

EVM User's Guide: DRV8334EVM

DRV8334 Evaluation Module



Description

The DRV8334EVM is a 30 A, 3-phase brushless DC drive stage based on the DRV8334 gate driver for BLDC motors.

The EVM allows quick evaluation of the DRV8334 device which spins a BLDC motor with trapezoidal commutation and control.

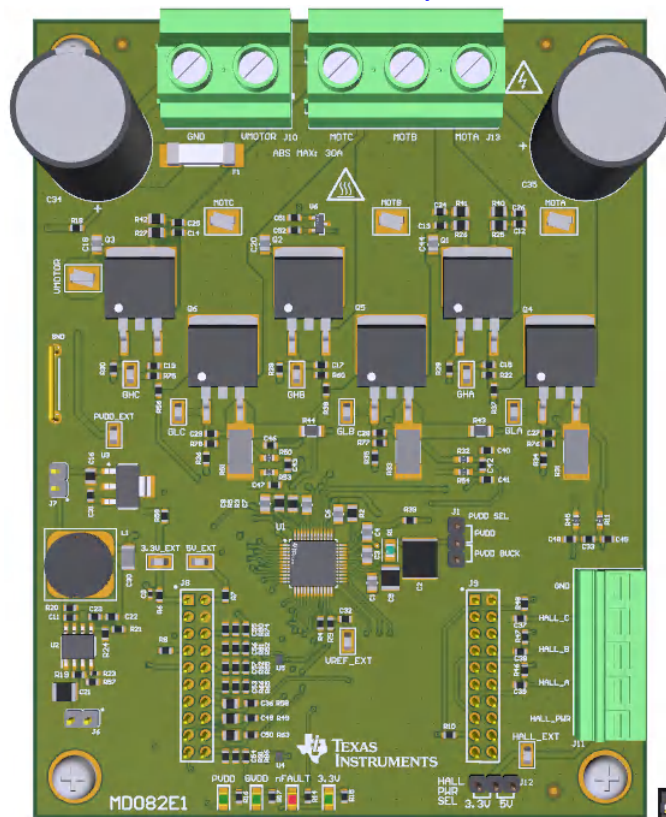
Status LEDs for all power supplies as well as a Fault LED are included for user feedback. The C2000 launchpad (LAUNCHXL-F280049C) is required for this kit and is used to control the DRV8334 as well as monitor and report faults.

Features

- 4.5V to 60 V operation with support for 12 V/24 V applications
- 100% duty cycle PWM control, with 1 A/2 A peak gate drive
- 40+ configurable IDRIVE steps for fine slew rate tuning
- 3x integrated CSAs with low input offset drift

Applications

- [Appliances](#), [cordless garden](#) and [power tools](#), lawnmowers
- [Brushless-DC \(BLDC\) motor modules](#) and PMSM
- [Fans](#), [pumps](#), and [servo drives](#)
- E-bikes, e-scooters, and e-mobility
- [Cordless vacuum cleaners](#)
- [Drones](#), [industrial and logistics robots](#), and [RC toys](#)



DRV8334EVM

1 Evaluation Module Overview

1.1 Introduction

This document is provided with the DRV8334 customer evaluation module (EVM) as a supplement to the DRV8334 data sheet. The user's guide details the hardware implementation of the EVM.

This document is designed to be used as a startup guide to the DRV8334EVM and LAUNCHXL-F280049C device. This document is intended for the engineers involved in the design, implementation, and validation of DRV8334 + TMS320F280049C reference software.

The scope of this document is to provide the user with a guide to evaluate the DRV8334 device with a TMS320F280049C board. This document covers the hardware connections required between boards and external motor/supplies. When the hardware connections are complete, the user can access the necessary tools and software to spin a motor using the online GUI.

The reference software is composed of GuiComposer software with sensored trapezoidal algorithm for BLDC motor control.

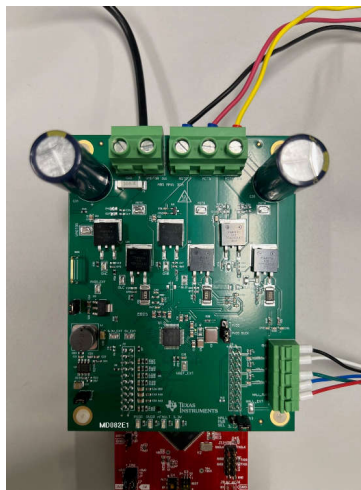


Figure 1-1. DRV8334EVM

CAUTION


The DRV8334EVM is designed to be evaluated only with the LAUNCHXL-F280049C MCU PCB, which must be ordered separately.

WARNING


Voltages exceeding the standard EVM ratings as specified on the data sheet can cause personal injury, electrical shock hazard, damage the EVM, or a combination.

Additionally, do not leave power connections to the EVM connected while not in operation.

WARNING

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

	High Voltage	For safety, use of isolated test equipment with overvoltage and overcurrent protection is highly recommended. Electric shock is possible when connecting board to live wire. The board must be handled with care by a professional.
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1.2 Kit Contents

Item	Description	Quantity
DRV8334EVM	PCB	1
Box	Cardboard box	1
Label	Standard label	1
Foam	Antistatic foam	2
Literature	EVM disclaimers	1

1.3 Specification

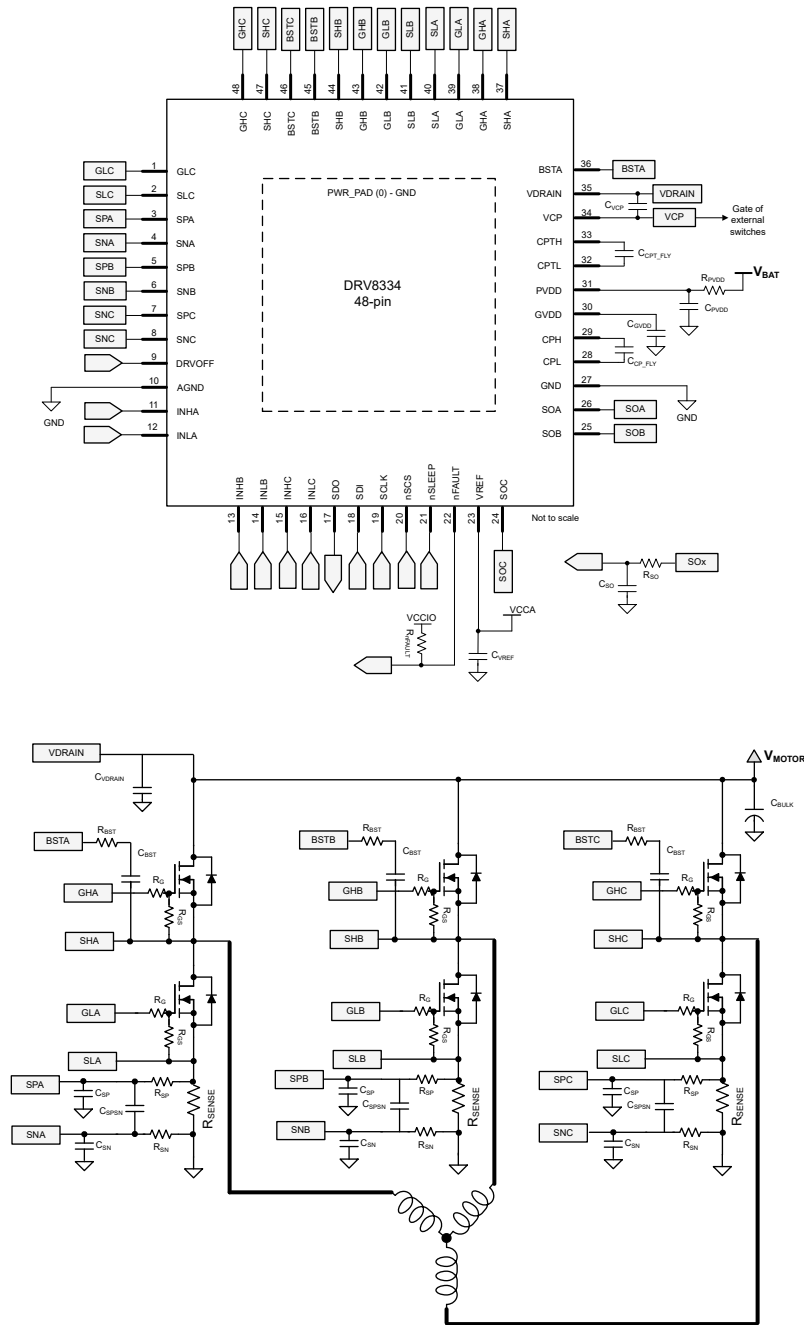


Figure 1-2. 3-phase BLDC Driver Simplified Schematic

1.4 Device Information

The DRV8334 enables customers to evaluate their motor performance within their gate driver system. The DRV8334 implements features such as enhanced Smart Gate Drive and expanded device protection features, making the device an excellent choice for applications such as power tools, appliances, pumps, and fans. The device supports both 12 V and 24 V applications while allowing up to 65 V PVDD abs max to support power supply transients.

2 Hardware

2.1 Hardware Connections Overview – DRV8334EVM + LAUNCHXL-F280049C

The following section describes the EVM hardware and connections to the external supply, hall sensors, PC via USB, and motor.

