EVM User's Guide: DRV8376EVM

DRV8376 Evaluation Module

Description

The DRV8376EVM is a integrated driver IC evaluation module for three-phase motor driver applications and provides single-chip power stage design for customers driving 4.5V to 65V brushless DC motors. Along with the hardware of the DRV8376, the TMS320F280049C microcontroller-based board has reference software that sends necessary signals to the DRV8376 to spin a 3-phase Brushless-DC motor. GUIComposer software allows the user to program settings, enable the motor to spin, and monitor the system from fault conditions.

Get Started

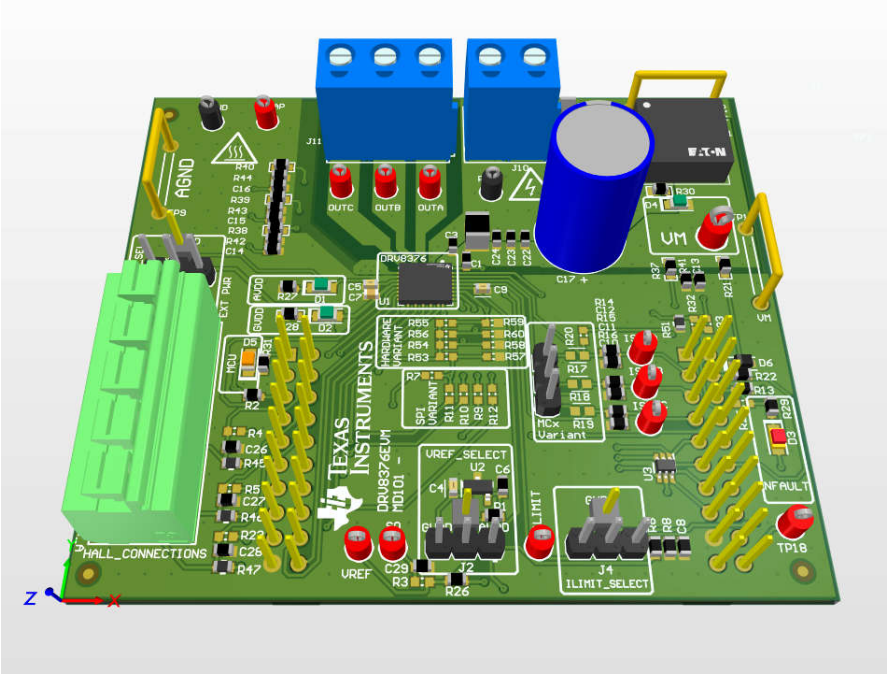
1. Order the DRV8376EVM and TMS320F280049C
2. Download the comprehensive reference design files from the DRV8376EVM tool page
3. Refer to the DRV8376 Three-Phase Integrated FET Motor Driver data sheet or refer to E2E for questions and support

Features

- 4.5V to 65V operating voltage (70V abs max)
- High output current capability: 4.5A peak
- AVDD and GVDD regulators
- Integrated CSAs for three-phase low-side current measurement
- Supply and fault LEDs
- C2000 (LAUNCHXL-F280049C) sensored trapezoidal firmware available

Applications

- Brushless-DC (BLDC) motor modules
- HVAC motors
- Office automation machines
- Factory automation and robotics
- Wireless antenna motor
- ATMs (Automated Teller Machines)
- Drones



DRV8376EVM

1 Evaluation Module Overview

1.1 Introduction

This document is designed to be used as a startup guide to the DRV8376EVM and LAUNCHXL-F280049C designs. This document is intended for the engineers involved in the design, implementation, and validation of DRV8376 and TMS320F280049C reference software.

The scope of this document is to provide the user with a guide to evaluate the DRV8376 device with a TMS320F280049C isolated board. This document covers the hardware connections required between boards and external motor and supplies. When the hardware connections are complete, the user is required to download the necessary tools and software to spin a motor.

This document is provided with the DRV8376EVM customer evaluation module (EVM) as a supplement to the DRV8376 Three-Phase Integrated FET Motor Driver data sheet. This user's guide details the hardware implementation of the EVM.

1.2 Kit Contents

- DRV8376EVM
- EVM Disclaimer Read Me

1.3 Specification

The DRV8376EVM can support voltages up to 65V and currents up to 4.5A. To prevent damage to both the IC and the EVM, confirm that these voltage and current specifications are not exceeded.

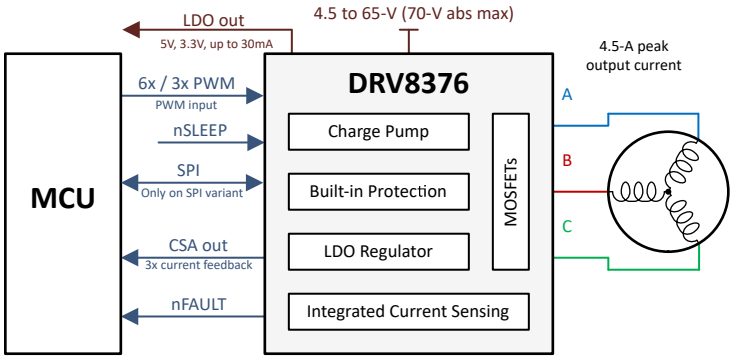


Figure 1-1. Simplified Schematic

1.4 Device Information

The DRV8376 integrates three 1/2-H bridges, has a very low RDS(ON) of 400mΩ (high-side plus low-side) to enable high power drive capability, and allows customer to drive 4.5V - 65V (70V absolute maximum) brushless-DC motors

Current is sensed using an integrated current sensing feature which eliminates the need for external sense resistors. Power management features with integrated LDO generate the necessary voltage rails for the device and can be used to power external circuits.

The DRV8376 is capable of driving a PWM frequency up to 100kHz. The control scheme is highly configurable through hardware pins or register settings ranging from motor current limiting behavior to fault response.

2 Hardware

The following section describes the EVM hardware and connections to the external supply, hall sensors, PC via USB, and motor. The major blocks of the DRV8376EVM are shown in Figure 2-1. The DRV8376EVM is designed for an input supply from 4.5V to 65V.

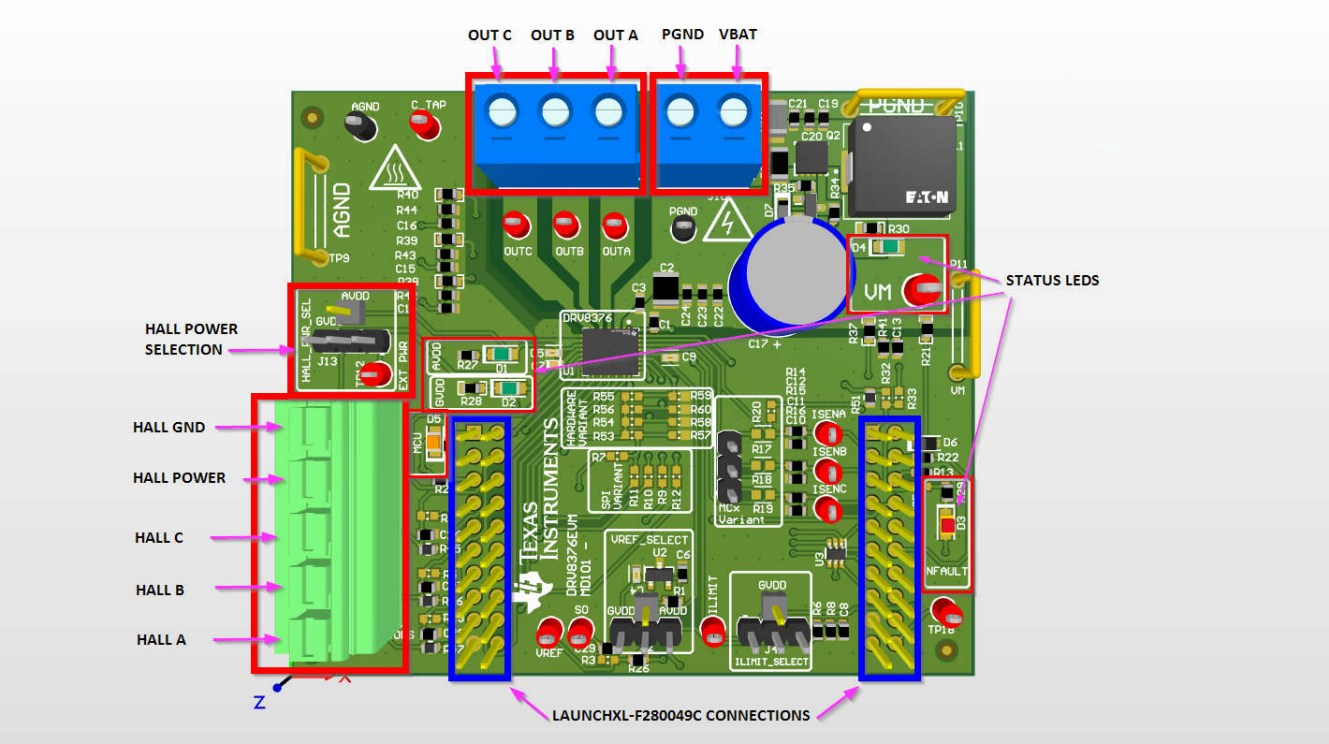


Figure 2-1. DRV8376EVM Major Hardware Blocks

2.1 Quick Start

The DRV8376EVM requires a power supply source, which has a recommended operating range from a 4.5V to 65V. To set up and power the EVM, follow the sequence below.

1. Make sure the DRV8376EVM has been configured according to the variant.
   a. Section 2.6
   b. Section 2.7
   c. Section 2.8
2. Connect the phases of the motor to OUT A, OUT B, and OUT C of the screw terminals on the DRV8376EVM.
3. Do not turn on the power supply yet. Connect the motor supply to VM and power supply ground to PGND. PGND and VM locations can be found in Figure 2-1.
4. For sensored applications, connect the hall sensors to the appropriate locations on the 5-pin connector as shown in Figure 2-4. Make sure the hall power has been configured according to Figure 2-4.
5. Mate the DRV8376EVM onto the top half of the LAUNCHXL-F280049C as seen in Figure 2-2. The motor and power connectors must face the opposite direction as the micro-USB connector on the LaunchPad™.
6. Power on the DRV8376EVM.
7. Connect a micro-USB cable from the computer into the micro-USB connector on the top of the LAUNCHXLF280049C.

2.2 LaunchXL-F280049C Setup

The DRV8376EVM must be connected to the LaunchXL-F280049C as shown in Figure 2-2. Make sure the power supply input and phase outputs of the DRV8376EVM are facing the opposite direction of the micro-USB on the LaunchXL-F280049C.

