EVM User's Guide: DRV8421AEVM, DRV8421BEVM

DRV8421x Evaluation Module

TEXAS INSTRUMENTS

Description

The DRV8421xEVM allows for easy evaluating of the DRV8421 dual H-bridge motor driver. The evaluation module (EVM) can support the DGQ and DFU packages of the DRV8421A and DRV8421B device variants. However, only one variant and package can be populated at a time since the input control signals (MCU Ctrl 1 and MCU Ctrl 2) are shared among the devices.

The DRV8421xEVM can drive one or two brushed-DC motors, or a single bipolar stepper motor. The two onboard potentiometers provide a convenient way to manually adjust speed and direction on the fly, an excellent choice for prototyping and evaluating new designs.

Get Started

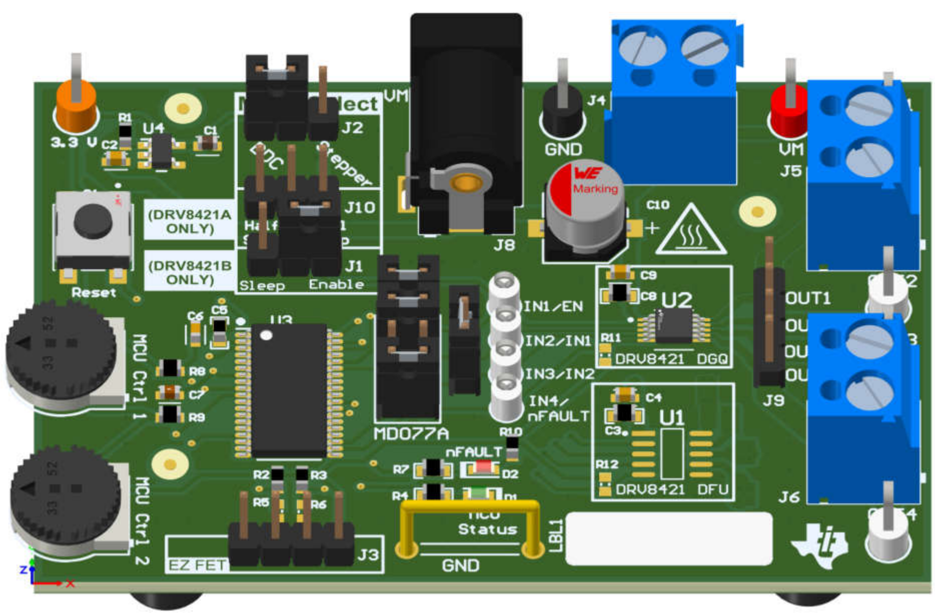
1. Order the EVM: DRV8421BEVM
2. Download the data sheet: SLVSHA4

Features

- DRV8421 is a dual H-bridge motor driver
- Two device versions:
  - DRV8421A (4-wire input): independent half-bridge control
  - DRV8421B (2-Wire Input): sleep mode, fault detection
- PWM control interface
- Onboard 3.3V LDO for digital voltage supply
- Main signal header with removable shunts to disconnect main signals going to the motor driver IC from the MCU

Applications

- Household appliances
  - Printers and Scanners
  - Refrigerators
  - Vacuum cleaners
  - Clothes dryer
- General brushed and stepper motors



DRV8421xEVM

1 Evaluation Module Overview

1.1 Introduction

The DRV8421 is a low voltage integrated dual H-bridge motor driver with the following features:

- The DRV8421 has a high output current capability of 2A per H-bridge at 12V.
- A parallel mode is also configurable on the EVM to provide up to 4A of maximum drive current at 12V.
- Two device variants are supported on the EVM.
  – The DRV8421A has four inputs that can be configured for independent half-bridge control.
  – The DRV8421B has two inputs and offers a low-power sleep mode (3μA) and fault detection.
- Thermally-enhanced surface mount packages.
- Protection features
  – VM Undervoltage Lockout (UVLO)
  – Overcurrent Protection (OCP)
  – Thermal Shutdown (TSD)
  – Fault Condition Indication Pin (nFAULT) (2-wire version only)

This document is provided with the DRV8421xEVM as a supplement to the DRV8421 data sheets. This user's guide covers EVM hardware setup, usage, and variant and package swap instructions.

1.2 Kit Contents

The Kit Contents table lists the contents of the EVM kit. Contact the nearest Texas Instruments Product Information Center if any component is missing.

Table 1-1. Kit Contents

ITEM	QUANTITY
DRV8421AEVM or DRV8421BEVM	1

1.3 Specification

The DRV8421xEVM is preprogrammed with firmware for quick and easy evaluation. An onboard eZ-FET header is available to connect an external debugger for reprogramming or debugging purposes but is not required for normal operation. A 3.3V LDO generates a 3.3V rail from the VM power supply. This 3.3V is used to power the MSP430, and motor driver EN pin on the DRV8421B. Signal header J7 uses removable shunts to pass the signals from the MCU to the motor driver. Remove any of these shunts to easily jump in the control signals to the driver. Provide an external motor power supply to the J4 screw terminal within the operating range of the device. An optional power jack (J8) can be used instead of the screw terminal (J4) for convenience; however, only one power supply must be used at a time. The DRV8421 supports 4V to 18V supply voltage range.

1.4 Device Information

The documents in Table 1-2 provide information regarding Texas Instruments integrated circuits used in the assembly of the EVM. This user's guide is available from the TI web site under literature number SLOU571. Any letter appended to the literature number corresponds to the document revision that is current at the time of the writing of this document. Newer revisions are available from the TI web site at www.ti.com, or call the Texas Instruments Literature Response Center at (800) 477-8924 or the Product Information Center at (972) 644-5580. When ordering, identify the document by both title and literature number.

Table 1-2. Related Device Documents

DESCRIPTION	DATA SHEET
Main MSP430 MCU	MSP430G2955
3.3V LDO	TPS7B6933DBVR
Motor Driver	DRV8421

2 Hardware

2.1 EVM Setup and Mode Select

The following sections provide an overview of the hardware connections necessary to evaluate the both the DRV8421A and DRV8421B variants as well as both supported load configurations.

The Mode Select jumper (J2) must always be populated in one of the two configurations. This jumper allows the user to select from a brushed-DC or stepper motor mode.

The Step Select jumper (J10) and Sleep Enable jumper (J1) depends on which variant is populated on the EVM.

All shunts on jumper (J7) must always be populated to allow MCU signals to control the DRV8421.

Note

All setups and mode selections remain the same for both the DGQ and DFU packages.

2.1.1 Jumpers

- Please refer to the following figure and table for the location and description of components and jumpers on the board. These jumpers are used to configure the pins on the MSP430 to support various load configurations and board variants.

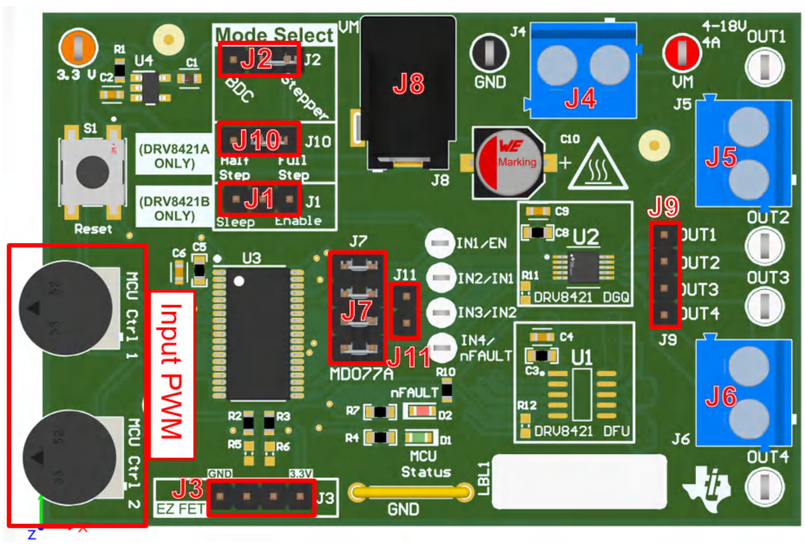


Figure 2-1. Jumper Population Guide

Table 2-1. Jumper Identification

JUMPERS	DRV8421A	DRV8421B	DESCRIPTION
J1	Not populated	Sleep/enable jumper	Select low-power sleep mode or enable
J2	Mode select jumper	Mode select jumper	Select Brushed-DC or Stepper Motor
J3	EZ-FET	EZ-FET	Used for programming the MCU
J4	Main power supply terminal	Main power supply terminal	Supplies power to the EVM (only one power supply needed)
J5-J6	Main output terminals	Main output terminals	Output terminals for load connections
J7	MCU to DRV8421	MCU to DRV8421	Must be populated if using onboard MCU
J8	DC power jack	DC power jack	Alternate power supply connection (only one power supply needed)
J9	Output pins	Output pins	Alternate output pins for connection convenience
J10	Step select jumper	Not populated	Select Full-Step or Half-Step when in Stepper Mode
J11	Parallel mode jumper	Parallel mode jumper	Remove shunt 3 from J7 to use to populate J11 (See Section 2.1.7 for more details)

For more detailed information, download the hardware files and schematics. Once users have verified that all shunts and jumpers are in the correct location, users can move on to the EVM setup.