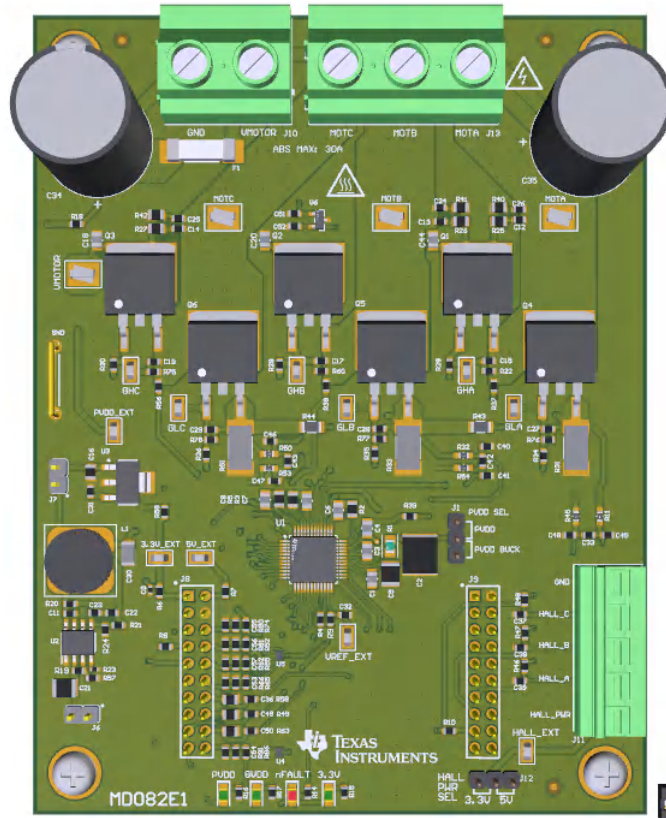


Figure 2-1. EVM Board Overview

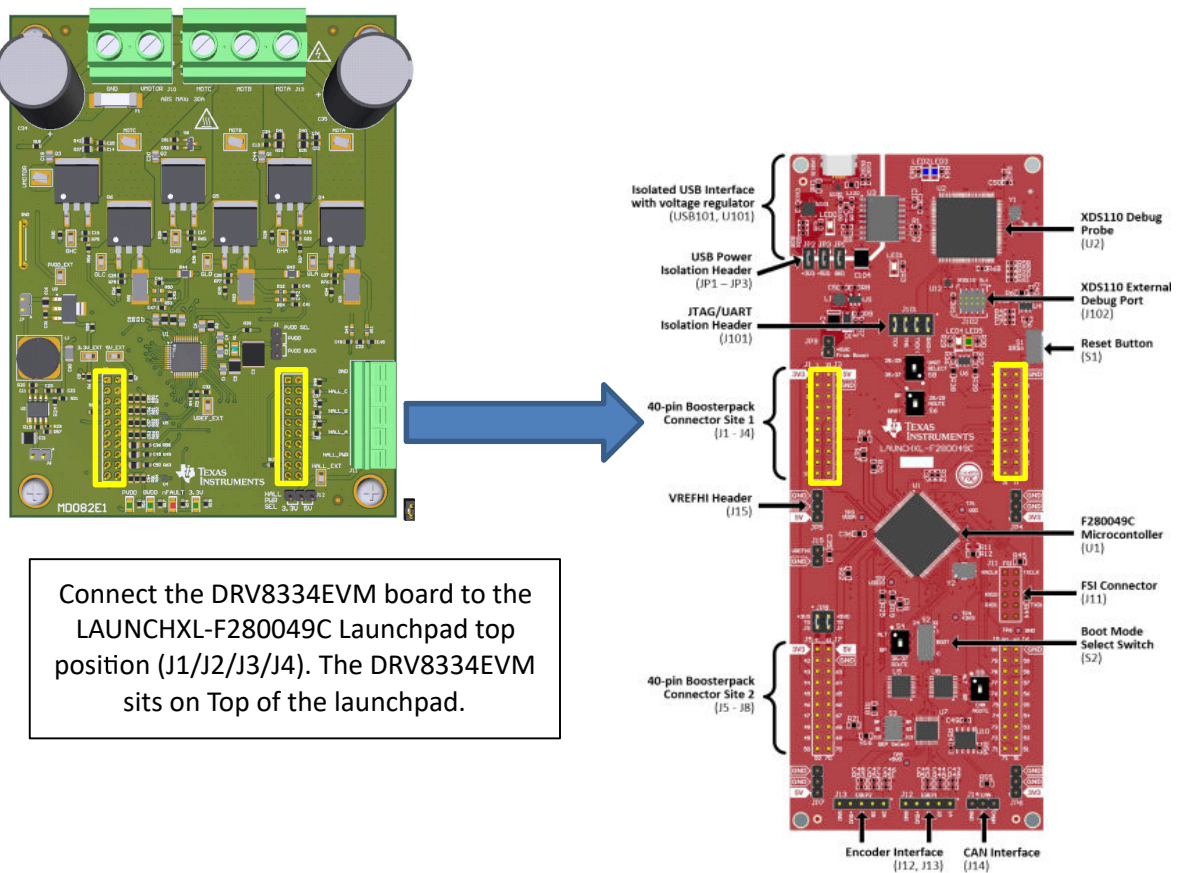


Figure 2-2. DRV8334EVM Mating to LAUNCHXL-F280049C

The DRV8334EVM must plug into the LAUNCHXL-F280049C Launchpad headers closest to the USB port as shown above.

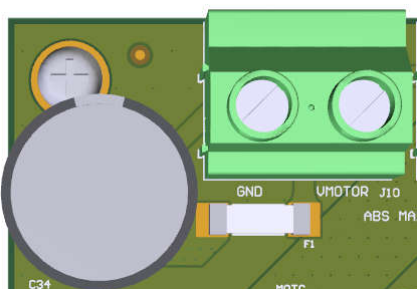


Figure 2-3. VMOTOR Input (J10)

WARNING

To minimize the risk of potential shock hazard and personal injury, remove all power connections and interfaces to the DRV8334EVM when not in use.

The DRV8334EVM is designed for an input supply from 4.5 V_{DC} to 60 V_{DC} and up to 30-A continuous drive current (in-line fuse limited). The input connects to J10 with the noted polarity. VMOTOR test point connects to the same node but must not be used for high current input. VMOTOR input is fused with a 30 A fuse and the input connector is rated for 32 A.

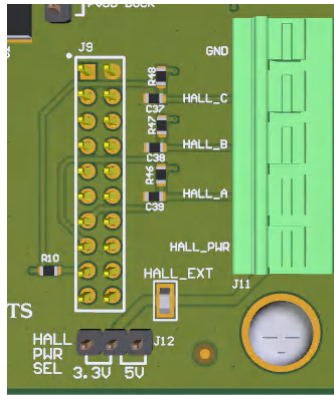


Figure 2-4. Hall Sensor Input and Power Connections (J11)

Hall sensors are connected to J11 including hall power and GND. The 3.3 V_{DC} supply to the Hall sensors is supplied from the 3.3 V LDO on the EVM. External hall power can be input through the HALL_EXT test point if a different supply or voltage level is desired. To use the included 3.3 V LDO to power the halls, connect J12 on the left side to pins 1:2 as shown. To use HALL_EXT, connect J12 on the right side to pins 2:3. To insert or remove wires/terminals on J11, use a flat blade screwdriver to push down the respective tab on top of the J11 connector.



Figure 2-5. Motor Phase Connector (J13)

WARNING

Motor Phase connections must match the hall sensor connection sequence. For example, MOTA must match HALL_A, MOTB must match HALL_B, MOTC must match HALL_C. The phases must also be in sequential order; A, then B, then C.

If the motor phases do not match the hall sensors or the connections are made out of order, then the motor does not spin smoothly and current consumption increases.

The three phase inputs of the motor connect to MOTA/MOTB/MOTC through connector J13.

2.2 Faults, Indicators, and Jumper Settings

The DRV8334 implements Bootstrap Undervoltage, GVDD Undervoltage, and Thermal Shutdown in case of overtemperature. See the DRV8334 data sheet for more information on DRV8334 fault support.

Status LEDs for the 3.3 V, PVDD, GVDD, and FAULT are included and shown below.



Figure 2-6. Status LEDs

The FAULT LED lights up if the EVM senses a fault and the same fault is reported in the SPI register. See the complete data sheet for fault response and corrective actions.

The Faults can be reset in the GUI software using the CLEAR FAULTS button. More details on the GUI can be found in [Section 3](#).

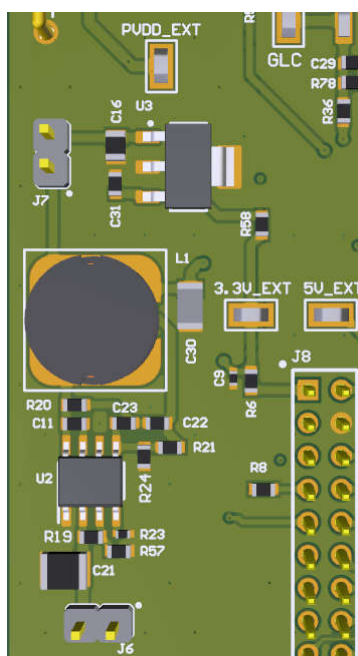


Figure 2-7. On-Board PVDD Buck and 3.3V LDO

The EVM includes a buck regulator for reducing VMOTOR to 12 V in case PVDD regulation is required. The buck feeds into the 3.3V LDO, which powers the EVM 3.3V rail.

