



ABSTRACT

This document is provided with the DRV82xx family customer evaluation modules (EVM) as a supplement to the DRV8210, DRV8212, and DRV8220 data sheets. This user's guide describes the hardware implementation of the EVM.

CAUTION

Hot surface. Contact may cause burns. Do not Touch.

DRV8210EVM and DRV8212EVM are rated for power supply voltages between 1.65 VDC and 11 VDC max. The DRV8210 can support peak output currents up to a maximum of 1.6 ADC and the DRV8212 can support peak output currents up to a maximum of 4 ADC. To maintain component temperatures below the 130°C rating of the printed circuit board material, TI requires that the continuous current of both channels be limited to **0.9 A-RMS** when operating for extended periods of time at an ambient temperature of 25°C.

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PCB (Top-Assembly View)

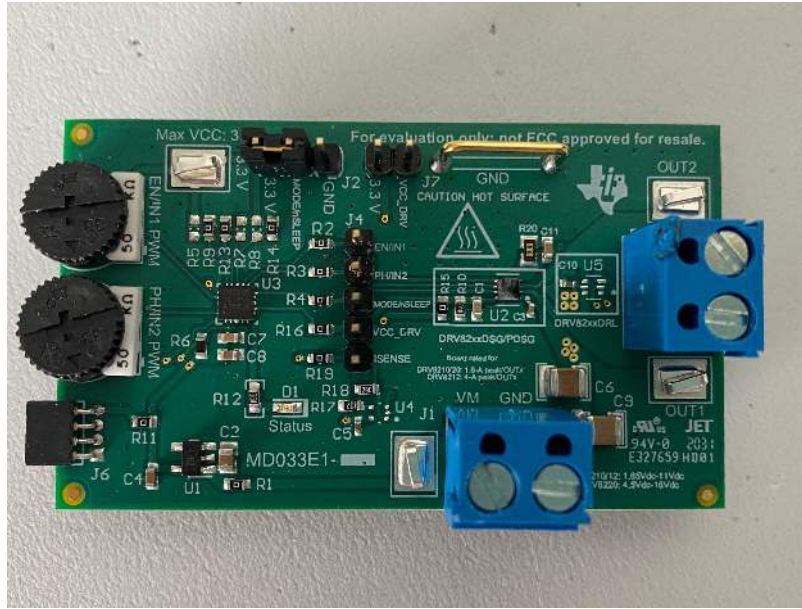


Figure 1-1. PCB (Top 3-D View)

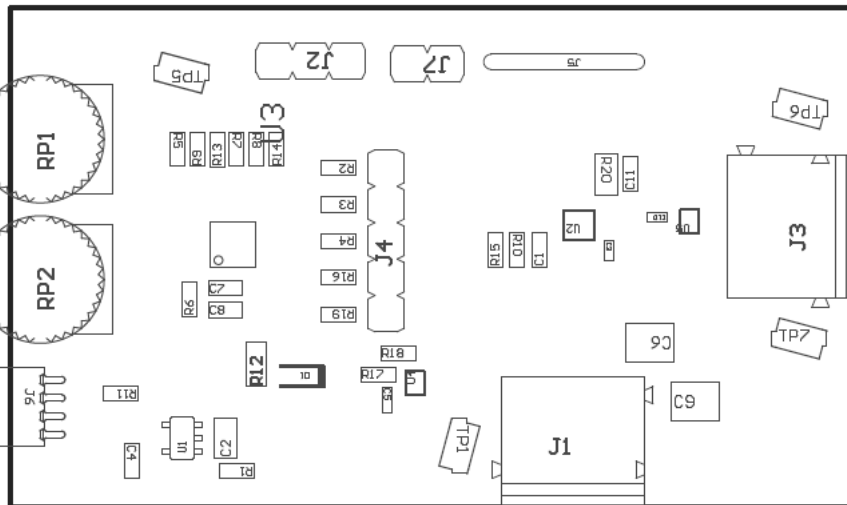


Figure 1-2. PCB (Assembly View)

1 Introduction

The DRV821x/8220EVM is a complete solution for evaluating the DRV821x/8220 H-bridge motor drivers. The evaluation module (EVM) can support the DSG, PDSG, and DRL package variants of the DRV8210/12/20 devices. However, only one component can be populated at a time since the input control signals (EN/IN1 and PH/IN2) are shared among the two components.

The EVM includes current sensing circuitry using a current sensing resistor and current sense amplifier (for additional details about the current sensing see [Section 3](#)). The EVM includes an MSP430™ microcontroller that is preprogrammed to take input from two dedicated analog potentiometers for PWM speed control of one or two brushed DC motors. The jumper on the PMODE/nSLEEP pin (J2) allows the user to select the input control mode or the sleep state of the driver depending on which component is populated on the EVM (further details are provided in [Section 2](#)).

Power can be provided externally up to 11 V for the DRV8210/12 and 18V for the DRV8220 through the power header. 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.