2.1.2 DRV8421A: Brushed-DC Setup

The following configuration must be used when driving a brushed-DC motor and the DRV8421A variant is populated on the EVM.

- J2: Populated for brushed-DC motor mode
- J7: All populated for MCU communication with DRV8421

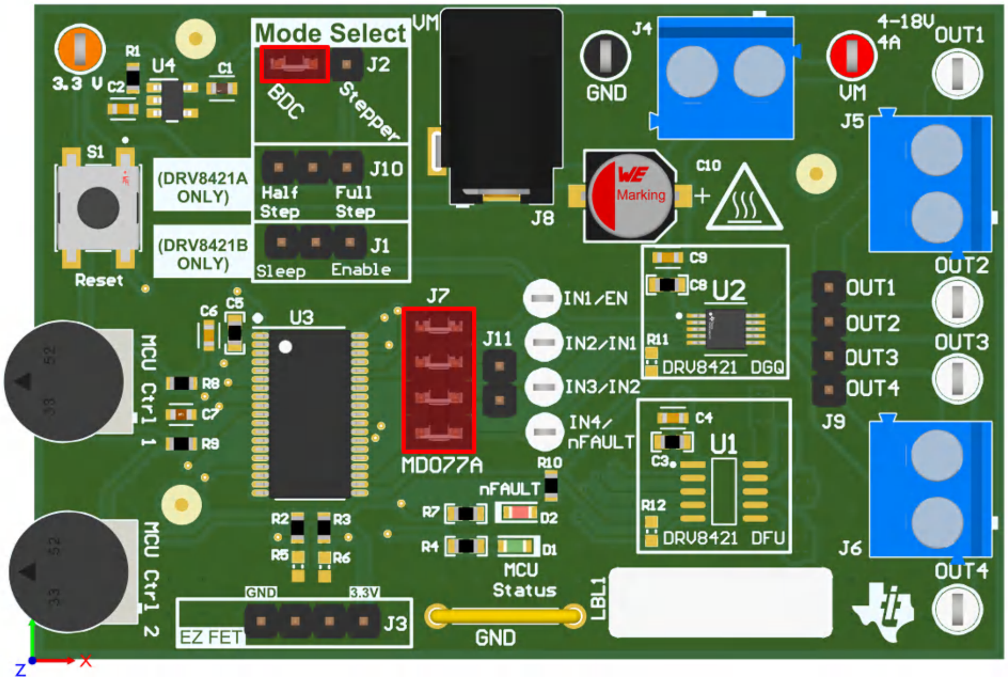


Figure 2-2. Jumper Configuration for Brushed-DC Control with DRV8421A

2.1.3 DRV8421A: Stepper Setup

The following configuration must be used when driving a stepper motor and the DRV8421A variant is populated on the EVM.

- J2: Populated for stepper motor mode
- J10: Select Full-Step or Half-Step sequence (Blue: Full-Step, Red: Half-Step)
- J7: All populated for MCU communication with DRV8421

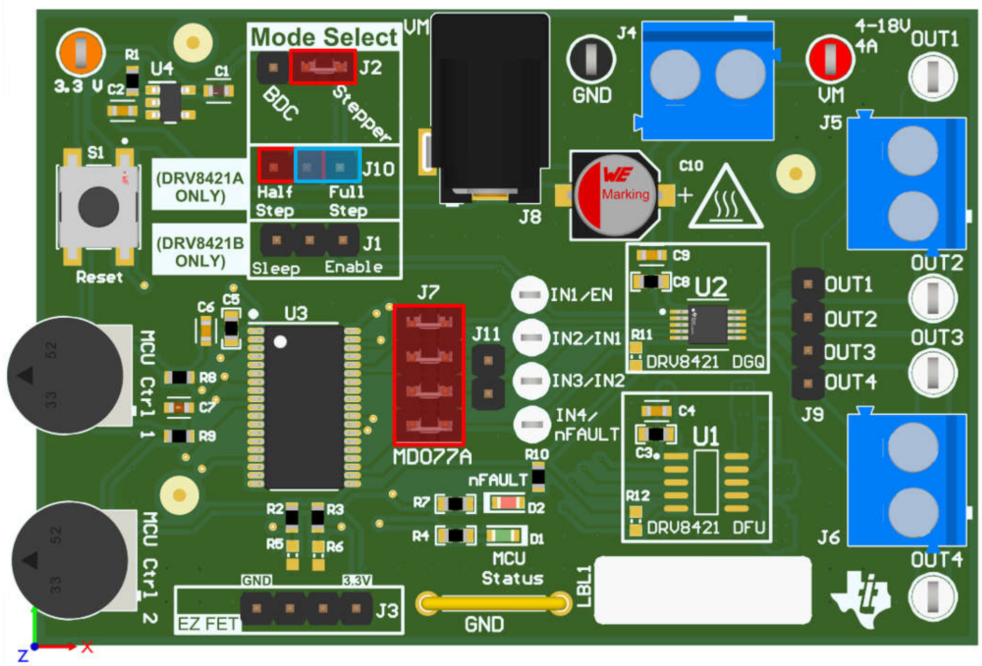


Figure 2-3. Jumper Configuration for Stepper Motor Control with DRV8421A

2.1.4 DRV8421B: Brushed-DC Setup

The following configuration must be used when driving a brushed-DC motor and the DRV8421B variant is populated on the EVM.

- J2: Populated for brushed-DC motor mode
- J1: Select enable or sleep configuration (blue: enables device, red: low-power sleep mode)
- J7: All populated for MCU communication with DRV8421

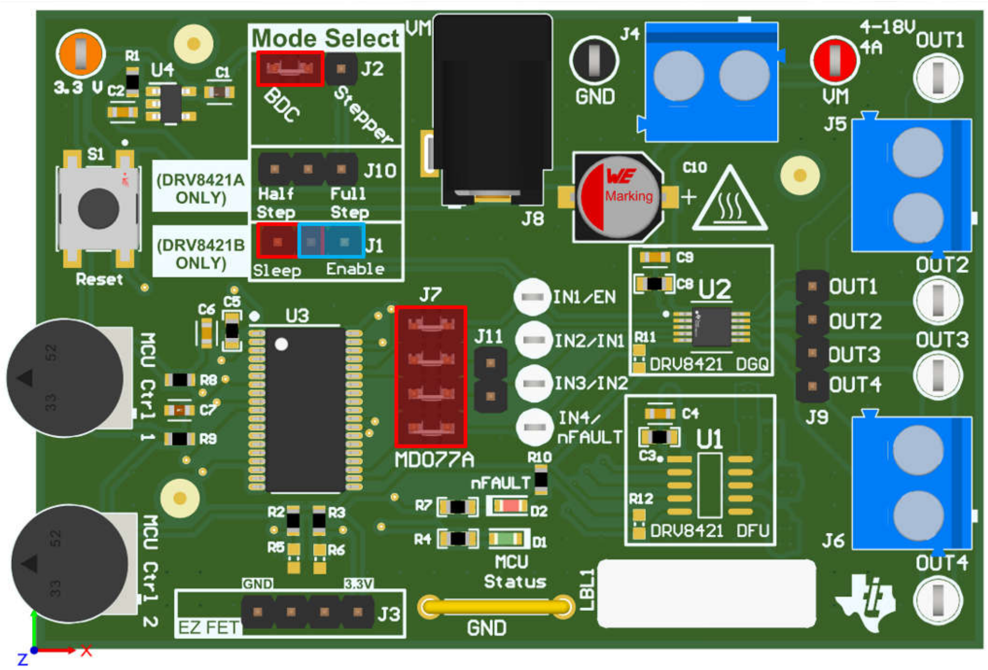


Figure 2-4. Jumper Configuration for Brushed-DC Motor Control with DRV8421B

2.1.5 DRV8421B: Stepper Setup

The following configuration must be used when driving a stepper motor and the DRV8421B variant is populated on the EVM.