Jumper J6 connects VMOTOR/PVDD to the PVDD buck. Remove this jumper to power down the buck regulator.

Jumper J7 connects the PVDD buck output (12V) to the 3.3V LDO. Remove this jumper to power down the 3.3V rail.

GVDD is generated internally to the DRV8334 device and the options are explained in the complete data sheet.

2.3 EVM Hardware Quick-Start

This section describes the steps to prepare the DRV8334EVM for first motor spin-up. This section assumes the default jumper positions mentioned above are used.

1. Plug the DRV8334EVM onto the upper position of the LAUNCHXL-F280049C board.
2. Connect motor phase connections to their respective MOTA/MOTB/MOTC inputs on J13, making sure to match A, B, and C.
3. Connect the Hall sensor connections, Hall power, and ground to J11. Make sure that Hall A, B, and C are in the correct order.
4. Connect the provided micro-USB cable to the LAUNCHXL-F280049C.
5. Connect VMOTOR and GND to connector J10. A low current limit of 300 mA on the VMOTOR supply is recommended for first power-up to verify the EVM is connected correctly. If there is no issue upon power-up, then the current limit can be raised to allow for current based on your motor specifications. VMOTOR range is 5 V to 60 V.
6. Start the GUI per the instructions below in [Section 3.1](#).

3 Software

3.1 DRV8334 EVM 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.

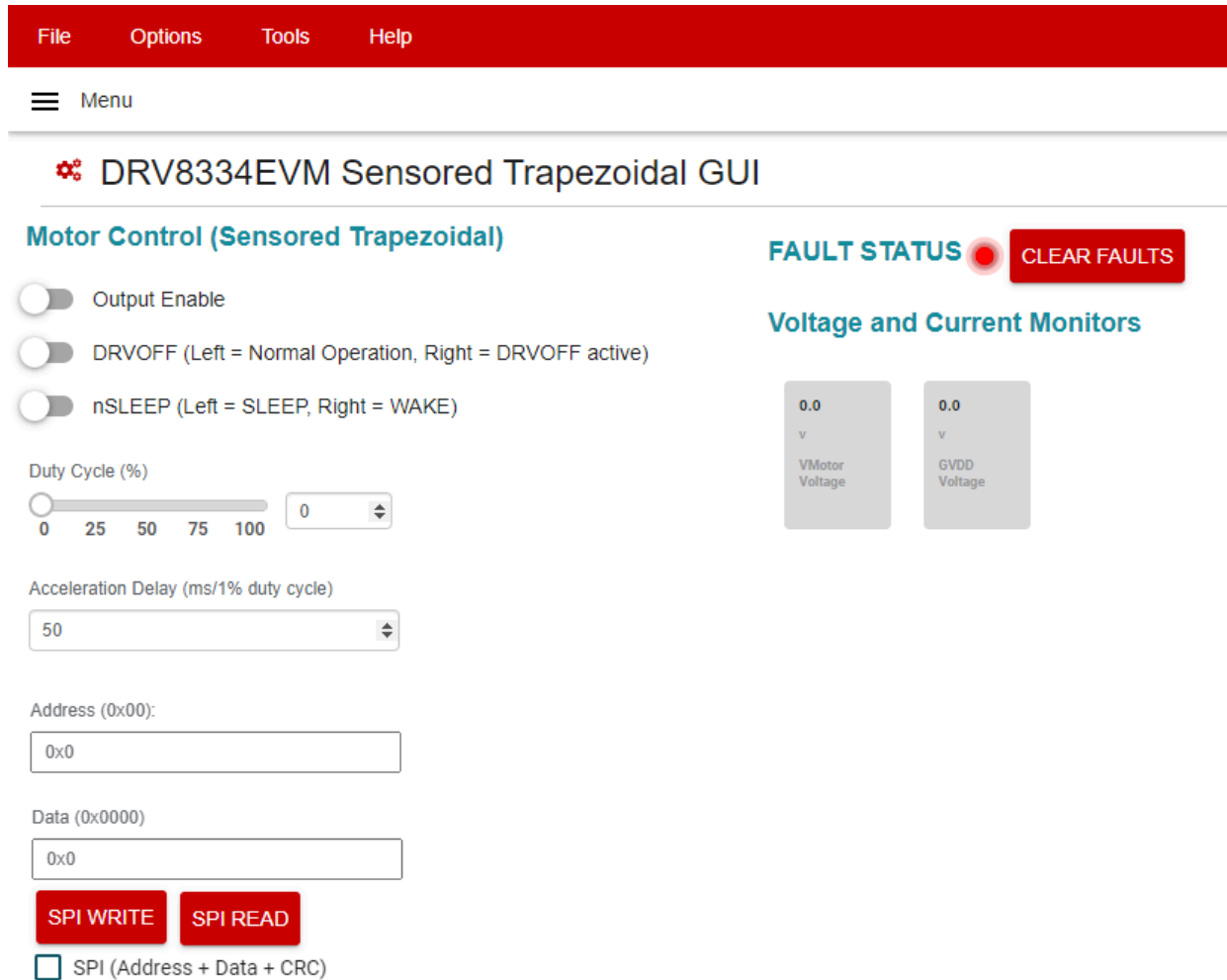


Figure 3-1. DRV8334EVM GUI Software

The GUI connects and programs the C2000 MCU on the LAUNCHXL-F280049C board when launched, assuming the board is connected/powered.

Once the hardware is connected, the FAULT Status and Voltage Monitors match the EVM. If these do not match, then please remove EVM power and recheck the setup.

To spin the motor:

1. Launch the GUI located on dev.ti.com/gallery.
2. Take the DRV8334 out of sleep mode by toggling nSLEEP to WAKE.
3. Enable the PWM using the Output Enable toggle switch.
 - a. The DRV8334 reports no faults (Fault LED green on GUI, no red nFAULT LED on the EVM) and VMOTOR/GVDD voltage is reported by the GUI.
4. Set acceleration (update rate) of Duty cycle and increase PWM Duty Cycle using the slider or text input.
5. The motor now spins.

To Read and Write SPI registers:

1. Enter the Address in Hex (0x00) in the **Address (0x00)** field.
2. Enter the data (for write transaction) in the **Data (0x0000)** field. For Read transactions, the data is Don't Care and is ignored.
3. Click anywhere on the screen to deselect the text input field.
4. Click **SPI WRITE** or **SPI READ** to send the command to the DRV8334. If the text field is not deselected first, then click the **SPI WRITE** or **SPI READ** a second time to execute the transaction.
5. If the complete SPI readback is needed for a Read transaction, then the user can enable the full SPI readback including the address/data/CRC using the checkbox.