2 Power Connectors

The DRV821x/8220EVM 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 1.65 V and the maximum is 18 V. 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 [Figure 2-1](#). 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.

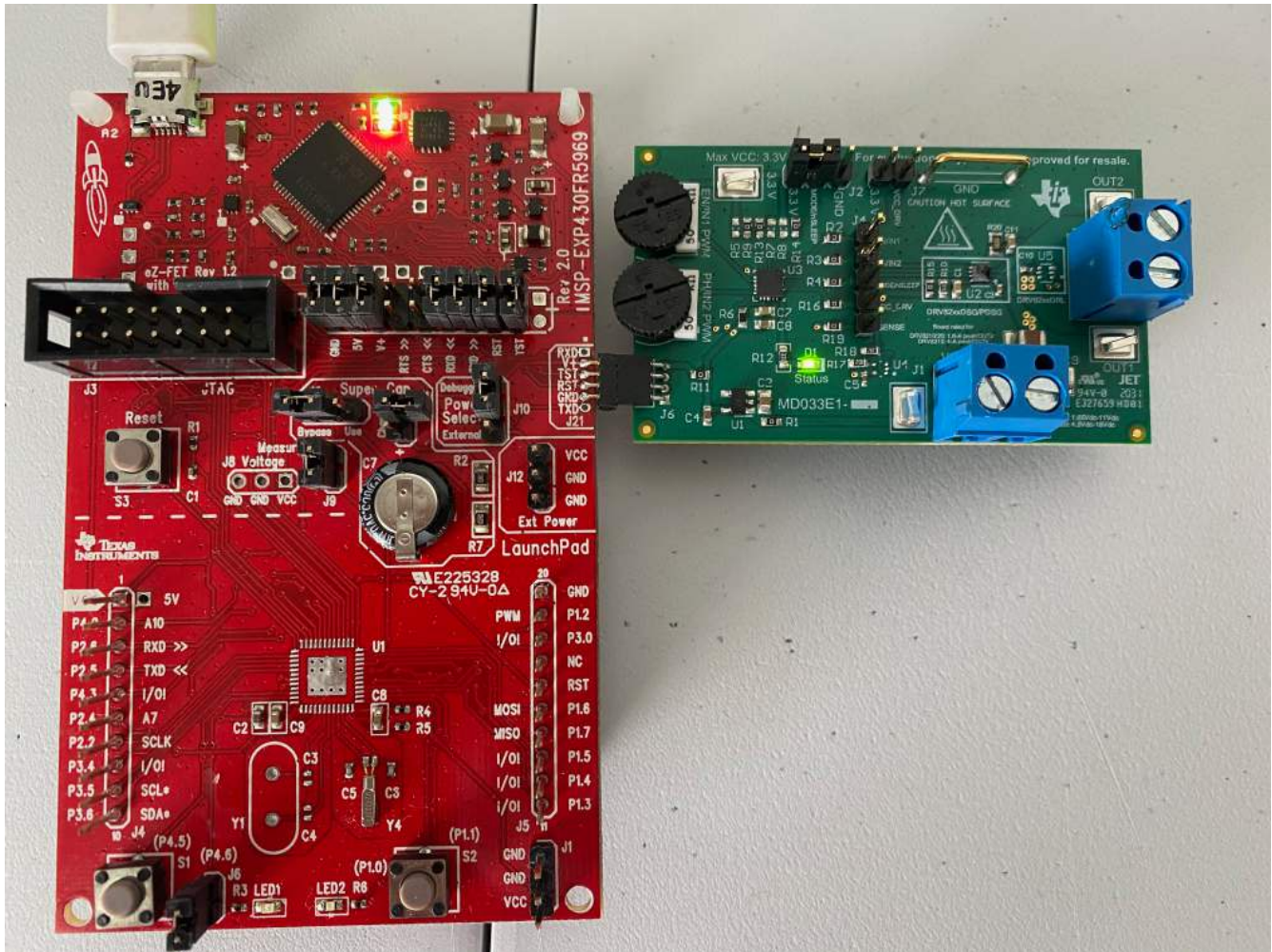


Figure 2-1. MSP-EXP430FR5969 LaunchPad connected to EVM

3 Test Points

Table 3-1. DRV821xEVM and DRV8220EVM Test Points

Test Point	Description
J4	<ul style="list-style-type: none"> • Header contains all the MCU control signals (EN/IN1, PH/IN2, MODE/nSLEEP, VCC_DRV, and ISENSE). <ul style="list-style-type: none"> – EN/IN1 & PH/IN2: input control signals – MODE/nSLEEP: multi-purpose pin; pin used as MODE selector pin when DRV821xDSDG or DRV8220DSDG is populated; pin used as nSLEEP when DRV821xPDSG is populated. – VCC_DRV: signal functions as nSLEEP when the DRV8220DSDG is populated. – ISENSE: output from the current sense amplifier (U4). • R2, R3, R4, R16, and R19 can be removed to connect external MCU to J4.
J2	Header use to set the state of the MODE/nSLEEP signal. MODE/nSLEEP can be set to either GND or 3.3 V.
J7	Header use to short VCC_DRV to 3.3 V to awake the DRV8220DSDG
J6	4-pin connector to program MSP430FR2100 on the EVM (read Section 2)
J5	GND test point
TP6 and TP7	OUT1 and OUT2 test points
TP1	VM test point
TP5	VCC (3.3 V LDO output) test point.