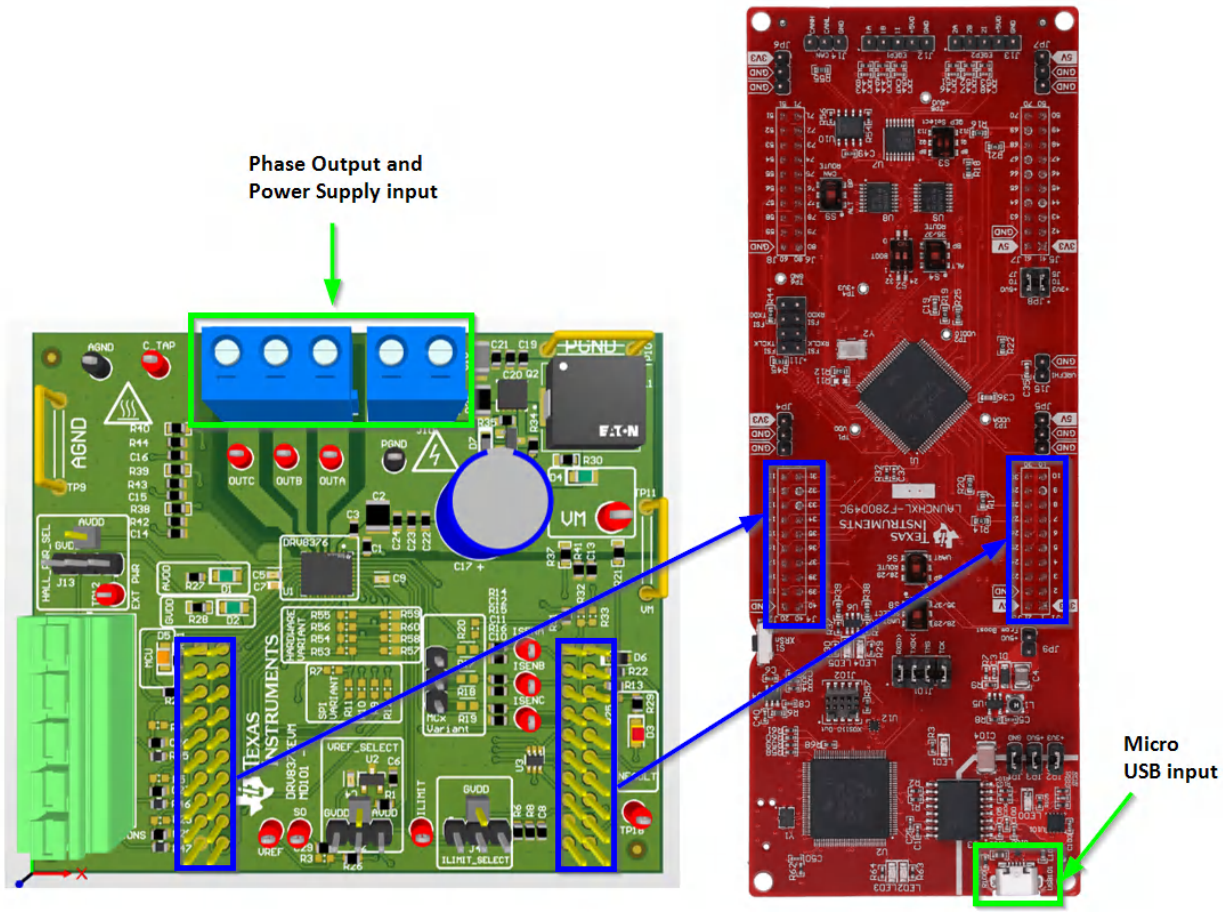


Figure 2-2. DRV8376EVM LaunchXL-F280049C Connection

WARNING

To minimize the risk of potential shock hazard and personal injury, remove all power connections and interfaces to the DRV8376EVM when not in use.

WARNING

Hot surface. Contact can cause burns. Do not touch.

WARNING

High voltage. Electric shock is possible when connecting board to live wire. The board must be handled with care by a professional.

For safety, use of isolated test equipment with overvoltage and overcurrent protection is highly recommended.

2.3 LED Indicators

The DRV8376EVM has a few LEDS on the board that indicate the status of the board.

All the LED indicators that are present on the DRV8376EVM are shown in Figure 2-3.

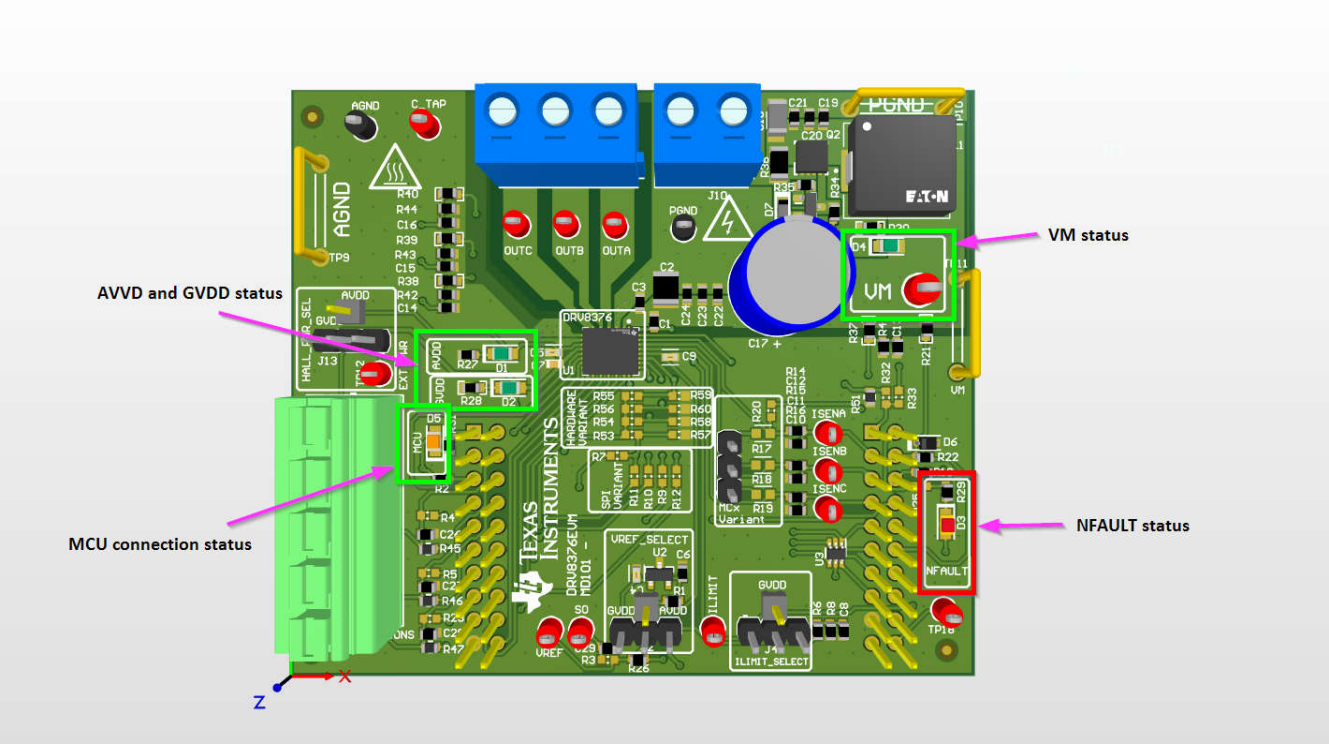


Figure 2-3. DRV8376EVM LED Indicators

These LEDs need to be monitored throughout the use of the DRV8376EVM. The status LEDs for VM, AVDD, and GVDD turn on once power is supplied to the board. The MCU LED turns on once the GUI or Firmware runs on the LaunchXL-F280049C while the DRV8376EVM is connected. The NFAULT status LED turns on as soon as a driver fault occurs.

2.4 Jumper Information

The DRV8376EVM has a few configurations that can be made with jumpers. Use these sections as a guide on how to make those configurations using jumpers.

Hall Sensors

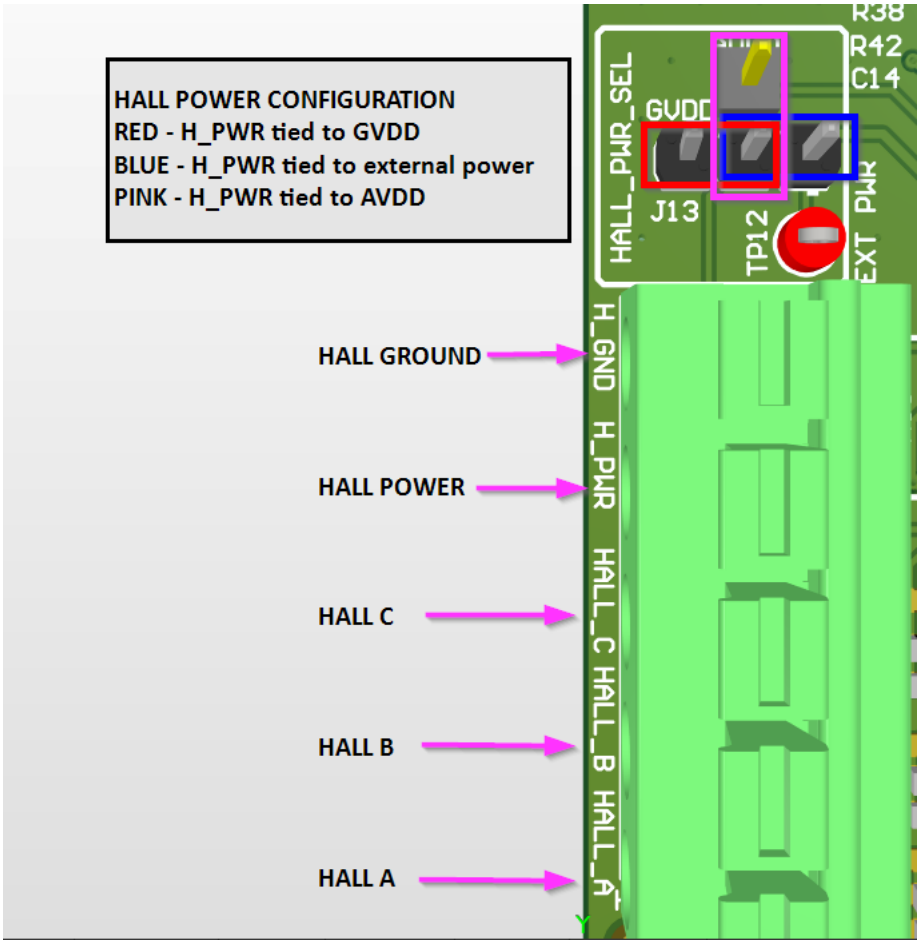


Figure 2-4. DRV8376EVM Hall Configuration

The connections that need to be made to the Hall terminal block are shown in Figure 2-4. The figure also shows how to configure the hall power. For externally supplied hall power, supply the power to TP12 and make sure there is a jumper where the blue rectangle is, as seen in the figure above.