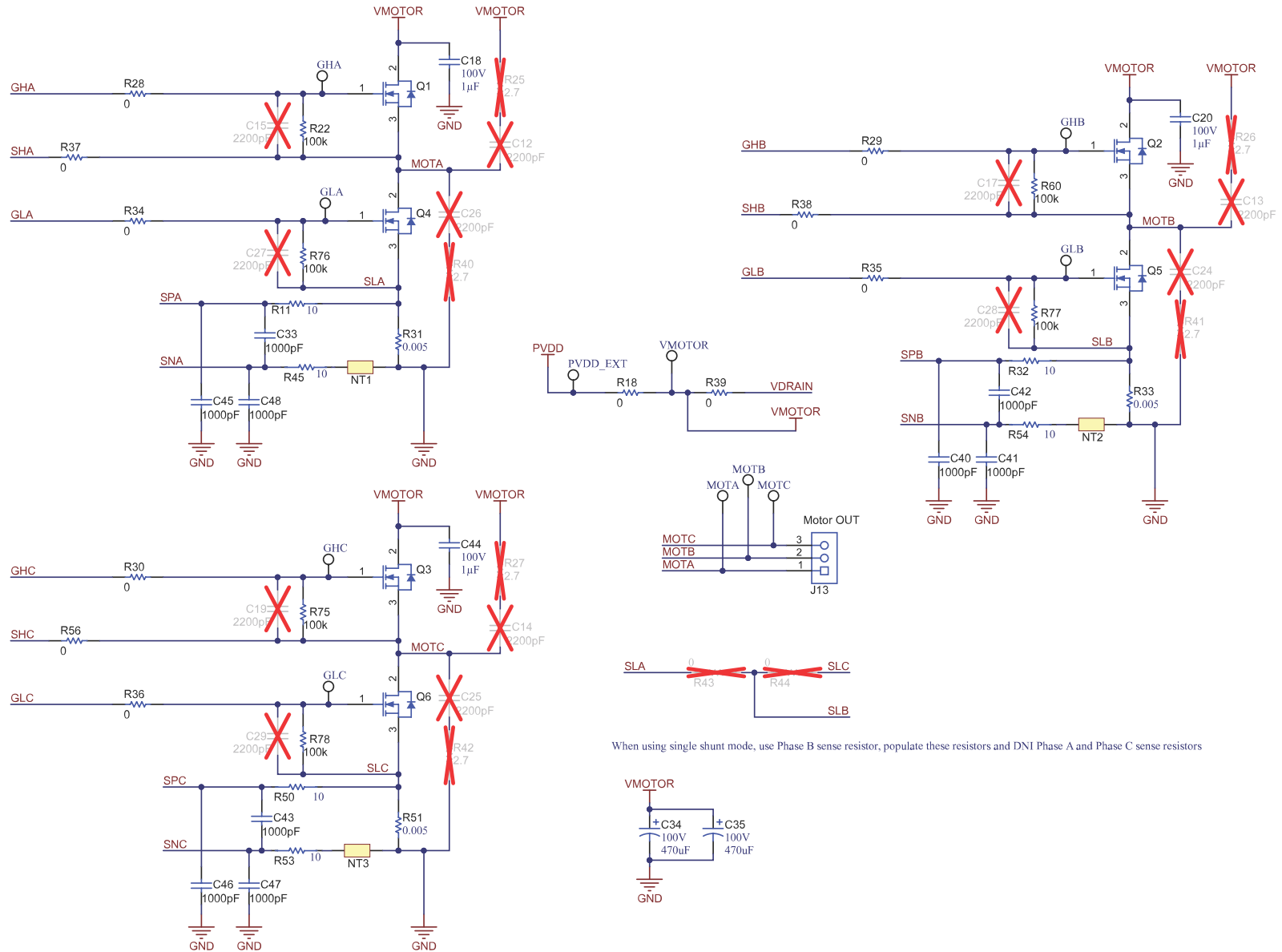


Figure 4-2. Schematic 2

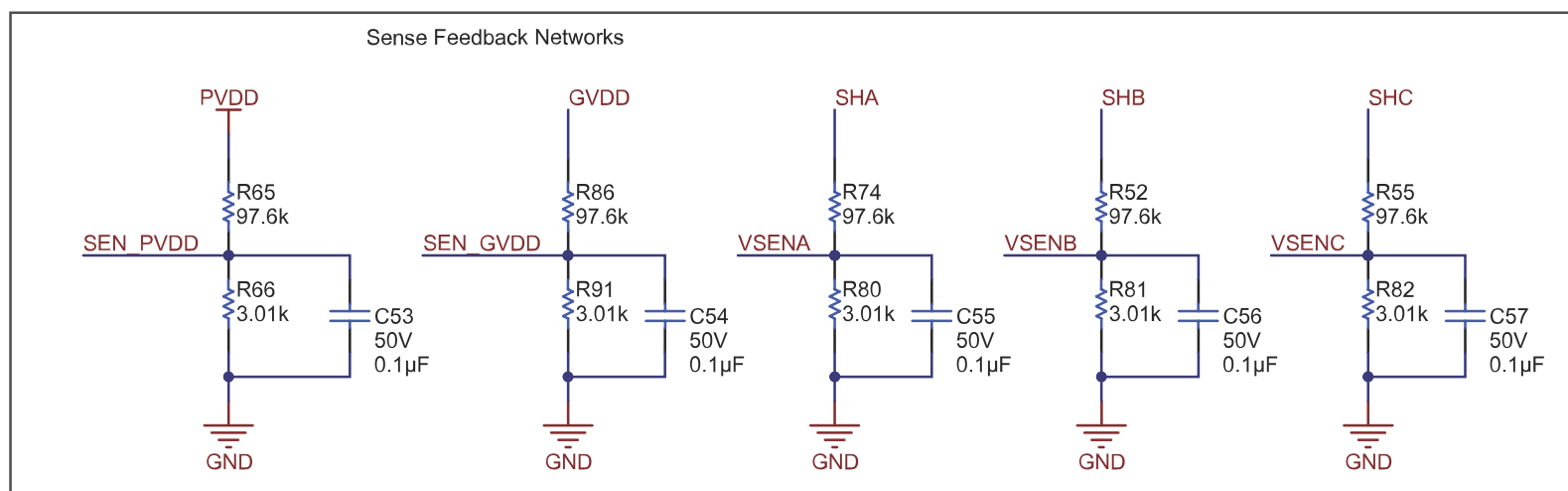
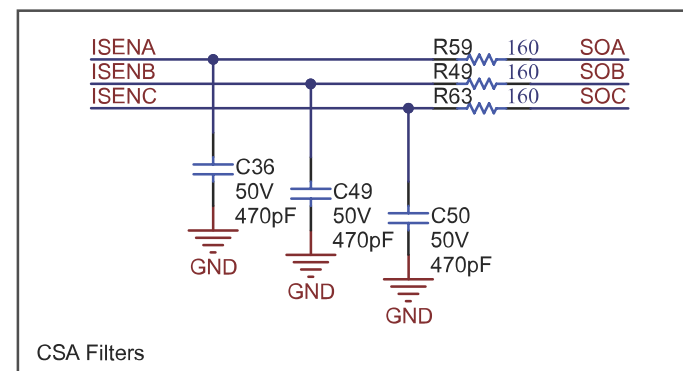
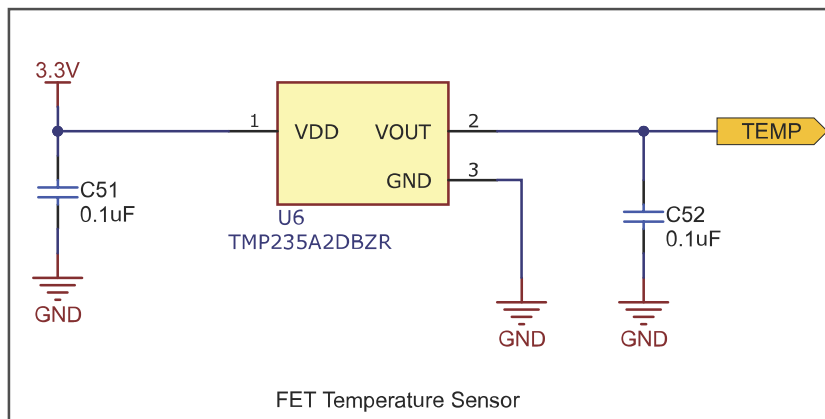


Figure 4-3. Schematic 3

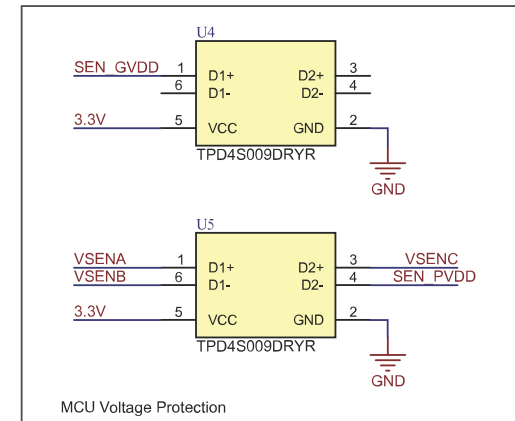
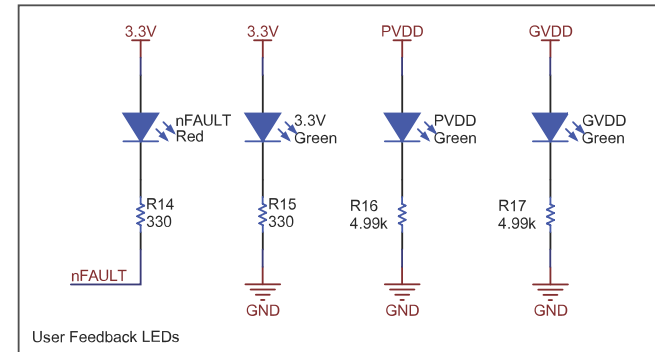
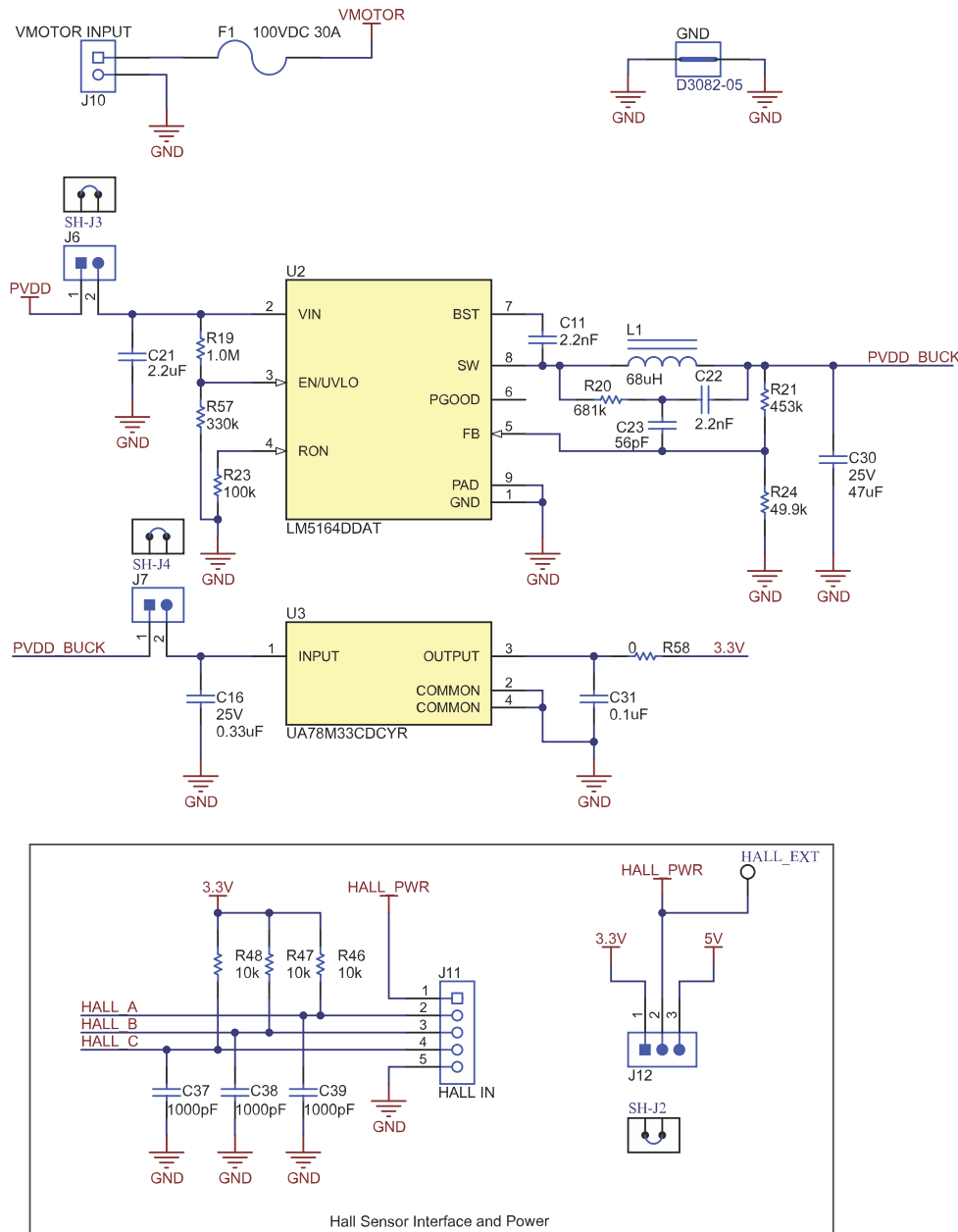