4 MODE/nSLEEP Jumper and Speed-Adjustment Potentiometers

The MODE/nSLEEP header (J2) and jumper allow the user to set the state of the MODE pin or nSLEEP pin depending on the device populated on the EVM. If the DRV821xDSG is populated, J2 allows the user to select from the input modes of PWM (GND), PH/EN (3.3 V), and independent half-bridge control (Hi-Z).

If the DRV821xPDSG is populated, J2 allow the user to set the device to a low-power sleep mode (GND) or to enable the device (3.3V). MODE is only applicable to the DRV821xDSG and DRV8220DSG. The inputs to the DRV821xDSG are EN/IN1 and PH/IN2. The functions of these inputs are IN1 and IN2 when the MODE is GND (PWM mode) or Hi-Z (independent half-bridge mode). When MODE is connected to 3.3 V (PH/EN control mode) the input function is a phase/enable (PH/EN) interface.

The MSP430 produces PWM signals for the EN/IN1 and PH/IN2 pins with duty cycles proportional to the voltage from the PWM potentiometers. The tables below show how to configure the potentiometers for each MODE configuration.

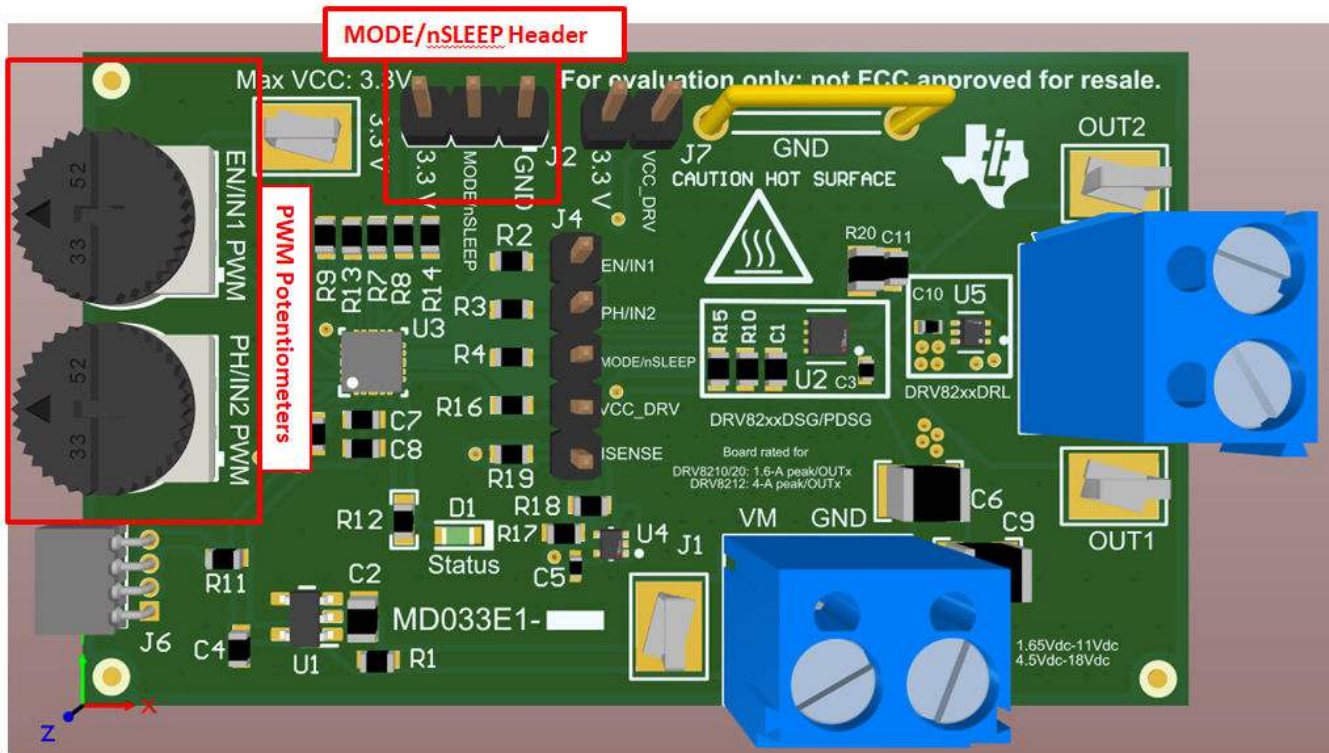


Figure 4-1. MODE /nSLEEP header and PWM Potentiometers

4.1 PH/EN Control Mode (MODE=Logic High)

When the MODE /nSLEEP pin is logic high on power up, the device latches into PH/EN mode (Figure 4-2). PH/EN control mode is only supported by the DRV821xDSG devices. PH/EN mode allows for the H-bridge to be controlled with a speed and direction type of interface. The truth table for PH/EN mode is shown in (Table 4-1). This method is best for bidirectional driving for one motor.

