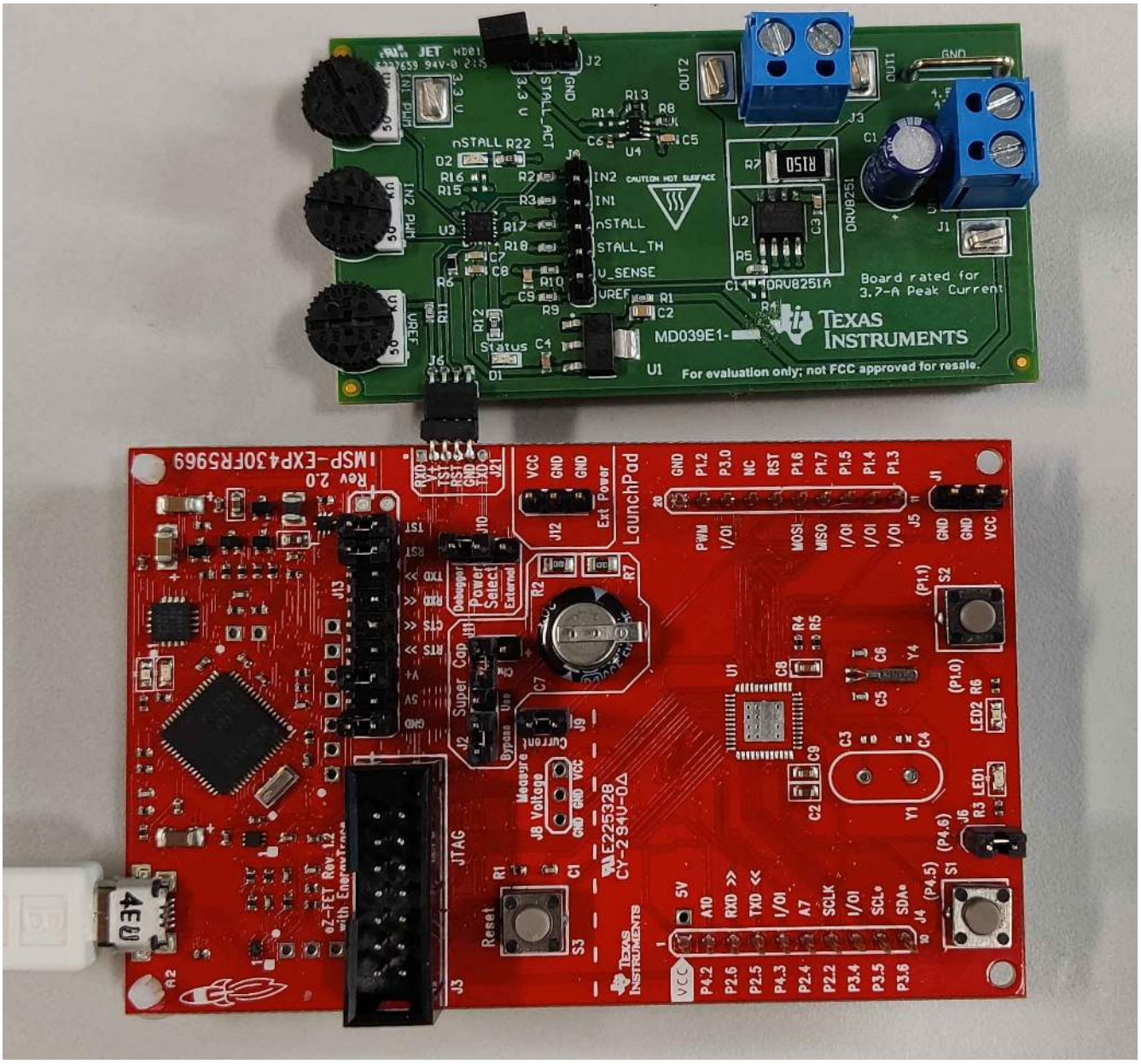

Figure 3-1. MSP-EXP430FR5969 connected to EVM

3. Once the code is ready to be flashed to the MCU, click on the "Debug" icon on the top left of the window.

a.