Figure 4-4. Schematic 4

4.2 PCB Layouts

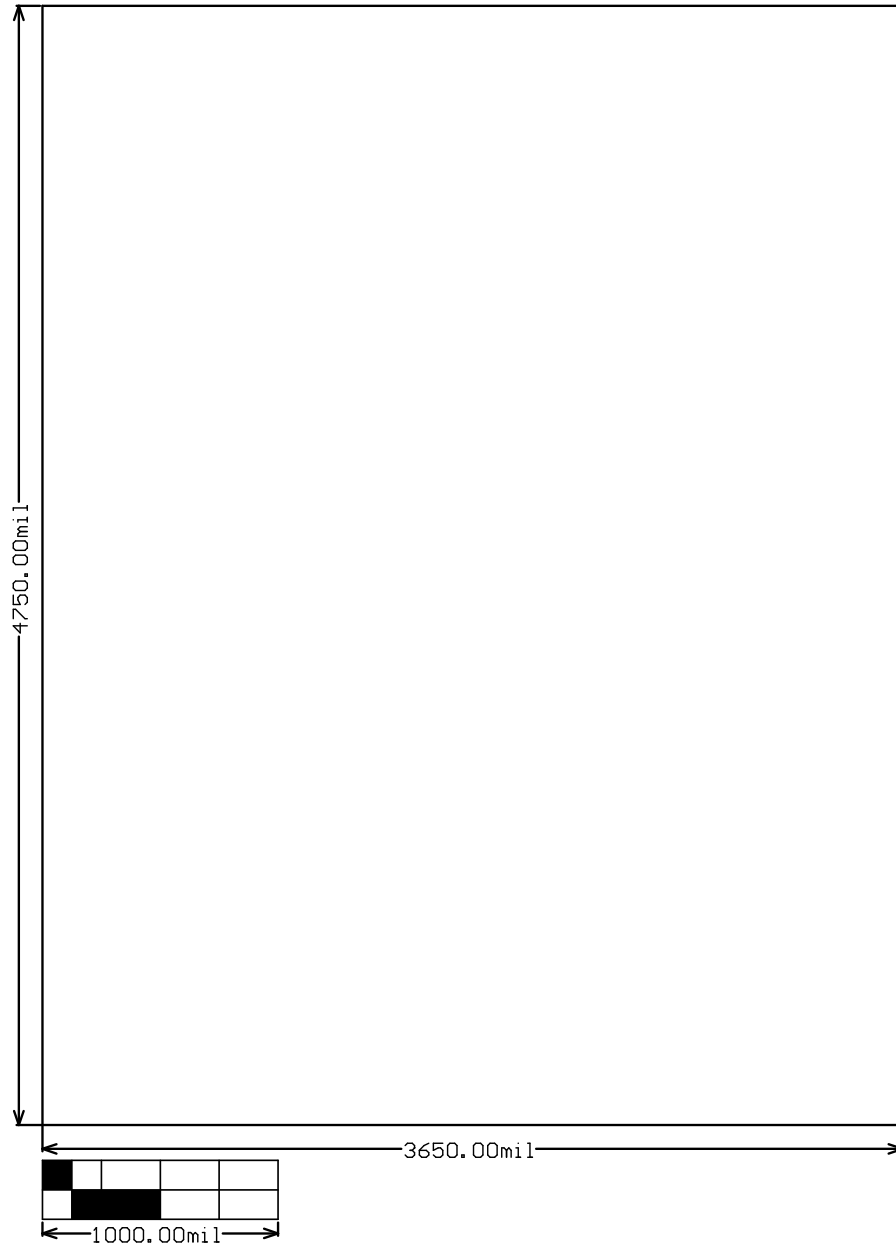


Figure 4-5. EVM Dimensions

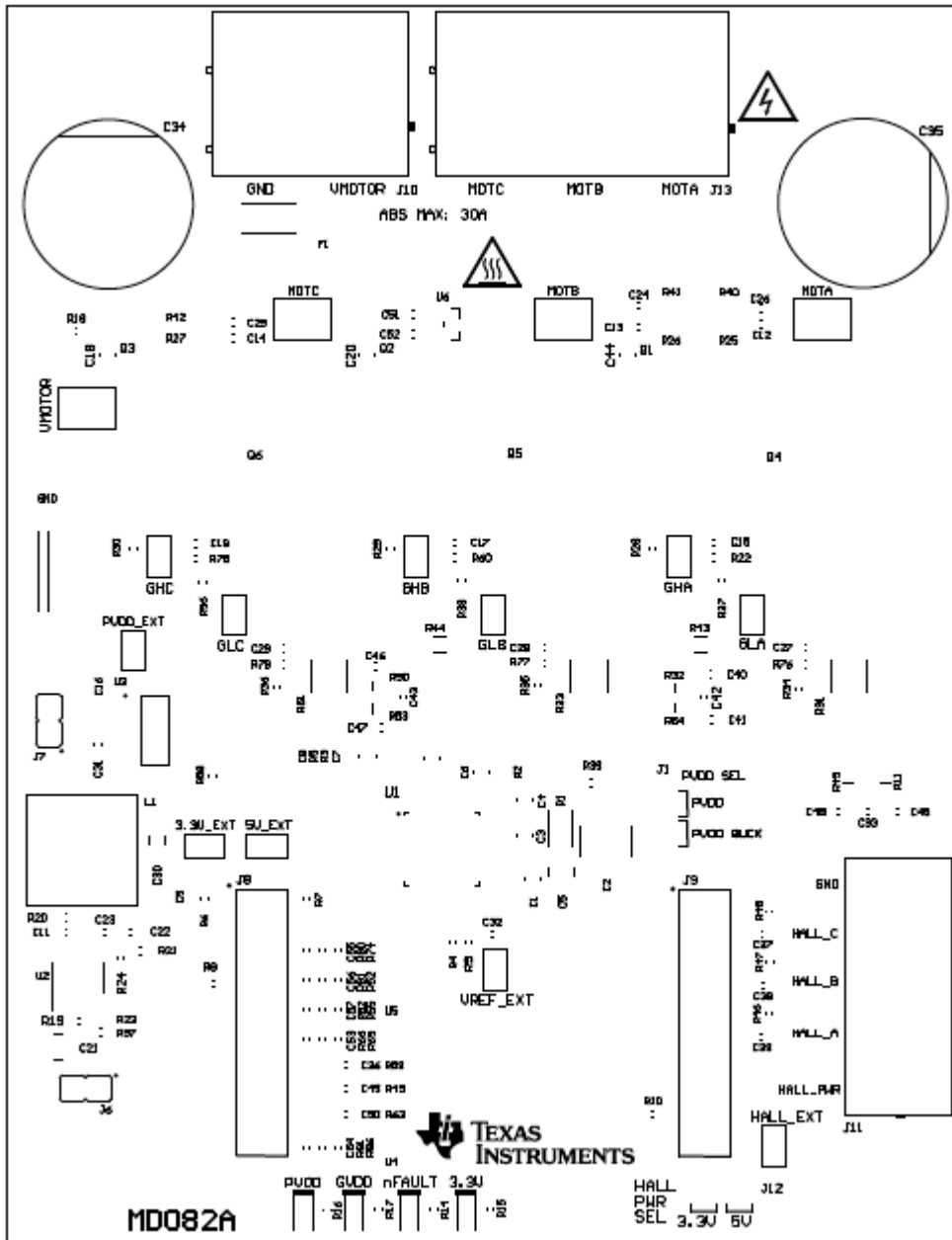


Figure 4-6. EVM Top Overlay

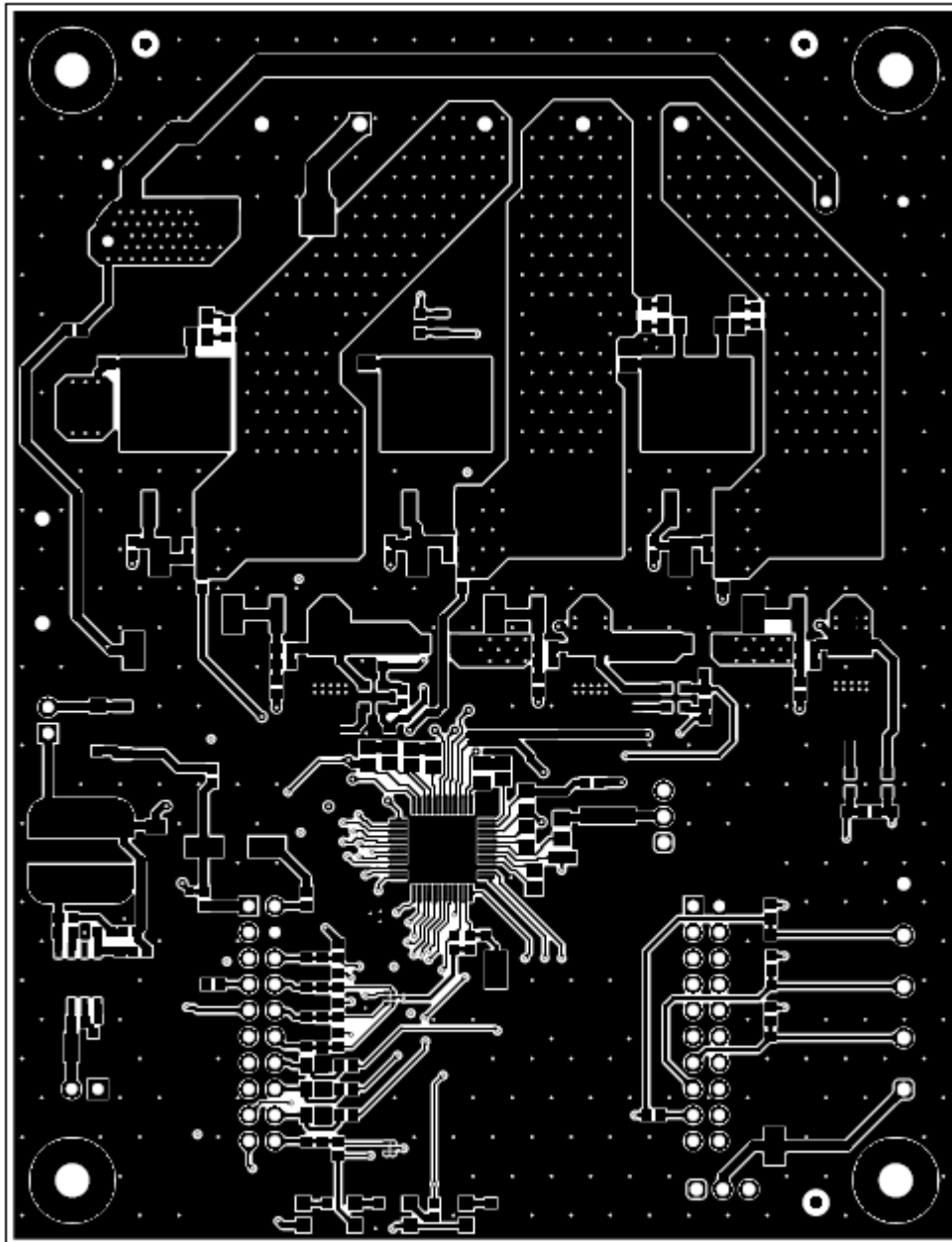


Figure 4-7. EVM Top Layer

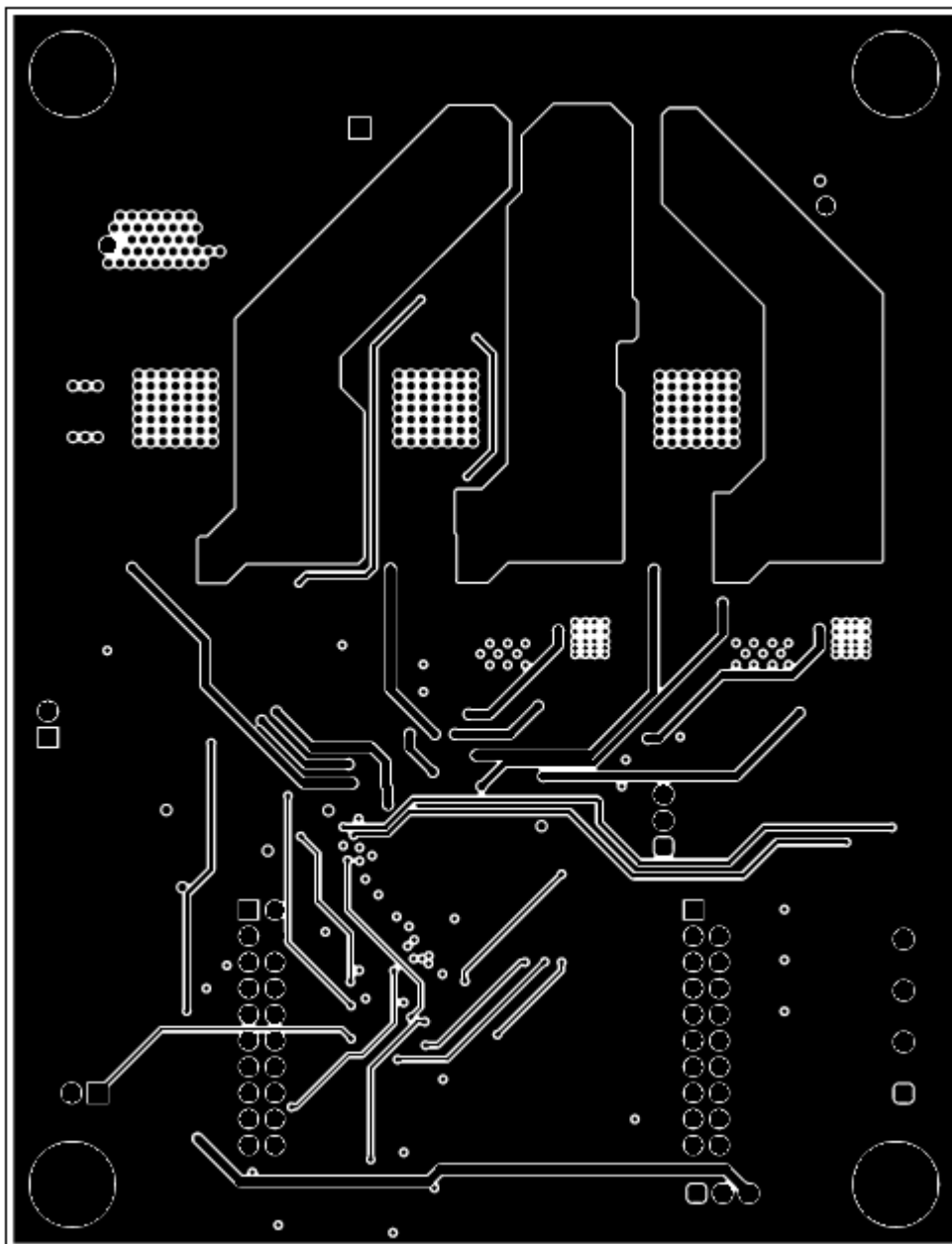


Figure 4-8. EVM Signal Layer 1

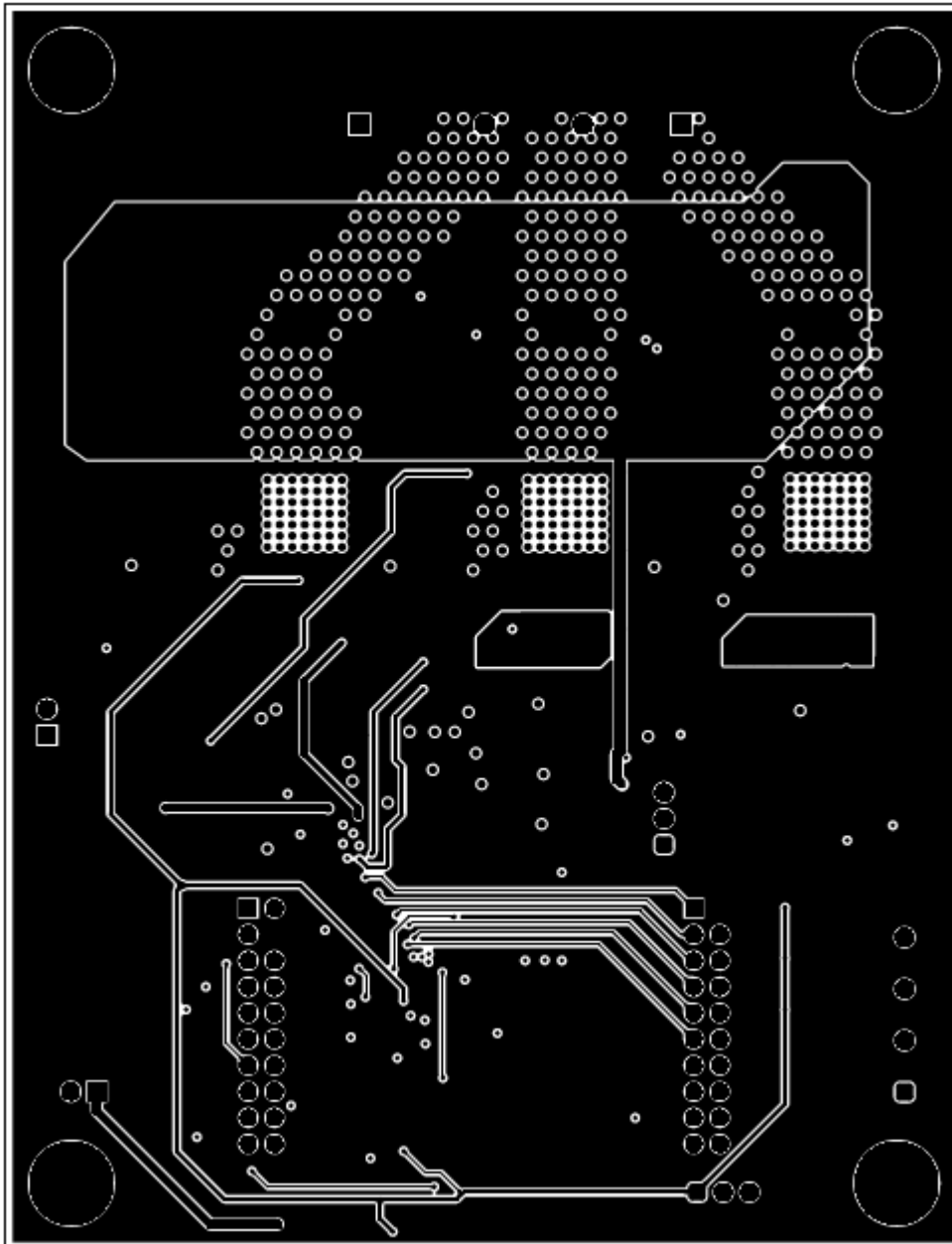


Figure 4-9. EVM Signal Layer 2

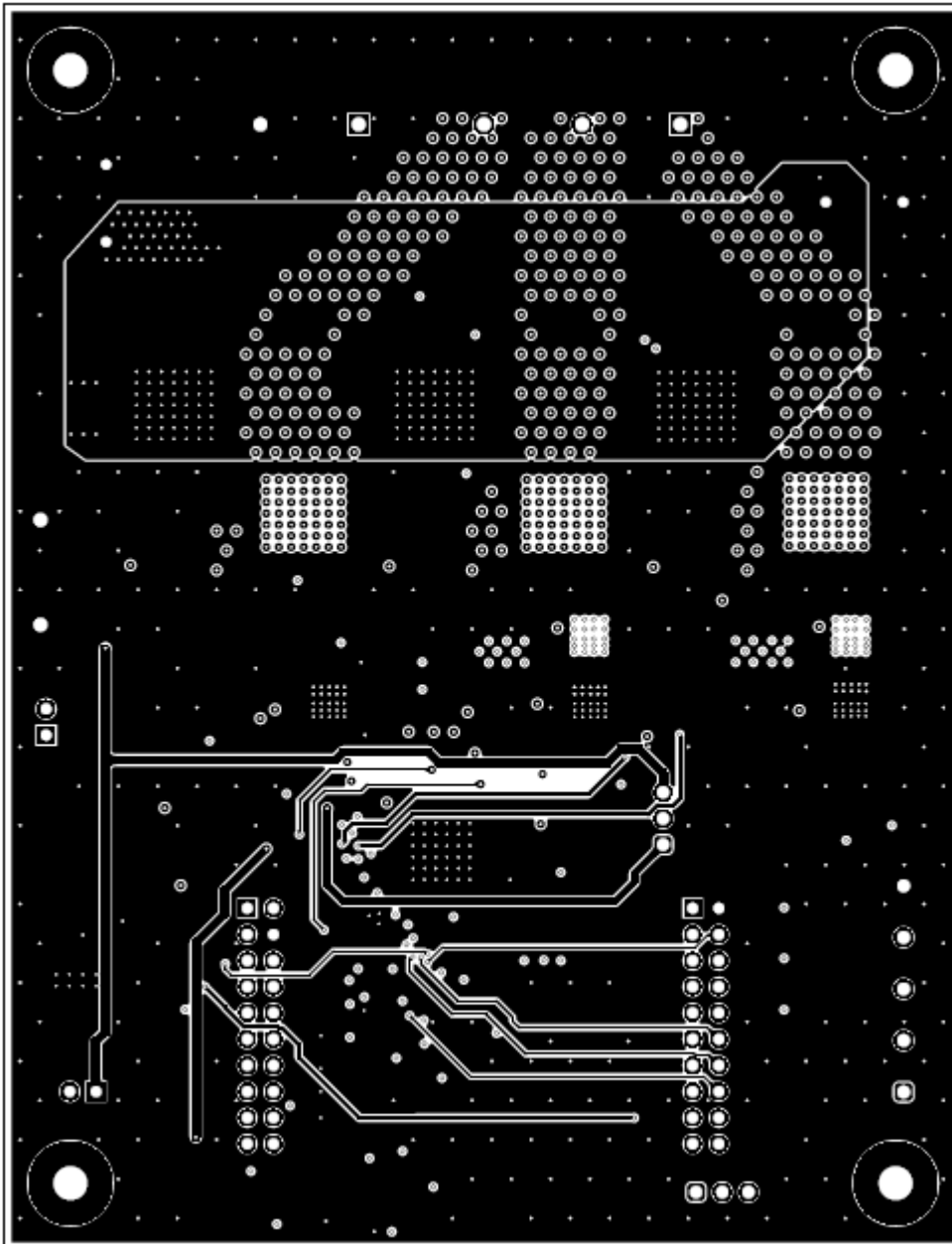


Figure 4-10. EVM Bottom Layer

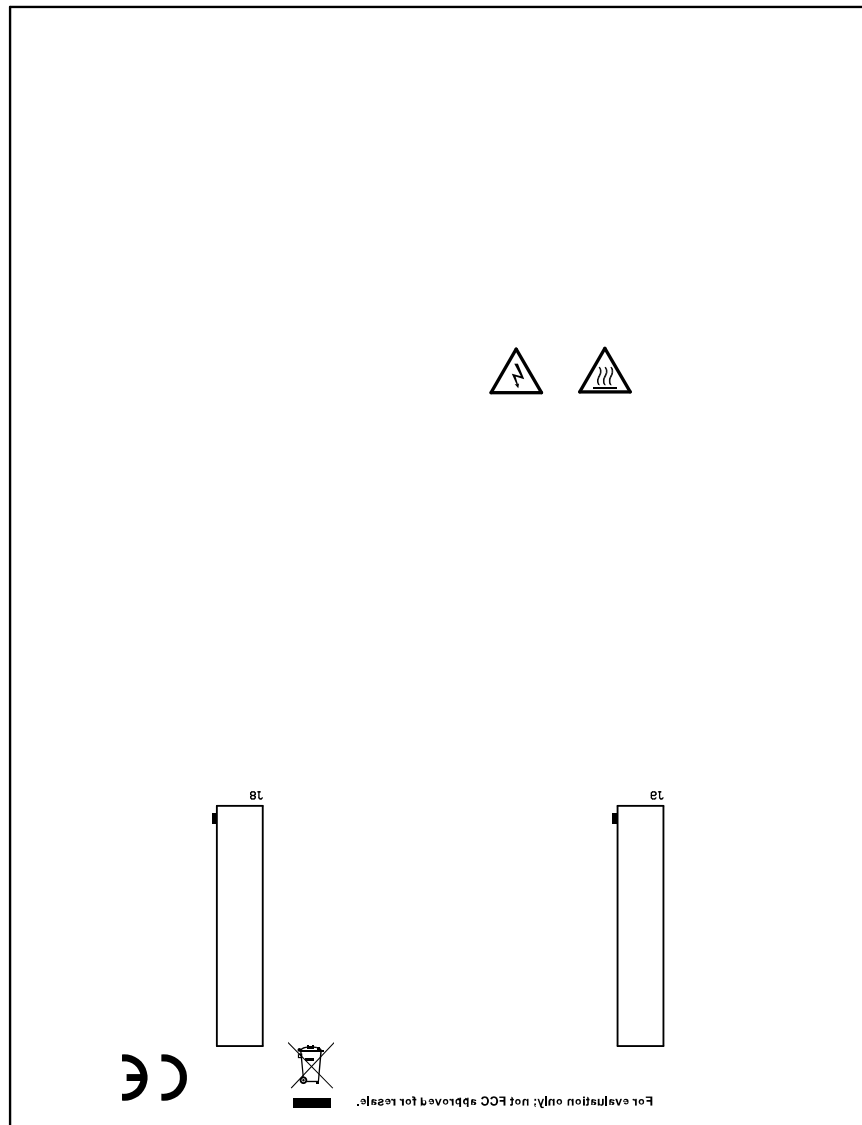


Figure 4-11. EVM Bottom Overlay

4.3 Bill of Materials (BOM)

Table 4-1. Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number
3.3V, GVDD, PVDD	3	Green	LED, Green, SMD	0805 LED	LTST-C171GKT	Lite-On	
3.3V_EXT, 5V_EXT, GHA, GHB, GHC, GLA, GLB, GLC, HALL_EXT, PVDD_EXT, VREF_EXT	11		Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone Electronics	
C1, C3, C4, C6, C7, C8, C18, C20, C44	9	1uF	CAP, CERM, 1 μ F, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	0805	KAF21KR72A105KU	AVX	
C2	1	10uF	CAP, CERM, 10 μ F, 100 V, +/- 10%, X7S, AEC-Q200 Grade 1, 2220	2220	CGA9N3X7S2A106K230KE	TDK	
C5	1	10uF	CAP, CERM, 10 μ F, 50 V, +/- 10%, X7R, 1210	1210	CL32B106KBJNNWE	Samsung Electro-Mechanics	
C9	1	2.2uF	CAP, CERM, 2.2 μ F, 10 V, +/- 10%, X5R, 0402	0402	C1005X5R1A225K050BC	TDK	
C11, C22	2	2200 pF	CAP, CERM, 2200 pF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E2X7R2A222K080AA	TDK	
C16	1	0.33uF	CAP, CERM, 0.33 μ F, 25 V, +/- 10%, X5R, 0805	0805	KGM21AR51E334KU	AVX	
C21	1	2.2uF	CAP, CERM, 2.2 μ F, 100 V, +/- 10%, X7R, 1210	1210	C1210C225K1RAC7800	Kemet	
C23	1	56 pF	CAP, CERM, 56 pF, 100 V, +/- 5%, C0G/NP0, 0603	0603	GRM1885C2A560JA01D	MuRata	
C30	1	47uF	CAP, CERM, 47 μ F, 25 V, +/- 20%, X5R, 1206_190	1206_190	C3216X5R1E476M160AC	TDK	
C31, C32, C51, C52	4	0.1uF	CAP, CERM, 0.1 μ F, 16 V, +/- 5%, X7R, 0603	0603	C0603C104J4RAC7867	Kemet	