- J2: Populated for stepper motor mode
- J10: Remove Step Select Jumper (DRV8421B is automatically configured for Full-Step when (J2) is populated in stepper mode)
- J1: Select Enable or Sleep configuration (Blue: Enables device, Red: Low-power sleep mode)
- J7: All populated for MCU communication with DRV8421

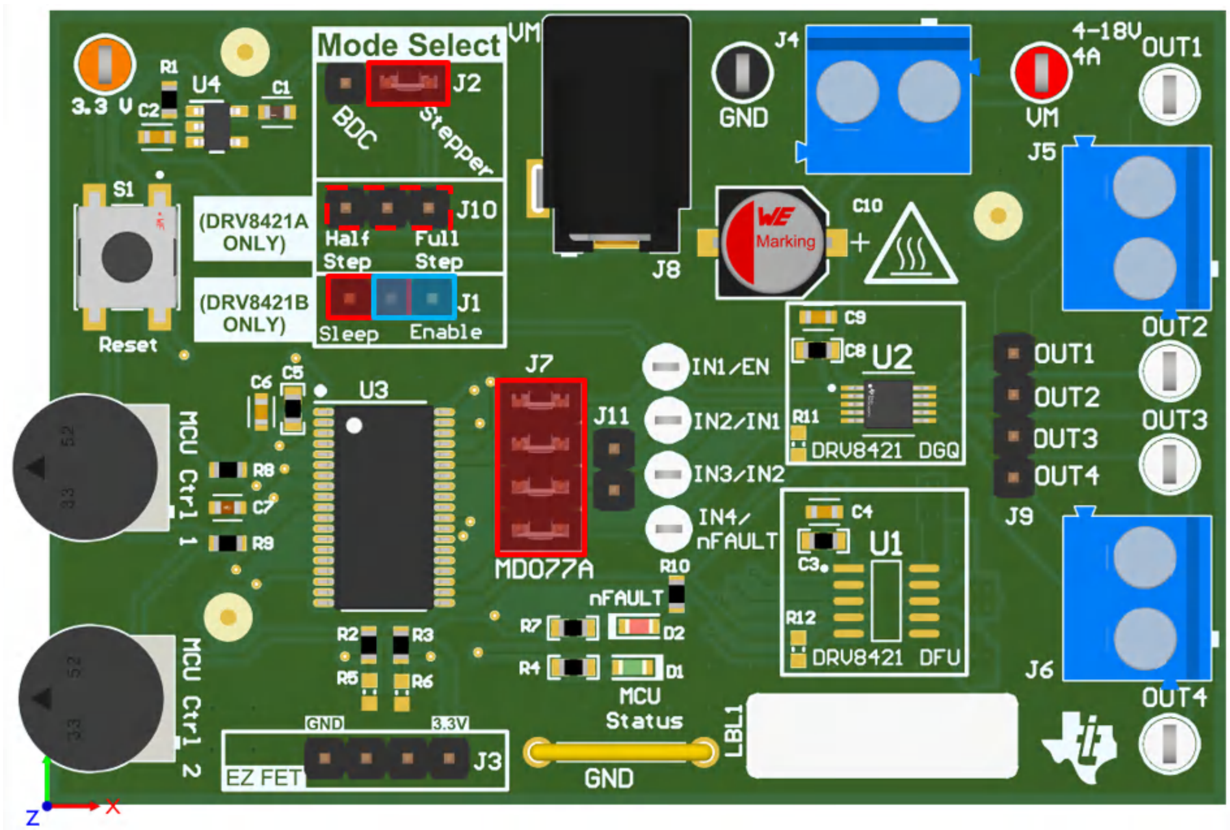


Figure 2-5. Jumper Configuration for Stepper Motor Control with DRV8421B

2.1.6 EVM Control

The input PWM potentiometers, MCU Ctrl 1 and MCU Ctrl 2, are used to control the speed and direction of the motor. The starting positions and control logic are slightly different depending on which load (brushed-DC or stepper motor) is being driven. The following sections must be used as a control reference.

2.1.6.1 DRV8421A: Brushed-DC Motor Control

The MSP430 produces PWM signals for the IN1, IN2, IN3 and IN4 pins with duty cycles proportional to the voltage from the MCU Ctrl 1 and MCU Ctrl 2 potentiometers. To achieve a 1 or 0 for the outputs, the input potentiometers must be turned completely clockwise or counterclockwise. The table below shows how to configure the potentiometers for different modes of operation.

Table 2-2. DRV8421A Control

IN1/IN3	IN2/IN4	OUT1	OUT2	OUT3	OUT4	FUNCTION
Low – turn MCU CTRL 1 completely counter-clockwise	Low – turn MCU CTRL 2 completely counter-clockwise	Hi-Z	Hi-Z	Hi-Z	Hi-Z	Standby Mode (Hi-Z)
High – turn MCU CTRL 1 completely clockwise	Low – turn MCU CTRL 2 completely counter-clockwise	1	0	1	0	Forward
Low – turn MCU CTRL 1 completely counter-clockwise	High – turn MCU CTRL 2 completely clockwise	0	1	0	1	Reverse
High – turn MCU CTRL 1 completely clockwise	High – turn MCU CTRL 2 completely clockwise	0	0	0	0	Brake

Note

Due to the limitation of two inputs, the EVM firmware in place is only configured to control two outputs. Separate firmware must be configured on an external MCU with inputs connected to J7 to utilize all four outputs with independent half-bridge control.

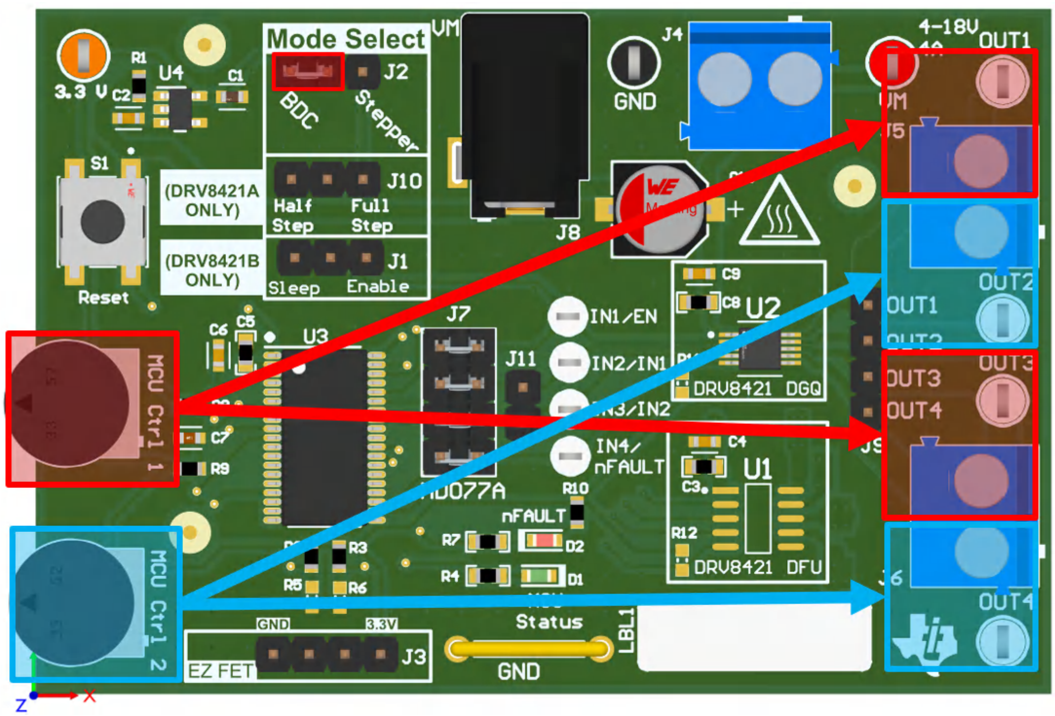


Figure 2-6. EVM Controls for Brushed-DC Motor Operation with DRV8421A

2.1.6.2 DRV8421A: Stepper Motor Control

The MSP430 produces PWM signals for the IN1, IN2, IN3 and IN4 pins with frequencies proportional to the voltage from the MCU Ctrl 1 potentiometer.

