

EVM User's Guide: DRV8762-Q1EVM

DRV8762-Q1 Evaluation Module



Description

The DRV8762-Q1 is an integrated smart gate driver for 48V automotive H-bridge brushed DC (BDC) applications. The device provides low-side current sense amplifiers to support resistor based low-side current sensing. The low offset of the amplifiers enables the system to obtain precise motor current measurements.

The gate drivers support external N-channel high-side and low-side power MOSFETs and can drive up to 224mA source, and 448mA sink peak currents. A bootstrap capacitor generates the supply voltage of the high-side gate drive. The supply voltage of the low-side gate driver is supplied externally at a nominal 12V.

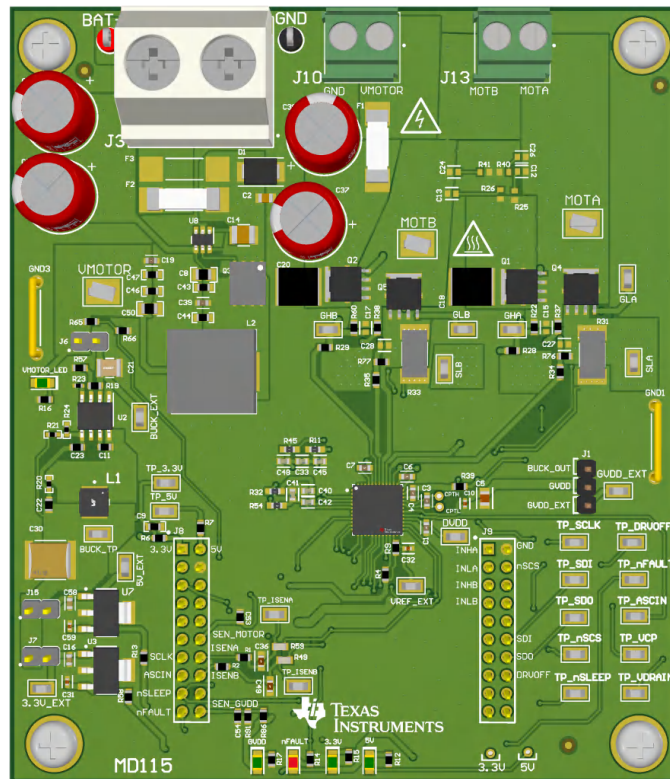
The C2000™ launchpad (LAUNCHXL-F280049C) is required for this kit and controls the DRV8762-Q1 as well as monitor and report faults.

Features

- 8V to 85V maximum operation with support for 12V to 48V applications
- 100% duty cycle PWM control, with 224mA/448mA peak gate drive
- 32 configurable IDRIVE steps for fine slew rate tuning
- Three integrated CSAs with low input offset drift
- 3.3V and 5V on-board LDOs.

Applications

- [Seat position & comfort module](#)
- [Zone & body domain controller](#)
- [Trunk module](#)
- [Brushed DC \(BDC\) motor drivers](#)



DRV8762-Q1EVM

1 Evaluation Module Overview

1.1 Introduction

This document is provided with the DRV8762-Q1 customer evaluation module (EVM) as a supplement to the DRV8762-Q1 datasheet. The user's guide details the hardware implementation of the EVM.

This document is designed to be used as a startup guide to the DRV8762-Q1EVM and LAUNCHXL-F280049C device. This document is intended for the engineers involved in the design, implementation, and validation of DRV8762-Q1 + TMS320F280049C reference software.

The scope of this document is to provide the user with a guide to evaluate the DRV8762-Q1 device with a TMS320F280049C board. This document covers the hardware connections required between boards and external motor or supplies. When the hardware connections are complete, the user can access the necessary tools and software to spin a motor using the online GUI.

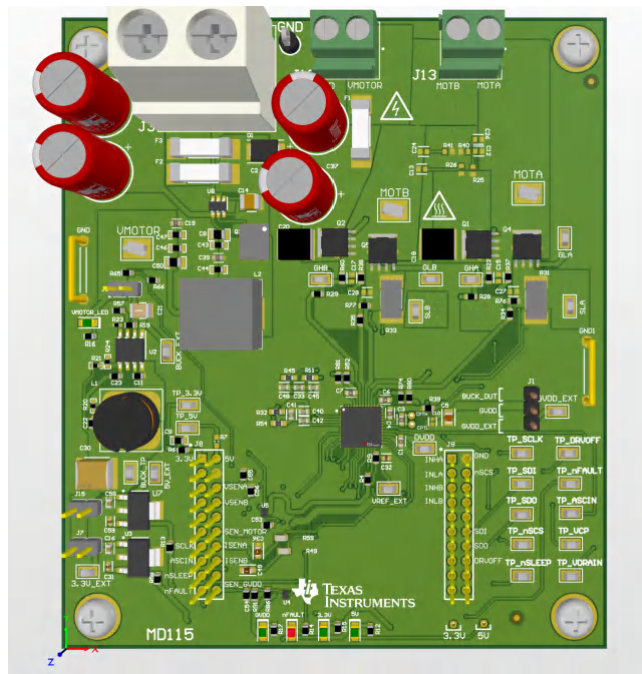


Figure 1-1. DRV8762-Q1EVM

CAUTION

The DRV8762-Q1EVM 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 datasheet 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.

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.

1.2 Kit Contents

Item	Description	Quantity
DRV8762-Q1EVM	PCB	1
Box	Cardboard box	1
Label	Standard label	1
Foam	Antistatic foam	2
Literature	EVM disclaimers	1

1.3 Specifications

The DRV8762-Q1 is an integrated 8V to 85V gate driver for H-bridge motor drive applications, which enables users to evaluate the motor performance within the gate driver system. The DRV8762-Q1 implements features such as enhanced smart gate drive and expanded device protection features, making the device an excellent choice for applications such as power seats, zonal control, and trunk lifts. The device supports 12V, 24V, and 48V applications and has an 85V VDRAIN absolute maximum to support power supply transients.

1.4 Device Information

The DRV8762-Q1EVM integrates multiple devices on the board to provide additional protection features and to provide the required additional voltage levels to operate the evaluation module so that only the power supply for VBATT or VMOTOR is required. To safeguard against accidental reverse polarity connections, a diode controller that is compatible with LM74700-Q1 is included near the VBATT terminal. The GVDD supply input pin of the DRV8762-Q1 requires an external supply between 8V and 15V. The EVM provides this voltage through the LM5164 buck converter that outputs 12V. Additionally, to support the digital logic and interface circuitry, the EVM includes two linear regulators: a UA78M05C to generate 5V and a UA78M33C to generate 3.3V.

2 Hardware

2.1 Hardware Connections Overview – DRV8762-Q1EVM + LAUNCHXL-F280049C

The following section describes the EVM hardware and connections to the external supply, PC through a USB, and motor.

