EVM User's Guide: DRV8161EVM
DRV8161 Evaluation Module

TEXAS INSTRUMENTS

Description

The DRV8161EVM is a 30A, 3-phase brushless DC drive stage using three DRV8161 gate drivers for spinning BLDC motors.

The EVM allows quick evaluation of the DRV8161 device which spins a BLDC motor with trapezoidal commutation and control.

Status LEDs for all power supplies as well as FAULT LEDs for the drivers are included for user feedback. The C2000™ LaunchPad™ (LAUNCHXL-F280049C) is required for this kit and is required for this kit and is used to control the DRV8161 drivers as well as to monitor and report faults.

Features

- 8V to 20V Gate drive voltage with 8V to 90V drain voltage suited for up to 48V applications
- 16mA-1A source and 32mA-2A sink current settings
- Integrated CSA's per half bridge driver for accurate current sensing

Applications

- Servo drives
- Industrial and collaborative robot
- Industrial mobile robot (AGV/AMR)
- Linear motor transport systems
- Drones
- E-bikes, e-scooters, and e-mobility
- Industrial and appliances fans and pumps
- 12V, 24V and 48V automotive BLDC motor drives
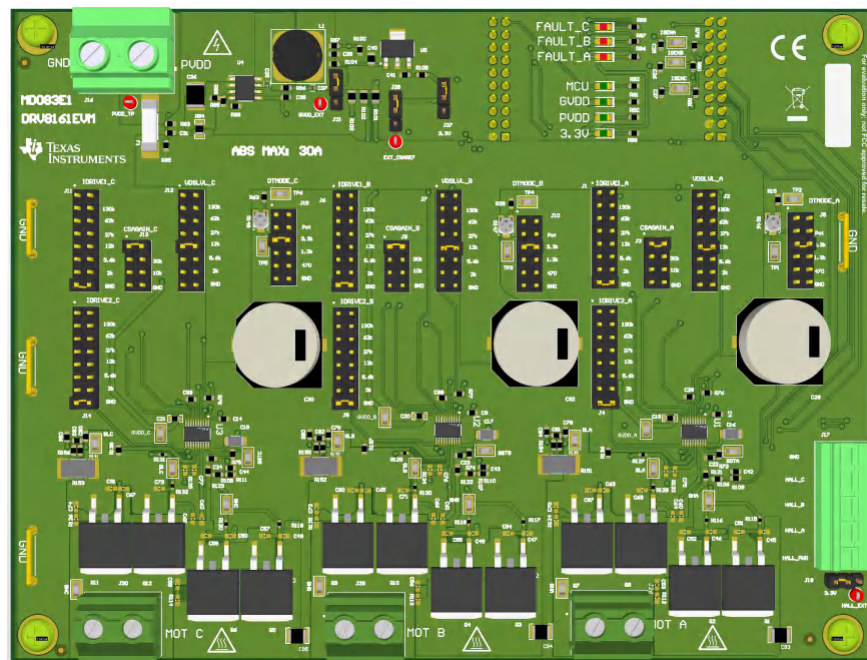
DRV8161EVM

1 Evaluation Module Overview

1.1 Introduction

This document is provided with the DRV8161 customer evaluation module (EVM) as a supplement to the DRV8161 data sheet *DRV816x 100V Half-Bridge Smart Gate Driver with Integrated Protection and Current Sense Amplifier* (SLVSGZ1). This user's guide details the hardware implementation of the EVM and how to set up and power the board. The DRV8161EVM allows users to evaluate the performance of a DRV8161 motor driver. A LAUNCHXL-F280049C BoosterPack™ is used to control the PWM and commutation logic of the driver.

The scope of this document is to provide users with a guide to evaluate the DRV8161 device with a TMS320F280049C board. This document covers the hardware connections required between boards and external motor and supplies. When the hardware connections are complete, the user can access the necessary tools and software to spin a motor using the online GUI.

This document is designed to be used as a startup guide to the DRV8161EVM and LAUNCHXL-F280049C devices. This document is intended for the engineers involved in the design, implementation, and validation of DRV8161 and TMS320F280049C reference software. The reference software is made up of the GUIComposer software with sensored trapezoidal algorithm for BLDC motor control.

CAUTION
The DRV8161EVM 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.

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
DRV8161EVM	PCB	1
Box	Cardboard box	1
Label	Standard label	1
Foam	Antistatic foam	2
Literature	EVM disclaimers	1

1.3 Specification

The DRV8161EVM can support voltages up to 48V and currents up to 30A. To prevent damage to both the IC and the EVM, confirm that these voltage and current specifications are not exceeded.

1.4 Device Information

The DRV816x is a 100V half bridge driver with a gate drive power supply ranging from 8V–10V. The DRV816x devices are integrated half-bridge gate drivers capable of driving high-side and low-side N-channel power FETs. The device generates the gate drive voltages from the GVDD supply pin and uses a bootstrap circuit to drive the high-side FET. The gate drive architecture supports peak gate drive currents up to 1A source and 2A sink. These devices can be used to drive various types of loads including brushless and brushed DC motors, PMSM, stepper motors, switched reluctance motors (SRM), and solenoids. Internal protection functions are provided for undervoltage lockout, FET overcurrent, and overtemperature. The nFAULT pin indicates fault events detected by the protection features.

2 Hardware

## 2.1 Hardware Connections Overview – DRV8161EVM and 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 shows the major blocks of DRV8161EVM evaluation module. The DRV8161EVM is designed for an input supply from 4.5V to 48V. The EVM uses parallel MOSFET configuration using CSD19536KTT N-Channel MOSFETs and a 5 mOhm sense resistor.
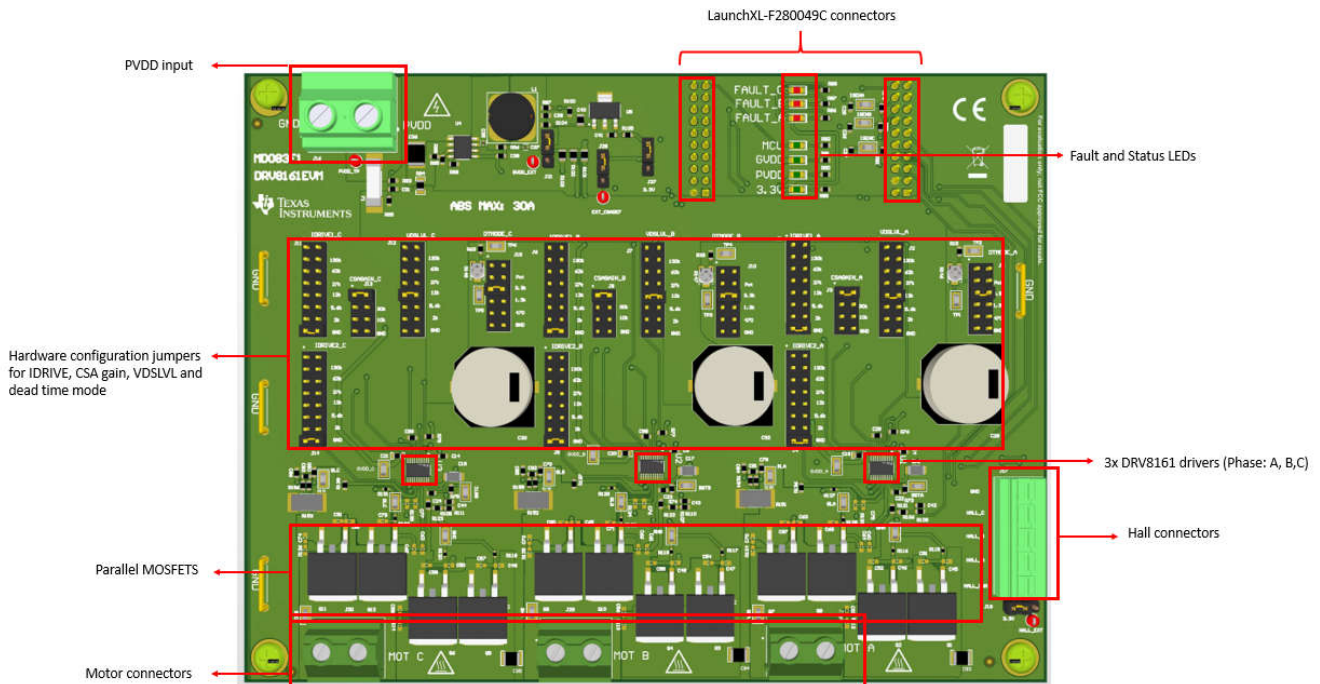
Figure 2-1. DRV8161EVM Major Hardware Blocks