MCU Ctrl 1 controls the speed of the stepper motor. Begin with potentiometer fully clockwise and slowly rotate counter-clockwise to increase speed.

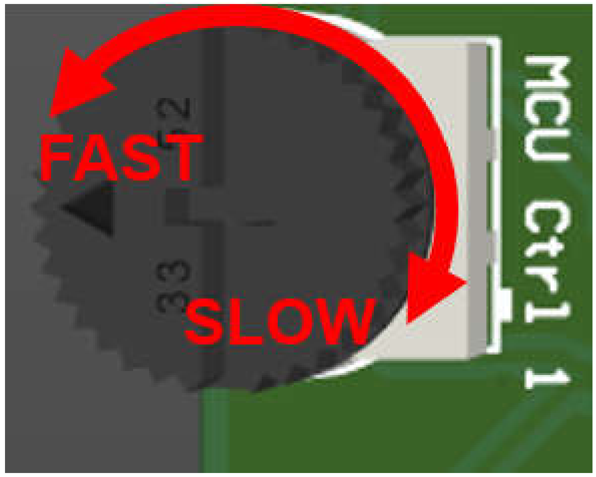


Figure 2-7. Speed Control Direction

When operating in Stepper Mode (J2) and Step Select (J10), the speed of the stepper motor is controlled by MCU Ctrl 1 potentiometer.

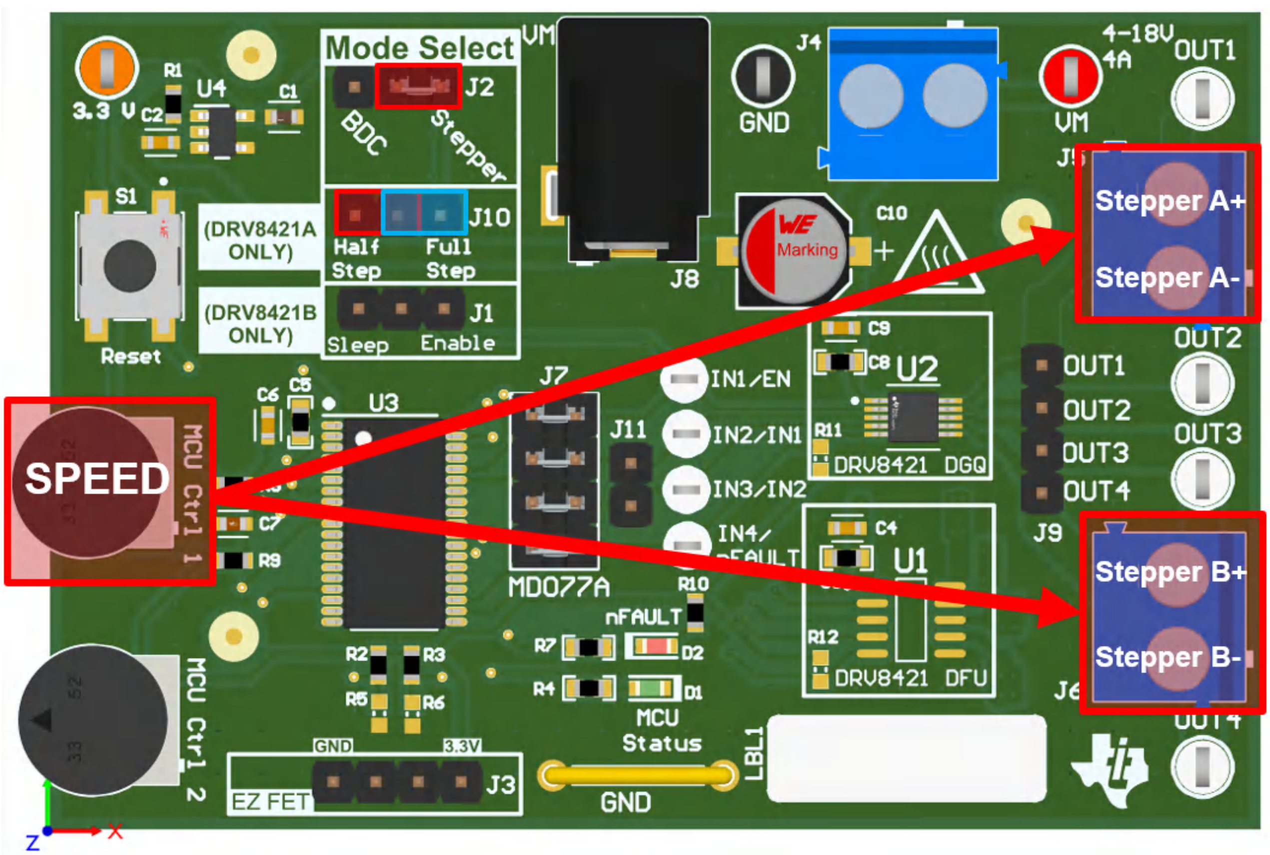


Figure 2-8. EVM Controls for Stepper Motor Operation with DRV8421A

The following figure shows an example of input and output waveforms while in full-step mode. The DRV8421B is configured in a full-step sequence by default.

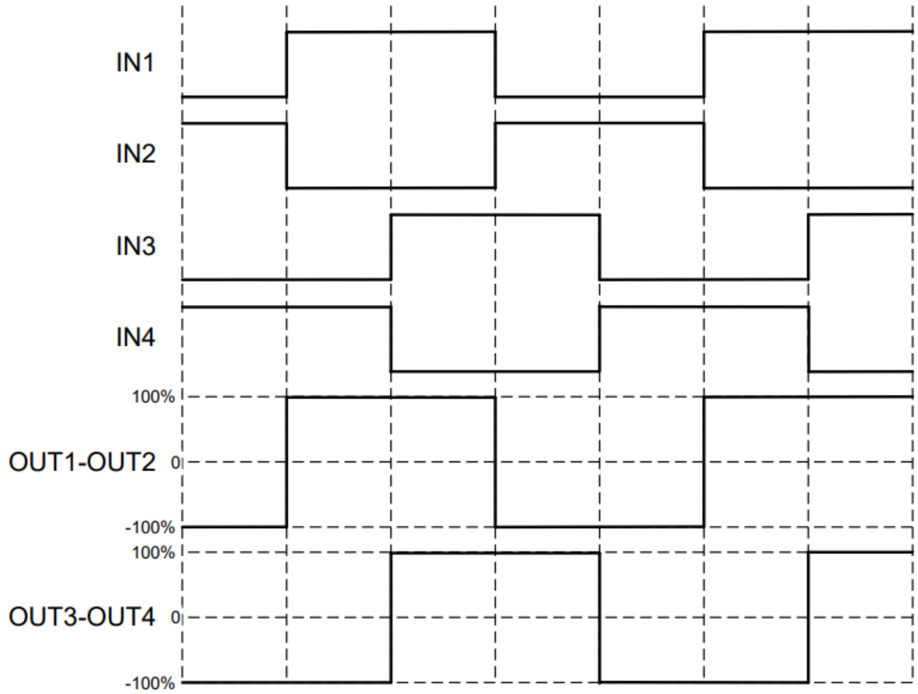


Figure 2-9. Full-Step Sequence Waveforms

The following figure shows an example of input and output waveforms while in half-step mode. This step sequence is only available through the Step Select jumper (J10) for the DRV8421A only.