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number
C33, C37, C38, C39, C40, C41, C42, C43, C45, C46, C47, C48	12	1000 pF	CAP, CERM, 1000 pF, 16 V, +/- 10%, X7R, 0603	0603	885012206034	Würth Elektronik	
C34, C35	2	470 µF	470 µF 100 V Aluminum Electrolytic Capacitors Radial, Can 2000 Hrs @ 105°C	RADIAL	ESH477M100AM2AA	KEMET	
C36, C49, C50	3	470 pF	CAP, CERM, 470 pF, 50 V, +/- 10%, X7R, 0805	0805	C0805C471K5RAC7800	Kemet	
C53, C54, C55, C56, C57	5	0.1µF	CAP, CERM, 0.1 µF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	C0603C104K5RACAUTO	Kemet	
F1	1		Fuse, 30 A, 250 VAC, 100 VDC, SMD	10.1x3.12mm	0463030.ER	Littelfuse	
GND	1		1 mm Uninsulated Shorting Plug, 10.16mm spacing, TH	Shorting Plug, 10.16mm spacing, TH	D3082-05	Harwin	
H1, H2, H3, H4	4			Standoff	1902E	Keystone	
H5, H6, H7, H8	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply	
J1, J12	2		Header, 2.54 mm, 3x1, Gold, TH	Header, 2.54mm, 3x1, TH	61300311121	Würth Elektronik	
J6, J7	2		Header, 100mil, 2x1, Gold, TH	Sullins 100mil, 1x2, 230 mil above insulator	PBC02SAAN	Sullins Connector Solutions	
J8, J9	2		Receptacle, 2.54mm, 10x2, Gold, TH	Receptacle, 2.54mm, 10x2, TH	SSQ-110-03-G-D	Samtec	
J10	1		Terminal Block, 9.52mm, 2x1, R/A, TH	Terminal Block, 2x1, Pitch 9.52mm	1902547	Phoenix Contact	
J11	1		Terminal Block, 5 mm, 5x1, R/A, TH	Terminal Block, 5 mm, 5x1, R/A, TH	1792892	Phoenix Contact	
J13	1		Terminal Block, 9.52mm, 3x1, R/A, TH	Terminal Block, 3x1, Pitch 9.52mm	1904150	Phoenix Contact	
L1	1	68µH	Inductor, Drum Core, Ferrite, 68 µH, 1.1 A, 0.22 ohm, SMD	SDR1006	SDR1006-680KL	Bourns	

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number
MOTA, MOTB, MOTC, VMOTOR	4		Test Point, Compact, SMT	Testpoint_Keystone_Compact	5016	Keystone Electronics	
nFAULT	1	Red	LED, Red, SMD	Red 0805 LED	LTST-C170KRKT	Lite-On	