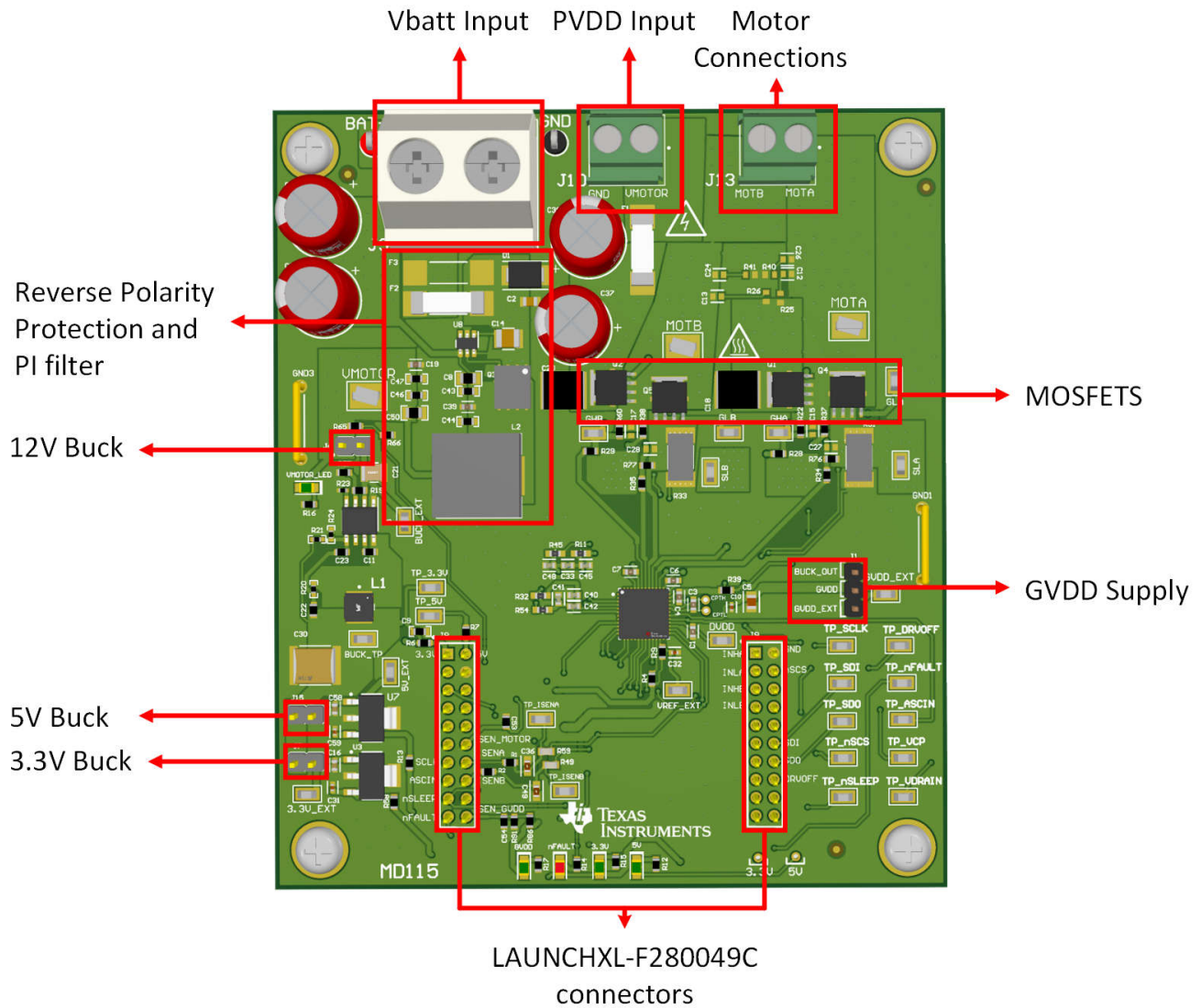
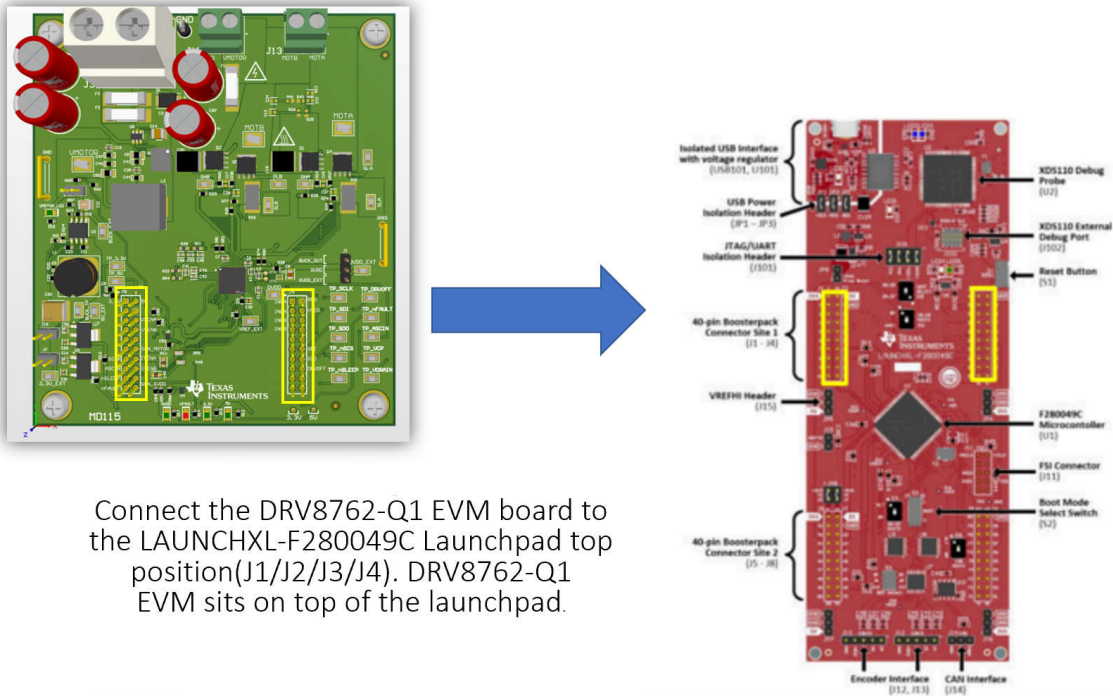


Figure 2-1. EVM Board Overview



Connect the DRV8762-Q1 EVM board to the LAUNCHXL-F280049C Launchpad top position(J1/J2/J3/J4). DRV8762-Q1 EVM sits on top of the launchpad.

Figure 2-2. DRV8762-Q1EVM Mating to LAUNCHXL-F280049C

The DRV8762-Q1EVM must plug into the LAUNCHXL-F280049C Launchpad headers closest to the USB port as shown in [Figure 2-2](#).

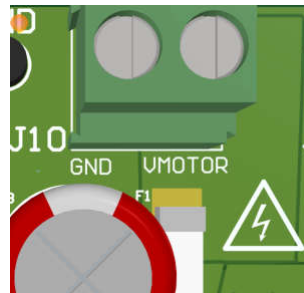


Figure 2-3. VMOTOR Input (J10)

WARNING

To minimize the risk of potential shock hazard and personal injury, remove all power connections and interfaces to the DRV8762-Q1EVM when not in use.

The DRV8762-Q1EVM is designed for an input supply from 8V_{DC} to 48V_{DC} and up to 30A 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 30A fuse and the input connector is rated for 30A.

