EVM User's Guide: TPS61381-Q1EVM-126

TPS61381-Q1EVM-126 Evaluation Module

Description

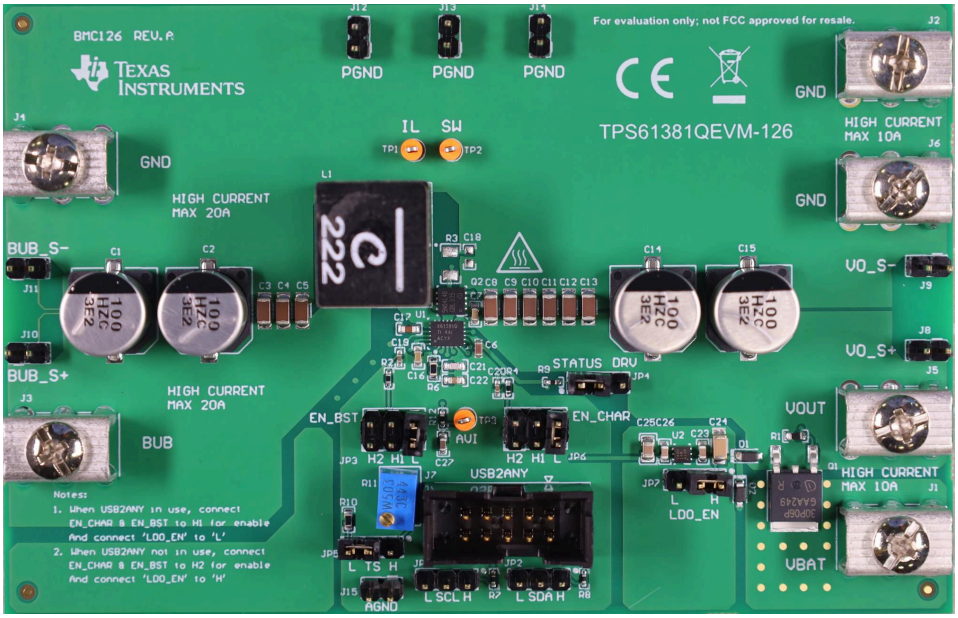
The TPS61381QEVM-126 operates over a wide back up battery voltage range of 0V to 12V and main battery (VBAT port) voltage range of 0V-40V to achieve a bi-directional operation. The EVM supports an output up to 7.5A load at 3.6V BUB and 6.2V output in boost mode, and supports 50-100mA charging current in charger mode. The TPS61381QEVM-126 can support output voltage regulation accuracy better than 2.5% in boost mode and support better than 1% voltage accuracy in charger mode. The device functions are adjustable using I2C interface.

Features

- AEC-Q100 qualified for automotive applications
- Back-up battery (BUB) voltage in boost mode: 0.5V to 12V, 3V minimum voltage for start up
- Support absmax (VOUT pin) up to 40V
- Boost output voltage: up to 12V
- Adjustable boost average input current limit from 5A to 15A
- Integrated 20mΩ high-side MOSFET and 6mΩ ISO FET to support true disconnection
- I2C programmable CC, CV charger with integrated charging strategy
- Auto detection on system voltage and automatic transition into boost mode when car battery malfunction occurs
- Fault or operation status indication by STATUS pin and I2C
- Backup battery State-of-Health(SOH) detection
- 20µA quiescent current in standby mode
- < 1µA shutdown current
- < 1µA leakage current for pins connected to the back up battery (at Tj up to 60°C)
- Frequency: 400kHz for automotive applications
- Programmable spread spectrum for optimizing EMI
- 3mm × 4mm 25-pin package with wettable flank

Applications

- Emergency call (eCall)
- Door handle module
- Fault indicator (FI)



TPS61381QEVM-126

1 Evaluation Module Overview

1.1 Introduction

The TPS61381-Q1 is a 40V, 15A, bi-directional boost converter and LDO charger that integrates battery state of health detection function. This user's guide describes the characteristics, operation, and the use of the TPS61381-Q1 evaluation module (EVM). The EVM contains the TPS61381-Q1, bi-directional boost converter with integrated charger, boost and state of health (SOH) detection function. The user's guide includes EVM specifications, recommended test setup, test result, schematic diagram, bill of materials, and the board layout.