shows how to mount DRV8161EVM board to the LaunchXL-F280049C LaunchPad top position (J1/J2/J3/J4). The DRV8161EVM sits on top of the LaunchPad.
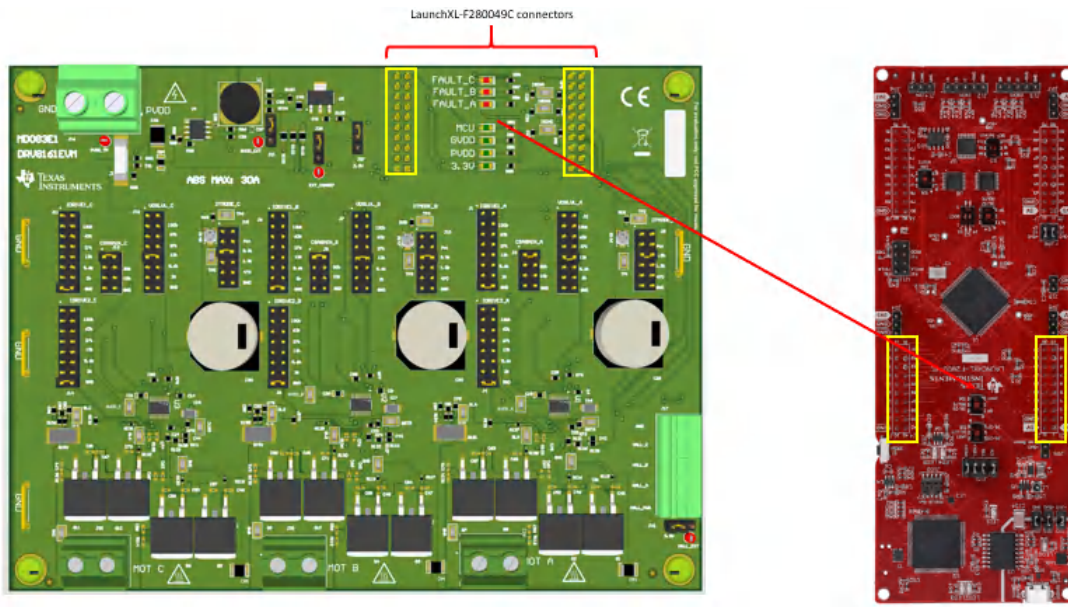
**Figure 2-2. DRV8161EVM Mating to LAUNCHXL-F280049C**


Figure 2-3. PVDD Input

WARNING
To minimize the risk of potential shock hazard and personal injury, remove all power connections and interfaces to the DRV8161EVM when not in use.

The DRV8161EVM is designed for an input supply from 8 VDC to 48 VDC and up to 30A continuous drive current (in-line fuse limited). The input connects to J16 with the noted polarity. PVDD_TP test point connects to the same node but must not be used for high current input. PVDD input is fused with a 30A fuse.
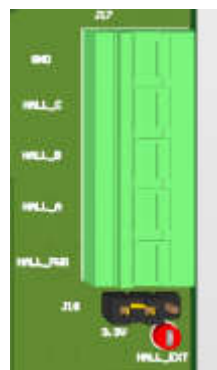
Figure 2-4. Hall Sensor Inputs and Power Connections (J17 ,J18)

Hall sensors are connected to J17 including hall power and GND. The 3.3 VDC supply to the hall sensors is supplied from the 3.3V 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 3.3V LDO to power the halls, connect J18 on the left side to pins 1:2 as shown below. To use HALL_EXT, connect J18 on the right side to pins 2:3. To insert or remove wires and terminals on J17, use a flat blade screwdriver to push down the respective tab on top of the J17 connector.
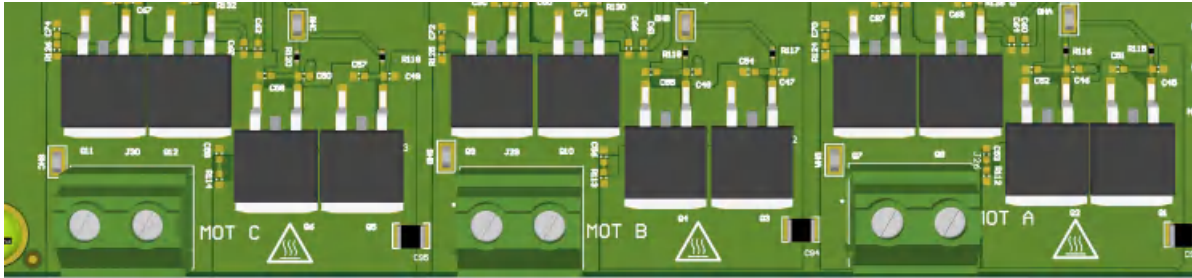
Figure 2-5. Motor Phase Connector (J26, J28, J30)

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 phases of the motor connect to either connector for the same phase.

2.2 Faults, Indicators, and Jumper Settings

The DRV8161 implements bootstrap undervoltage, GVDD undervoltage, overcurrent protection, and thermal shutdown in case of overtemperature. See the DRV8161 data sheet for more information on DRV8161 fault support.