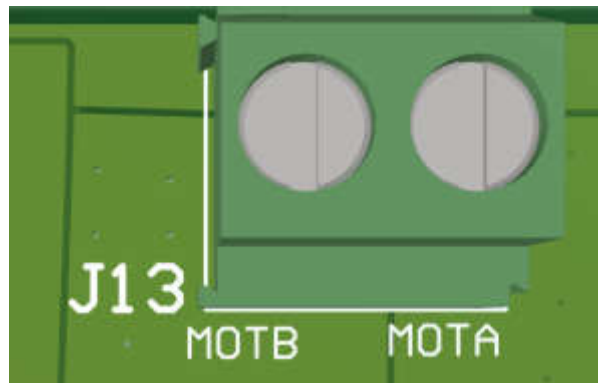


Figure 2-4. Motor Phase Connector (J13)

The two phase inputs of the motor connect to MOTA and MOTB through connector J13.

2.2 Faults, Indicators, and Jumper Settings

The DRV8762-Q1 implements Bootstrap Undervoltage, GVDD Undervoltage, VDS and VGS monitoring, and Thermal Shutdown in case of overtemperature. See the DRV8762-Q1 data sheet for more information on DRV8762-Q1 fault support.

Status LEDs for the 3.3V, 5V, PVDD, GVDD, and FAULT are included and shown below.

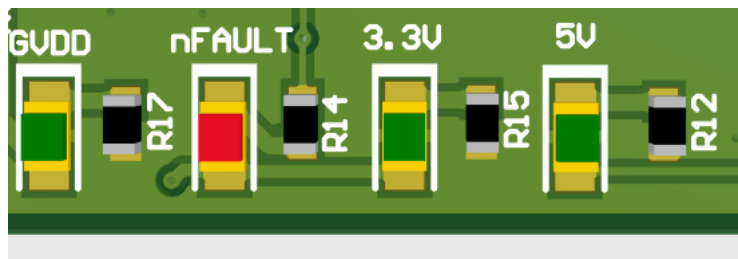


Figure 2-5. Status LEDs

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

The nFAULT LED lights up when the board is powered, until logic high is applied to nSLEEP pin.

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](#).

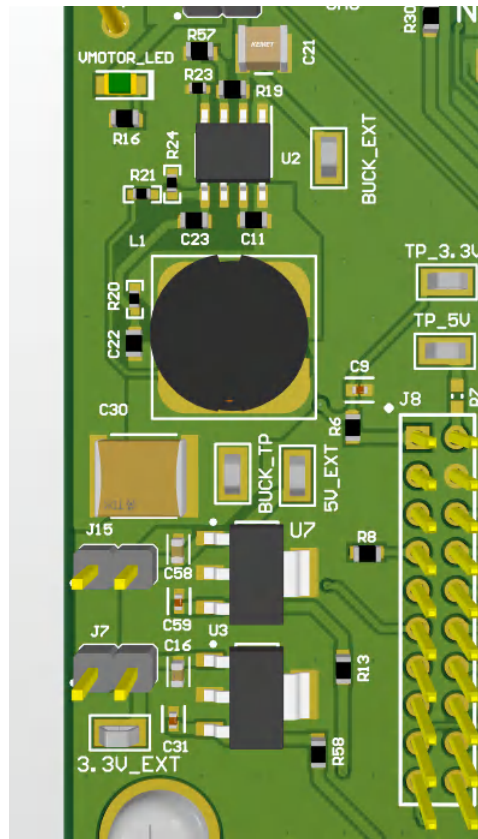


Figure 2-6. On-Board VMOTOR Buck, 3.3V LDO, and 5V LDO

The EVM includes a buck regulator for reducing VMOTOR to 12V if regulation is required. The buck feeds into the 3.3V LDO and 5V LDO, which powers the EVM 3.3V and 5V rails.

Jumper J6 connects VMOTOR to the buck (default). Remove this jumper if you want to power down the buck regulator.

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

Jumper J15 connects the PVDD buck output (12V) to the 5V LDO (default). Remove this jumper if you want to power down the 5V rail.

The buck output powers the GVDD by default but can be configured for external supply support by placing J1 shunt on pins 1:2 as shown.

2.3 EVM Hardware Quick-Start

This section describes the steps to prepare the DRV8762-Q1EVM for first motor spin-up. This section assumes the default jumper positions mentioned above are used.

1. Plug the DRV8762-Q1EVM onto the upper position of the LAUNCHXL-F280049C board.
2. Connect motor phase connections to the respective MOTA/MOTB inputs on J13.
3. Connect the provided micro-USB cable to the LAUNCHXL-F280049C.
4. Populate JP1 on LAUNCHXL-F280049C to maintain Launchpad receives power from USB.
5. Connect VMOTOR and GND to connector J10. A low current limit of 300mA 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 8V to 48V.
6. Start the GUI per the instructions below in [Section 3.1](#).

3 Software

3.1 DRV8762-Q1 EVM GUI Software

This section details the features of the EVM GUI Software. The GUI is written in GUI Composer and is available on TI's [development software gallery](#).

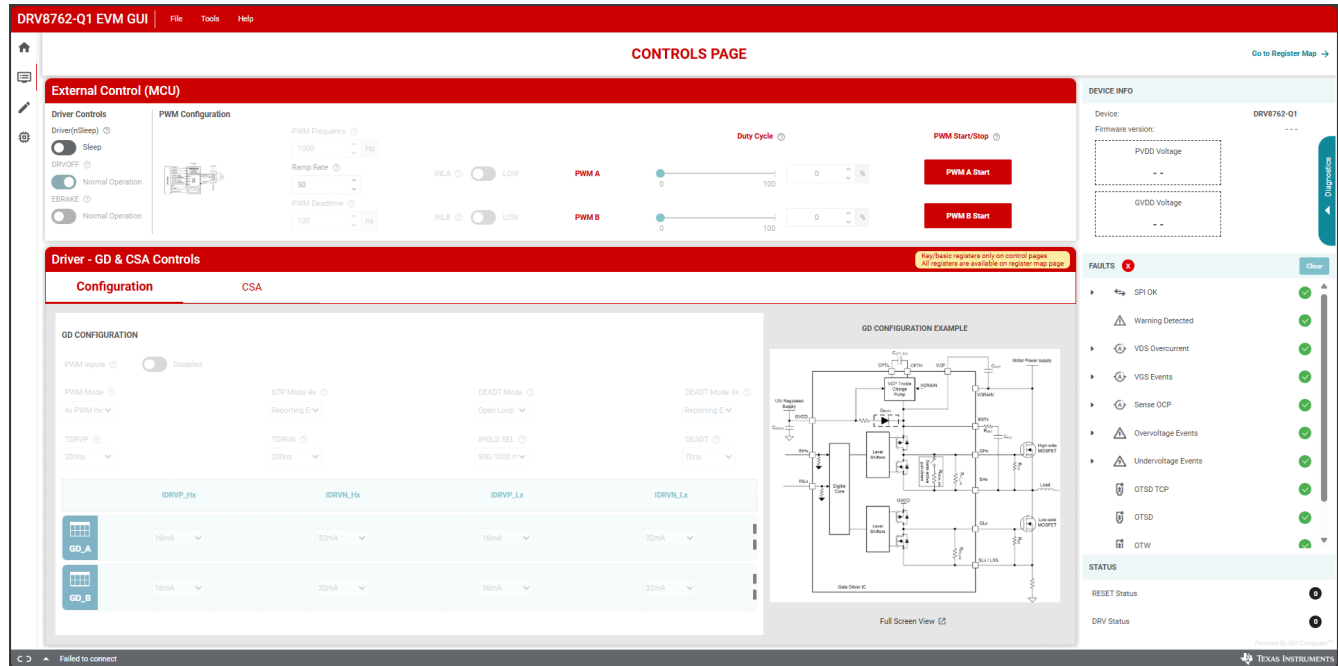


Figure 3-1. DRV8762-Q1EVM GUI

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, remove EVM power and recheck the setup.