Q1, Q2, Q3, Q4, Q5, Q6	6	100V	MOSFET, N-CH, 100 V, 180 A, DDPAK	DDPAK	STH310N10F7-2	STMicroelectronics	
R1	1	0.75	750 mOhms \pm 1% 0.333W, 1/3W Chip Resistor 0805 (2012 Metric) Current Sense Thin Film	0805	RL1220S-R75-F	Susumu	
R2, R3, R5	3	2.7	RES, 2.7, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	CRCW08052R70JNEA	Vishay-Dale	
R4, R46, R47, R48	4	10k	RES, 10 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310K0JNEA	Vishay-Dale	
R7, R8, R9, R18, R28, R29, R30, R34, R35, R36, R37, R38, R39, R56	14	0	RES, 0, 0%, 0.25 W, AEC-Q200 Grade 0, 0603	0603	RCS06030000Z0EA	Vishay-Dale	
R11, R32, R45, R50, R53, R54	6	10	10 Ohms \pm 0.1% 0.063W, 1/16W Chip Resistor 0603 (1608 Metric) Anti-Sulfur, Automotive AEC-Q200, Moisture Resistant Thin Film	0603	CPF-A-0603B10RE	TE Connectivity	
R14, R15	2	330	RES, 330, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603330RJNEA	Vishay-Dale	
R16, R17	2	4.99k	RES, 4.99 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06034K99FKEA	Vishay-Dale	
R19	1	1.0Meg	RES, 1.0 M, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06031M00JNEA	Vishay-Dale	
R20	1	681k	RES, 681 k, 1%, 0.1 W, 0603	0603	RC0603FR-07681KL	Yageo	
R21	1	453k	RES, 453 k, 1%, 0.1 W, 0603	0603	RC0603FR-07453KL	Yageo	
R22, R60, R75, R76, R77, R78	6	100k	RES, 100 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100KFKEA	Vishay-Dale	
R23	1	100k	RES, 100 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402100KFKEA	Vishay-Dale	

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer	Alternate Part Number
R24	1	49.9k	RES, 49.9 k, 1%, 0.1 W, 0603	0603	RC0603FR-0749K9L	Yageo	
R31, R33, R51	3	0.005	RES, 0.005, 1%, 3 W, AEC-Q200 Grade 0, 2512	2512	CRE2512-FZ-R005E-3	Bourns	
R49, R59, R63	3	160	RES, 160, 0.5%, 0.1 W, 0603	0603	RT0603DRE07160RL	Yageo America	
R52, R55, R65, R74, R86	5	97.6k	RES, 97.6 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060397K6FKEA	Vishay-Dale	