Status LEDs for the MCU, 3.3V, PVDD, GVDD, and FAULT (per phase) are included and shown below.
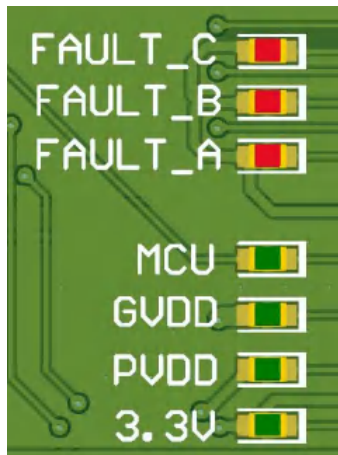
Figure 2-6. Status and Fault LEDs

The FAULT LED lights up if the EVM senses a fault. See the 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 3.1.
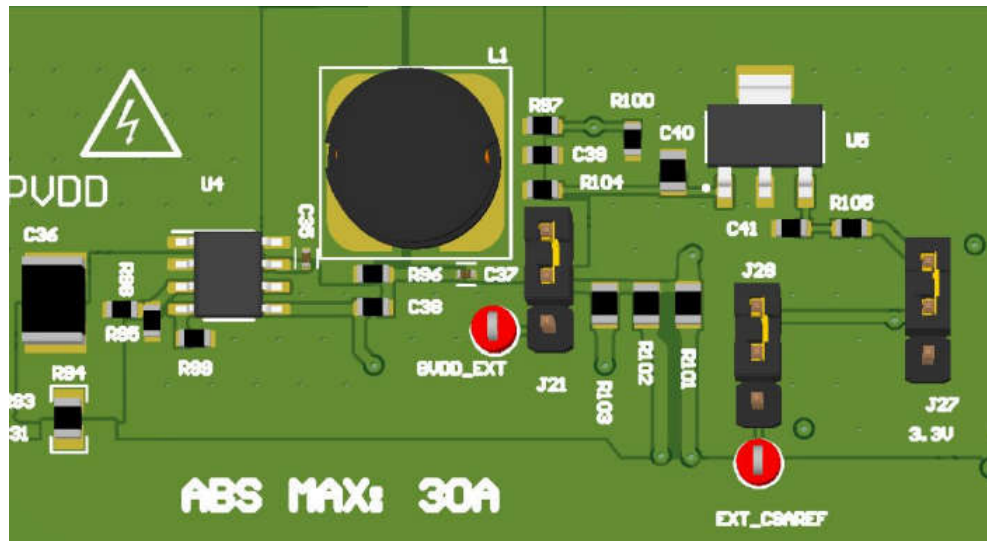

Figure 2-7. On-Board Buck and LDO

The EVM includes a buck regulator to generate a 12V GVDD Buck voltage from PVDD supply. If external GVDD is needed, then move the J21 jumper to the bottom position.

The GVDD voltage is used to generate 3.3V LDO output. If external 3.3V is needed, then move the J27 jumper to the bottom position. The 3.3V LDO is used to generate the CSAREF voltage. This LaunchPad and EVM works with the 3.3V only. If external voltage is needed, then move the J28 Jumper to the bottom position. (Note this can require board modifications.)
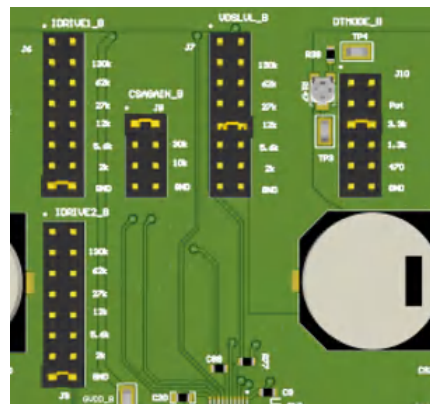

Figure 2-8. Driver Hardware Settings

The hardware settings of the DRV8161 can be set as shown in Table 2-1. For more information on resistor to settings, please consult the data sheet.

Setting	Phase A	Phase B	Phase C
IDRIVE 1	J1	J6	J11
IDRIVE 2	J4	J9	J14
CSAGAIN	J3	J8	J13
VDSLVL	J2	J7	J12
DTMODE	J5	J10	J15

2.3 EVM Hardware Quick-Start

The 8161EVM requires a power supply source, which has a recommended operating range from a 4.5V to 48V. To setup and power the EVM, follow the sequence below.

1. Connect motor phases to A, B, C to the respective MOT X connecter on the EVM (either screw terminal works).
2. Do not turn on the power supply yet. Connect motor supply to PVDD and GND on connector J16.
3. For sensored applications, connect the hall sensors to the appropriate locations on the 5-pin connector J17 as shown in Figure 2-9. Select on-board 3.3 (left position) or external (right position) on jumper J18 to choose the hall power source voltage.
4. Adjust the gate current (IDRIVE1_X, IDRIVE2_X), deadtime (DTMODE_X), VDS Level (VDS_LVL), CSA gain (CSAGAIN_X) on the EVM using the jumper headers.

Note

The CSA Gain is fixed in SW for 40V/V .