To spin the motor:

1. Launch the GUI located on dev.ti.com/gallery.
2. Take the DRV8762-Q1 out of sleep mode by toggling nSLEEP to WAKE.
3. Select "Yes" on the Pop-up to configure the device in 2x PWM mode
4. Verify that the DRV8762-Q1 reports no faults (Fault LED green on GUI, no red nFAULT LED on the EVM). The GUI reports the VMOTOR/GVDD voltage.
5. Set the Ramp Rate of the Duty Cycle and set the PWM Duty Cycle using the slider or text input.
6. The motor spins.

3.2 4x PWM Mode

In 4x PWM mode of DRV8762-Q1, high-side INHx and low-side INLx inputs operate independently, except to prevent cross conduction when the high and low side of the same half-bridge are turned ON at same time.

If the system is configured in a half-bridge configuration, shoot-through occurs when the high-side and low-side MOSFETs are turned on at the same time. The system also reports a STP_FLT fault.

Table 3-1. 4x PWM Mode Truth

The device pulls high- and low- side gate outputs low to prevent shoot through condition of power stage.

INLx	INHx	GLx	GHx	Note
0	0	L	L	
0	1	L	H	
1	0	H	L	
1	1	L	L	Shoot through protection

4 Hardware Design Files

4.1 Schematics

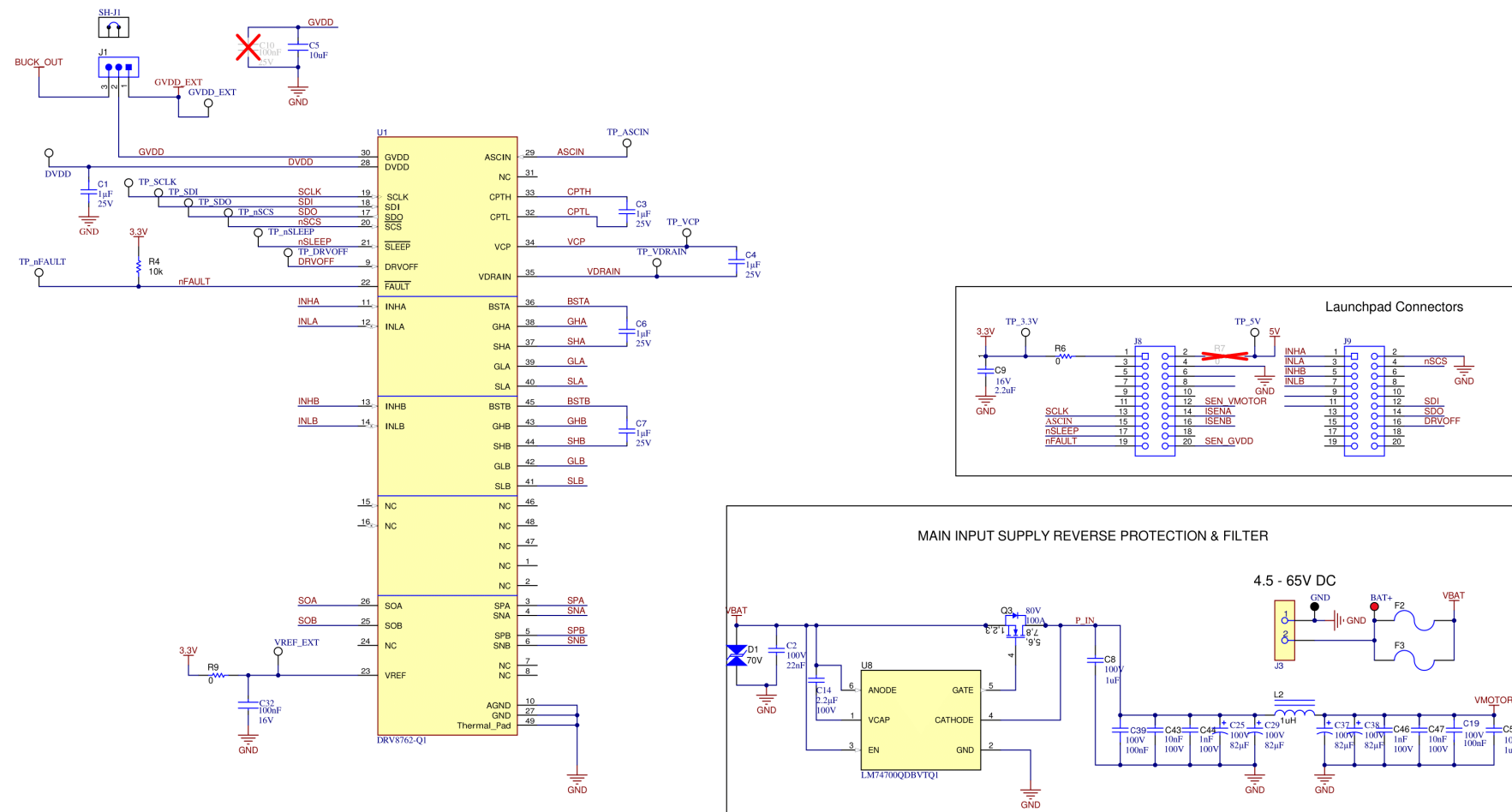


Figure 4-1. Schematic 1

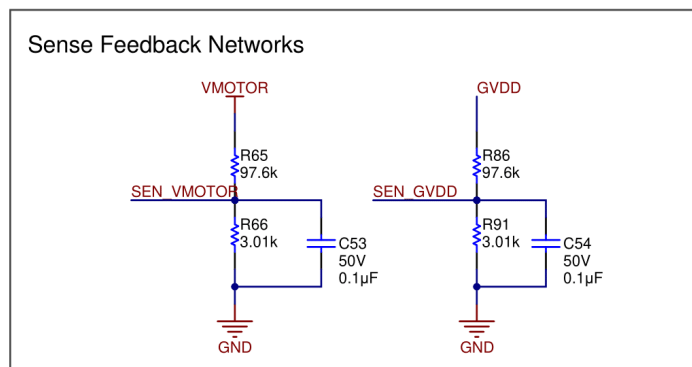
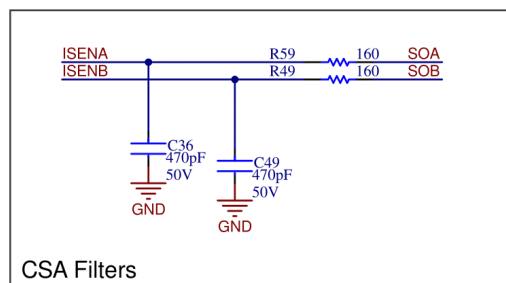