Figure 3-2. CCS Debug Icon

4. If there are no compiling or linking issues, a "Play" button will appear on the top left window. Click on it to run the program. If you get any errors in the code or any other error messages, please submit a post on e2e.ti.com for assistance.
5. Congrats! Your EVM is now programmed with your custom code. You may now disconnect the EVM from the LP.

4 Component Description

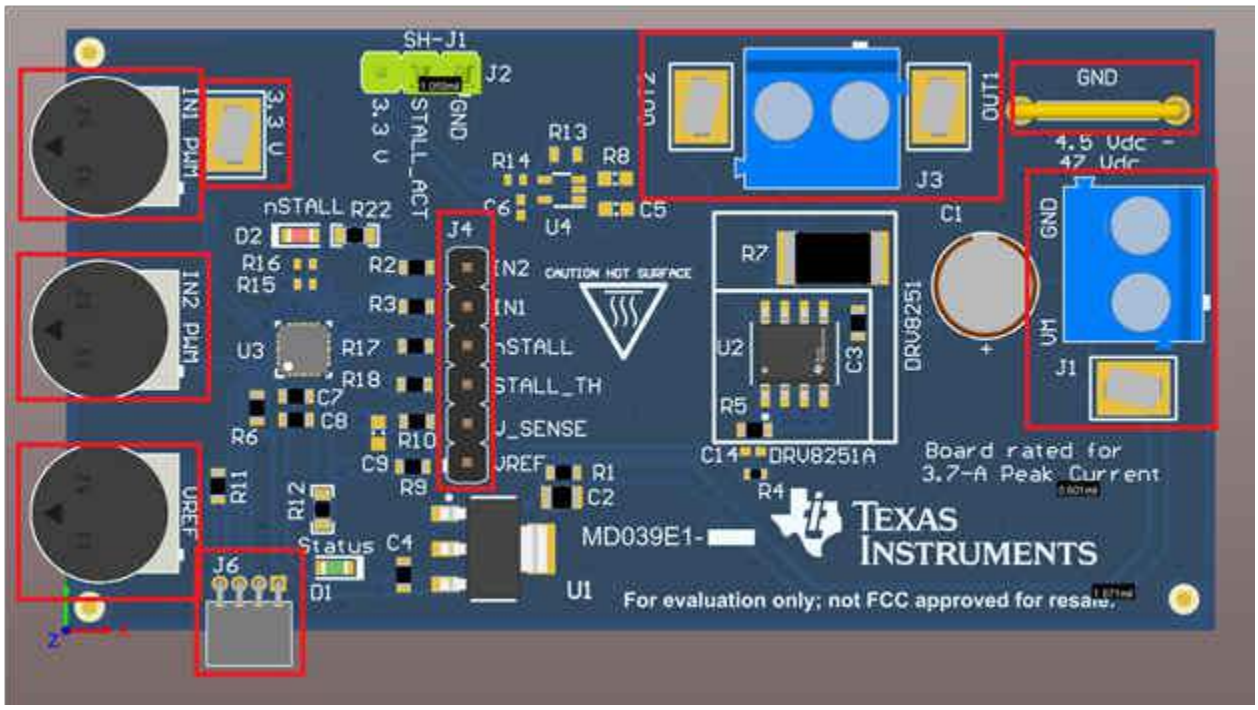

Figure 4-1. Render With Components Labelled

Table 4-1. Component Reference

Connector/Component	Function
J1	Main poer supply connector
J3	Motor connection
J4	Signal header test points
J6	Header for launchpad connection
VREF	Potentiometer for VREF Adjustment
3.3 V	3.3-V LDO Test point
IN1 PWM	Potentiometer for VREF Adjustment
GND	Main ground

Explanation of Components:

1. Pot1 controls the PWM signal that goes into IN1, by turning it clockwise you increase the duty cycle from 0% to 100%.
2. Pot 2 controls the PWM signal that goes into IN2, by turning it clockwise you increase the duty cycle from 0% to 100%.
3. The potentiometer labelled VREF controls the setting for VREF. When turning it clockwise it increases gradually until it reaches its limit adjusting VREF for 3.3 V
   a. VREF is responsible for current regulation threshold, by lowering the value in VREF turning it counterclockwise you will lower the current regulation threshold.
4. IN1 and IN2 test points will display the PWM signals coming from the microcontroller. Be sure to refer to the stickers in the board to correctly identify IN1 and IN2 test points.
5. Vsense/Ipropi test point provides a voltage that is dependent on the current going through the load for current regulation.
   a. Said curent, and current regulation can be calculated by the equations in the current sensing and current regulation section.