---

5. Mate the DRV8161EVM onto the top half of the LAUNCHXL-F280049C (LaunchPad headers J1/J3 and J2/J4) as shown in Figure 2-2. The motor connectors face the same direction as the Micro-USB connector on the LaunchPad.
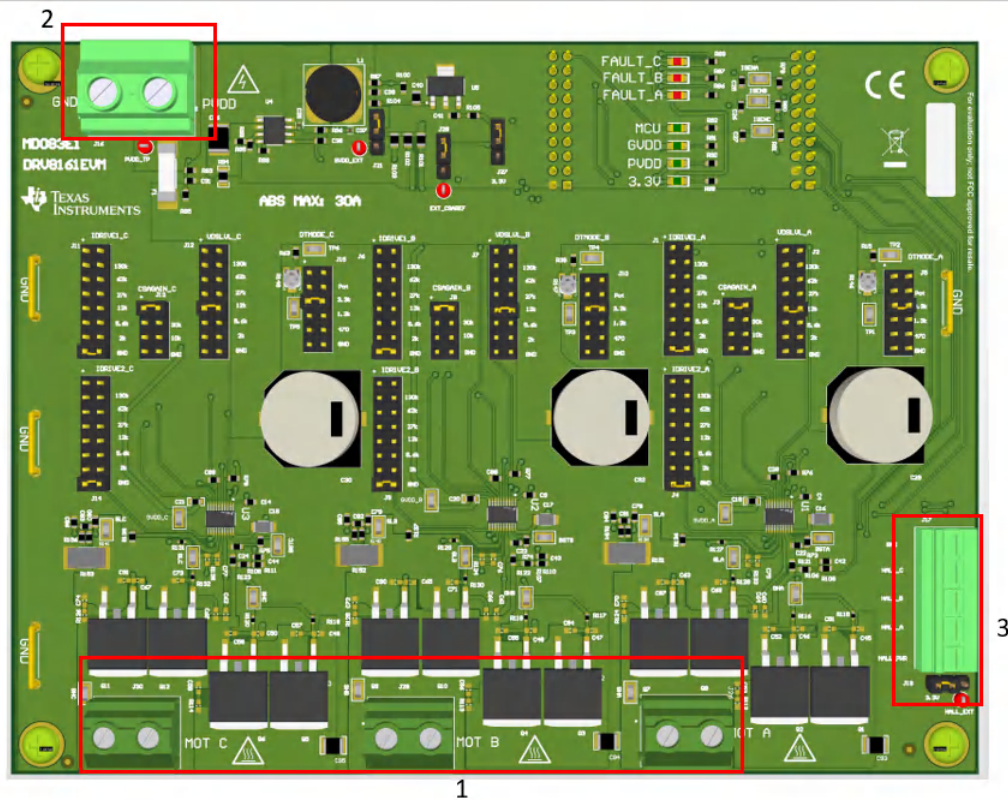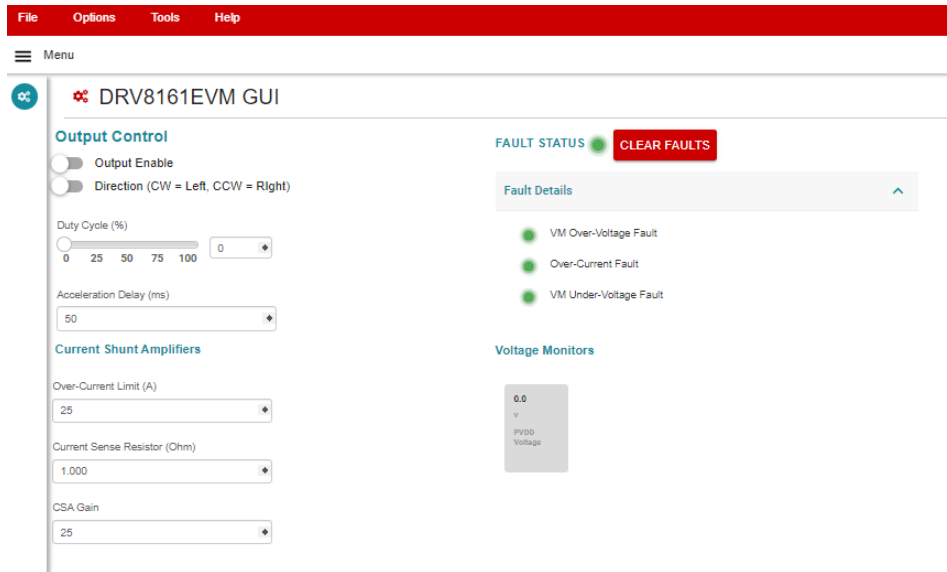6. Connect the micro-USB cable from the computer into the Micro-USB connector on the top of the LAUNCHXLF280049C.

Figure 2-9. Reference for Quick Start Guide

3 Software

3.1 DRV8161 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. DRV8161EVM GUI Software

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 Google Chrome® browser, navigate to https://dev.ti.com/gallery/view/InternalBLDC/DRV8161-EVM-GUI/ver/0.1.4/.
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 24V and 1A limit, board cannot take more than 300mA. (Depending on motor voltage and load.)
5. 3.3V, PVDD, and GVDD LEDs lights up green.
6. Click the Clear Faults button on the GUI and confirm all faults lights on GUI are cleared (green) and check to see no board FAULT_X LEDs are lit.
7. Check the following:
    a. GUI reads back approximately 24V for the PVDD voltage.
    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 motor slowing down to a stop and then spinning in opposite direction.
11. Disable the motor by switching the *Output Enable* to OFF.

Note

The overcurrent limit is used to set software current limit (max 30A). Current sense resistor value and gain dependent on what is populated on the EVM.
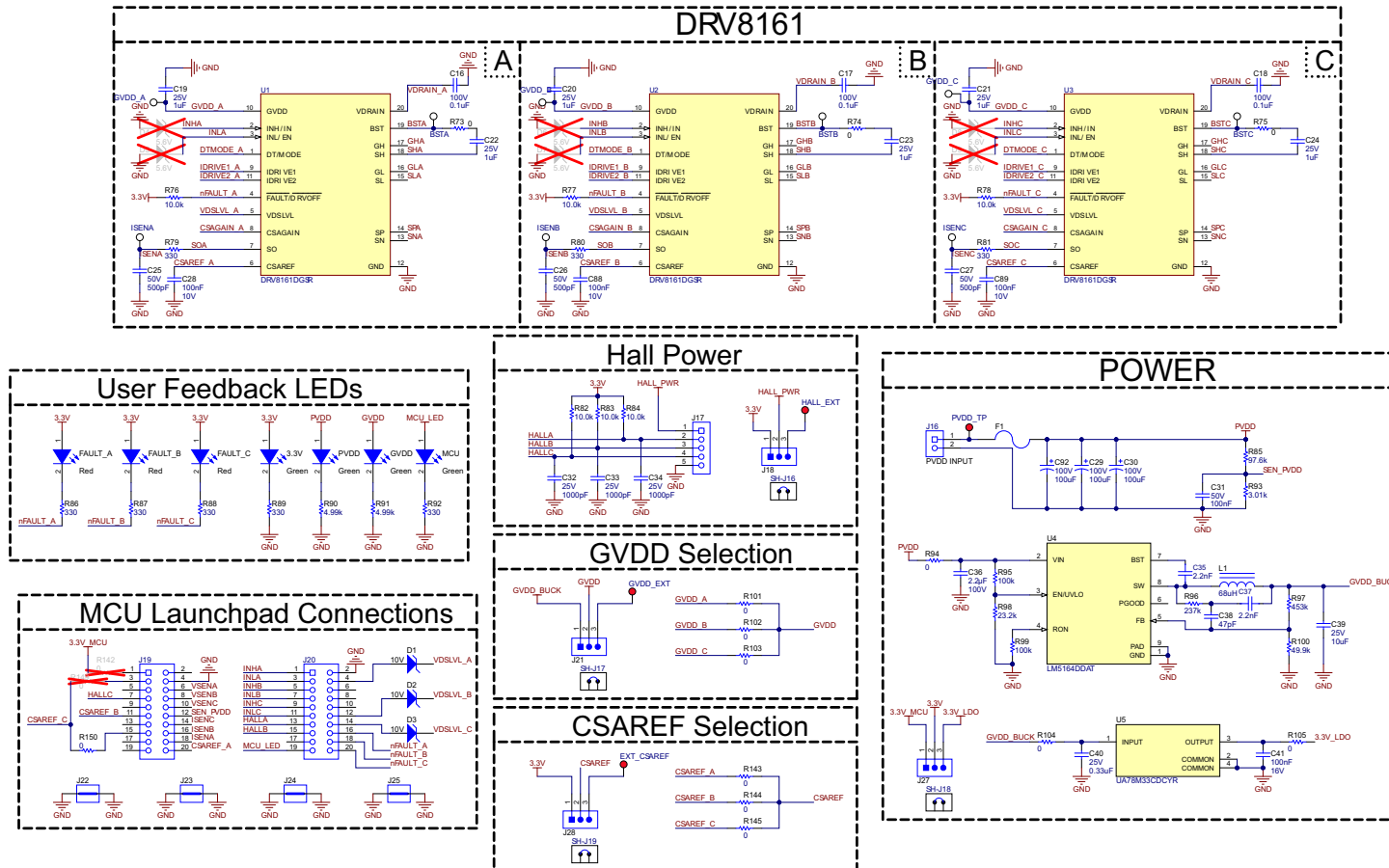
---