Figure 4-3. Schematic 3

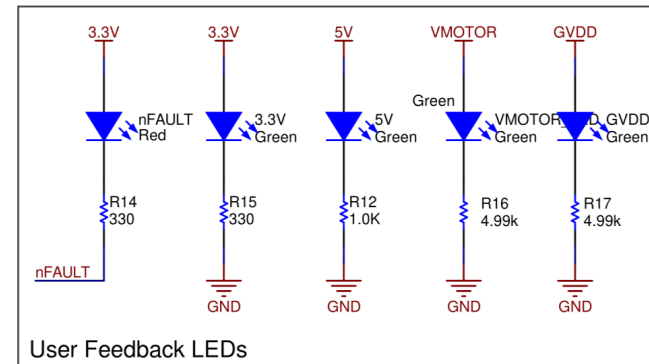
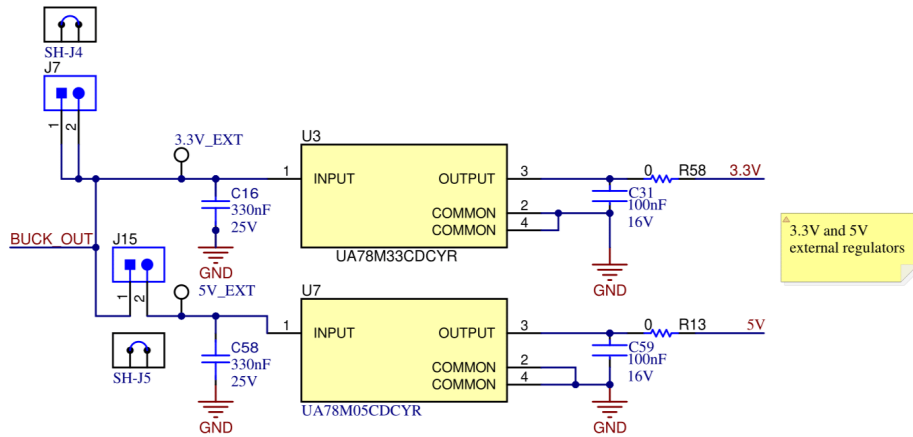
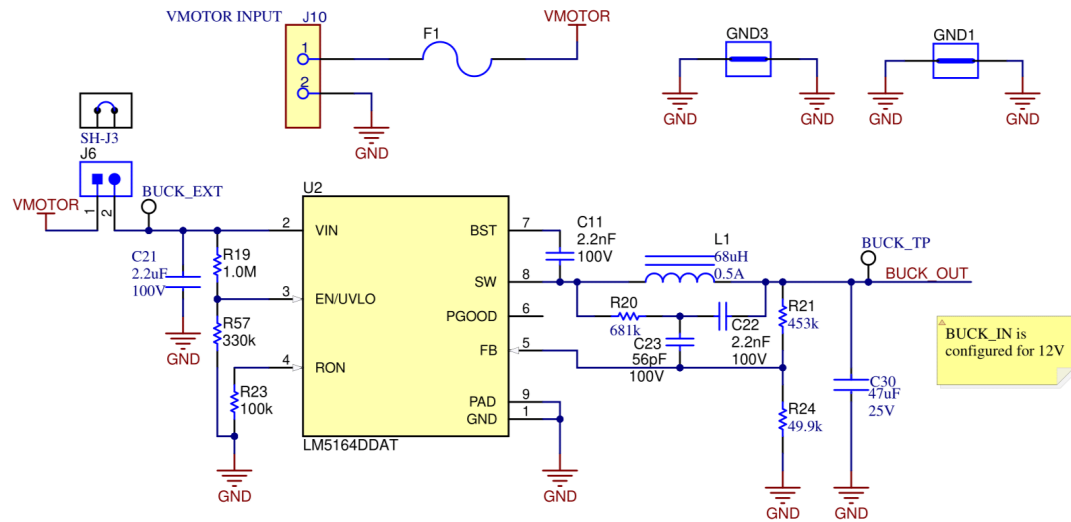