VREF

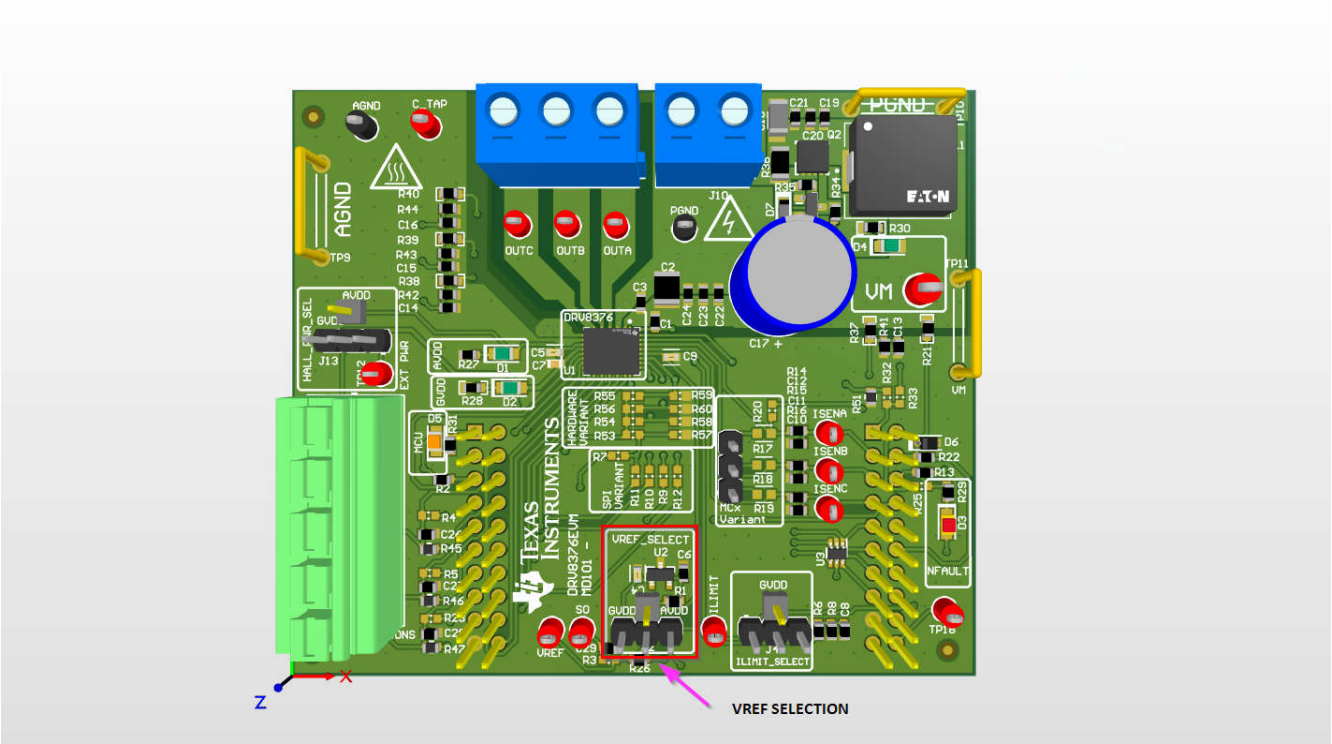


Figure 2-5. DRV8376EVM VREF Selection Location

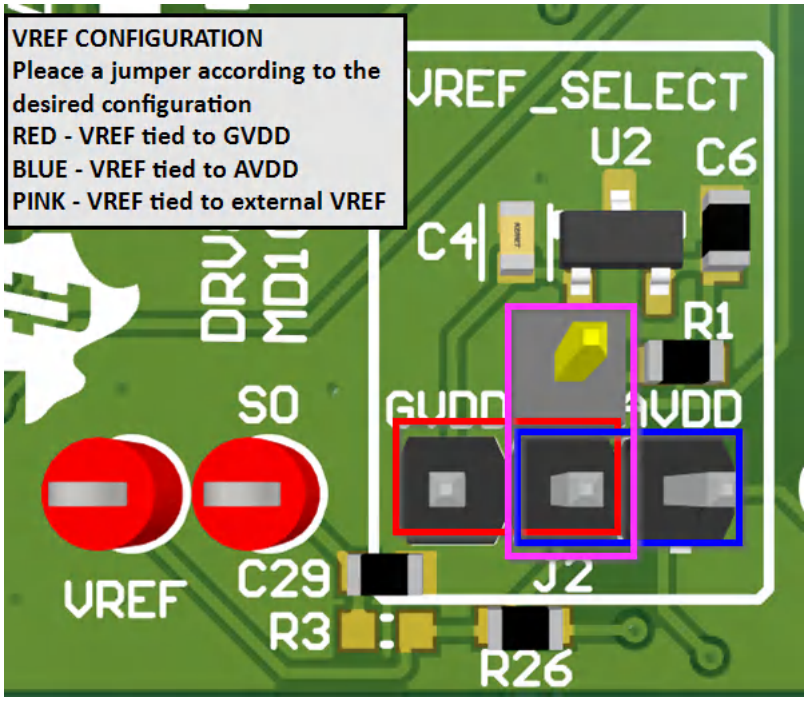


Figure 2-6. DRV8376EVM VREF Configuration

ILIMIT

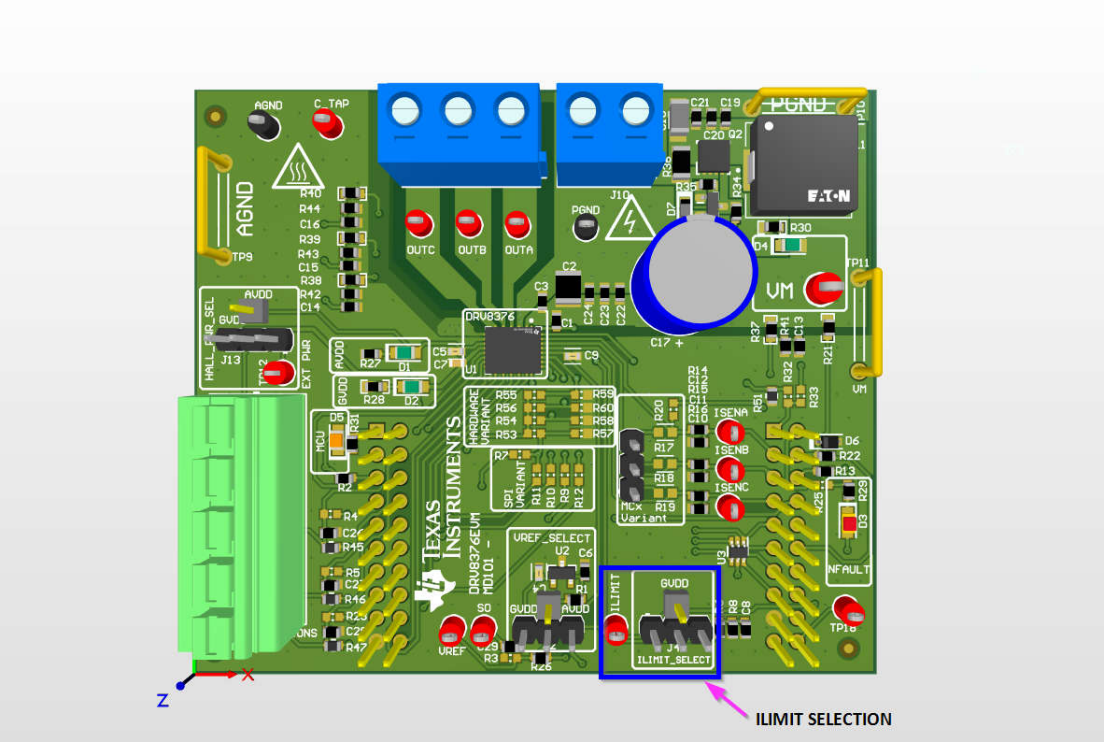


Figure 2-7. DRV8376EVM ILIMIT Selection Location

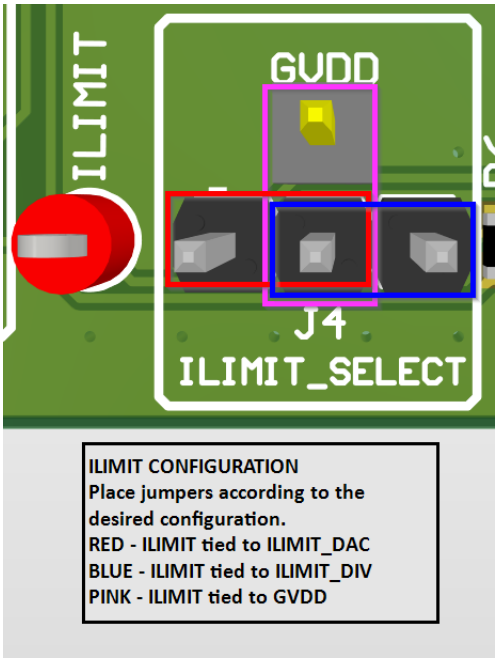


Figure 2-8. DRV8376EVM ILIMIT Configuration

LaunchXL-F280049C Connector Pins

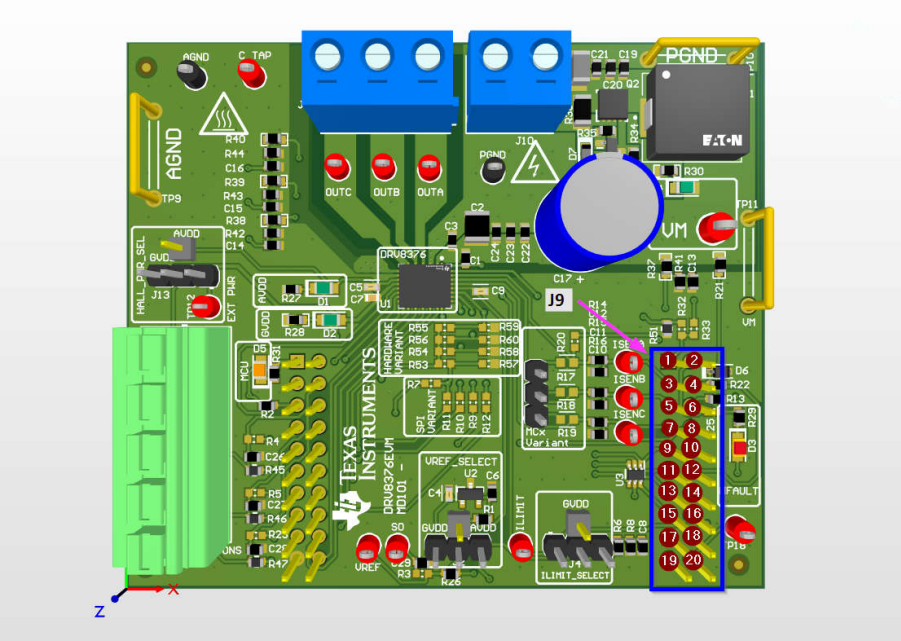


Figure 2-9. DRV8376EVM J9 Header

Table 2-1. DRV8376EVM J9 Header Pin Description

J9 Pin number (DRV8376EVM Schematic)	DRV8376EVM Function	LAUNCHXL-F280049C Function	Description
20	Not used	3.3V	3.3V LaunchPad supply
19	Not used	5V	5V LaunchPad supply
18	Not used	PGA1/3/5_GND	Not used
17	AGND	GND	GND connection
16	Not used	GPIO13/SCIBRX	Not used
15	VSENVM	ADCINA5	VM Bus voltage sense
14	Not used	GPIO40/SCIBTX	Not used (HALLC internal use only)
13	VSENC	ADCINB0	Phase C voltage sense
12	nSLEEP	NC	For internal use only
11	VSENB	ADCINC2	Phase B voltage sense
10	Not used	ADCINB3/VDAC	Not used
9	VSENA	ADCINB1	Phase A Voltage Sense
8	SCLK	SPIACLK	SPI clock (DRV8376 SPI Variant only)
7	ISENA	ADCINB2	Phase A current sense
6	nFAULT (DNP)	ADCINC4	For internal use only
5	ISENB	ADCINC0	Phase B current sense
4	nSLEEP	GPIO37	Active-low output sleep pin
3	ISENC	ADCINA9	Phase C current sense
2	nFAULT	GPIO35	Active-low input fault pin
1	C_TAP/ILIM_DAC (populate only R32 or R33, not both)	ADCINA1/DACB_OUT	ADC for center tap sensing or DAC for ILIM voltage reference