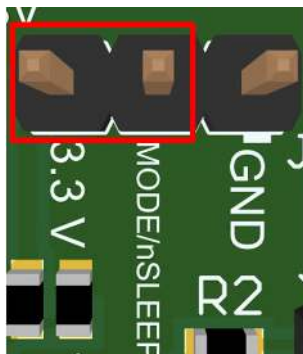


Figure 4-2. MODE /nSLEEP jumper configuration for PH/EN

Table 4-1. PH/EN Control Mode

EN	PH	OUT1	OUT2	Description
LOW - turn IN1 PWM Pot completely counter-clockwise	X	L	L	Brake, (Low-Side Slow Decay)
PWM - set IN1 PWM pot in any position	LOW - turn IN2 PWM pot completely counterclockwise	L	H	Reverse (OUT2 -> OUT1)
PWM - set IN1 PWM pot in any position	HIGH - turn IN2 PWM pot completely clockwise	H	L	Forward (OUT1 -> OUT2)

4.2 PWM Control Mode (MODE = Logic High, DRL, PDSG)

When the MODE pin is logic high on power up, the device latches into PWM mode (Figure 4-3). PWM is the standard control mode for the DRV82xxDRL and DRV82xxPDSG devices. PWM mode allows for the H-bridge to enter the Hi-Z state without taking the nSLEEP pin logic low. The truth table for PWM mode for the DSG variants is shown in Table 4-2 and for the PDSG variants in Table 4-3. This method is best for bidirectional driving for one motor.

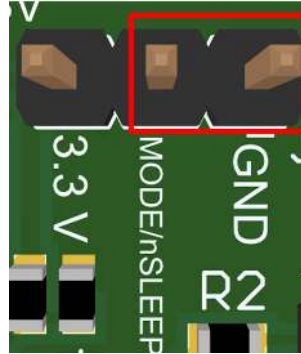


Figure 4-3. MODE /nSLEEP jumper configuration for PWM

Table 4-2. PWM Control Mode for DSG Devices

IN1	IN2	OUT1	OUT2	Description
LOW- turn EN/IN1 PWM pot completely counter-clockwise	LOW- turn PH/IN2 PWM pot completely counter-clockwise	Hi-Z	Hi-Z	Coast (H-bridge Hi-Z)/ Low-power automatic sleep mode
PWM - turn EN/IN1 PWM pot in any position	HIGH- turn PH/IN2 PWM pot completely clockwise	L	H	Reverse (OUT2 -> OUT1)
PWM - turn EN/IN1 PWM pot in any position	LOW- turn PH/IN2 PWM pot completely counter-clockwise	H	L	Forward (OUT1 -> OUT2)
HIGH- turn EN/IN1 PWM pot completely clockwise	HIGH- turn PH/IN2 PWM pot completely clockwise	L	L	Brake, (Low-Side Slow Decay)

Table 4-3. PWM Control Mode for PDSG Devices

nSLEEP	IN1	IN2	OUT1	OUT2	Description
0 (connect MODE/ nSLEEP pin to GND pin)	X	X	Hi-Z	Hi-Z	Coast (H-bridge Hi-Z)/ Low-power automatic sleep mode
1 (connect MODE/ nSLEEP pin to 3.3V pin)	PWM - turn EN/IN1 PWM pot in any position	HIGH- turn PH/IN2 PWM pot completely clockwise	L	H	Reverse (OUT2 -> OUT1)
1 (connect MODE/ nSLEEP pin to 3.3V pin)	PWM - turn EN/IN1 PWM pot in any position	LOW- turn PH/IN2 PWM pot completely counter-clockwise	H	L	Forward (OUT1 -> OUT2)
1 (connect MODE/ nSLEEP pin to 3.3V pin)	HIGH- turn EN/IN1 PWM pot completely clockwise	HIGH- turn PH/IN2 PWM pot completely clockwise	L	L	Brake, (Low-Side Slow Decay)

4.3 Independent Half-Bridge Control Mode (MODE=Hi-Z)

When the MODE pin is Hi-Z on power up, the device is latched into independent half-bridge control mode. Independent half bridge control is only supported by the DRV821xDSG devices. This mode allows for each half-bridge to be directly controlled in order to support high-side slow decay or driving two independent loads. The truth table for independent half-bridge mode is shown in [Table 4-4](#).