Figure 4-4. Schematic 4

4.2 PCB Layouts

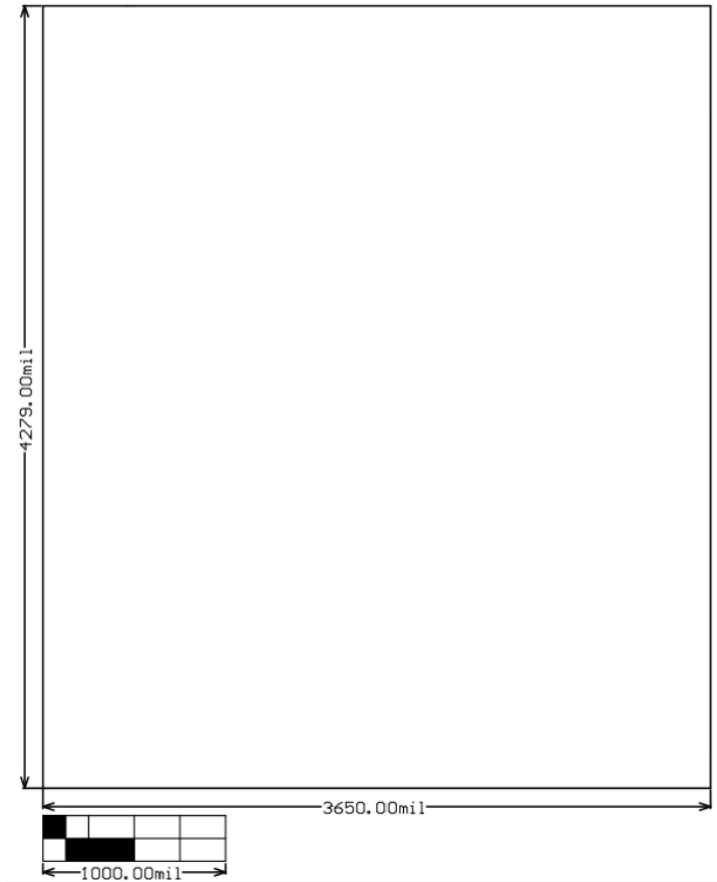


Figure 4-5. EVM Dimensions

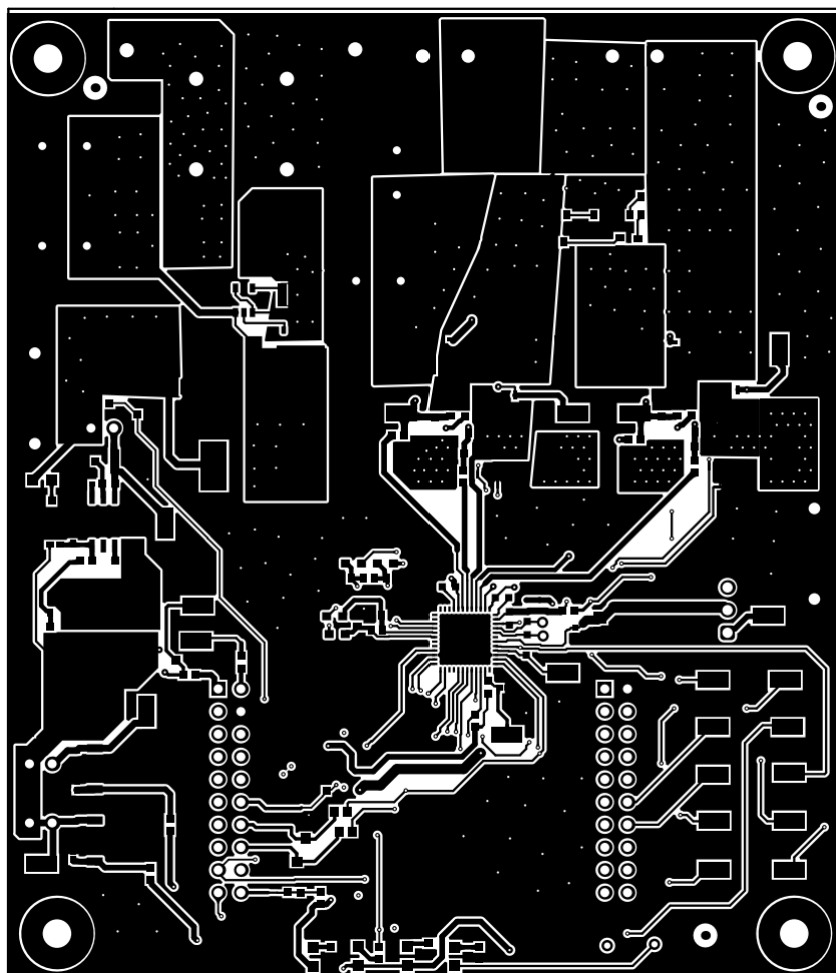


Figure 4-6. EVM Top Layer

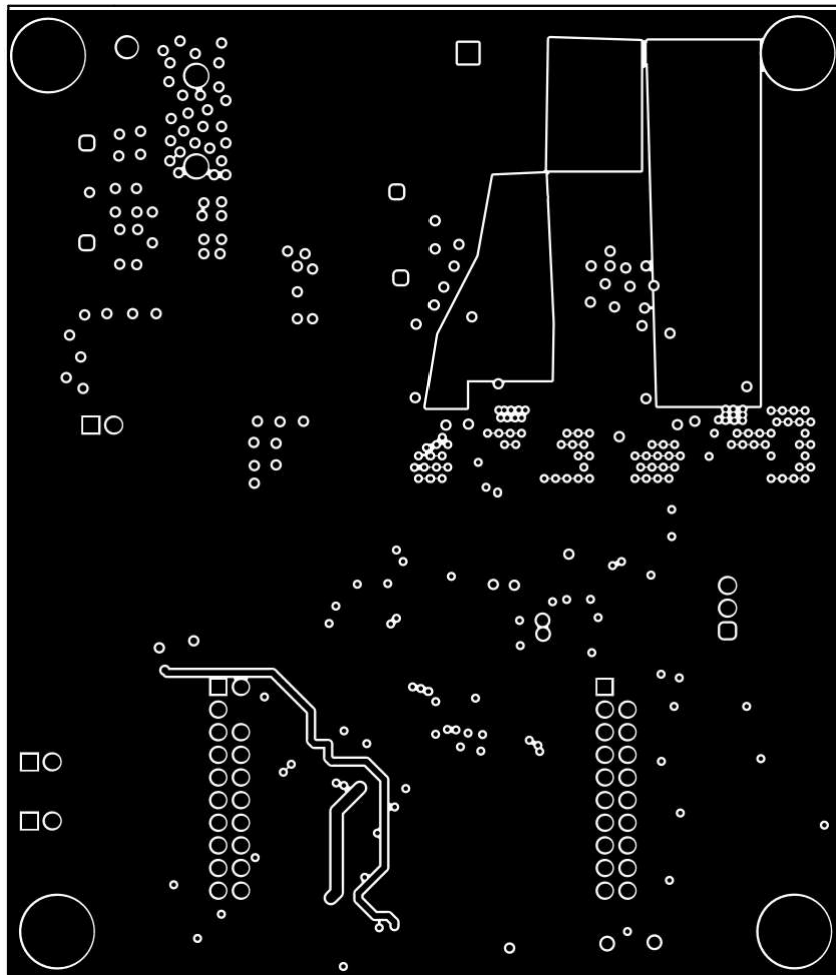


Figure 4-7. EVM Signal Layer 1

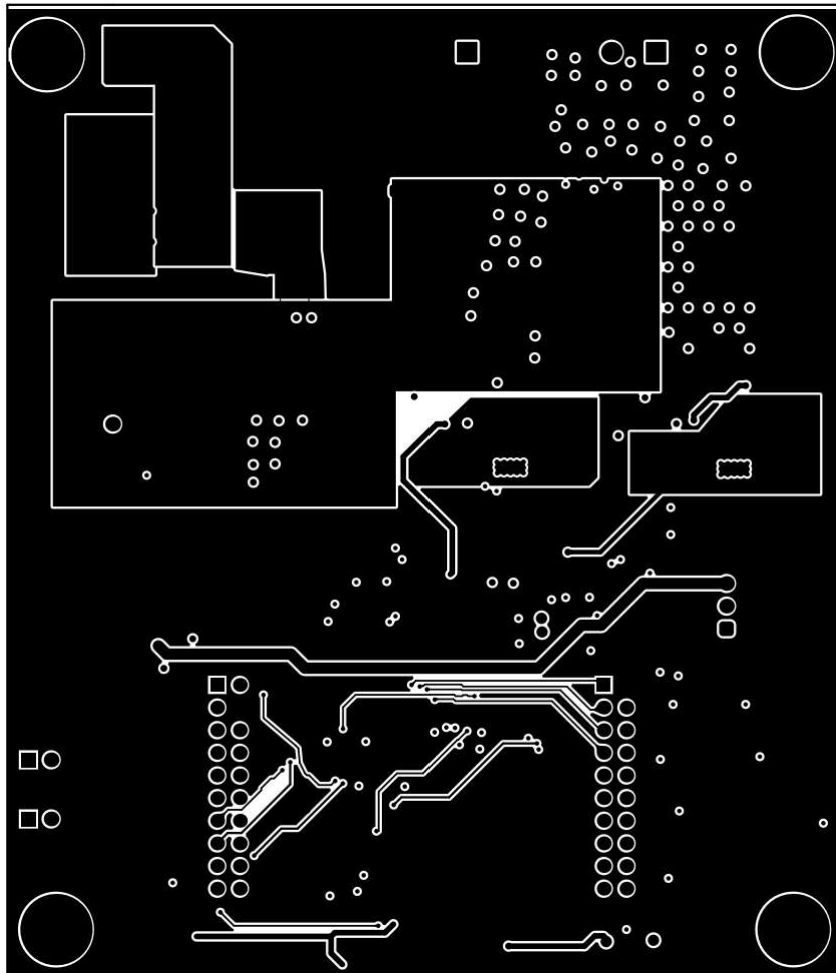


Figure 4-8. EVM Signal Layer 2

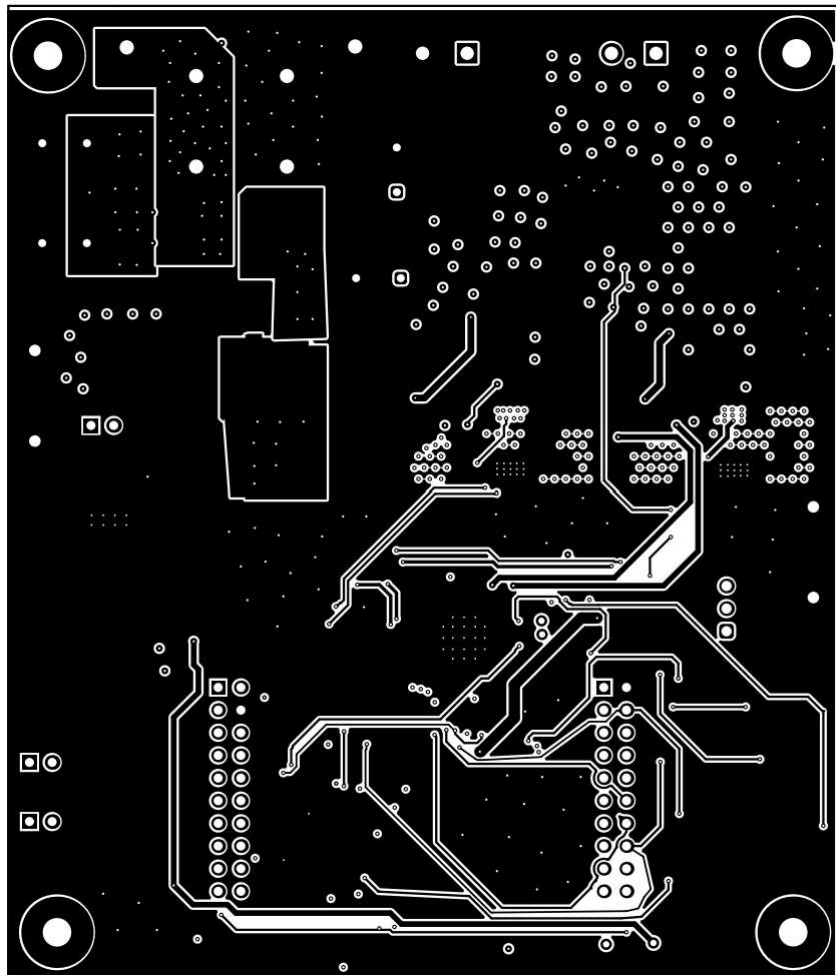


Figure 4-9. EVM Bottom Layer

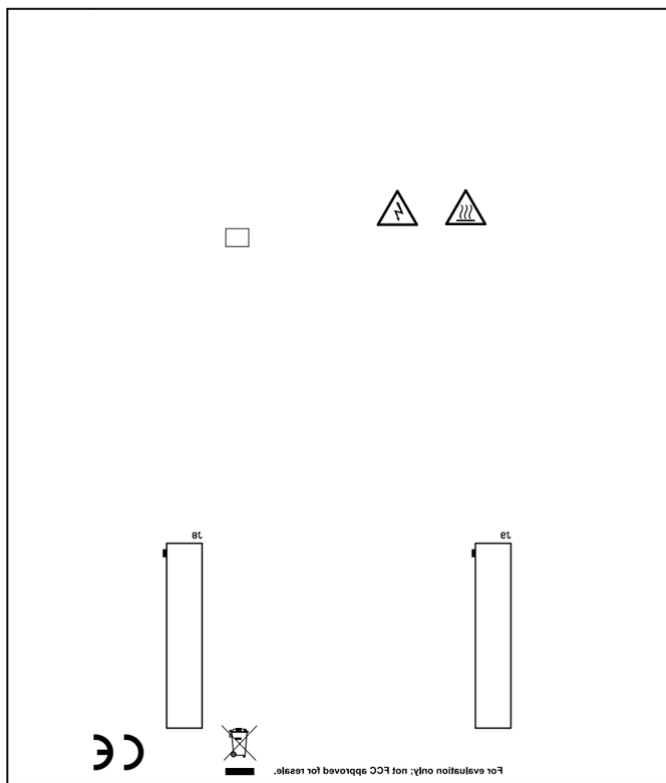


Figure 4-10. EVM Bottom Overlay

4.3 Bill of Materials (BOM)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
!PCB1	1		Printed Circuit Board		MD115	Any
3.3V, GVDD, VMOTOR_LED	3	Green	LED, Green, SMD	0805 LED	LTST-C171GKT	Lite-On™
3.3V_EXT, 5V_EXT, BUCK_EXT, BUCK_TP, DVDD, GHA, GHB, GLA, GLB, GVDD_EXT, SLA, SLB, TP_3.3V, TP_5V, TP_ASCIN, TP_DRVOFF, TP_ISENA, TP_ISENB, TP_nFAULT, TP_nSCS, TP_nSLEEP, TP_SCLK, TP_SDI, TP_SDO, TP_VCP, TP_VDRAIN, VREF_EXT	27		Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone Electronics
5V	1		LED, Green, SMD	0805 LED	LTST-C171GKT	Lite-On
BAT+	1		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone Electronics
C1, C3, C4, C6, C7	5	1µF	1µF ±10% 25V Ceramic Capacitor X7R 0603 (1608 Metric)	0603	885012206076	Würth Elektronik®