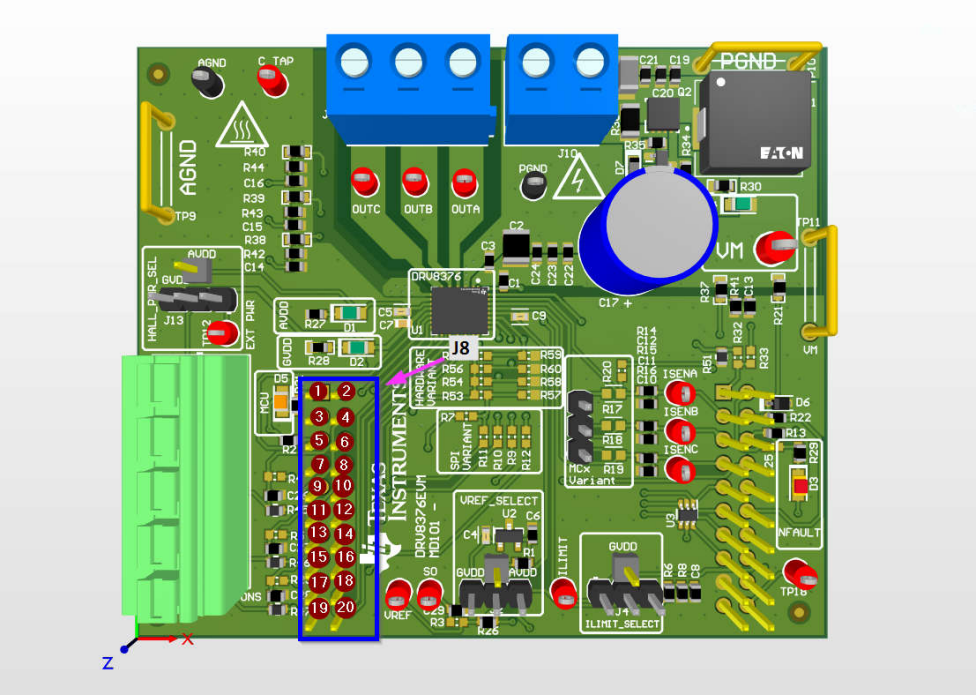


Figure 2-10. DRV8376EVM J8 Header

Table 2-2. DRV8376EVM J8 Header Pin Description

J8 Pin Number (DRV8376EVM Schematic)	DRV8376EVM Function	LAUNCHXL-F280049C Function	Description
20	INHA/HPA	GPIO10/PWM6A	PWM used to switch Phase A highside FET
19	AGND	GND	GND connection
18	INLA/HNA	GPIO11/PWM6B	PWM used to switch Phase A lowside FET
17	nSCS	SPIASTE	SPI active-low chip select (DRV8316R only)
16	INHB/HPB	GPIO8/PWM5A	PWM used to switch Phase B highside FET
15	Not used	NC	Not used
14	INLB/HNB	GPIO9/PWM5B	PWM used to switch Phase B lowside FET
13	Not used	NC	Not used
12	INHC/HPC	GPIO4/PWM3A	PWM used to switch Phase C highside FET
11	Not used	XRSn	Not used
10	INLC/HNC	GPIO5/PWM3B	PWM used to switch Phase C lowside FET
9	SDI	SPIAPICO	SPI data input (DRV8376 SPI Variant only)
8	HALLA	GPIO58	HALL sensor A from motor
7	SDO	SPIAPOCI	SPI data output (DRV8376 SPI Variant only)
6	HALLB	GPIO30	HALL sensor B from motor
5	DRVOFF	GPIO39	Active-high output to disable gate drivers
4	HALLC	GPIO18*/XCLKOUT	HALL sensor C from motor
3	Not used	GPIO23/LED4	LED reserved on LaunchPad
2	VREF	GPIO25	For internal use only
1	MCU_LED	GPIO59	Visual feedback for LaunchPad connection

2.5 Test Points

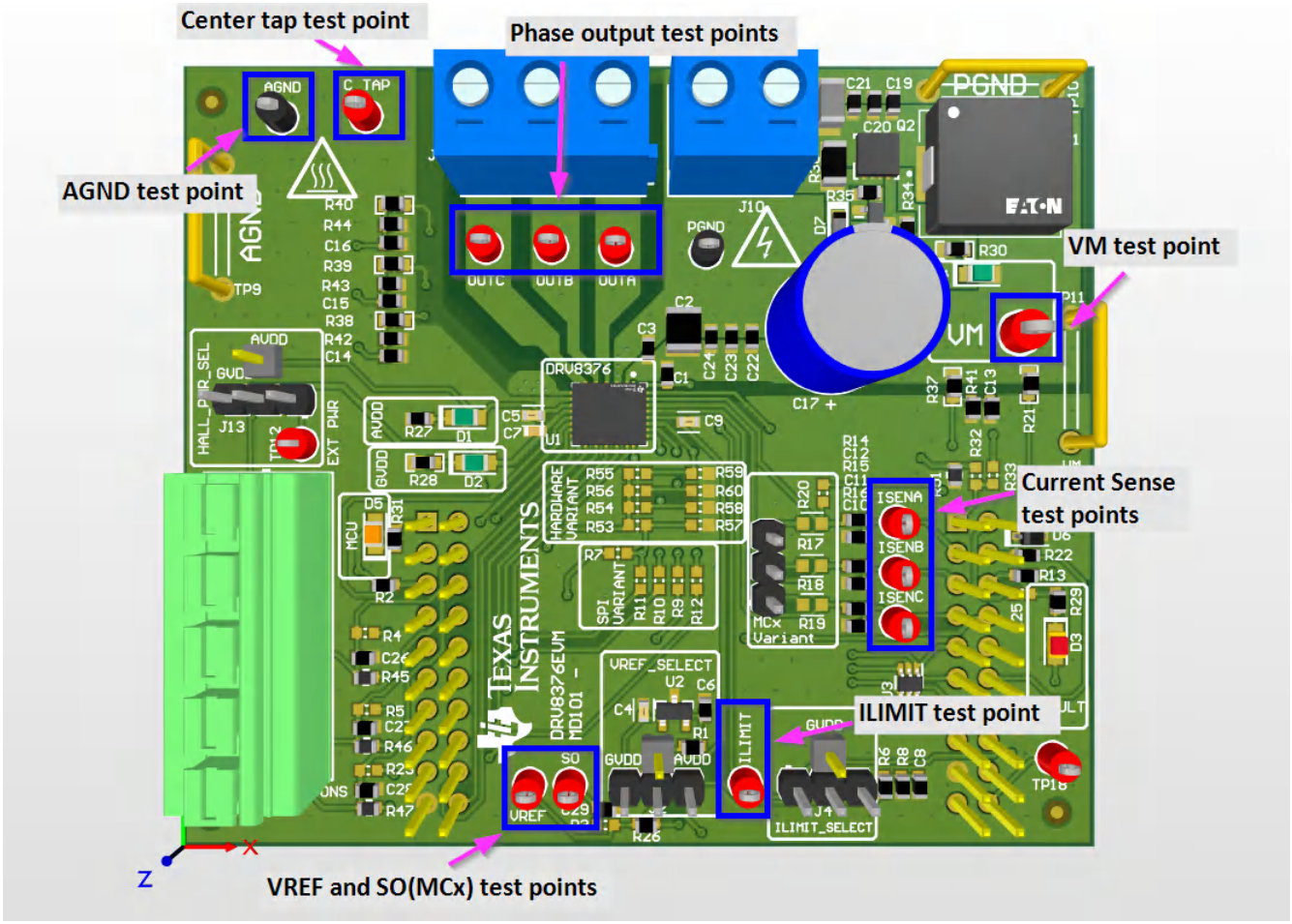


Figure 2-11. DRV8376EVM Test Points

All the test points available on the DRV8376EVM are shown in Figure 2-11.

2.6 Hardware Variant Configuration

To use the DRV8376EVM using the hardware variant IC, use the tables and figure below to configure the device correctly. Make sure the resistors for SPI variant and MCx variant are unpopulated or DNP.

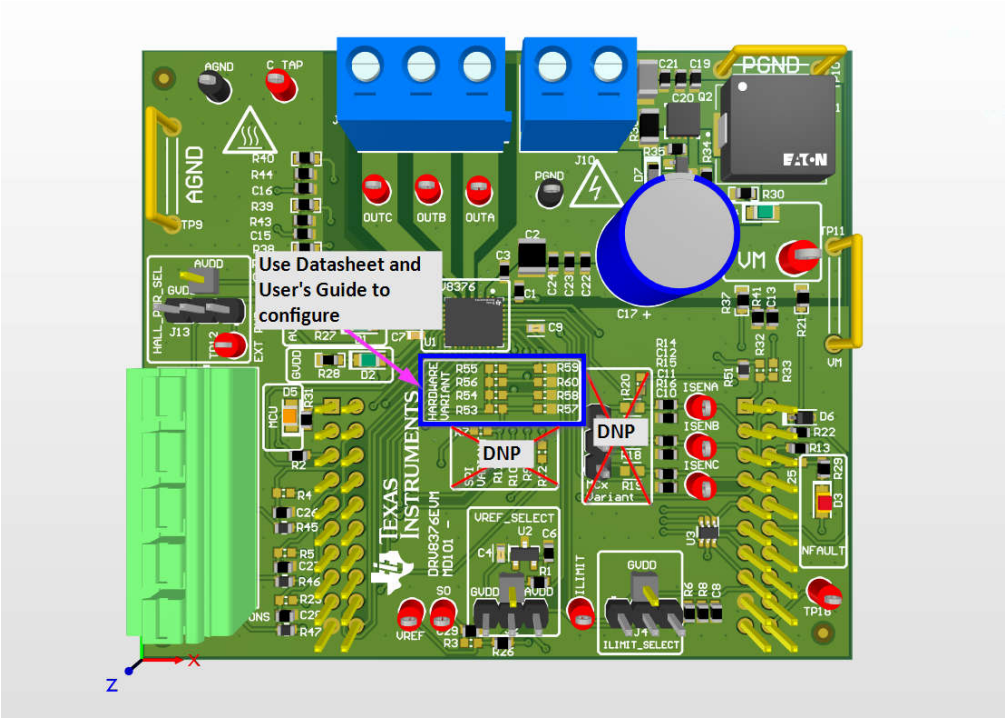


Figure 2-12. Hardware Configuration Resistors

Table 2-3. PWM and ASR/AAR Mode Configuration

MODE Type	PWM MODE	ASR and AAR Mode	MODE_SR Pin	DRV8376EVM
Mode 1	6x Mode	ASR and AAR disabled	Connected to AGND	Populate R57 with 0 ohm resistor or short
Mode 2	6x Mode	ASR and AAR enabled	Hi-Z	Populate R57 with >200k ohm resistor
Mode 3	3x Mode	ASR and AAR disabled	Connected to GVDD with 47 kohm resistor	Populate R53 with 47 k ohm resistor
Mode 4	3x Mode	ASR and AAR enabled	Connected to GVDD	Populate R53 with 0 ohm resistor or short