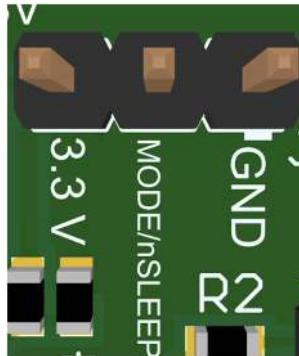


Figure 4-4. MODE /nSLEEP does not require a jumper for independent half-bridge mode

Table 4-4. Independent Half-Bridge Control Mode

INx	OUTx	Description
LOW - turn INx PWM pot completely counter-clockwise	L	OUTx Low-Side ON
HIGH - turn INx PWM pot completely clockwise	H	OUTx High-Side ON
PWM - turn INx PWM pot in any position	PWM	PWM = 0 -> OUTx Low-Side ONPWM = 1 -> OUTx High-Side ON

5 Current Sensing

The DRV821x/8220EVM comes with current sensing circuitry consisting of a low-side sense resistor and a current sensing amplifier. The current sensing capabilities can only be used with the DSG/PDSG devices. [Figure 5-1](#) show the schematic for the current sensing circuitry. The components enclosed by the red rectangles are the current sensing components. The sense resistor (R20) is connected between the GND pin of the device to the larger GND plane of the EVM. R20 is populated with a 0Ω resistor on the EVM but can be replaced with another resistor value if the user desires to use it for current sensing. C11 is used for filtering noise at the GND pin of the device and is not populated on the EVM.

The user needs to populate C11 with a desired value. The current sense amplifier and the surrounding components (R17, R18, and C6) are not populated on the EVM. The user needs to populate the amplifier and the surrounding components to use the current sensing capabilities. The current sense amplifier is the TLV9051IDRL which can be ordered [here](#). R17 and R18 set the closed loop gain of the amplifier and have to be chosen by the user.

The output of the current sense amplifier (AMP_OUT) can be measured at the “ISENSE” pin on header J4. AMP_OUT is connected to an ADC pin on the MCU to monitor the current and to create current sensing algorithms.

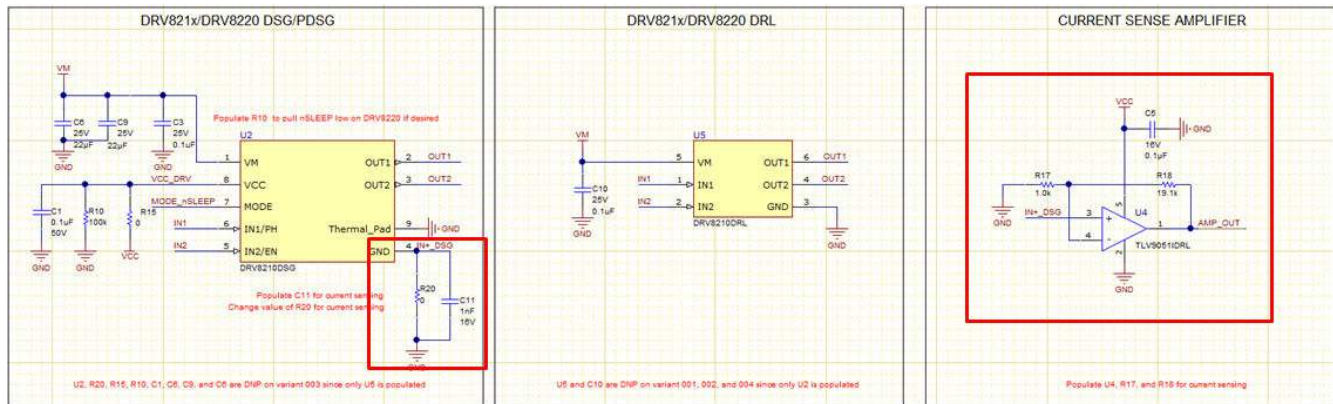


Figure 5-1. Current Sensing Schematic

6 Operation of the EVM

6.1 Dual Motor Operation

This mode allows for up to two motors to be controlled independently. The DRV821xDSG are the only devices that can support dual motor operation.

Use the following steps to operate the EVM with up to two loads with single direction speed control:

1. Make sure only one driver is populated and no power is being supplied to the EVM.
2. Connect a DC motor across OUT1 and GND. If desired, connect an additional DC motor across OUT2 and GND. See [Figure 6-2](#) below for a diagram.
3. Adjust the potentiometer, EN/IN1 PWM and PH/IN2 PWM, to minimum voltage by turning the wheel counter-clockwise all the way. This minimizes the motor speed of the motor connected across OUT1. If using a second motor, perform this process with potentiometer IN2 PWM as well.
4. Remove the jumper from the MODE/nSLEEP header (J2) so the MODE pin is Hi-Z.
5. Apply power to J1 header.
6. Turn potentiometer, EN/IN1 PWM, clockwise and the motor connected across OUT1 will begin to turn. Continue adjusting, as desired, until the maximum speed is reached. If using a second motor perform this process with potentiometer PH/IN2 PWM as well.
7. The direction of the motor turning can be reversed by removing the connection from GND to the motor and connecting the motor to VM. If this is done, the potentiometer associated with controlling the motor will operate in reverse and thus should be turned all the way clockwise before powering on the board and then slowly turned counter-clockwise to speed up the motor.