R57	1	330k	RES, 330 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603330KJNEA	Vishay-Dale	
R58	1	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06030000Z0EA	Vishay-Dale	
R66, R80, R81, R82, R91	5	3.01k	RES, 3.01 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06033K01FKEA	Vishay-Dale	
SH-J1, SH-J2, SH-J3, SH-J4	4	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec	969102-0000-DA
U1	1		12-V / 24-V Gate Driver Unit (GDU) with enhanced diagnostics	HTQFP48	DRV8334PHPR	Texas Instruments	
U2	1		100-V Low IQ Synchronous Buck Regulator, DDA0008E (SOIC-8)	DDA0008E	LM5164DDAT	Texas Instruments	
U3	1		500-mA, 25-V, Linear Voltage Regulators, DCY0004A (SOT-223-4)	DCY0004A	UA78M33CDCYR	Texas Instruments	UA78M33CDCY
U4, U5	2		4-Channel ESD Solution for High-Speed Differential Interface, DRY0006A (USON-6)	DRY0006A	TPD4S009DRYR	Texas Instruments	
U6	1		Temperature Sensor Analog, Local approx. -40°C - 150°C 10 mV/°C SOT-23-3	SOT-23	TMP235A2DBZR	Texas Instruments	

5 Additional Information

5.1 Trademarks

All trademarks are the property of their respective owners.

6 References

See these documents for additional reference:

- Texas Instruments, [DRV8334 data sheet](#)
- Texas Instruments, [TMS320F280049C Product Page](#)
- Texas Instruments, [LAUNCHXL-F280049C Product Page](#)

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。

<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 2 4 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/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。 <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.

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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.
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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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