4 Hardware Design Files

4.1 Schematics

Figure 4-1. Schematic 1

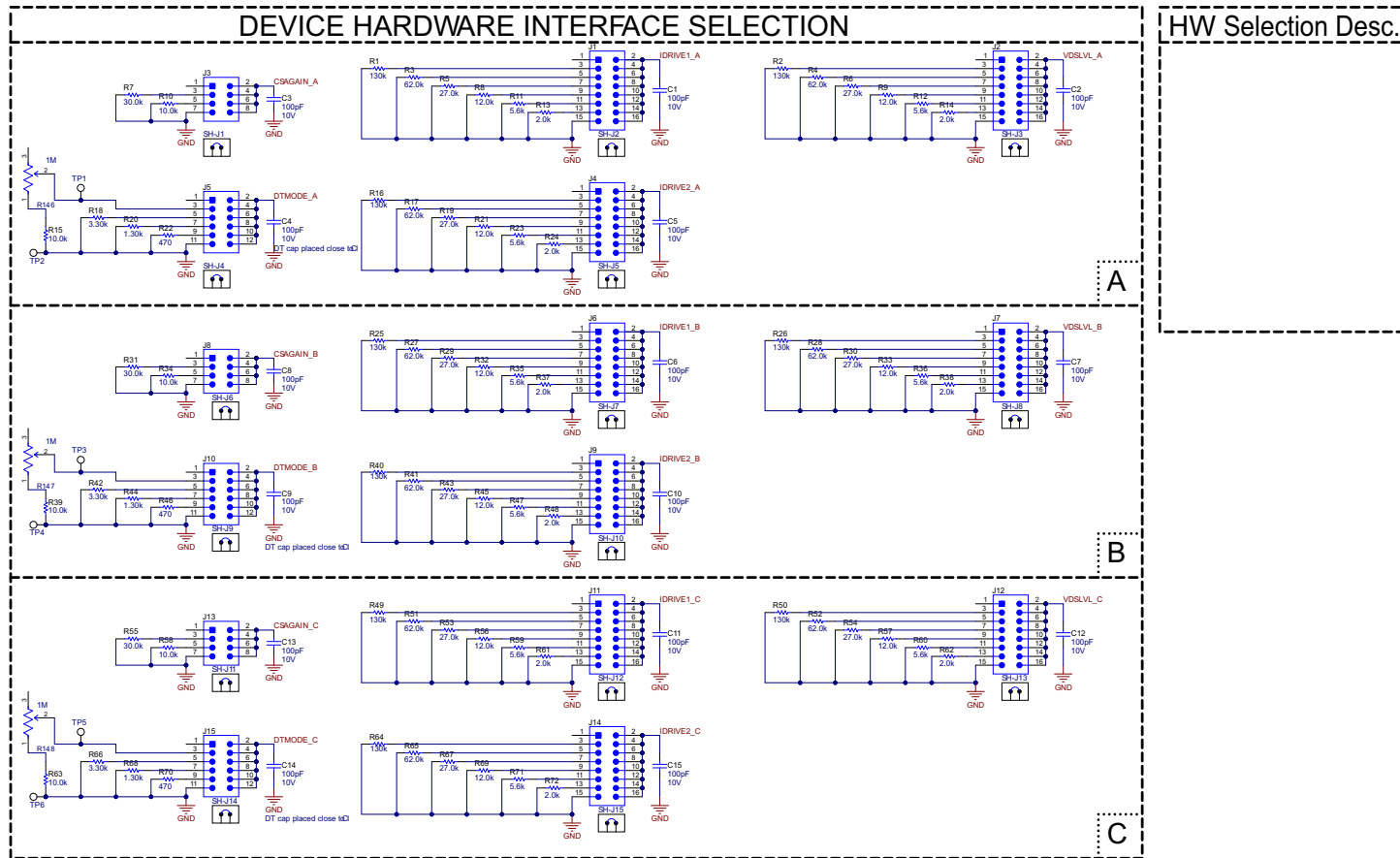Copyright © 2024 Texas Instruments Incorporated

DEVICE HARDWARE INTERFACE SELECTION

HW Selection Desc.