Use the following steps to operate the EVM with outputs paralleled to decrease the overall RDS(on) by half and accommodate larger current requirements:

1. Make sure only one driver is populated and no power is being supplied to the EVM.
2. Short EN/IN1 and PH/IN2 pins on J4 with a jumper. See [Figure 6-1](#).
3. Short OUT1 and OUT2 at connector J3 with an unexposed small wire or short the OUT1 and OUT2 test points with a small cable with clips. Make sure the wire is low resistance and can support at minimum 4-A continuous peak current. Connect one end of the motor or desired load on either OUT1 or OUT2 on connector J3 and the other end on either VM (for low-side driving) or GND (for high-side driving). See [Figure 6-3](#) and [Figure 6-4](#) for a block diagram.
4. Adjust the potentiometer, EN/IN1 PWM and PH/IN2 PWM, to minimum voltage by turning the wheel all the way counter-clockwise (if one end of the motor is connected to GND) or clockwise (if one end of the motor is connected to VCC). This minimizes the speed of the motor connected across OUT1 and OUT2.
5. Remove the jumper from the MODE/nSLEEP header (J2) so the MODE pin is Hi-Z.
6. Apply power to J1 header.
7. Turn potentiometer, EN/IN1 PWM, clockwise and the motor connected across OUT1 will begin to turn. Continue adjusting, as desired, until the maximum speed is reached. Make sure to not move PH/IN2 PWM potentiometer.
8. The direction of the motor turning can be reversed by removing the connection from GND to the motor and connecting the motor to VM and vice-versa. If this is done, the potentiometer associated with controlling the motor will operate in reverse and thus should be turned all the way clockwise (if motor originally connected to GND) or counter-clockwise (if motor originally connected to VCC) before powering on the board and then slowly turning the EN/IN1 PWM potentiometer in the opposite direction to increase the motor speed.

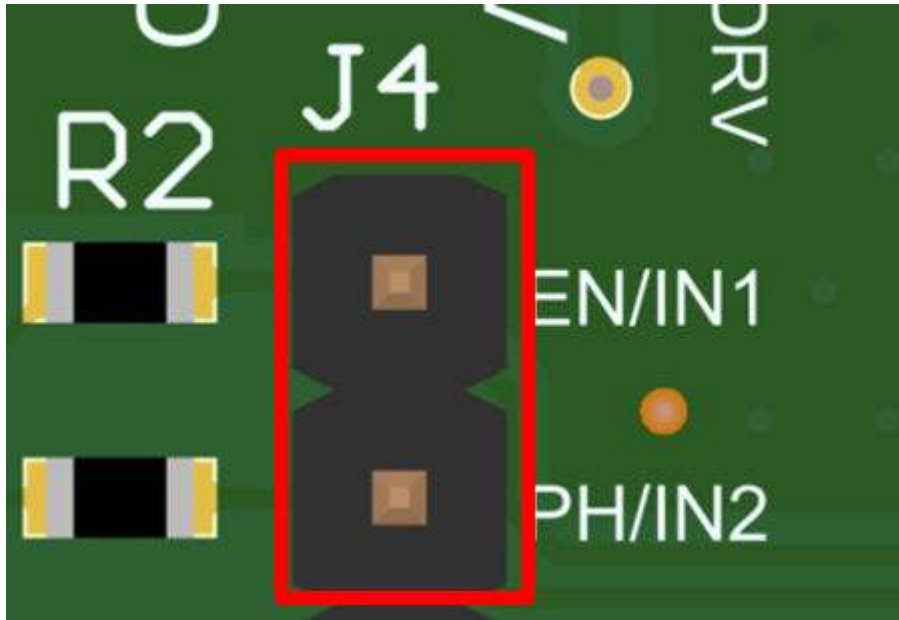


Figure 6-1. EN/IN1 and PH/IN2 pins shorted

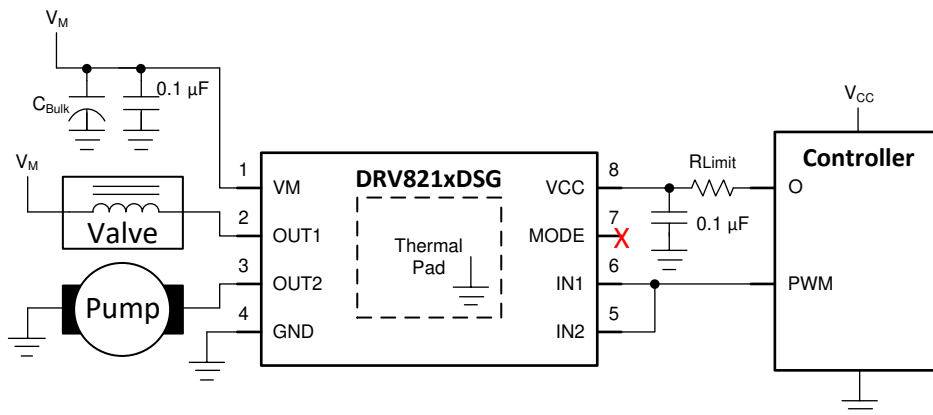


Figure 6-2. Half-bridge mode used as a high-side and low-side driver for two loads

