

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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Trademarks

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1 PCB (Top and Assembly View)

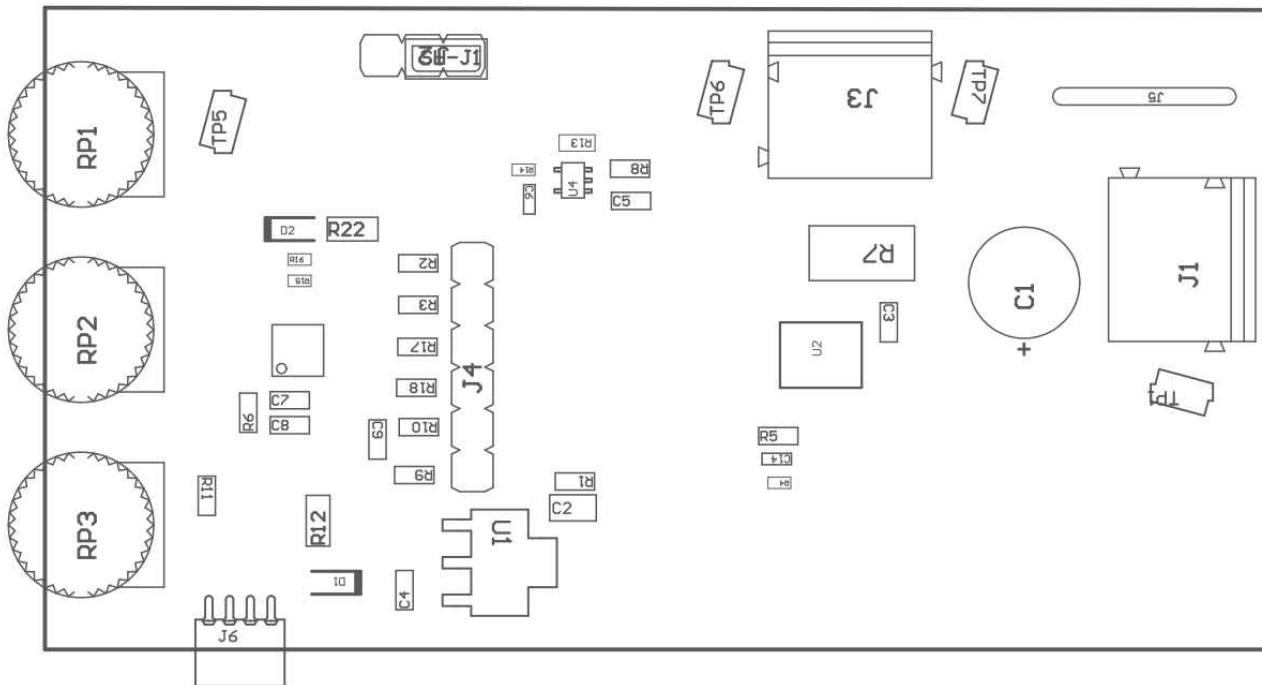


Figure 1-1. PCB Assembly View

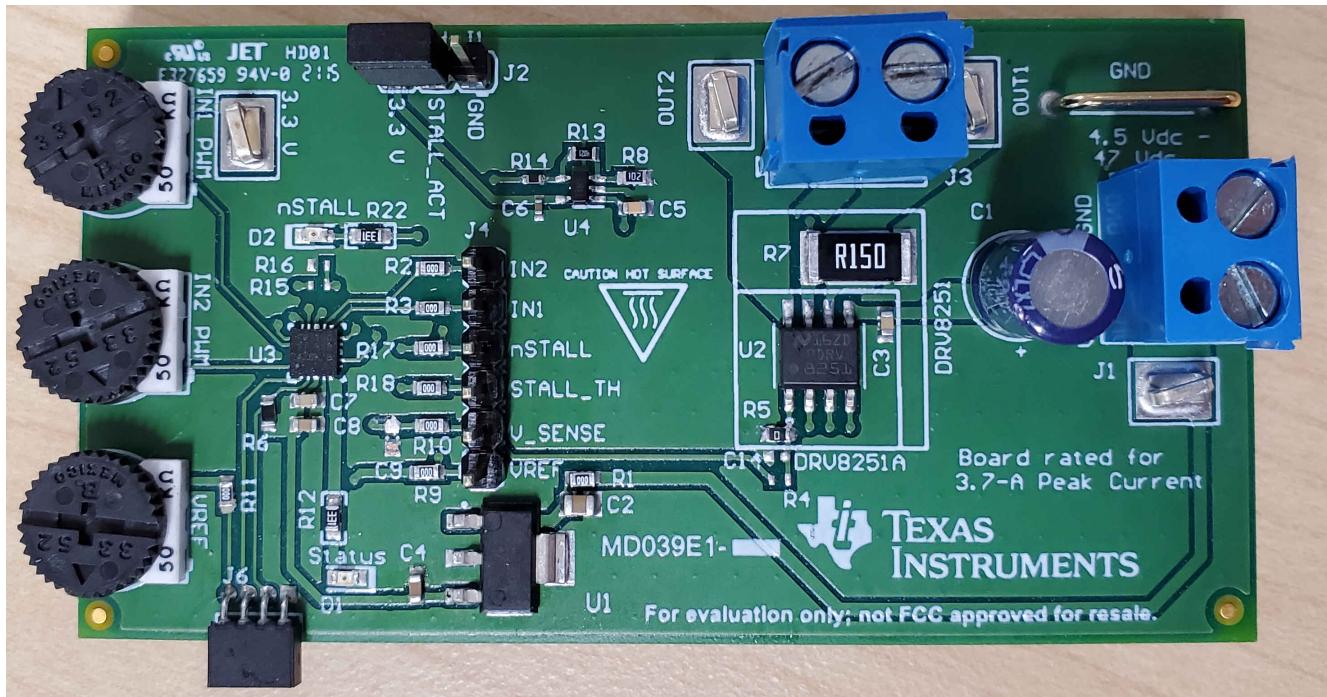


Figure 1-2. PCB Top 3-D View

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 an MSP430 microcontroller that is preprogrammed to take input from three dedicated analog potentiometers for PWM (POT1) (POT2) speed control as well as VREF (POT3) for current regulation and monitoring. The jumper for STALL_ACT allows for the selection of different 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. Alternatively, 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:

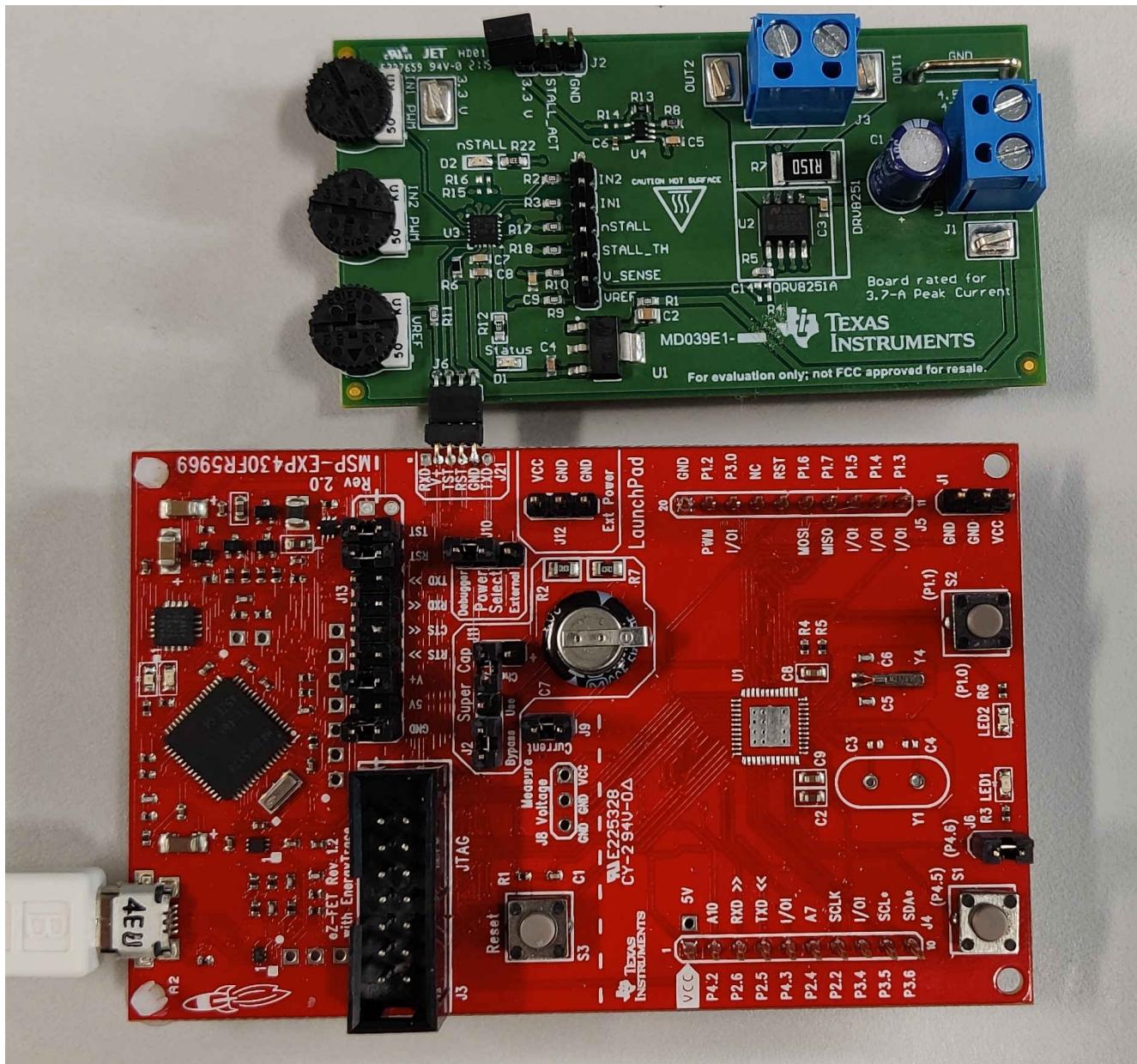


Figure 3-1. MSP-EXP430FR5969 connected to EVM

- 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

- 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.
- Congrats! Your EVM is now programmed with your custom code. You may now disconnect the EVM from the LP.

4 Component Description

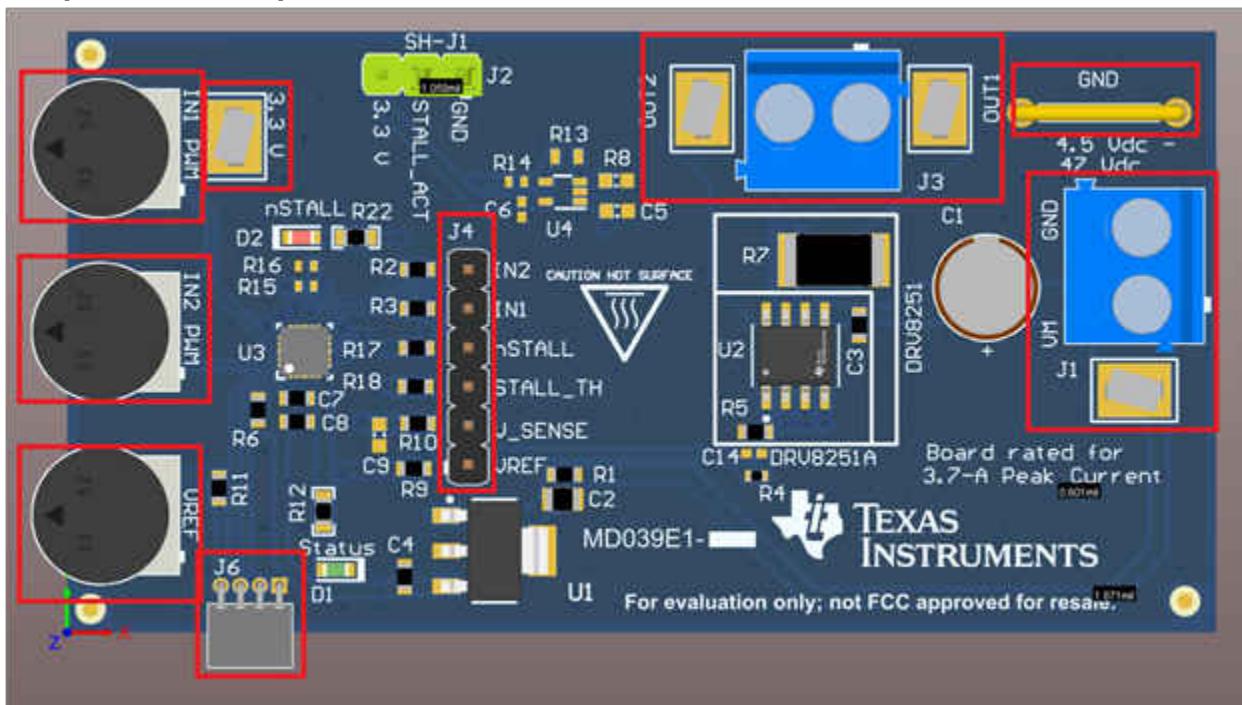


Figure 4-1. Render With Components Labelled

Table 4-1. Component Reference

| Connector/Component | Function |
|---------------------|-----------------------------------|
| J1 | Main power 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/Ipropri test point provides a voltage that is dependent on the current going through the load for current regulation.
 - a. Said current, 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.