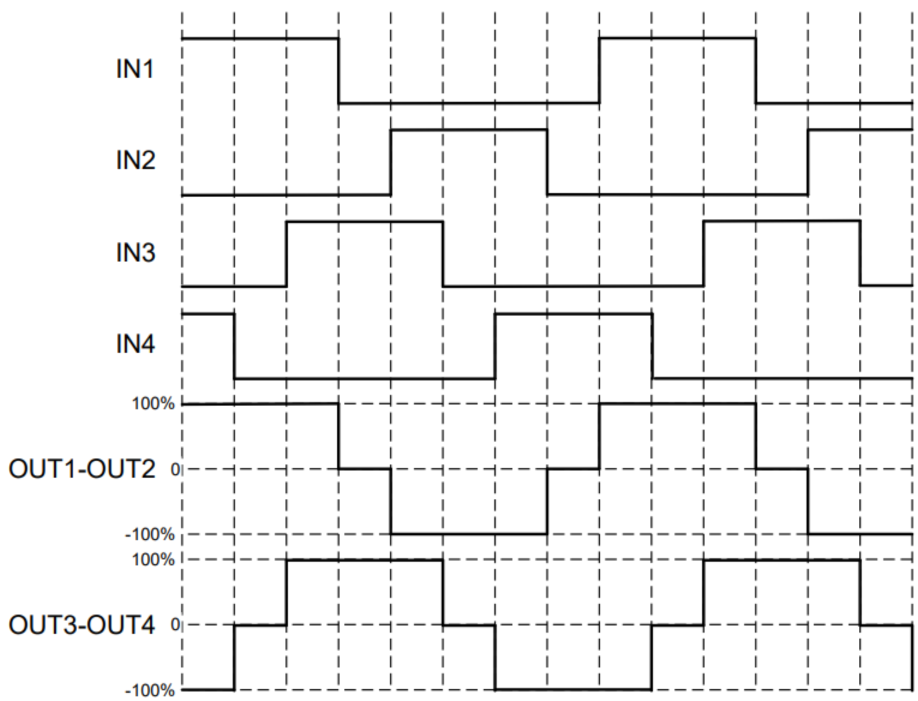


Figure 2-10. Half-Step Sequence Waveforms

2.1.6.3 DRV8421B: Brushed-DC Motor Control

The MSP430 produces PWM signals for the IN1 and IN2 pins with duty cycles proportional to the voltage from the MCU Ctrl 1 and MCU Ctrl 2 potentiometers. To achieve a 1 or 0 for the outputs, the input potentiometers must be turned completely clockwise or counterclockwise. The table below shows how to configure the input potentiometers for different modes of operation.

Table 2-3. DRV8421B Control

EN	IN1	IN2	OUT1	OUT2	OUT3	OUT4		Description
0	X	X	OFF	OFF	OFF	OFF		Low-power sleep mode
1	Low – turn MCU CTRL 1 completely counter-clockwise	X	1	0	X	X	Channel 1	Forward
1	High – turn MCU CTRL 1 completely clockwise	X	0	1	X	X	Channel 1	Reverse
1	X	Low – turn MCU CTRL 2 completely counter-clockwise	X	X	1	0	Channel 2	Forward
1	X	High – turn MCU CTRL 1 completely clockwise	X	X	0	1	Channel 2	Reverse

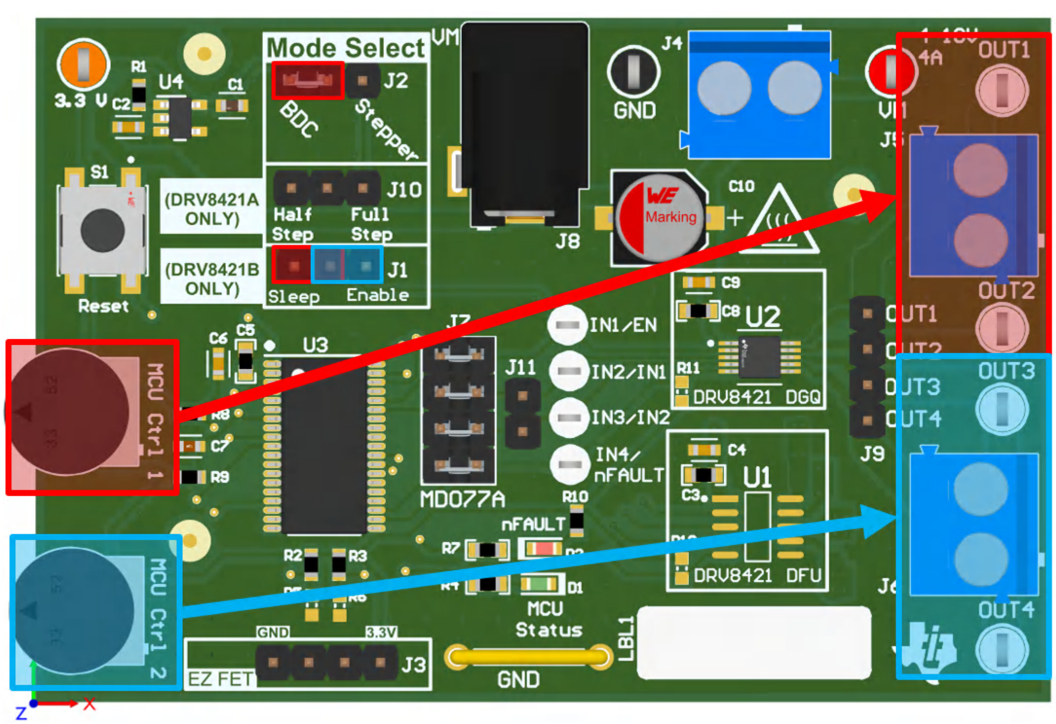


Figure 2-11. EVM Controls for Brushed-DC Motor Operation with DRV8421B

2.1.6.4 DRV8421B: Stepper Motor Control

The MSP430 produces PWM signals for the IN1 and IN2 pins with frequencies proportional to the voltage from the MCU Ctrl 1 potentiometer.

MCU Ctrl 1 controls the speed of the stepper motor. Begin with potentiometer fully clockwise and slowly rotate counter-clockwise to increase speed.

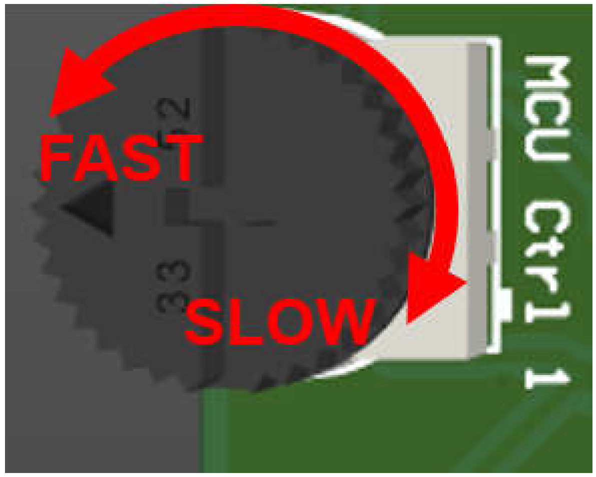


Figure 2-12. Speed Control Direction

When operating in Stepper Mode (J2) and the device is Enabled (J1), the speed of the stepper motor is controlled by MCU Ctrl 1 potentiometer. The DRV8421B is configured in a full-step sequence by default and the Step Select (J10) jumper must not be populated.