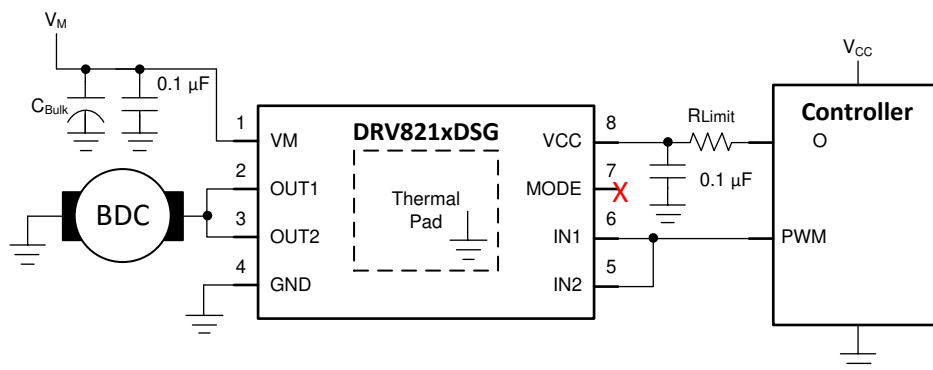


Figure 6-3. Half-bridge mode used as a high-side driver with outputs paralleled

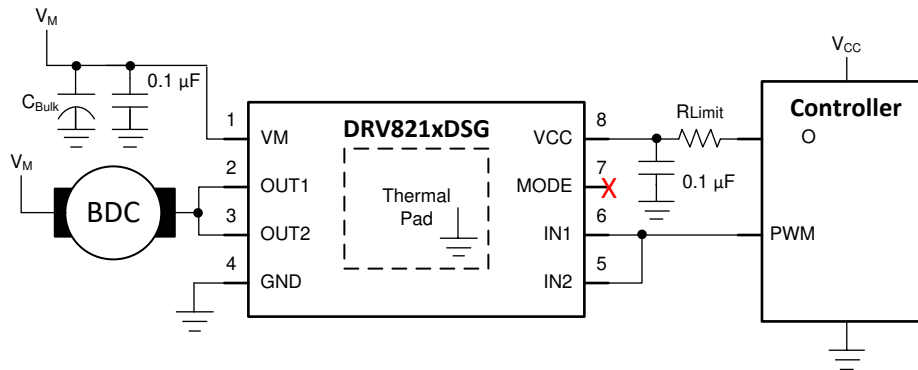


Figure 6-4. Half-bridge mode used as a low-side driver with outputs paralleled

6.2 Single Motor Operation

This mode allows for bidirectional control of one motor. Connect a DC motor across OUT1 and OUT2. Reversing direction is controlled by the potentiometer. This is described in detail in [Section 4](#). Use the following steps to operate the EVM with a signal motor and bidirectional speed control:

1. Make sure only one driver is populated and no power is being supplied to the EVM.
2. Connect a motor across OUT1 and OUT2. See [Figure 6-5](#) for a block diagram of the DRV821xDSG.
3. If the DRV821xDSG is populated on the EVM, use a jumper to connect the MODE/nSLEEP header (J2) to 3.3 V or GND to set the input mode to PWM control mode or PH/EN mode respectively.
4. If the DRV8220DSG is populated on the EVM, use a jumper to connect the MODE/nSLEEP header (J2) to 3.3 V or GND to set the input mode to PWM control mode or PH/EN mode respectively. Also connect VCC_DRV (J7) to 3.3V via a jumper to enable the device.
5. If the DRV821xPDSG is populated, connect the MODE/nSLEEP header to 3.3V to set nSLEEP logic high and enable the device (The MODE pin becomes the nSLEEP pin for the PDSG devices). The DRV821xPDSG only supports PWM control mode.
6. If a DRV82xxDRL is populated, the state of the MODE/nSLEEP jumper is ignored and the control mode is set to PWM by default. The DRL devices only support PWM control mode.
7. Adjust the potentiometer, EN/IN1 PWM and PH/IN2 PWM, to minimum voltage by turning the wheel counter-clockwise all the way. This minimizes the speed of the motor connected across OUT1 and OUT2.
8. Apply power to J1 header.
9. Turn potentiometer, EN/IN1 PWM, clockwise and the motor connected across OUT1 and OUT2 will begin to turn. Continue adjusting, as desired, until the maximum speed is reached.
10. Control the motor direction and speed by adjusting the potentiometers according to the tables in [Section 4](#).