Figure 4-2. Schematic 2

OUTPUT CONNECTORS/V SENSE

POWER STAGE

Figure 4-3. Schematic 3

Copyright © 2024 Texas Instruments Incorporated
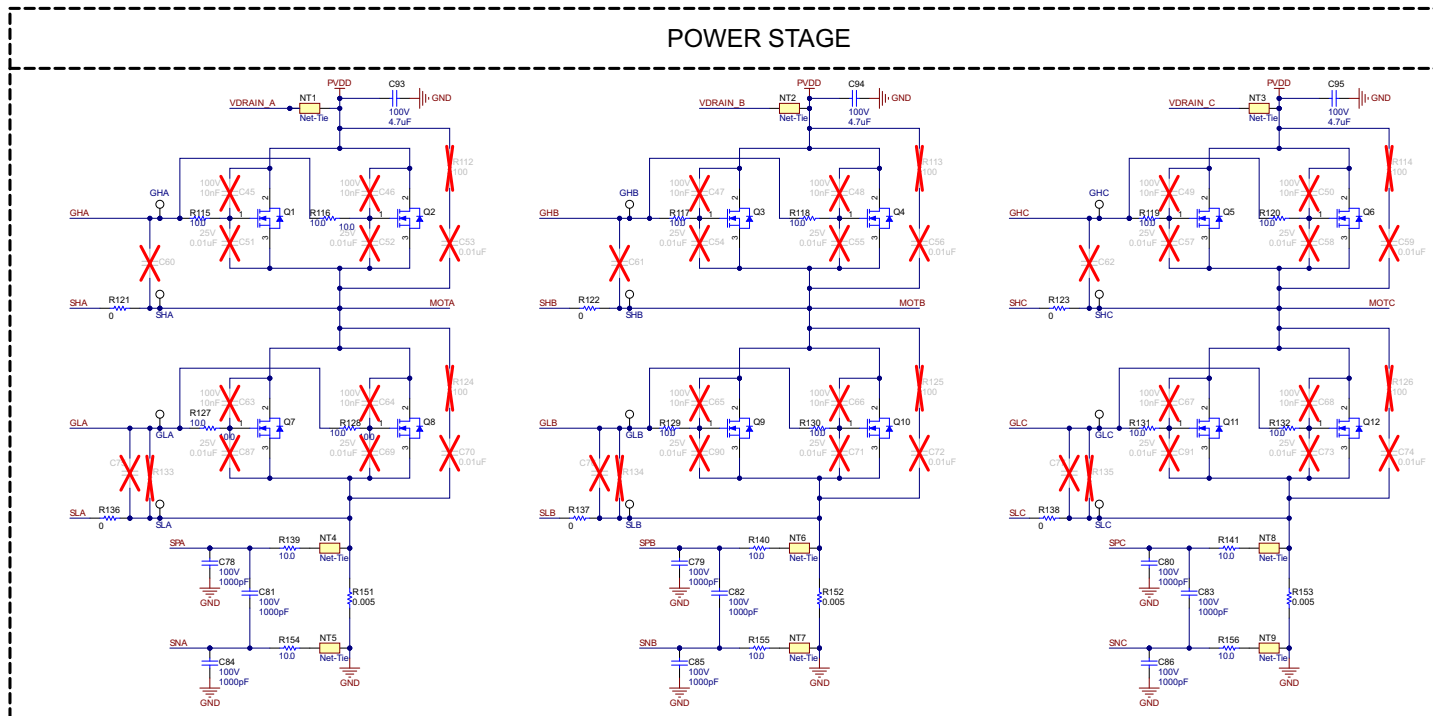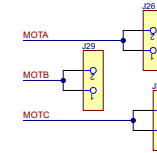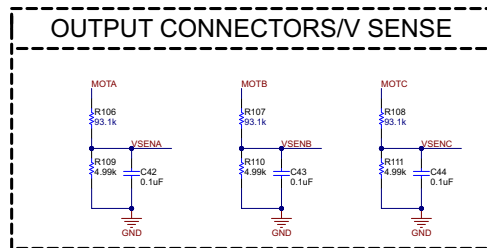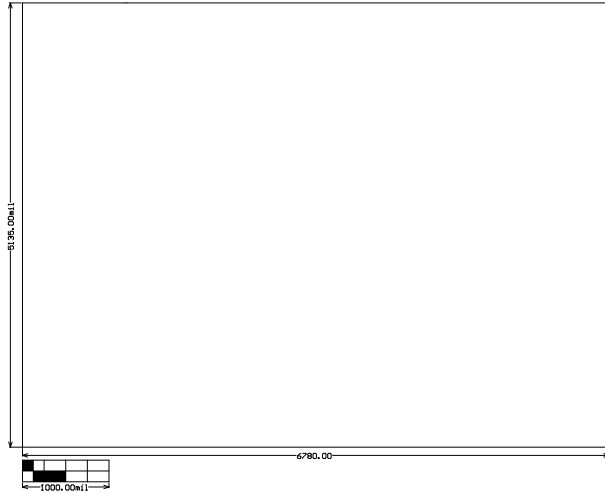
4.2 PCB Layouts

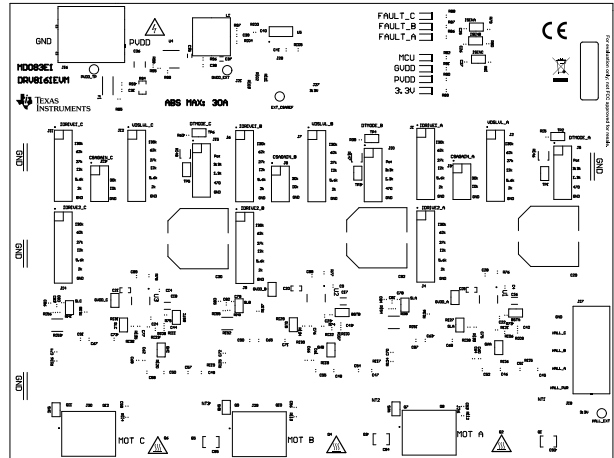**Figure 4-4. EVM Dimensions**
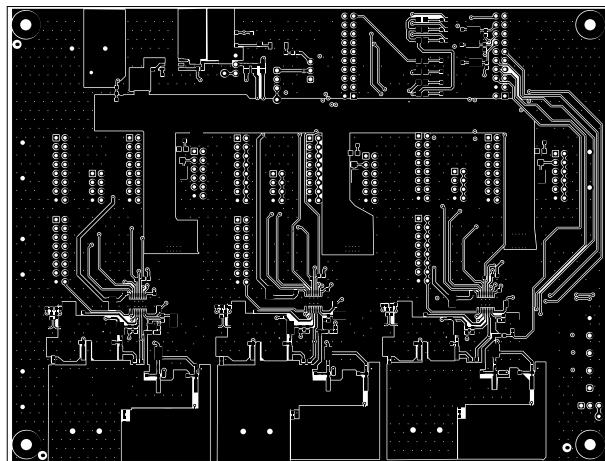