C2	1	22nF	WCAP-CSGP Multilayer Ceramic Chip Capacitor, General Purpose, size 0805, X7R, 22nF, 100VDC	0805	885012207124	Würth Elektronik
C5	1	10uF	Multi-Layer Ceramic Capacitor 10uF 25V X7S ±10% 0805 Emboss T/R GRT21BC71E106KE13L	0805	GRT21BC71E106KE13L	
C8, C50	2	1uF	CAP, CERM, 1uF, 100V, ±10%, X7S, 0805	0805	C2012X7S2A105K125AB	TDK
C9	1	2.2uF	CAP, CERM, 2.2uF, 16V, ±20%, X5R, 0603	0603	885012106018	Würth Elektronik
C10	1	100nF	Ceramic Capacitor for Automotive 100nF ±10% 25VDC X7R 0402 Paper T/R	0402	GCM155R71E104KE02D	
C11, C22	2	2200pF	CAP, CERM, 2200pF, 100V, ±10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E2X7R2A222K080AA	TDK
C14	1	2.2uF	WCAP-CSST Multilayer Ceramic Chip Capacitor, Soft Termination, size 1210, X7R Class II, 2.2µF, 100VDC	1210	885382209002	Würth Elektronik
C16, C58	2	330nF	Cap Ceramic 330nF 25V X7R 10% Pad SMD 0603 +125°C Automotive T/R	0603	CGA3E3X7R1E334K080AB	TDK
C18, C20	2	10uF	CAP, CERM, 10uF, 100V, ±10%, X7S, AEC-Q200 Grade 1, 2220	2220	CGA9N3X7S2A106K230KE	TDK
C19, C39	2	100nF	0.1µF ±10% 100V Ceramic Capacitor X7R 0603 (1608 Metric)	0603	885012206120	Würth Elektronik