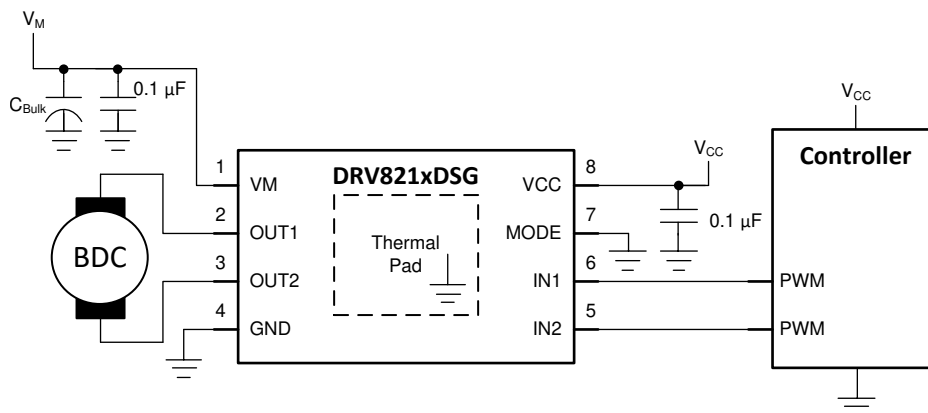


Figure 6-5. DRV821xDSG PWM single motor operation

7 Removing and Installing Supported Motor Drivers

The EVM can support the DRV8210/8212/8220DSG, DRV8210/8212PDSG, and DRV8210/8212/8220DRL devices. The EVM contains two footprints that can support the devices listed above. Footprint U2 supports the DSG and PDSG devices and footprint U5 supports the DRL devices. U2 and U5 share the same output connector so only one of the two footprints should be populated at any time. 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. See [Table 7-1](#) for further instructions. 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. [Figure 7-1](#) show the resistors used for device identification. The MCU reads the values of ID1, ID2, and ID3 to determine the device that is installed on the EVM. The firmware will function slightly different depending on the device that is on the board. Each of the supported devices have unique values for ID1, ID2, and ID3 which are set by R5, R7, R8, R9, R13, and R14. After installing the new device, make sure to populate the appropriate resistors. [Table 7-2](#) show the unique device ID for each supported device and the resistor combination to populate.

Table 7-1. Procedure For Soldering New Device and Passives to EVM

New device being installed	Soldering procedures
DRV8210/8212DSG or DRV8210/8212PDSG	<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 • If not already de-populated, de-populate R10 • If not already populated, populate C6 (1210, 25V, 22μF), C9 (1210, 25V, 22μF), C3 (0402, 25V, 0.1μF), C1 (0603, 25V, 0.1μF), and R15 (0603, 0Ω)
DRV8220DSG	<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 • If not already de-populated, de-populate R15 • If not already populated, populated C6 (1210, 25V, 22μF), C9 (1210, 25V, 22μF), C3 (0402, 25V, 0.1μF), C1 (0603, 25V, 0.1μF). • If not already populated, populate J7 (2x1, 2.54 mm, TH header). See Table 3-1 to learn about the function of J7 header.
DRV8210/8212/8220DRL	<ul style="list-style-type: none"> • Solder the device to footprint U5. Make sure pin 1 of device aligns with the dot on the PCB. • If not already de-populated, de-populate C6, C9, C3, C1, R10, and R15. • If not already populated, populate C10 (0402, 25V, 0.1μF).

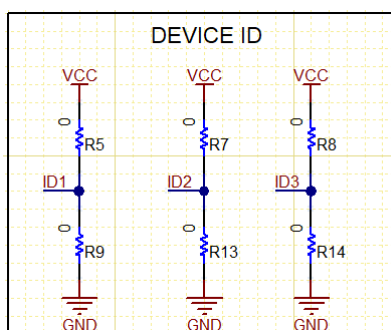


Figure 7-1. Device ID Resistors

Table 7-2. Unique Device Identifier Resistors

Device	Device ID	Device ID resistors to populate
DRV8210DSG	ID1=0; ID2=0; ID3=0	R9, R13, R14
DRV8210PDSG	ID1=0; ID2=0; ID3=1	R9, R13, R8

Table 7-2. Unique Device Identifier Resistors (continued)

Device	Device ID	Device ID resistors to populate
DRV8210DRL	ID1=0; ID2=1; ID3=0	R9, R7, R14
DRV8212DSG	ID1=0; ID2=1; ID3=1	R9, R7, R8
DRV8212PDSG	ID1=1; ID2=0; ID3=0	R5, R13, R14
DRV8212DRL	ID1=1; ID2=0; ID3=1	R5, R13, R8
DRV8220DSG	ID1=1; ID2=1; ID3=0	R5, R7, R14
DRV8220DRL	ID1=1; ID2=1; ID3=1	R5, R7, R8

8 Revision History

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

Changes from Revision * (November 2020) to Revision A (December 2020)	Page
• Updated Caution information.....	1

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 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 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/lstds/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/lstds/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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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。

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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lstds/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。
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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.

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- 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, INDEMNITY 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.

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