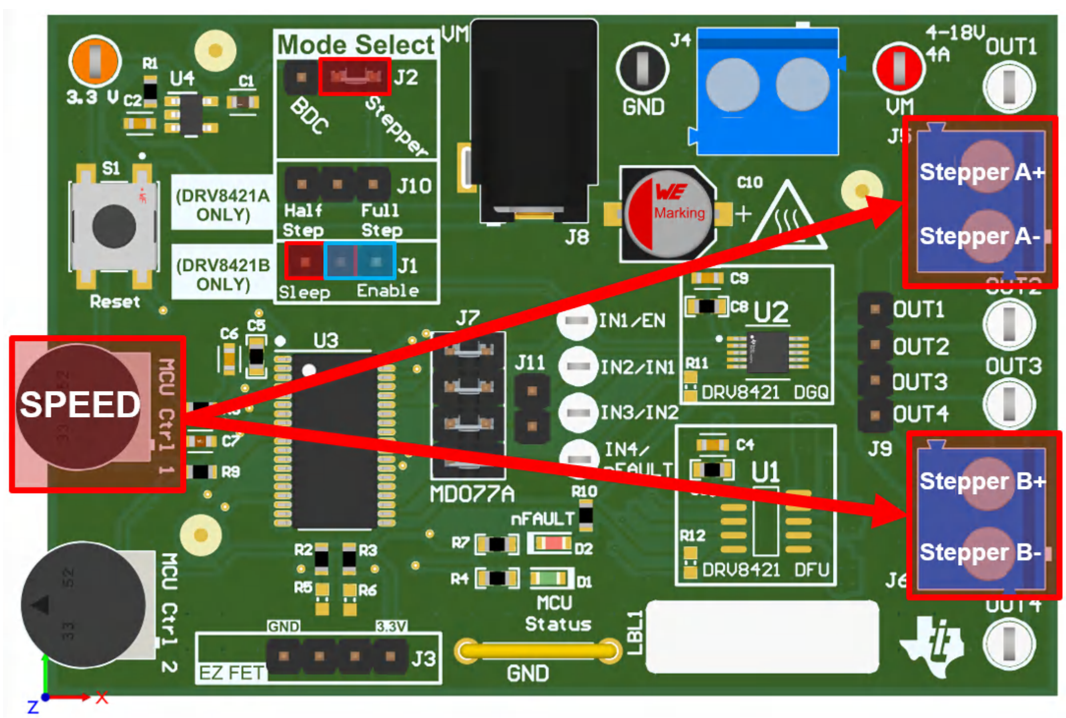


Figure 2-13. EVM Controls for Stepper Motor Operation with DRV8421B

2.1.7 Parallel Mode

2.1.7.1 DRV8421A: Parallel Mode

The two H-bridges can be used in parallel to deliver twice the current to a single motor. To enter parallel mode in DRV8421A, the 4-wire version, the following actions must be taken:

1. IN1 and IN3 must be tied together
2. IN2 and IN4 must be tied together
3. OUT1 and OUT3 must be tied together
4. OUT2 and OUT4 must be tied together

After making the connections for parallel mode, all setup and controls are the same as mentioned in previous sections.

Note

The DRV8421AEVM is not designed for parallel mode operation. All connections, controls, and operations in parallel mode with the A-Variant must be done externally.

2.1.7.2 DRV8421B: Parallel Mode

The two H-bridges can be used in parallel to deliver twice the current to a single motor. For the DRV8421B, the 2-wire version, parallel mode operation can be achieved by taking the following steps:

1. IN1 and IN2 must be tied together
   a. Remove third jumper from the top from jumper (J7)
   b. Use this jumper to populate jumper (J11)
2. OUT1 and OUT3 must be tied together
   a. Use external wire connections
3. OUT2 and OUT4 must be tied together
   a. Use external wire connections

While in parallel mode, the speed adjust comes from the MCU Ctrl 1 input potentiometer.

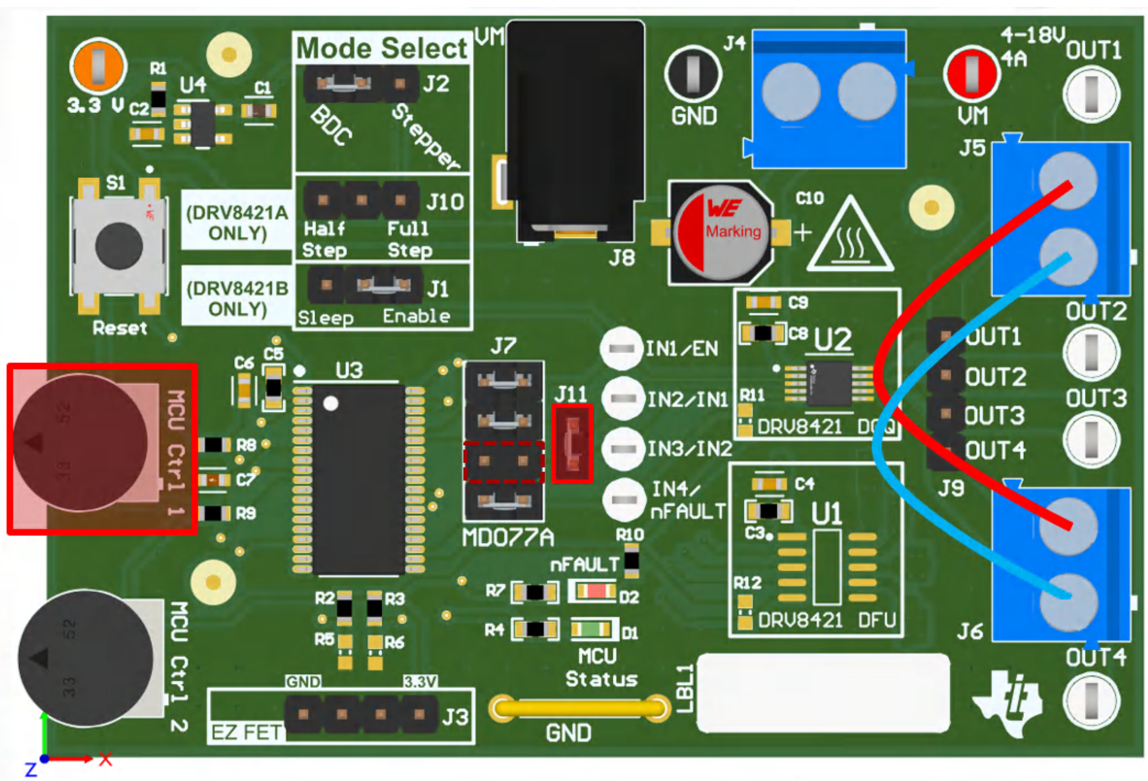


Figure 2-14. Parallel Mode Operation with DRV8421B

2.1.8 Removing and Installing Supported Motor Drivers

The EVM can support two variants and two packages the DRV8421ADGQ, DRV8421ADFU, DRV8421BDGQ, and DRV8421BDFU devices. The EVM contains two footprints that can support the devices listed above. Footprint U2 supports the DGQ devices and footprint U1 supports the DFU devices. U2 and U1 share the same output connectors so only one of the two footprints must 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. 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. The figure below shows the resistors used for device identification. The MCU reads the values of ID1, and ID2 to determine the device that is installed on the EVM. The firmware functions slightly different depending on the device that is on the board. Each of the supported devices have unique values for ID1, and ID2 which are set by R2, R3, R5, and R6. After installing the new device, make sure to populate the appropriate resistors.

NEW DEVICES BEING INSTALLED	SOLDERING PROCEDURES
DRV8421ADGQ	• 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 R2. • If not already populated, populate R5 (0603, 10kΩ).
DRV8421ADFU	• Solder the device to footprint U1. Make sure pin 1 of device aligns with the dot on the PCB. • If not already de-populated, de-populate R2. • If not already populated, populate R5 (0603, 10kΩ).
DRV8421BDGQ	• 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 R5. • If not already populated, populate R2 (0603, 10kΩ).
DRV8421BDFU	• Solder the device to footprint U1. Make sure pin 1 of device aligns with the dot on the PCB. • If not already de-populated, de-populate R5. • If not already populated, populate R2 (0603, 10kΩ).