Figure 4-5. EVM Top Overlay
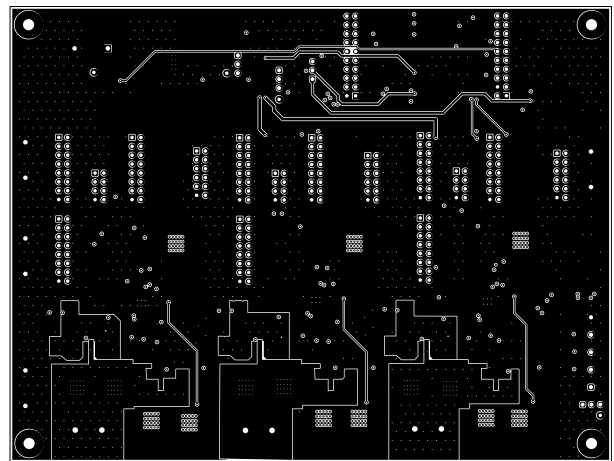

Figure 4-6. EVM Top Layer
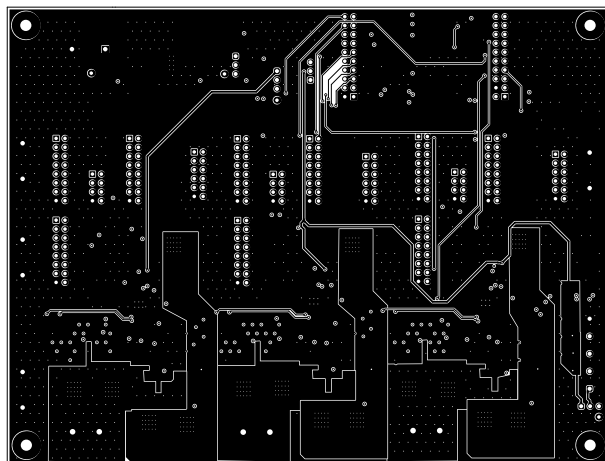

Figure 4-7. EVM Signal Layer 1

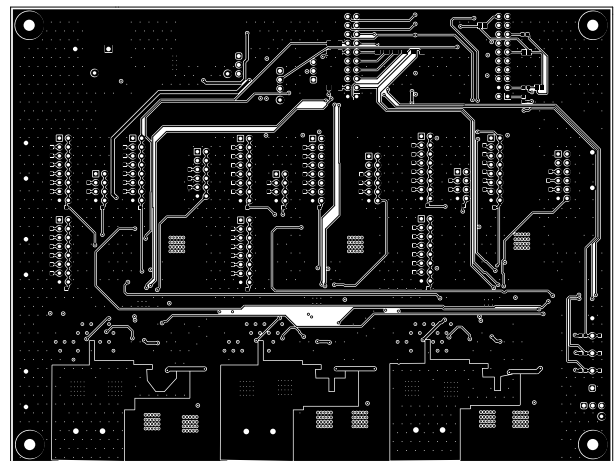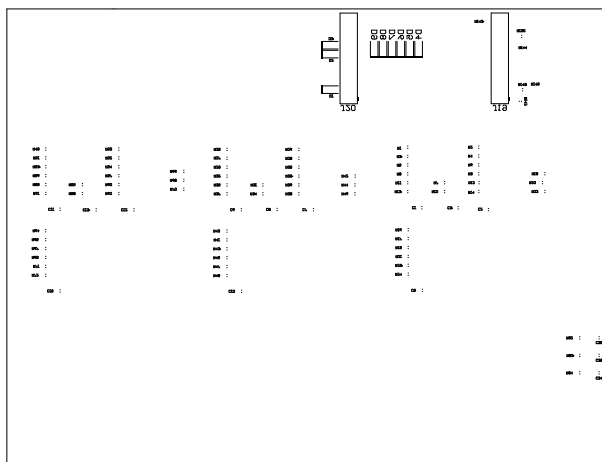**Figure 4-8. EVM Signal Layer 2**

Figure 4-9. EVM Bottom Layer

Figure 4-10. EVM Bottom Overlay

4.3 Bill of Materials (BOM)

Table 4-1. Bill of Materials

Designator	Quantity	Description	Manufacturer	Part Number
!PCB1	1	Printed Circuit Board	Any	MD083
3.3V, GVDD, MCU, PVDD	4	LED, Green, SMD	Lite-On	LTST-C171GKT
BSTA, BSTB, BSTC, GHA, GHB, GHC, GLA, GLB, GLC, GVDD_A, GVDD_B, GVDD_C, ISENA, ISENB, ISENC, SHA, SHB, SHC, SLA, SLB, SLC, TP1, TP2, TP3, TP4, TP5, TP6	27	Test Point, Miniature, SMT	Keystone Electronics	5015
C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C15	15	CAP, CERM, 100pF, 10V, +/- 10%, X7R, 0603	AVX	0603ZC101KAT2A
C16, C17, C18	3	CAP, CERM, 0.1uF, 100V, +/- 10%, X7R, 1206	TDK	C3216X7R2A104K160AA
C19, C20, C21, C22, C23, C24	6	CAP, CERM, 1uF, 25V, +/- 10%, X5R, 0603	TDK	C1608X5R1E105K080AC
C25, C26, C27	3	CAP, CERM, 500pF, 50V, +/- 5%, C0G/NP0, 0603	Yageo America	CC0603JRNPO9BN501
C28, C88, C89	3	CAP, CERM, 0.1uF, 10V, +/- 10%, X7R, 0603	Kemet	C0603C104K8RACTU
C29, C30, C92	3	CAP, AL, 100uF, 100V, +/- 20%, 0.17 ohm, AEC-Q200 Grade 2, SMD	Panasonic	EEV-FK2A101M
C31	1	CAP, CERM, 0.1μF, 50V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	Kemet	C0603C104K5RACAUTO
C32, C33, C34	3	CAP, CERM, 1000pF, 25V,+/- 1%, C0G/NP0, 0603	Kemet	C0603C102F3GACTU
C35, C37	2	Cap Ceramic 2.2nF 50V X8R 10% Pad SMD 0402 +150°C Automotive T/R	TDK Corporation	CGA2B2X8R1H222K050BE
C36	1	CAP, CERM, 2.2μF, 100V,+/- 10%, X7R, 1812	Kemet	C1812C225K1RACTU
C38	1	CAP, CERM, 47pF, 50V,+/- 5%, C0G/NP0, AEC-Q200 Grade 0, 0603	TDK	CGA3E2NP01H470J080AA
C39	1	CAP, CERM, 10uF, 25V, +/- 20%, X5R, 0603	MuRata	GRT188R61E106ME13D
C40	1	CAP, CERM, 0.33uF, 25V, +/- 10%, X5R, 0805	AVX	08053D334KAT2A
C41, C42, C43, C44	4	CAP, CERM, 0.1uF, 16V, +/- 5%, X7R, 0603	Kemet	C0603C104J4RACTU

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Description	Manufacturer	Part Number
C78, C79, C80, C81, C82, C83, C84, C85, C86	9	CAP, CERM, 1000pF, 100V, +/- 5%, C0G/NP0, 0603	TDK	C1608C0G2A102J080AA
C93, C94, C95	3	CAP, CERM, 4.7uF, 100V, +/- 10%, X7S, 1210	MuRata	GRM32DC72A475KE01L
D1, D2, D3	3	Diode, Zener, 10V, 500 mW, SOD-123	Diodes Inc.	DDZ10C-7
EXT_CSAREF, GVDD_EXT, HALL_EXT, PVDD_TP	4	Test Point, Miniature, Red, TH	Keystone Electronics	5000
F1	1	Fuse, 30A, 250 VAC, 100 VDC, SMD	Littelfuse	0463030.ER
FAULT_A, FAULT_B, FAULT_C	3	LED, Red, SMD	Lite-On	LTST-C170KRKT
FID1, FID2, FID3	3	Fiducial mark. There is nothing to buy or mount.	N/A	N/A
H1, H2, H3, H4	4	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	B&F Fastener Supply	NY PMS 440 0025 PH
H5, H6, H7, H8	4	Standoff, Hex, 1"L #4-40 Nylon	Keystone	1902E
J1, J2, J4, J6, J7, J9, J11, J12, J14	9	Header, 100mil, 8x2, Gold, TH	Samtec	TSW-108-07-G-D
J3, J8, J13	3	Header, 100mil, 4x2, Gold, TH	Samtec	TSW-104-07-G-D
J5, J10, J15	3	Header, 100mil, 6x2, Gold, TH	Samtec	TSW-106-07-G-D
J16	1	Terminal Block, 9.52mm, 2x1, R/A, TH	Phoenix Contact	1902547
J17	1	Terminal Block, 5mm, 5x1, R/A, TH	Phoenix Contact	1792892
J18, J21, J27, J28	4	Header, 2.54mm, 3x1, Gold, TH	Wurth Elektronik	61300311121
J19, J20	2	Receptacle, 2.54mm, 10x2, Gold, TH	Samtec	SSQ-110-03-G-D
J22, J23, J24, J25	4	1mm Uninsulated Shorting Plug, 10.16mm spacing, TH	Harwin	D3082-05
J26, J29, J30	3	TERM BLOCK 2POS 7.62MM PCB HORIZ	Amphenol Anytek	T70243500000G
L1	1	Inductor, Drum Core, Ferrite, 68uH, 1.1A, 0.22 ohm, SMD	Bourns	SDR1006-680KL
LBL1	1	Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	Brady	THT-14-423-10
Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8, Q9, Q10, Q11, Q12	12	MOSFET, N-CH, 100V, 200A, KTT0002A (TO-263-2)	Texas Instruments	CSD19536KTT
R1, R2, R16, R25, R26, R40, R49, R50, R64	9	RES, 130 k, 0.1%, 0.1 W, 0603	Yageo America	RT0603BRD07130KL
R3, R4, R17, R27, R28, R41, R51, R52, R65	9	RES, 62.0 k, 0.1%, 0.1 W, 0603	Susumu Co Ltd	RG1608P-623-B-T5