Table 2-4. Slew Rate Configuration

Slew Rate	SLEW Pin	DRV8376EVM
1100V/us	Connect to AGND	Populate R60 with 0 ohm resistor or short
500V/us	Hi-Z	Populate R60 with >200k ohm resistor
250V/us	47 k ohm to GVDD	Populate R56 with 47 k ohm resistor
50V/us	Connect to GVDD	Populate R56 with 0 ohm resistor or short

Table 2-5. Gain Configuration

Gain	Gain Pin	DRV8376EVM
0.4V/V	Connect to AGND	Populate R58 with 0 ohm resistor or short
1V/V	Hi-Z	Populate R58 with >200k ohm resistor
2.5V/V	47 k ohm to GVDD	Populate R54 with 47 k ohm resistor
5V/V	Connect to GVDD	Populate R54 with 0 ohm resistor or short

Table 2-6. OCP Configuration

OCP	OCP Pin	DRV8376EVM
4.5A	Connect to AGND	Populate R59 with 0 ohm resistor or short
2A	Connect to GVDD	Populate R55 with 0 ohm resistor or short

2.7 SPI Variant Configuration

To use the DRV8376EVM using the SPI variant IC, configure the device as shown in Figure 2-13. Make sure the resistors for hardware variant and MCx variant are unpopulated or DNP.

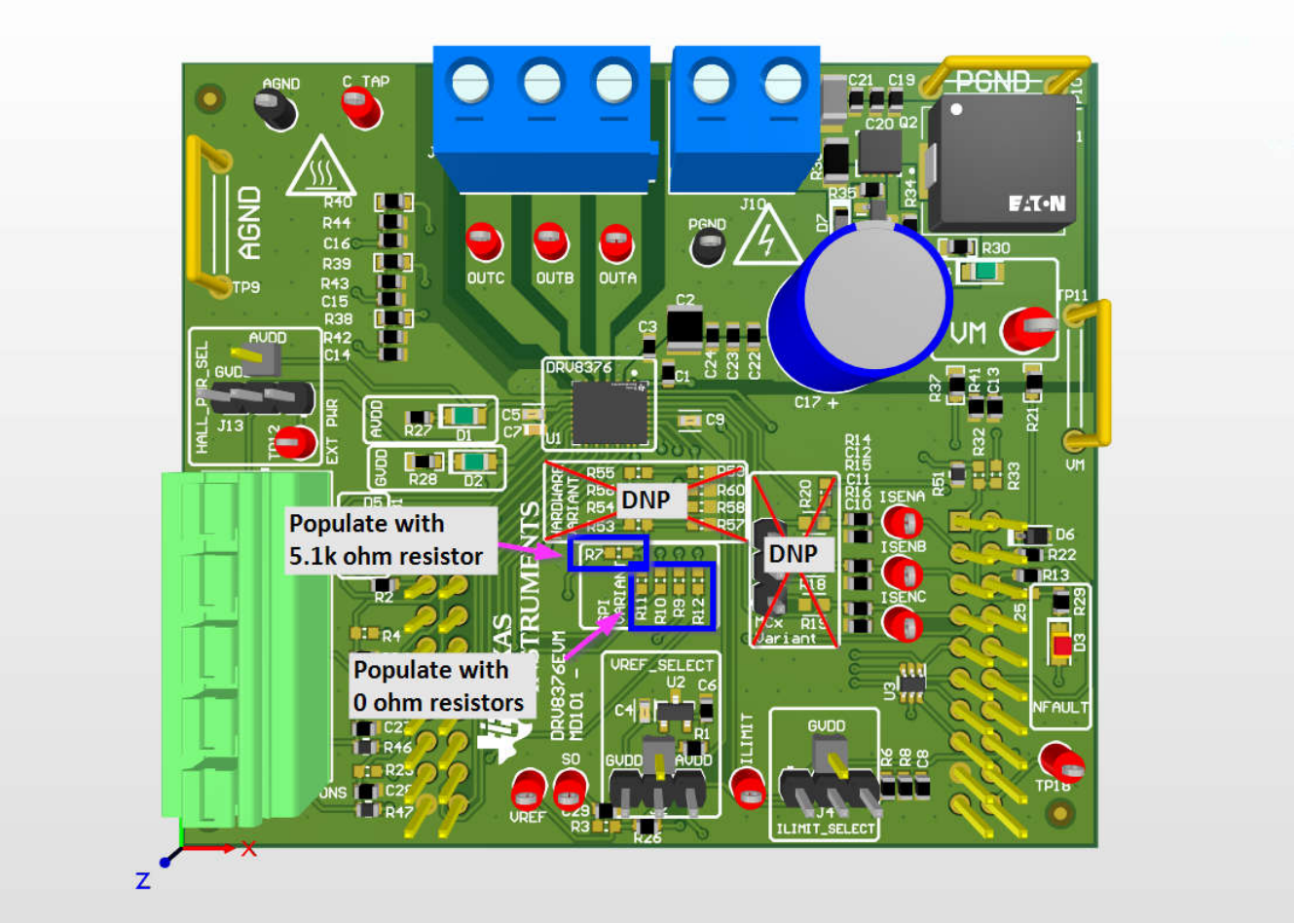


Figure 2-13. SPI Configuration Resistors

Once the appropriate resistors have been populated, the DRV8376 IC can be configured through SPI.

2.8 MCx Variant Configuration

To use the DRV8376EVM using the MCx variant IC, use the tables and figure below to configure the device correctly. Make sure the resistors for SPI variant are unpopulated or DNP, that R17, R18, and R19 are populated with 0 ohm resistors or shorted, and R20 is populated with a 5.1k ohm resistor.

The MCx variant of the DRV8376 IC utilizes the Hardware variant resistors for configuration of MODE, GAIN_SLEW_tLOCK, DIR, and ADVANCE.

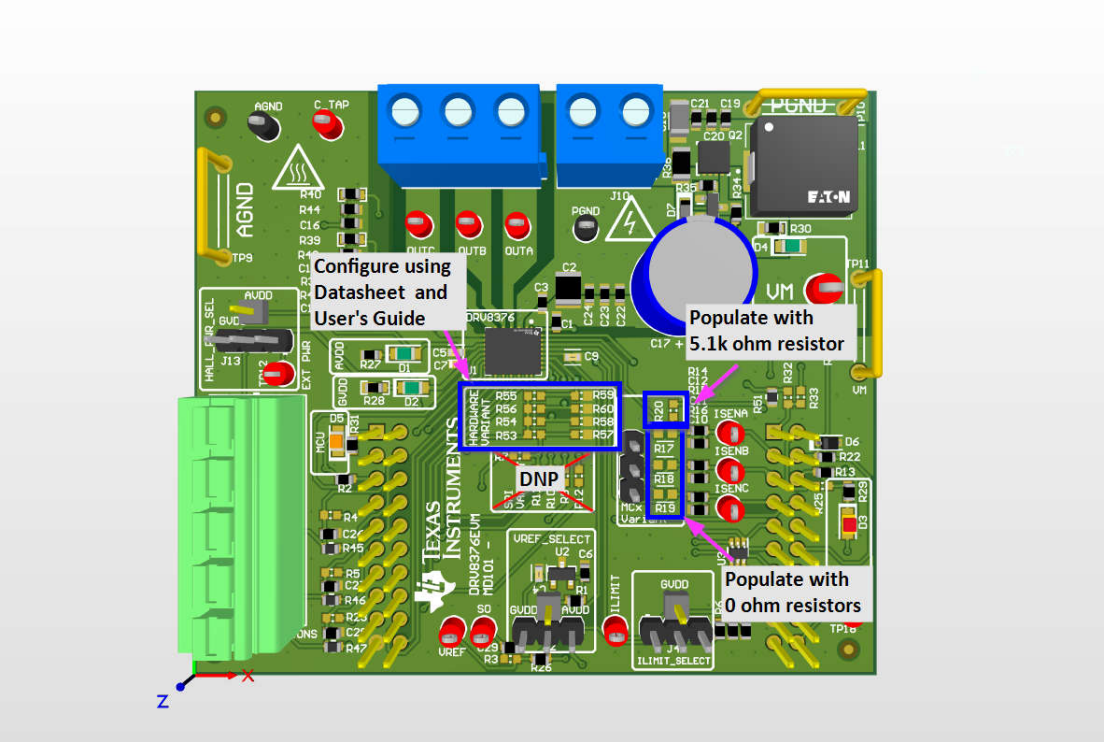


Figure 2-14. MCx Configuration Resistors

Table 2-7. MODE Pin Configuration

MODE Pin	Hall Configuration	Modulation	ASR and AAR Mode	DRV8376EVM
Connect to AGND	Analog Hall Input	Asynchronous	ASR and AAR Disabled	Populate R57 with 0 ohm resistor or short
22k ohm to AGND	Digital Hall Input	Asynchronous	ASR and AAR Disabled	Populate R57 with 22k ohm resistor
100k ohm to AGND	Analog Hall Input	Synchronous	ASR and AAR Disabled	Populate R57 with 100k ohm resistor
Hi-Z	Digital Hall Input	Synchronous	ASR and AAR Disabled	Populate R57 with >200k ohm resistor
100k ohm to GVDD	Analog Hall Input	Synchronous	ASR and AAR Enabled	Populate R53 with 100k ohm resistor
22k ohm to GVDD	Digital Hall Input	Synchronous	ASR and AAR Enabled	Populate R53 with 22k ohm resistor
Connect to GVDD	Digital Hall Input	Synchronous	ASR and AAR Enabled	Populate R53 with 0 ohm resistor or short