5 Operation of the EVM

Quickstart guide

1. Move POT1, POT2, and VREF all the way counter-clockwise
2. Connect power supply to connector J1. J1 is positive terminal and GND negative terminal as shown in Figure 5-1.

Figure 5-1. Power Connected

3. Set power supply to desired voltage dependent on load, do not exceed the maximum limits of the device see section above for max limits, for 8231 series it is 33 V
4. Enable power supply
5. The status LED D1 (Bottom left green led) will turn on
6. Disable power and connect load in J3 as shown in Figure 5-2:

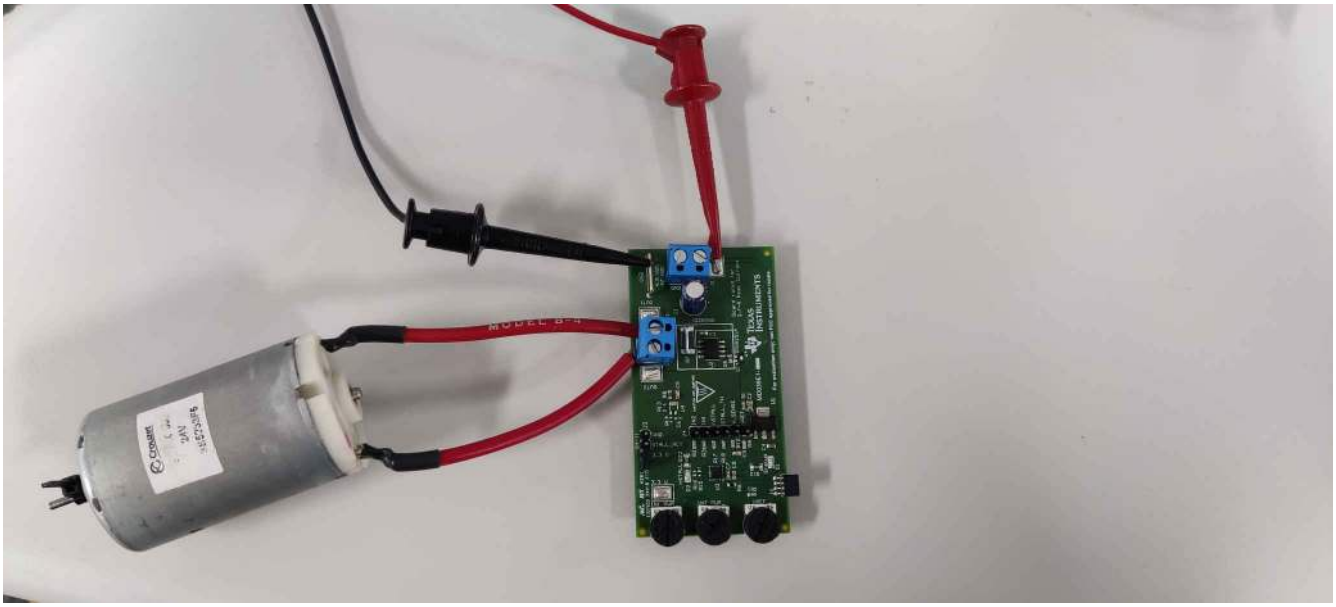

Figure 5-2. Power and Load Connected

7. Re-enable power
8. Turn VREF potentiometer all the way clockwise.
   a. This will make Itrip the maximum value possible.