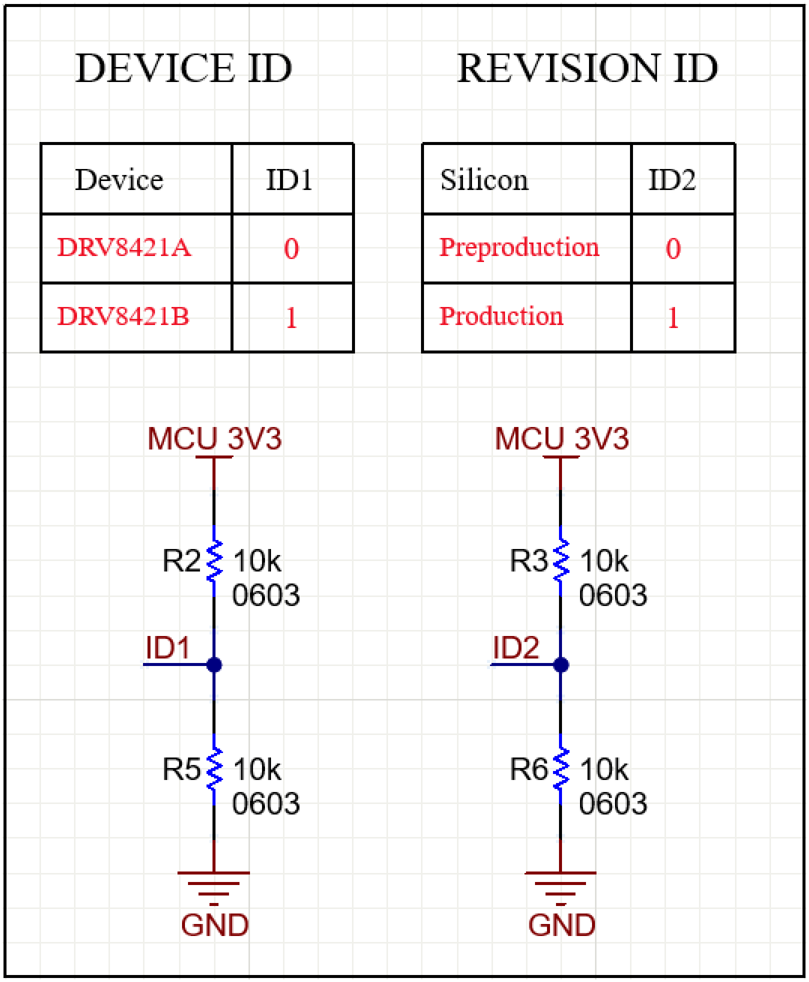


Figure 2-15. Device ID Resistors

3 Hardware Design Files

The schematics, bill of materials (BOM), pcb layout, and 3D model STEP file for each EVM can be downloaded on the respective product folder page under the Design Files section.

- Design Files

3.1 Schematics

Figure 3-1 shows the schematics for DRV8214EVM. Other variants have minor differences of which components are marked as Do Not Populate (DNP). See schematics of another variant by downloading the *Hardware Design Files* from any EVM tool folder under the *Design Files* section.

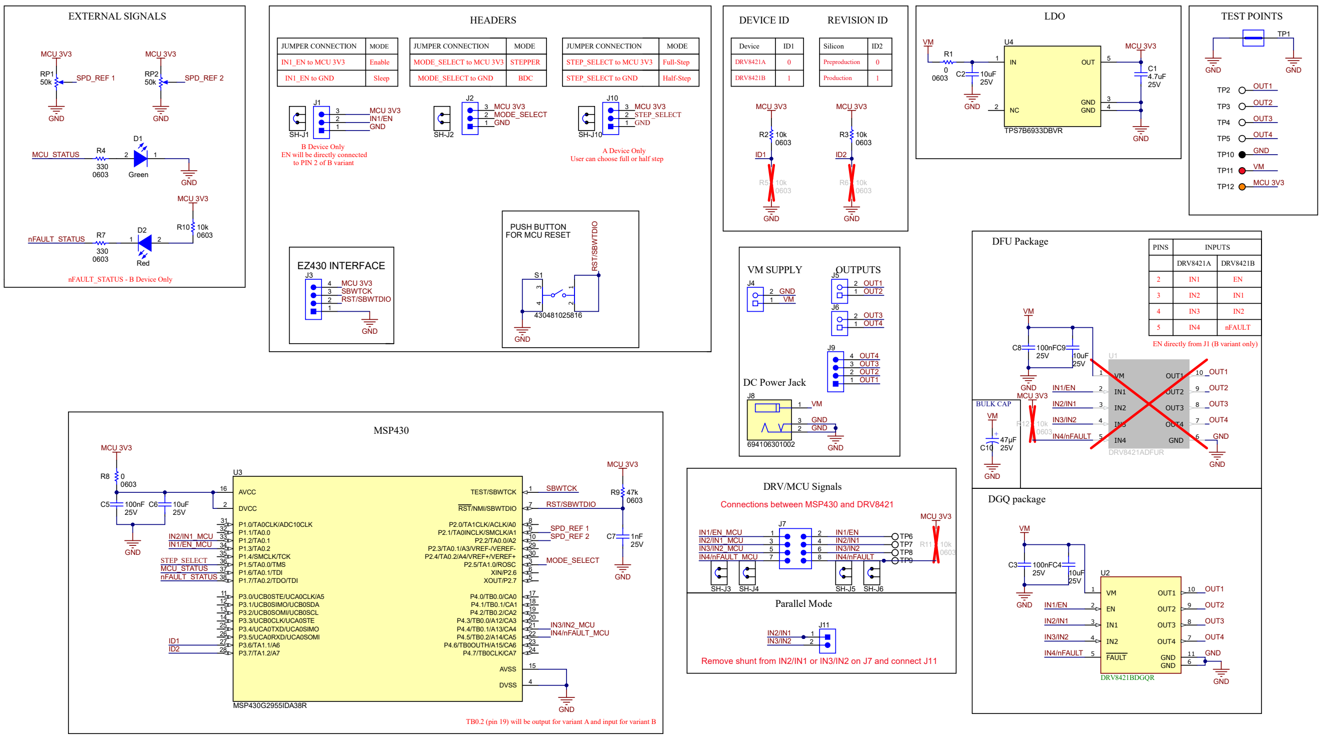


Figure 3-1. EVM Schematic

3.2 PCB (Top-Assembly View)

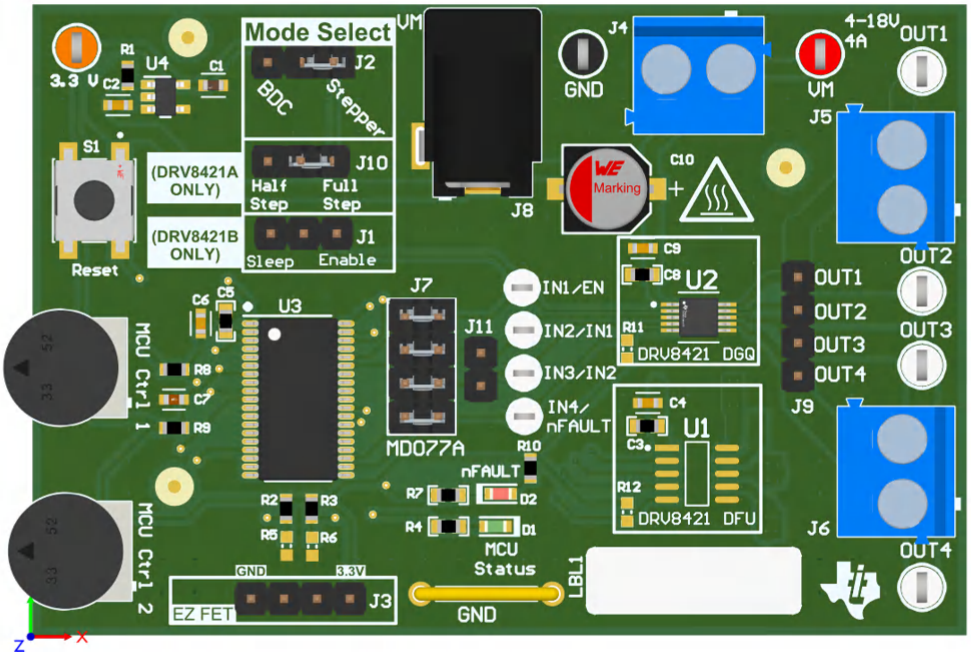


Figure 3-2. PCB (Top 3-D View)