Table 2-8. GAIN_SLEW_tLOCK Pin Configuration

GAIN_SLEW_tLOCK Pin	GAIN	SLEW	LOCK_DET_TIME	DRV8376EVM
Connected to AGND	0.4V/A	1.1V/ns	500ms	Populate R58 with 0 ohm resistor or short
22k ohm to AGND	0.4V/A	1.1V/ns	5000ms	Populate R58 with 22k ohm resistor
100k ohm to AGND	0.4V/A	0.25V/ns	500ms	Populate R58 with 100k ohm resistor
Hi-Z	0.4V/A	0.25V/ns	5000ms	Populate R58 with >200k ohm resistor
100k ohm to GVDD	2.5V/A	1.1V/ns	500ms	Populate R54 with 100k ohm resistor
22k ohm to GVDD	2.5V/A	1.1V/ns	5000ms	Populate R54 with 22k ohm resistor
Connected to GVDD	2.5V/A	0.25V/ns	500ms	Populate R54 with 0 ohm resistor or short

Table 2-9. DIR Pin Configuration

DIR pin	DIR operation	DRV8376EVM
Connect to GND	Disable direction change feature	Populate R59 with 0 ohm resistor or short

Table 2-10. ADVANCE Pin Configuration

Advance Pin	Phase Advance Setting	DRV8376EVM
Connected to AGND	0°	Populate R60 with 0 ohm resistor or short
22k ohm to AGND	4°	Populate R60 with 22k ohm resistor
100k ohm to AGND	11°	Populate R60 with 100k ohm resistor
Hi-Z	15°	Populate R60 with >200k ohm resistor
100k ohm to GVDD	20°	Populate R56 with 100k ohm resistor
22k ohm to GVDD	25°	Populate R56 with 22k ohm resistor
Connected to GVDD	30°	Populate R56 with 0 ohm resistor or short

3 Software

3.1 DRV8376EVM GUI Software

This section details the features of the EVM GUI Software. The GUI is written in GUI Composer and is available on the development software gallery at dev.ti.com/gallery.

The GUI connects and programs the C2000 MCU on the LAUNCHXL-F280049C board when launched, assuming the board is connected and powered. Once the hardware is connected, the FAULT status and voltage monitors match the EVM. If these do not match, then remove EVM power and recheck the setup. If the fault is triggered, then press the Clear Faults button on the GUI.

To spin the motor:

1. Using a Google Chrome® browser, navigate to dev.ti.com/gallery and search for the DRV8376EVM GUI.
2. After loading, make sure that the GUI connects to the board and shows *Hardware Connected* in the bottom status bar and that the MCU LED is turned on.
3. Confirm that the GUI reports VM_Undervoltage Fault and Over-Current Fault.
4. Turn on the power supply at and set the current limit on the power supply.
5. Make sure AVDD, GVDD, and VM LEDs lights up green.
6. Click the *Clear Faults* button on the GUI and confirm the fault light on GUI is clear (green) and check to see the DRV8376EVM NFAULT LED is off.
7. Check the following items:
   a. GUI reads back the voltage being supplied.
   b. GUI shows no FAULTs.
   c. FAULT LEDs is now OFF.
8. Toggle *Output Enable* to ON.
9. Raise the Duty Cycle (%) to desired value and the motor starts spinning.
10. If direction change is needed, then toggle the direction in the GUI, observe the motor slowing down to a stop, and then spinning in opposite direction.
11. Disable the motor by switching the *Output Enable* to OFF.

4 Hardware Design Files

4.1 Schematics

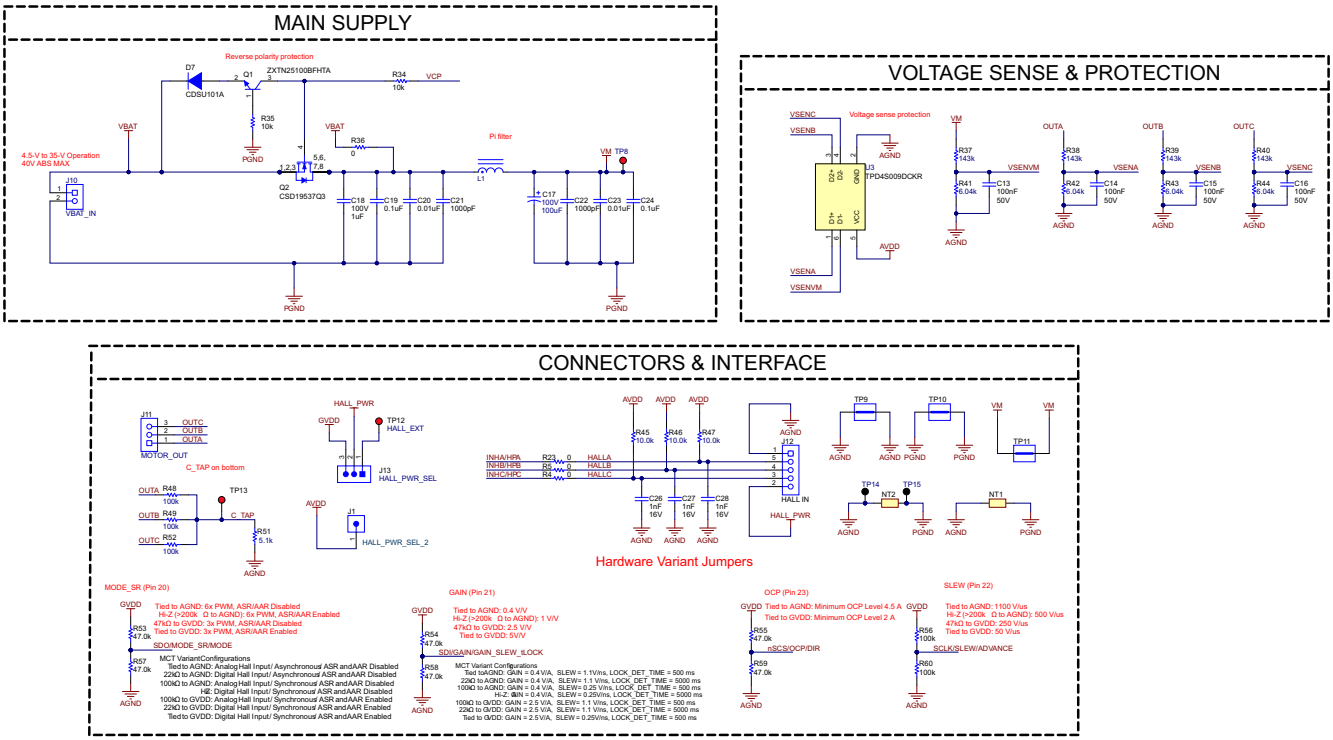


Figure 4-1. DRV8376EVM Schematic - Main supply, Voltage Sense & Protection, and Connectors & Interface