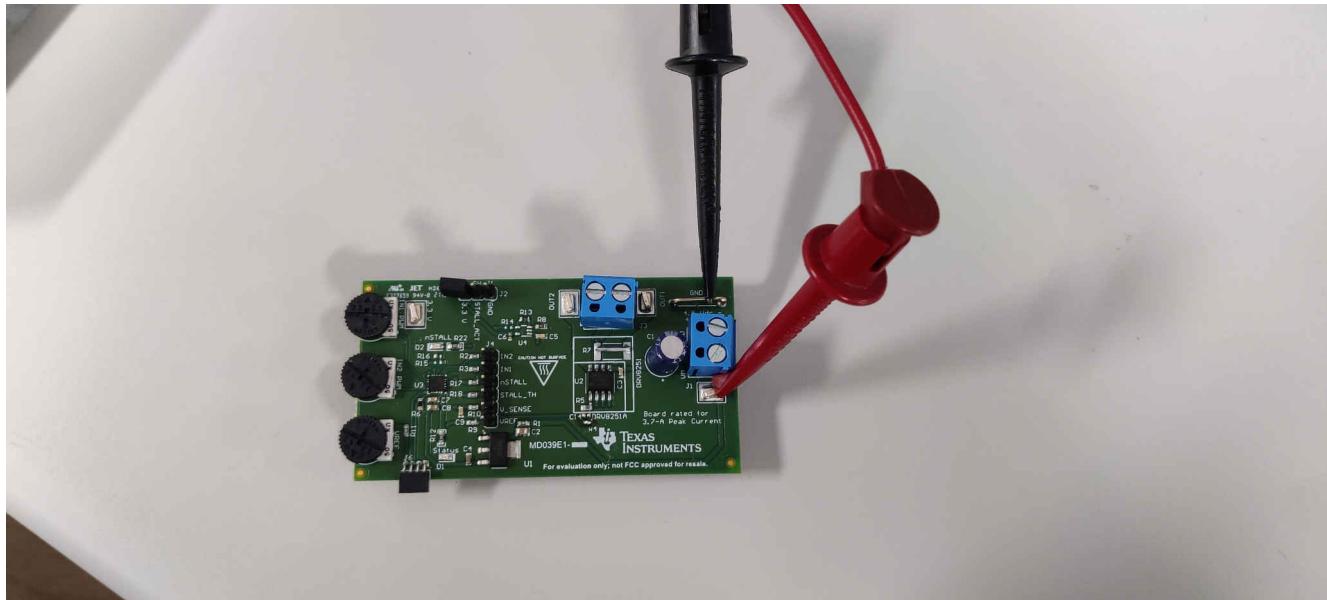


Figure 5-1. Power Connected

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:

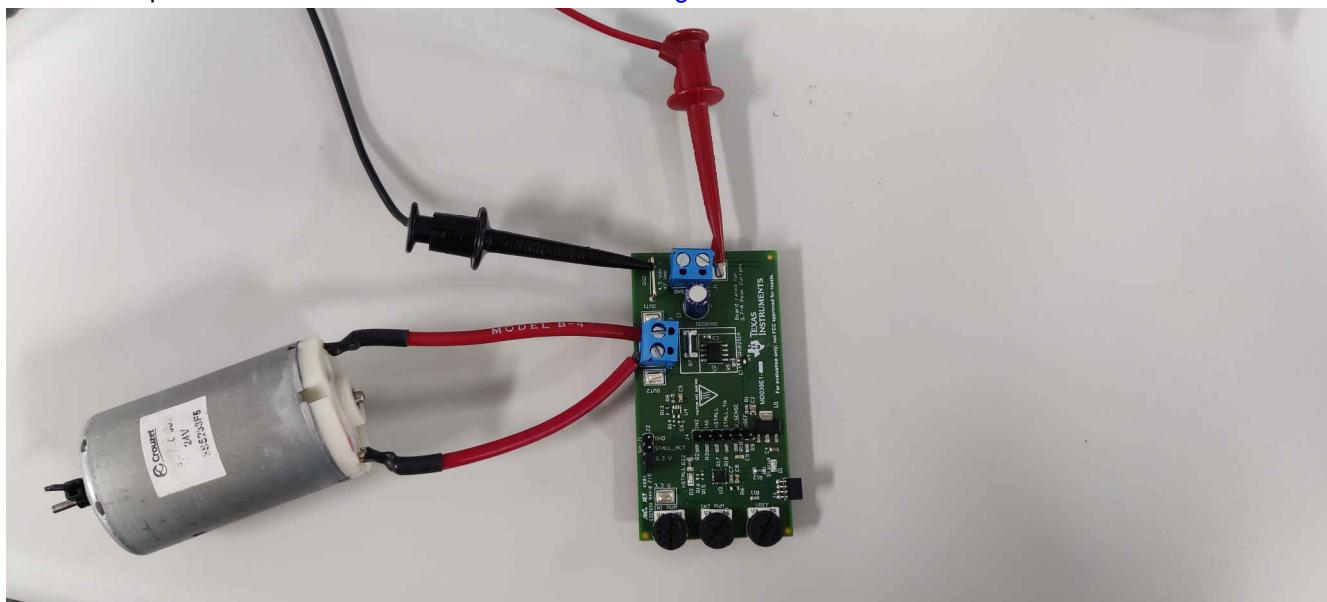


Figure 5-2. Power and Load Connected

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 = 1 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.

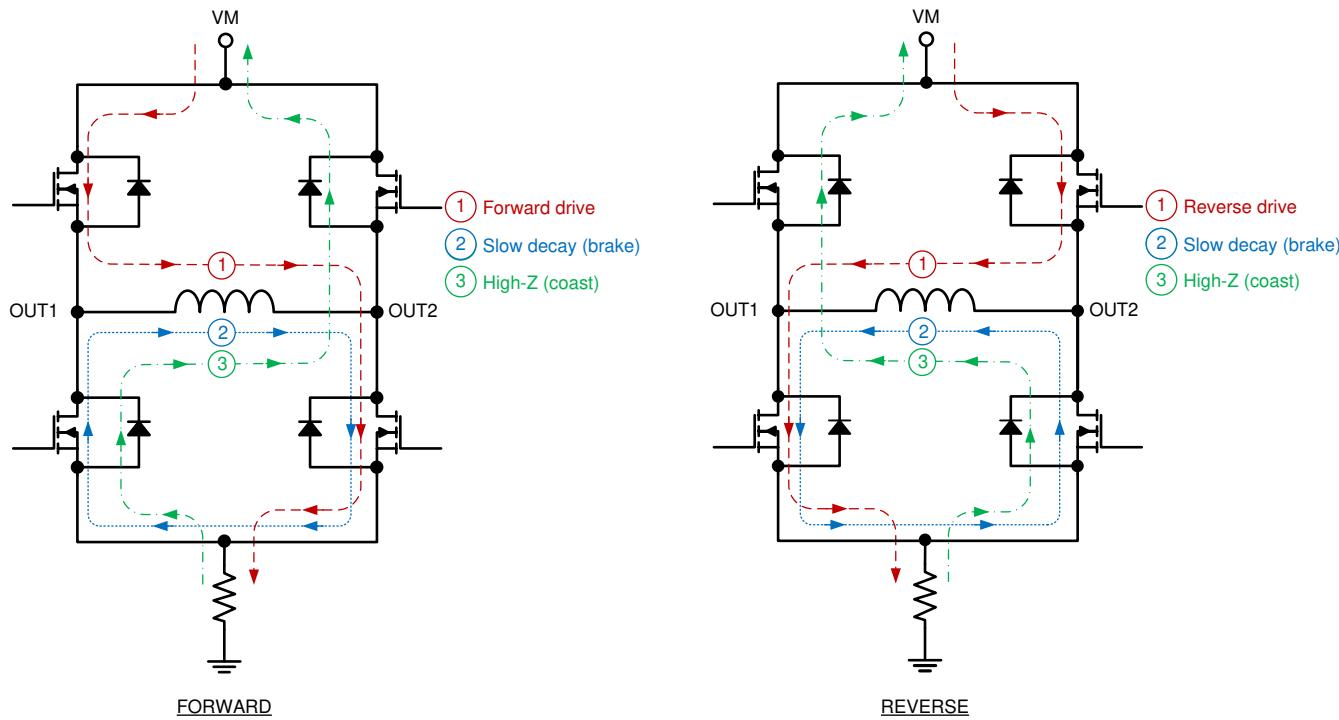


Figure 5-3. H-Bridge Current Paths

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 architecture 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 monitored 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 I_{trip} , 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 | <ul style="list-style-type: none"> • 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 | <ul style="list-style-type: none"> • 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 |

STANDARD TERMS FOR EVALUATION MODULES

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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:*
 - 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 DEGRADATION 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 isotope 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/lsts/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。

<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html>

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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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsts/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。<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html>

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.

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