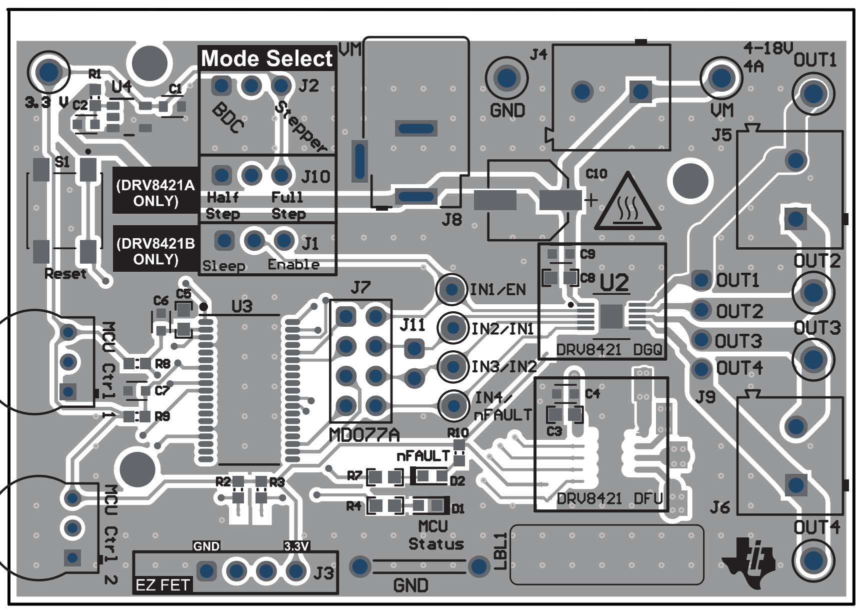


Figure 3-3. PCB (Top-Assembly View)

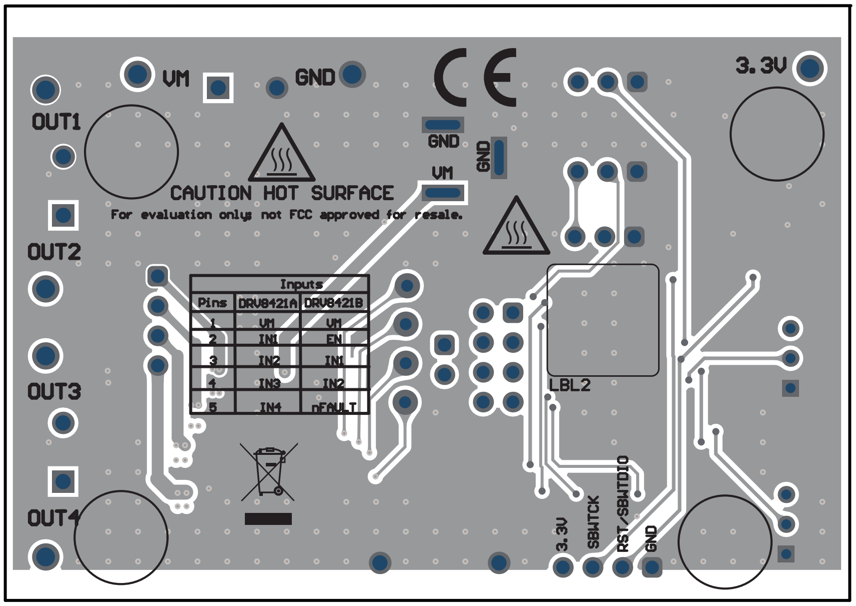


Figure 3-4. PCB (Bottom-Assembly View)

3.3 Bill of Materials (BOM)

Table 3-1. Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number
!PCB1	1		Printed Circuit Board		MD077
C1	1	4.7μF	4.7μF ±10% 25V Ceramic Capacitor X5R 0603 (1608 Metric)	0603	GRM188R61E475KE15D
C2, C4, C6, C9	4	10μF	10μF ±20% 25V Ceramic Capacitor X5R 0603 (1608 Metric)	0603	885012106031
C3, C5, C8	3	0.1uF	CAP, CERM, 0.1uF, 25V, +/- 10%, X7R, 0603	0603	885012206071
C7	1	1nF	1000pF ±5% 25V Ceramic Capacitor C0G, NP0 0603 (1608 Metric)	0603	885012006044
C10	1	47uF	WCAP-ASLI Aluminum Electrolytic Capacitor, V-Chip, D6.3 x H5.5mm, 47uF, 25V		865080443007
D1	1	Green	LED, Green, SMD	LED_0603	150060VS75000
D2	1	Red	LED, Red, SMD	LED_0603	150060RS75000
H1, H2, H3, H4	4		Bumpon, Cylindrical, 0.312 X 0.200, Black	Black Bumpon	SJ61A1
J1, J2, J10	3		Header, 2.54mm, 3x1, Gold, TH	Header, 2.54mm, 3x1, TH	61300311121
J3, J9	2		Header, 2.54mm, 4x1, Gold, TH	Header, 2.54mm, 4x1, TH	61300411121
J4, J5, J6	3		Terminal Block, 5mm, 2x1, Tin, TH	Terminal Block, 5mm, 2x1, TH	691101710002
J7	1		CONN HEADER VERT 8POS 2.54MM	HDR8	61300821121
J8	1		WR-DC DC Power Jack, R/A, TH	WR-DC DC Power Jack, R/A, TH	694106301002
J11	1		Header, 2.54mm, 2x1, Gold, TH	Header, 2.54mm, 2x1, TH	61300211121
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650 x 0.200 inch	THT-14-423-10
LBL2	1		Harsh Environment Multi-Purpose Polyester Labels for 3" Core Printers - 0.375" x 0.375", White	PCB Label 0.375 x 0.375 inch	THT-14-423-10
R1, R8	2	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ-3GEY0R00V
R2, R3, R10	3	10k	RES, 10 k, 5%, 0.1 W, 0603	0603	RC0603JR-0710KL
R4, R7	2	330	RES, 330, 5%, 0.1 W, 0603	0603	RC0603JR-07330RL
R9	1	47k	RES, 47 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060347K0JNEA
RP1, RP2	2	50k	Trimming Potentiometer, 50K, 0.5W, TH	9.53x8.89mm	3352T-1-503LF

Table 3-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number
S1	1		Tactile Switch SPST-NO Top Actuated Surface Mount	SMT_SW_6MM2_6MM2	430481025816
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J10	7		Shunt, 2.54mm, Gold, Black	Shunt, 2.54mm, Black	60900213421
TP1	1		1mm Uninsulated Shorting Plug, 10.16mm spacing, TH	Shorting Plug, 10.16mm spacing, TH	D3082-05
TP2, TP3, TP4, TP5	4		Test Point, Multipurpose, White, TH	White Multipurpose Test point	5012
TP6, TP7, TP8, TP9	4		Test Point, Miniature, White, TH	White Miniature Test point	5002
TP10	1		Test Point, Multipurpose, Black, TH	Black Multipurpose Test point	5011
TP11	1		Test Point, Multipurpose, Red, TH	Red Multipurpose Test point	5010
TP12	1		Test Point, Multipurpose, Orange, TH	Orange Multipurpose Test point	5013
U2	1		Dual H-Bridge Stepper Driver	HVSSOP10	DRV8421BDGQR
U3	1		MSP430G2x55 Mixed Signal Microcontroller, DA0038A (TSSOP-38)	DA0038A	MSP430G2955IDA38R
U4	1		40V Ultralow-Iq Low-Dropout Regulator, DBV0005A (SOT-23-5)	DBV0005A	TPS7B6933DBVR
R5, R6, R11, R12	0	10k	RES, 10 k, 5%, 0.1 W, 0603	0603	RC0603JR-0710KL
U1	0		Dual H-Bridge Stepper Driver, SSOP10	SSOP10	DRV8421ADFUR

4 Additional Information

4.1 Trademarks

All trademarks are the property of their respective owners.

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。

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.

【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。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.

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.

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