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
C21	1	2.2uF	CAP CER 2.2UF 100V X7R 1210 AEC-Q200	1210	C1210C225K1RACAUTO	
C23	1	56pF	CAP, CERM, 56pF, 100V, ±5%, 0603, AEC-Q200	0603	C0603C560J1RACAUTO	MuRata™
C25, C29, C37, C38	4	82uF	WCAP-ATUL Aluminum Electrolytic Capacitor, Radial, THT, D10 × H20mm, 82µF, 100V	10mm diam × 20mm height	860040875004	Würth Elektronik
C30	1	47uF	Cap Ceramic 47uF 25V X7R 20% Pad SMD 2220 +125°C Automotive T/R	2220	CGA9N3X7R1E476M230K B	
C31, C32, C59	3	100nF	Ceramic Capacitor for Automotive 100nF ±10% 16VDC X7R 0402 Paper T/R	0402	GCM155R71C104KA55J	
C33, C40, C41, C42, C45, C48	6	1,000pF	CAP CER SMD 0603 1000PF 10% X7R	0603	C0603C102K4RACAUTO	KEMET
C36, C49	2	470pF	Cap Ceramic 470pF 50V C0G ±5% Pad SMD 0603 +125°C T/R	0603	CL10C471JB81PNL	
C43, C47	2	0.01uF	CAP, CERM, 0.01µF, 100V, +/- 10%, X7R, 0603	0603	885012206114	Würth Elektronik
C44, C46	2	1000pF	CAP, CERM, 1000pF, 100V, ±10%, X7R, 0603	0603	06031C102KAT2A	AVX
C53, C54	2	0.1uF	CAP, CERM, 0.1µF, 50V, ±10%, X7R, AEC-Q200 Grade 1, 0603	0603	C0603C104K5RACAUTO	Kemet
D1	1	70V	Diode, TVS, Bi, 70V, SMB	SMB	SMBJ70CA-13-F	Diodes Inc.
F1, F2	2		Fuse Fast Acting 60A 0.9mΩ 250V 2-Pin 3812 T/R	3812	SF-3812F6000T-2	Bourns
GND	1		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone Electronics
GND1, GND3	2		1mm 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	1		Header, 2.54mm, 3x1, Gold, TH	Header, 2.54mm, 3x1, TH	61300311121	Würth Elektronik
J3	1			HDR2	691256610002	Würth
J6, J7, J15	3		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, J13	2		2 Position Wire to Board Terminal Block Horizontal with Board 0.197	HDR2	691216710002	Würth Electronics

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
L1	1	68uH	68µH Shielded Wirewound Inductor 540mA 840mΩ Nonstandard	SMD2	74404042680	Würth Electronics
L2	1	1uH	Inductor, Shielded Drum Core, Ferrite, 1uH, 24A, 0.0012Ω, SMD	12.1x9.5x11.4mm	7443320100	Würth Elektronik
MOTA, MOTB, VMOTOR	3		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, Q4, Q5	4	100V	MOSFET, N-CH, 100V, 170A, AEC-Q101, PowerPAK_SO-8L	PowerPAK_SO-8L	SQJ456EP-T1_GE3	Vishay-Siliconix
Q3	1	80V	MOSFET, N-CH, 80V, 100A, DNK0008A (VSON-CLIP-8)	DNK0008A	CSD19502Q5B	Texas Instruments
R1, R2, R6, R7, R9, R28, R29, R34, R35, R37, R38, R39	12	0	RES, 0, 0%, 0.25W, AEC-Q200 Grade 0, 0603	0603	RCS06030000Z0EA	Vishay-Dale
R4	1	10k	RES, 10k, 5%, 0.1W, AEC-Q200 Grade 0, 0603	0603	CRCW060310K0JNEA	Vishay-Dale
R11, R32, R45, R54	4	10	10Ω ±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
R12, R14, R15	3	330	RES, 330, 5%, 0.1W, AEC-Q200 Grade 0, 0603	0603	CRCW0603330RJNEA	Vishay-Dale
R13, R58	2	0	RES, 0, 5%, 0.1W, AEC-Q200 Grade 0, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R16, R17	2	4.99k	RES, 4.99k, 1%, 0.1W, AEC-Q200 Grade 0, 0603	0603	CRCW06034K99FKEA	Vishay-Dale
R19	1	1.0Meg	RES, 1.0M, 5%, 0.1W, AEC-Q200 Grade 0, 0603	0603	CRCW06031M00JNEA	Vishay-Dale
R20	1	681k	RES, 681k, 1%, 0.1W, AEC-Q200 Grade 0, 0402	0402	ERJ-2RKF6813X	Panasonic®
R21	1	453k	RES, 453k 1%, 0.1W, AEC-Q200 Grade 0, 0402	0402	ERJ-2RKF4533X	Panasonic
R22, R60, R76, R77	4	100k	RES, 100k, 1%, 0.1W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100KFKEA	Vishay-Dale
R23	1	100k	RES, 100k, 1%, 0.063W, AEC-Q200 Grade 0, 0402	0402	CRCW0402100KFKED	Vishay-Dale
R24	1	49.9k	RES, 49.9k, 1%, 0.1W, AEC-Q200 Grade 0, 0402	0402	ERJ-2RKF4992X	Panasonic
R31, R33	2	5.000000000 0000001E-3	RES, 0.005, 1%, 3W, AEC-Q200 Grade 0, 2512	2512	CRE2512-FZ-R005E-3	Bourns
R49, R59	2	160	160, 0.1W, 0603, AEC-Q200 ERJ-3GEYJ161V	0603	ERJ-3GEYJ161V	Panasonic

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
R57	1	330k	RES, 330k, 5%, 0.1W, AEC-Q200 Grade 0, 0603	0603	CRCW0603330KJNEA	Vishay-Dale
R65, R86	2	97.6k	RES, 97.6k, 1%, 0.1W, AEC-Q200 Grade 0, 0603	0603	CRCW060397K6FKEA	Vishay-Dale
R66, R91	2	3.01k	RES, 3.01k, 1%, 0.1W, AEC-Q200 Grade 0, 0603	0603	CRCW06033K01FKEA	Vishay-Dale
SH-J1, SH-J3, SH-J4, SH-J5	4	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec
U1	1		48V Battery H-bridge Smart Gate Driver with Accurate Current Sensing and Advanced Monitoring	VQFN48	DRV8762-Q1	Texas Instruments
U2	1		100V Low IQ Synchronous Buck Regulator, DDA0008E (SOIC-8)	DDA0008E	LM5164DDAT	Texas Instruments
U3	1		500mA, 25V, Linear Voltage Regulators, DCY0004A (SOT-223-4)	DCY0004A	UA78M33CDCYR	Texas Instruments
U7	1		500mA, 25V, Linear Voltage Regulators, DCY0004A (SOT-223-4)	DCY0004A	UA78M05CDCYR	Texas Instruments
U8	1		Low Iq Always ON Smart Diode Controller, DBV0006A (SOT-23-6)	DBV0006A	LM74700QDBVTQ1	Texas Instruments
C12, C13, C15, C17, C24, C26, C27, C28	0	2,200pF	CAP CER 2200PF 100V X7R 0603			KEMET
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
R25, R26, R40, R41	0		2.7, 0.125W, 0603, AEC-Q200			KOA Speer

5 Additional Information

5.1 Trademarks

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6 References

See these documents for additional reference:

- Texas Instruments, [DRV8762-Q1 Datasheet](#)
- 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/llds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

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

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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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。

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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/llds/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:*

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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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