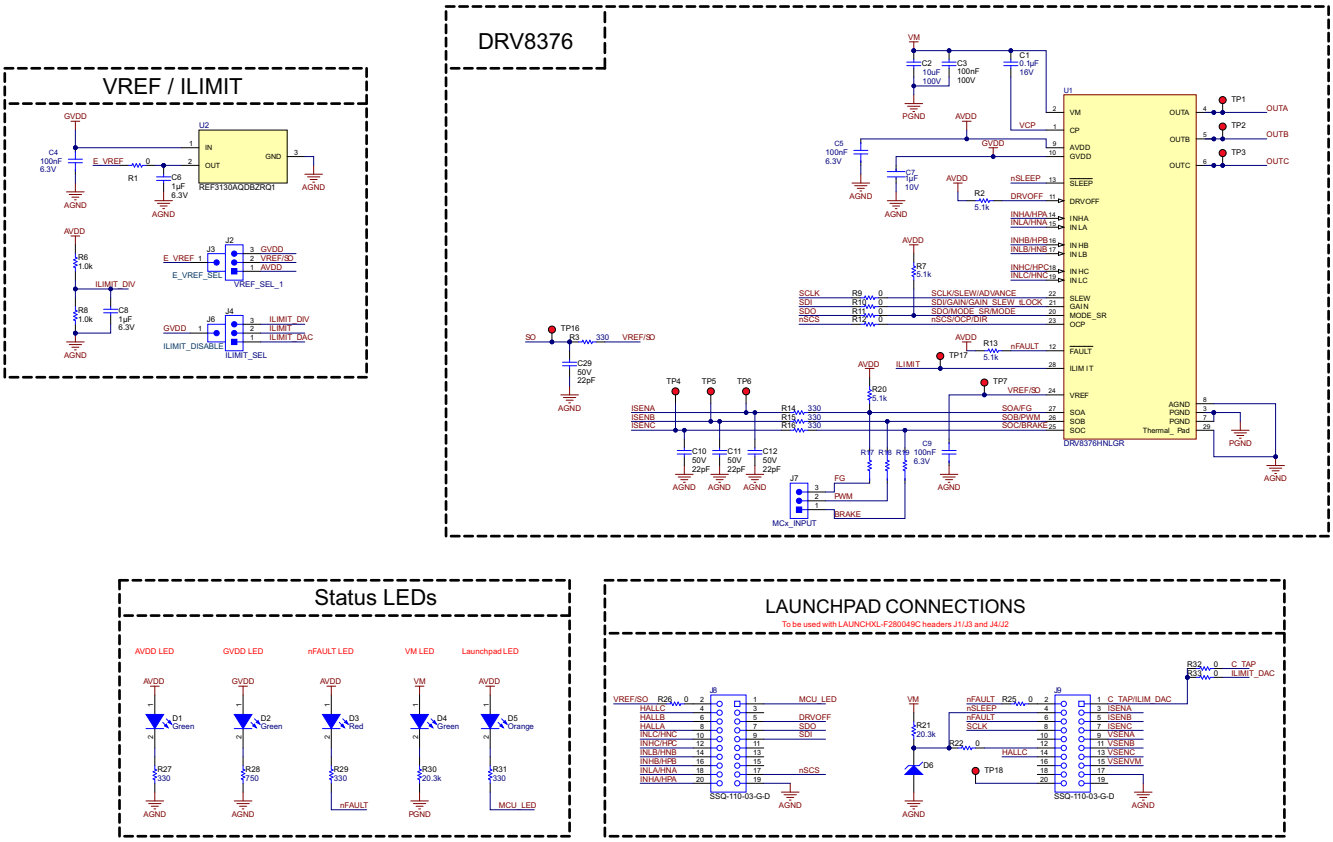


Figure 4-2. DRV8376EVM - IC, VREF/ILIMT, Status LEDs, and Launchpad Connections

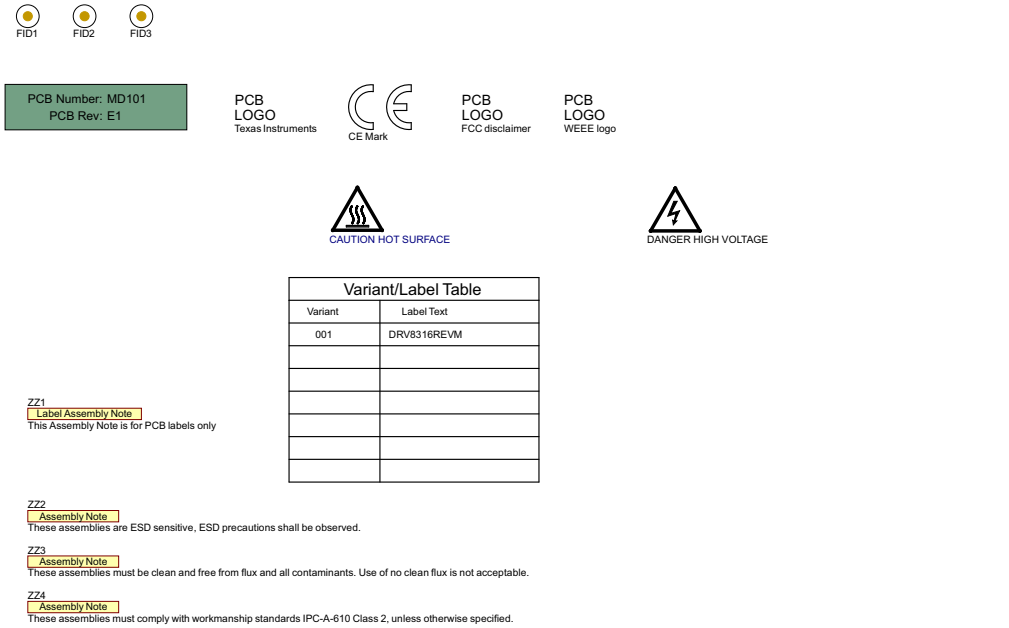


Figure 4-3. DRV8376EVM - Miscellaneous

4.2 PCB Layouts

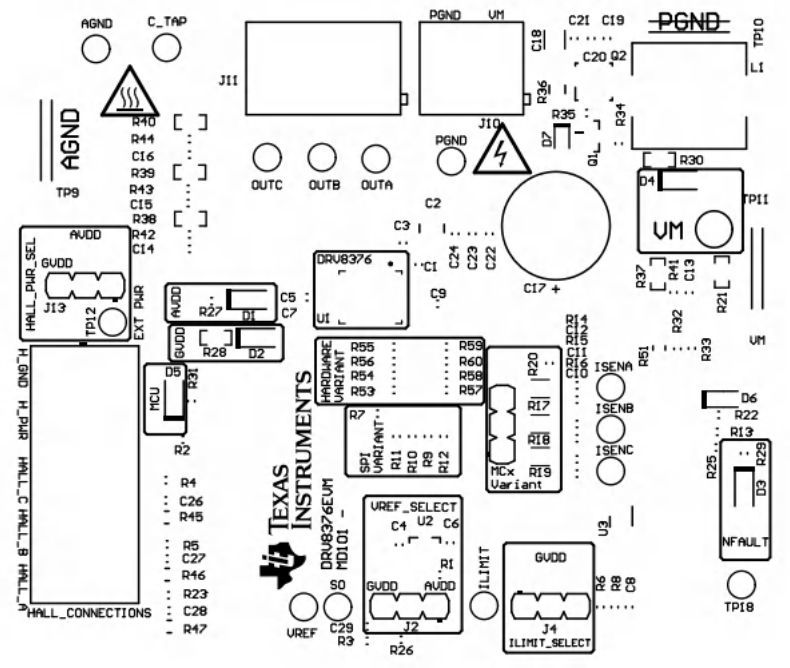


Figure 4-4. DRV8376EVM PCB Layer 1

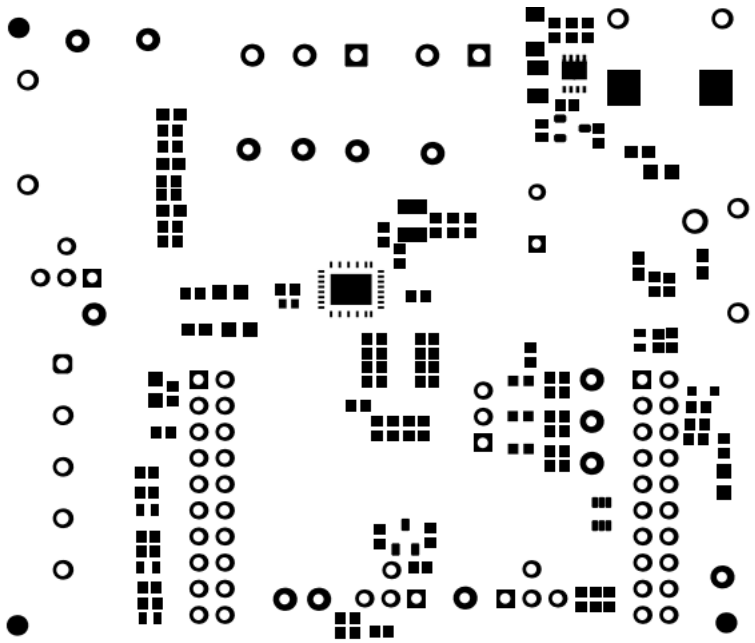


Figure 4-5. DRV8376EVM PCB Layer 2

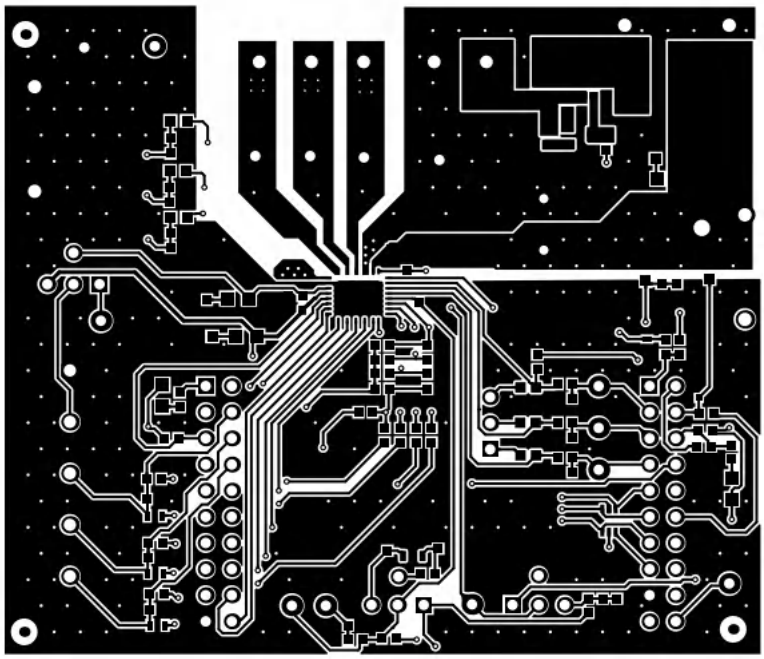


Figure 4-6. DRV8376EVM PCB Layer 3

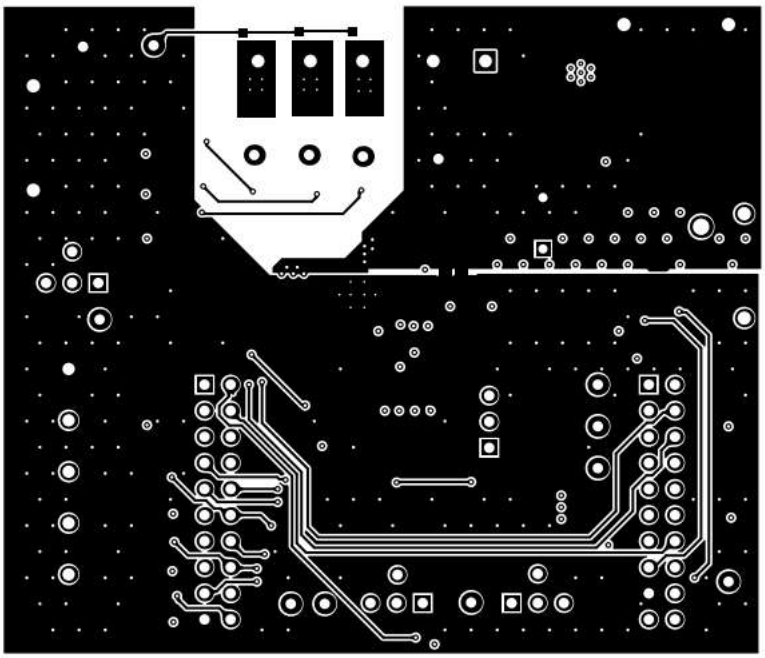


Figure 4-7. DRV8376EVM PCB Layer 4

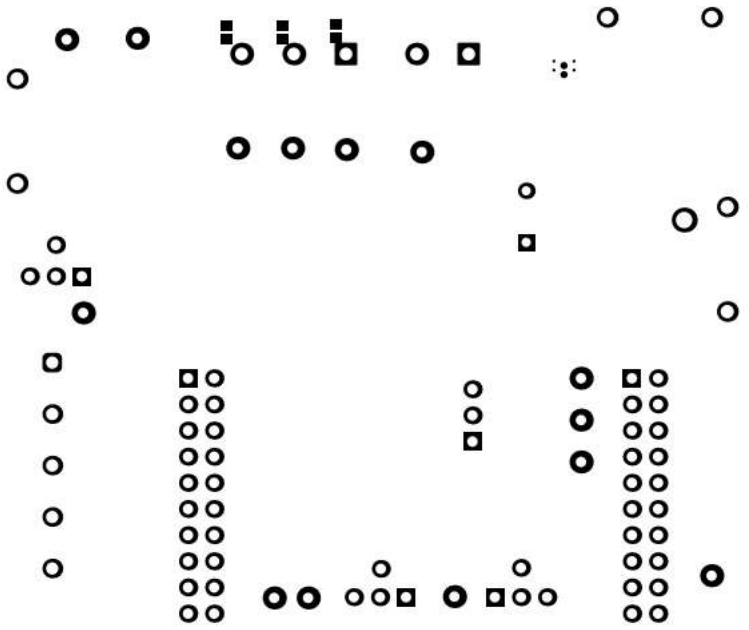


Figure 4-8. DRV8376EVM PCB Layer 5

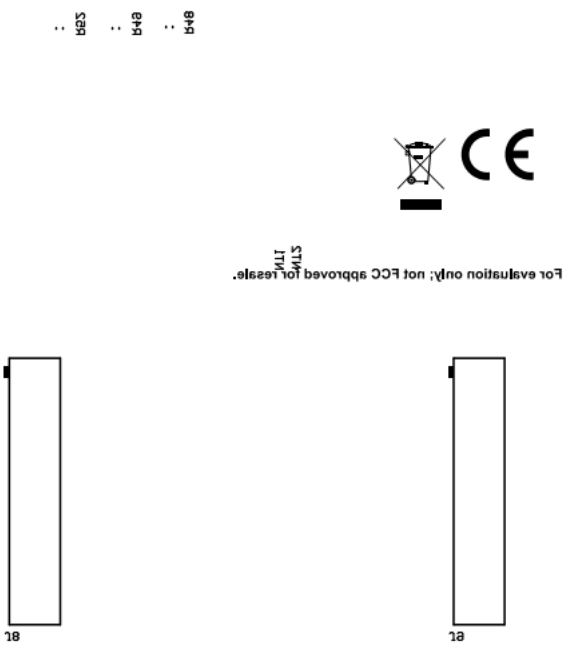
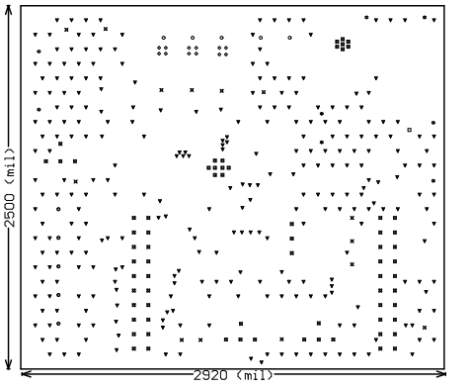