9. Turn “POT1” (labeled as “IN1_PWM” on silkscreen) clock-wise. The motor should start spinning and its speed should increase as the POT is turn more clockwise.
10. Slowly turn VREF counter clockwise while probing the VREF test point, this should allow you to set VREF to the desired value for current regulation. If not current regulation is desired then leave VREF fully clockwise.
11. Turn “IN1_PWM” POT all the way counter-clockwise. Motor should come to a complete stop.
12. Turn “IN2_PWM” POT clock-wise. Motor should begin to spin the opposite direction of step 9

5.1 H-Bridge Control

Table 5-1. H-Bridge Control

IN1	IN2	OUT1	OUT2	DESCRIPTION
0	0	High-Z	High-Z	Coast; H-bridge disabled to High-Z (sleep entered after 1 ms)
0	1	L	H	Reverse (current OUT2 → OUT1)
1	0	H	L	Forward (current OUT1 → OUT2)
1	1	L	L	Brake; low-side slow decay

The inputs can be set to static voltages for 100% duty-cycle drive, or they can be pulse-width modulated (PWM) for variable motor speed. When using PWM, switching between driving and braking typically works best. For example, to drive a motor forward with 50% of its max RPM, IN1 = 1 and IN2 = 0 during the driving period, and IN1 = 1 and IN2 = 0 during the other period. Alternatively, the coast mode (IN1 = 0, IN2 = 0) for *fast current decay* is also available. The input pins can be powered before VM is applied.

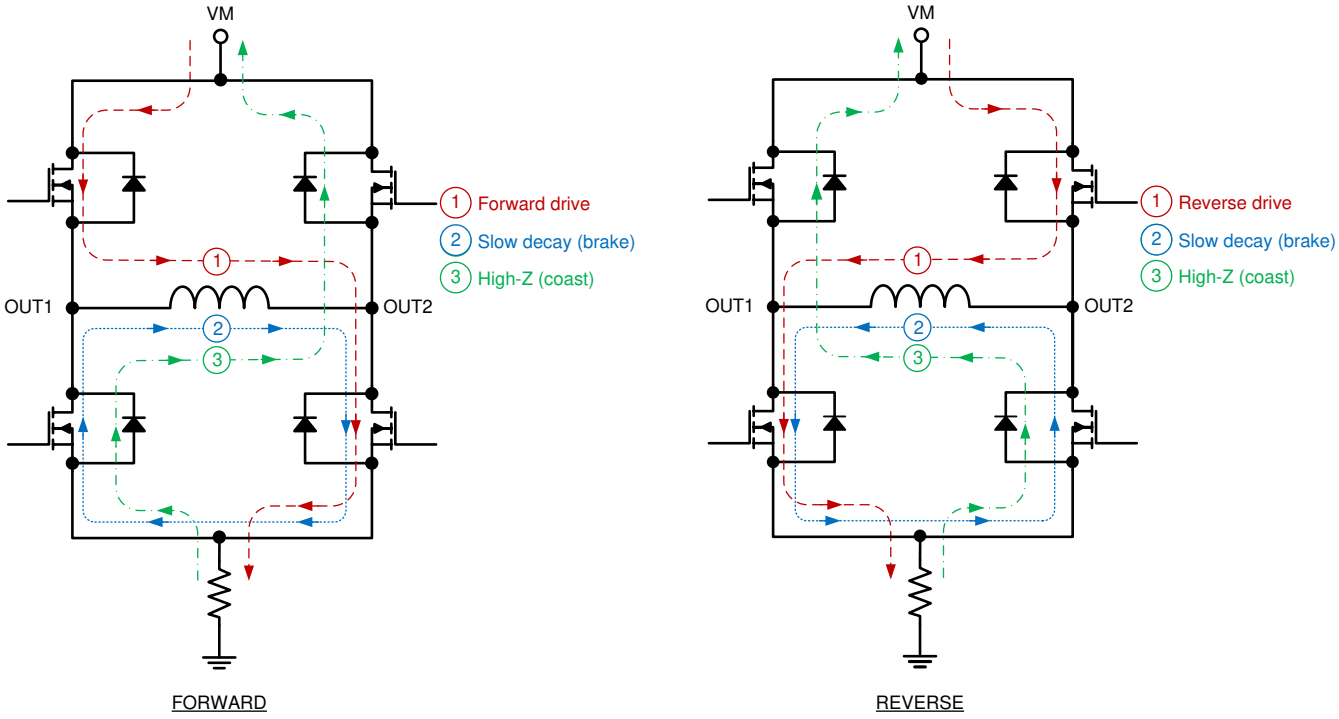

Figure 5-3. H-Bridge Current Paths

5.2 Current Sensing and Current Regulation Details

The current sensing and current regulation will depend on the device used:

DRV8251AEVM and DRV8231AEVM:

An internal current mirror architetcture on the IPROPI pin implements current sensing and regulation. This eliminates the need for a large power shunt resistor, saving board area and reducing system cost. The IPROPI current-sense output allows a microcontroller to detect motor stall or changes in load conditions. VREF determines the threshold of current regulation during start-up and stall events without interaction of a microcontroller.

The motor current can be monitor by the IPROPI pin voltage. The IPROPI voltage is the voltage proportional to the motor current. A more detailed explanation on how current regulation and sensing can be found on section 8.4.3 of the datasheet.

DRV8251EVM and DRV8231EVM:

Features integrated current regulation. This is implemented by comparing the analog input VREF and the voltage on the ISEN pin, which is proportional to motor current through an external sense resistor. The ability to limit current to a known level can significantly reduce the system power requirements and bulk capacitance needed to maintain stable voltage, especially for motor startup and stall conditions.

Current regulation for both variants will be dependent on Itrip, a set threshold which once exceeded will cause the device to enter current regulation. This threshold can be adjusted by the VREF potentiometer and follows the following equations:

$$I_{TRIP}\ (A) = \frac{VREF\ (V)}{A_v \times R_{ISEN}\ (\Omega)} = \frac{VREF\ (V)}{10 \times R_{ISEN}\ (\Omega)}$$

- DRV8870: 6.5-V to 45-V, 565-mΩ, shunt
- DRV8251: 4.5-V to 48-V, 450-mΩ, shunt
- DRV8251A: 4.5-V to 48-V, 450-mΩ, mirror
- DRV8231: 4.5-V to 33-V, 600-mΩ, shunt
- DRV8231A: 4.5-V to 33-V, 600-mΩ, mirror

Figure 5-4. Current Regulation Equations

For more information be sure to refer to the datasheet of the device installed on the EVM.

6 Removing and Installing Supported Motor Drivers

The EVM can support the DRV8251/DRV8251A/DRV8231/DRV8231A devices. Below are step-by-step instructions on how to remove and place different drivers on the EVM:

1. Disconnect power from the EVM.
2. Carefully de-solder the device from the PCB. Make sure to follow proper soldering and ESD protection procedures to prevent damage to the EVM.
3. Carefully solder the new device to the EVM. Visit ti.com or any authorized third party vendor to purchase the desired driver.
4. The EVM uses a combination of resistors to identify the device that is populated on the board.
5. The firmware will function slightly different depending on the device that is on the board. After installing the new device, make sure to populate the appropriate resistors.

The Table 6-1 shows the changes that need to be implemented when switching from one device to the other.

Table 6-1. Procedure For Soldering New Device and Passives to EVM

New device being installed	Soldering procedures
8251 switching to 8251A	• Solder the device to footprint U2. Make sure pin 1 of device aligns with the dot on the PCB • Depopulate C6, R5, R7, R8, R13, R14 and U2 • Populate R4 and R7 with 0 ohm resistor. • Populate R5 with 1.5 kOhm resistor
8251A switching to 8251	• Solder the device to footprint U2. Make sure pin 1 of device aligns with the dot on the PCB • Depopulate R4, R5, and R7 • Populate R5 and R14 with 0 ohm resistor • Populate R7 with 0.15 ohm resistor • Populate C6 with 0.1 uF cap • Populate R8 with 1k ohm resistor • Populate R13 with 4.02 k ohm resistor • Populate U4 with TLV9001IDCKRBe mindful of warnings in voltage differences.

This hardware can be used to test and validate the 8231 series as it is pin to pin compatible with the DRV8251 series. The steps of switching between DRV8231 and DRV8231A are identical as those between the DRV8251 to 8251A and vice versa.Be mindful of warnings in voltage differences.

7 Revision History

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

DATE	REVISION	NOTES
November 2021	*	Initial Release

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