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Description	Manufacturer	Part Number
R5, R6, R19, R29, R30, R43, R53, R54, R67	9	RES, 27.0 k, 0.1%, 0.1 W, 0603	Susumu Co Ltd	RG1608P-273-B-T5
R7, R31, R55	3	RES, 30.0 k, 0.1%, 0.1 W, 0603	Susumu Co Ltd	RG1608P-303-B-T5
R8, R9, R21, R32, R33, R45, R56, R57, R69	9	RES, 12.0 k, 0.1%, 0.1 W, 0603	Yageo America	RT0603BRD0712KL
R10, R15, R34, R39, R58, R63	6	RES, 10.0 k, 0.1%, 0.1 W, 0603	Yageo America	RT0603BRD0710KL
R11, R12, R23, R35, R36, R47, R59, R60, R71	9	RES, 5.6 k, 5%, 0.1 W, 0603	Yageo	RC0603JR-075K6L
R13, R14, R24, R37, R38, R48, R61, R62, R72	9	RES, 2.0 k, 5%, 0.1 W, 0603	Yageo	RC0603JR-072KL
R18, R42, R66	3	RES, 3.30 k, 0.1%, 0.1 W, 0603	Susumu Co Ltd	RG1608P-332-B-T5
R20, R44, R68	3	RES, 1.30 k, 0.1%, 0.1 W, 0603	Yageo America	RT0603BRD071K3L
R22, R46, R70	3	RES, 470, 0.1%, 0.1 W, 0603	Yageo America	RT0603BRD07470RL
R73, R74, R75, R104, R105, R121, R122, R123, R136, R137, R138, R150	12	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	Vishay-Dale	CRCW06030000Z0EA
R76, R77, R78, R82, R83, R84	6	RES, 10.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	Vishay-Dale	CRCW060310K0FKEA
R79, R80, R81, R86, R87, R88, R89, R92	8	RES, 330, 0.1%, 0.1 W, 0603	Susumu Co Ltd	RG1608P-331-B-T5
R85	1	RES, 97.6 k, 0.1%, 0.1 W, 0603	Yageo America	RT0603BRD0797K6L
R90, R91	2	RES, 4.99 k, 0.1%, 0.1 W, 0603	Yageo America	RT0603BRD074K99L
R93	1	RES, 3.01 k, 1%, 0.1 W, 0603	Yageo	RC0603FR-073K01L
R94	1	RES, 0, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	Vishay-Dale	CRCW08050000Z0EA
R95, R99	2	RES, 100 k, 0.1%, 0.1 W, 0603	Yageo America	RT0603BRD07100KL
R96	1	RES, 237 k, 1%, 0.1 W, 0603	Yageo	RC0603FR-07237KL
R97	1	RES, 453 k, 0.5%, 0.1 W, 0603	Yageo America	RT0603DRE07453KL
R98	1	RES, 23.2 k, 0.5%, 0.1 W, 0603	Yageo America	RT0603DRE0723K2L
R100	1	RES, 49.9 k, 1%, 0.1 W, 0603	Yageo	RC0603FR-0749K9L

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Description	Manufacturer	Part Number
R101, R102, R103, R143, R144, R145	6	RES, 0, 5%, 0.125 W, 0805	Yageo America	RC0805JR-070RL
R106, R107, R108	3	RES, 93.1 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	Vishay-Dale	CRCW060393K1FKEA
R109, R110, R111	3	RES, 4.99 k, 1%, 0.1 W, 0603	Bourns	CR0603-FX-4991ELF
R115, R116, R117, R118, R119, R120, R127, R128, R129, R130, R131, R132	12	RES, 10.0, 1%, 0.063 W, 0402	KOA Speer	RK73H1ETTP10R0F
R139, R140, R141, R154, R155, R156	6	RES, 10.0, 0.1%, 0.1 W, 0603	Yageo America	RT0603BRD0710RL
R146, R147, R148	3	Single Turn SMD Trimmers 3mm 1MEG, Open Type Trimmer	TT Electronics	35WR1MEGLFTR
R151, R152, R153	3	RES, 0.005, 1%, 3 W, AEC-Q200 Grade 0, 2512	Bourns	CRE2512-FZ-R005E-3
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8, SH-J9, SH-J10, SH-J11, SH-J12, SH-J13, SH-J14, SH-J15, SH-J16, SH-J17, SH-J18, SH-J19	19	Shunt, 100mil, Gold plated, Black	Samtec	SNT-100-BK-G
U1, U2, U3	3	100V Half-Bridge Smart Gate Driver	Texas Instruments	DRV8161DGSR
U4	1	100V Low IQ Synchronous Buck Regulator, DDA0008E (SOIC-8)	Texas Instruments	LM5164DDAT
U5	1	500mA, 25V, Linear Voltage Regulators, DCY0004A (SOT-223-4)	Texas Instruments	UA78M33CDCYR
C45, C46, C47, C48, C49, C50, C63, C64, C65, C66, C67, C68	0	CAP, CERM, 0.01uF, 100V, +/- 5%, X7R, 0603	AVX	06031C103JAT2A
C51, C52, C54, C55, C57, C58, C69, C71, C73, C87, C90, C91	0	CAP, CERM, 0.01uF, 25V, +/- 5%, C0G/NP0, 0603	Kemet	C0603H103J3GACTU
C53, C56, C59, C70, C72, C74	0	CAP, CERM, 0.01uF, 100V, +/- 10%, X7R, 0603	MuRata	GRM188R72A103KA01D
C60, C61, C62, C75, C76, C77	0	CAP, CERM, 2200pF, 100V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	TDK	CGA3E2X7R2A222K080AA
D4, D5, D6, D7, D8, D9	0	Diode, Zener, 5.6V, 500mW, SOD-123	Diodes Inc.	DDZ5V6B-7

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Description	Manufacturer	Part Number
R112, R113, R114, R124, R125, R126	0	RES, 100, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	Vishay-Dale	CRCW0603100RJNEA
R133, R134, R135	0	RES, 100 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	Vishay-Dale	CRCW0603100KJNEA
R142, R149	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	Vishay-Dale	CRCW06030000Z0EA

5 Additional Information

5.1 Trademarks

C2000™, LaunchPad™, and BoosterPack™ are trademarks 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

東京都新宿区西新宿６丁目２４番１号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。 https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4   *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5.   *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6.   *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7.   *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations.* IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.