Figure 4-9. DRV8376EVM PCB Layer 6

Layer	Name	Material	Thickness	Constant	Board Layer Stack
	Top Overlay				
	Top Solder	Solder Resist	0.40mil	3.5	
1	Top Layer		4.20mil		
	Dielectric 1	FR-4	8.00mil	4.2	
2	Ground		1.40mil		
	Dielectric 2	FR-4	40.00mil	4.2	
3	Power		1.40mil		
	Dielectric 3	FR-4	8.00mil	4.2	
4	Bottom Layer		4.20mil		
	Bottom Solder	Solder Resist	0.40mil	3.5	
	Bottom Overlay				
Total board thickness:			68.00mil		



Symbol	Count	Hole Size	Plated	Hole Type	Drill Layer Pair	Hole Tolerance
	15	7.87mil (0.200mm)	PTH	Round	Top Layer - Bottom Layer	
	12	8.00mil (0.203mm)	PTH	Round	Top Layer - Bottom Layer	
	285	12.00mil (0.305mm)	PTH	Round	Top Layer - Bottom Layer	
	2	35.43mil (0.900mm)	PTH	Round	Top Layer - Bottom Layer	
	14	40.00mil (1.016mm)	PTH	Round	Top Layer - Bottom Layer	
	55	40.16mil (1.020mm)	PTH	Round	Top Layer - Bottom Layer	
	5	47.24mil (1.200mm)	PTH	Round	Top Layer - Bottom Layer	
	5	49.21mil (1.250mm)	PTH	Round	Top Layer - Bottom Layer	
	6	51.18mil (1.300mm)	PTH	Round	Top Layer - Bottom Layer	
	1	63.00mil (1.600mm)	PTH	Round	Top Layer - Bottom Layer	
	400 Total					

Figure 4-10. DRV8376EVM PCB Layer 7

4.3 Bill of Materials (BOM)

The bill of materials for DRV8376EVM is listed in Table 4-1.

Table 4-1. Bill of Materials

Designator	Quantity	Value	Description	Part Number	Manufacturer	Package Reference
!PCB1	1		Printed Circuit Board	MD101	Any	
C1	1	1uF	CAP, CERM, 1µF, 16V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	EMK107B7105KAHT	Taiyo Yuden	0603
C2	1	10uF	CAP, CERM, 10uF, 63V, +/- 10%, X7R, 1210	GRM32ER71J106KA12L	MuRata	1210
C3	1	0.1uF	CAP, CERM, 0.1µF, 100V,+/- 10%, X7R, 0603	0603BB104KW101	Passive Plus	0603
C4, C5, C9	3	100nF	0.1µF ±10% 6.3V Ceramic Capacitor X7R 0603 (1608 Metric)	C0603C104K9RACTU	KEMET	0603
C6, C8	2	1uF	CAP, CERM, 1uF, 6.3V, +/- 10%, X7R, 0603	CL10B105KQ8NNNC	Samsung Electro-Mechanics	0603
C7	1		CAP CER 0603 1UF 10V X7R 10%	C0603C105K8RACAUTO	KEMET	0603 (1608 Metric)
C10, C11, C12,C29	4	22pF	CAP, CERM, 22pF, 50V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0603	CGA3E2C0G1H220J080AA	TDK	0603
C13, C14, C15,C16	4	0.1uF	CAP, CERM, 0.1µF, 50V,+/- 5%, X7R, 0603	06035C104JAT2A	AVX	0603
C17	1	100uF	CAP, AL, 100uF, 100V, +/- 20%, TH	ECA-2AM101	Panasonic	D10xL16mm
C18	1	1uF	CAP, CERM, 1uF, 100V, +/- 10%, X7R, 1206	C3216X7R2A105K160AA	TDK	1206
C19, C24	2	0.1uF	CAP, CERM, 0.1uF, 100V, +/- 10%, X7S, AEC-Q200 Grade 1, 0603	CGA3E3X7S2A104K080AB	TDK	0603
C20, C23	2	0.01uF	CAP, CERM, 0.01uF, 100V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	CGA3E2X7R2A103K080AA	TDK	0603
C21, C22	2	1000pF	CAP, CERM, 1000pF, 100V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	CGA3E2X7R2A102K080AA	TDK	0603
C26, C27, C28	3	1000pF	CAP, CERM, 1000pF, 16V, +/- 10%, X7R, 0603	8.85012E+11	Wurth Elektronik	0603
D1, D2, D4	3	Green	LED, Green, SMD	LTST-C170KGKT	Lite-On	LED_0805
D3	1	Red	LED, Red, SMD	LTST-C170KRKT	Lite-On	Red 0805 LED
D5	1	Orange	LED, Orange, SMD	LTST-C170KFKT	Lite-On	LED_0805
D6	1	3.3V	Diode, Zener, 3.3V, 300mW, AEC-Q101, SOD-323	SZMM3Z3V3ST1G	ON Semiconductor	SOD-323
D7	1	90V	Diode, Switching, 90V, 0.1A, SOD-523F	CDSU101A	Comchip Technology	SOD-523F
FID1, FID2, FID3	3		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
J1, J3, J6	3		Header, 2.54mm, 1x1, Gold, TH	TSW-101-08-G-S	Samtec	Header, 2.54mm,1x1, TH
J2, J4, J7, J13	4		Header, 2.54mm, 3x1, Tin, TH	68001-403HLF	FCI	Header, 2.54mm,3x1, TH

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Part Number	Manufacturer	Package Reference
J8, J9	2		Receptacle, 2.54mm, 10x2, Gold, TH	SSQ-110-03-G-D	Samtec	Receptacle, 2.54mm,10x2, TH
J10	1		Terminal Block, 5.08mm, 2x1, Brass, TH	ED120/2DS	On-Shore Technology	2x1 5.08 mmTerminal Block
J11	1		Terminal Block, 5.08mm, 3x1, Brass, TH	ED120/3DS	On-Shore Technology	3x1 5.08 mmTerminal Block
J12	1		Terminal Block, 5mm, 5x1, R/A, TH	1792892	Phoenix Contact	Terminal Block,5mm, 5x1, R/A, TH
L1	1	1uH	1µH Shielded Drum Core, Wirewound Inductor 18A 3.3mOhm MaxNonstandard	HCMA1104-1R0-R	Eaton	SMD2
Q1	1	100V	Transistor, NPN, 100V, 3A, AEC-Q101, SOT-23	ZXTN25100BFHTA	Diodes Inc.	SOT-23
Q2	1	100V	MOSFET, N-CH, 100V, 50A, DQG0008A (VSON-CLIP-8)	CSD19537Q3	Texas Instruments	DQG0008A
R1, R4, R5, R9, R10, R11, R12, R22, R23, R25,R26, R32, R33	13	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	ERJ-3GEY0R00V	Panasonic	0603
R2, R7, R13, R20	4	5.1k	RES, 5.1 k, 5%, 0.1 W, 0603	CRCW06035K10JNEA	Vishay-Dale	0603
R3, R14, R15,R16	4	330	RES, 330, 0.1%, 0.1 W, 0603	RG1608P-331-B-T5	Susumu Co Ltd	0603
R6, R8	2	1.0k	RES, 1.0 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	RCA06031K00JNEA	Vishay-Dale	0603
R17, R18, R19	3	0	0 Ohms Jumper Chip Resistor 0603 (1608 Metric) Metal Element	WSL060300000ZEA9	Vishay	0603
R21, R30	2	20.3k	RES, 20.3 k, 0.1%, 0.1 W, 0603	RT0603BRD0720K3L	Yageo America	0603
R27, R29, R31	3	330	RES, 330, 1%, 0.1 W, 0603	RC0603FR-07330RL	Yageo	0603
R28	1	750	RES, 750, 0.1%, 0.1 W, 0603	RG1608P-751-B-T5	Susumu Co Ltd	0603
R34, R35	2	10k	RES, 10 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW060310K0JNEA	Vishay-Dale	0603
R36	1	0	RES, 0, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	RCA12060000ZSEA	Vishay-Dale	1206
R37, R38, R39,R40	4	143k	RES, 143 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW0603143KFKEA	Vishay-Dale	0603
R41, R42, R43,R44	4	6.04k	RES, 6.04 k, 0.5%, 0.1 W, 0603	RT0603DRE076K04L	Yageo America	0603
R45, R46, R47,R51	4	10.0k	RES, 10.0 k, 0.1%, 0.1 W, AEC-Q200 Grade 1, 0603	TNPW060310K0BEEA	Vishay-Dale	0603
R48, R49, R52,R56, R60	5	100k	RES, 100 k, 0.1%, 0.1 W, AEC-Q200 Grade 0, 0603	ERA-3AEB104V	Panasonic	0603
R53, R54, R55,R57, R58, R59	6	47.0k	RES, 47.0 k, 0.5%, 0.15 W, AEC-Q200 Grade 0, 0603	MCT0603MD4702DP500	Vishay/Beyschlag	0603

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Part Number	Manufacturer	Package Reference
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP12, TP13, TP16, TP17,TP18	12		Test Point, Miniature, Red, TH	5000	Keystone	Red Miniature Testpoint
TP8	1		Test Point, Compact, Red, TH	5005	Keystone	Red CompactTestpoint
TP9, TP10, TP11	3		1mm Uninsulated Shorting Plug, 10.16mm spacing, TH	D3082-05	Harwin	Shorting Plug,10.16mm spacing, TH
TP14, TP15	2		Test Point, Miniature, Black, TH	5001	Keystone	Black MiniatureTestpoint
U1	1		Three-Phase Integrated FET Motor Driver	DRV8376HNLGR	Texas Instruments	VQFN28
U2	1		Automotive 20ppm / degC Max, 100uA, SOT23-3 Series VoltageReference, DBZ0003A (SOT-23-3)	REF3130AQDBZRQ1	Texas Instruments	DBZ0003A
U3	1		4-Channel ESD Solution for High-Speed Differential Interface, DCK0006A(SOT-SC70-6)	TPD4S009DCKR	Texas Instruments	DCK0006A

5 Additional Information

5.1 Trademarks

LaunchPad™ is a trademark of Texas Instruments.
Google Chrome® is a registered trademark of Google LLC.
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

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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.

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