1.2 Kit Contents

- One EVM to evaluate TPS61381-Q1
- EVM disclaimer Read Me

1.3 Specification

A summary of the TPS61381-Q1 EVM performance specifications is provided in Table 1-1. The ambient temperature is 25°C for all measurement, unless otherwise noted.

Table 1-1. Boost Mode Performance Specification Summary

PARAMETER	TEST CONDITION	VALUE	UNIT
Back up Battery (BUB) voltage	N/A	1 – 12	V
Output voltage	N/A	5 – 12	V
Maximum output current	BUB3V, VOUT6.2V	6	A
	BUB 3.6V, VOUT6.2V	7.5	
	BUB 4.5V, VOUT6.2V	9.5	
Default switching frequency	N/A	400	kHz

Table 1-2. Charger Mode Performance Specification Summary

PARAMETER	TEST CONDITION	VALUE	UNIT
Back up Battery (BUB) voltage	N/A	0 – 12	V
Output voltage	N/A	V_{BUB}+0.1V – 40	V
Charging current	N/A	50-100	mA

1.4 Device Information

The purpose of TPS61381-Q1 EVM is to showcase the typical application of the TPS61381-Q1 device. This EVM requires an appropriate I2C interface, such as the TI USB2ANY. This evaluation module is designed to evaluate TPS61381-Q1, which is an I2C compatible, low Iq, AEC-Q100 qualified bi-directional boost converter and LDO charger integrated with battery health detection function. This device provides an integrated power design in back-up power systems like e-Call. The TPS61381-Q1 supports a high absolute max voltage up to 40V on the VOUT pin to support load-dump condition and allow direct connection on 12V car battery system. The TPS61381-Q1 monitors system voltage and automatically switches to boost mode when car battery malfunction occurs and voltage drop on the system side is detected.

2 Hardware

2.1 Connector, Test Point, and Jumper Descriptions

This section describes how to properly connect, set up, and use the TPS61381-Q1 EVM.

2.1.1 Connector and Test Point Descriptions

This EVM includes I/O connectors and test points as shown in Table 2-1. The back up battery must be connected to BUB connectors, J3 and J4. The load must be connected to output connectors, J5 and J6. Car main battery must be connected to V_{BAT} connectors, J1 and J2.

Table 2-1. Connectors and Test Points

REFERENCE DESIGNATOR	DESCRIPTION
J1	Car main battery positive connection
J2	Car main battery return connection
J3	Back up battery positive connection
J4	Back up battery return connection
J5	Boost output positive connection
J6	Boost output return connection
J7	USB2ANY interface connector
J8	Boost output voltage positive sensing point
J9	Boost output voltage negative sensing point
J10	Back up battery voltage positive sensing point
J11	Back up battery voltage negative sensing point
J12, J13, J14	PGND sensing point
J15	AGND sensing point
TP1	IL pin test point
TP2	SW pin test point
TP3	AVI pin output test point

2.1.2 Jumper Configuration

2.1.2.1 JP1 and JP2 (I2C Interface Enable)

The JP1 jumper is used to configure SCL for the I2C interface. By default, this jumper is left open and the device uses the USB2ANY adapter internal pull up. Set this jumper to H position to enable pull-up circuit on the EVM. Put this jumper in the L position to disable the SCL.

The JP2 jumper is used to enable SDA for the I2C interface. By default, this jumper is left open and the device uses the USB2ANY adapter internal pull up. Set this jumper to H position to enable pull-up circuit on the EVM. Put this jumper in the L position to disable the SDA.

2.1.2.2 JP3 (Boost Enable)

The J5 jumper is used to enable boost function. By default, this jumper is set to the H2 position, which uses the LDO on the EVM to pull up the EN_BST pin and enable the boost function. Put this jumper in the H1 position to use the USB2ANY adapter to pull up the EN_BST pin and enable boost function. Put this jumper in the L position to disable boost function.

2.1.2.3 JP4 (Status or DRV Pin)

The JP4 jumper is used to configure Status or DRV pin. By default, this jumper is set to the STATUS position, which enables the pull-up circuit for the STATUS indicator function. Put this jumper in the DRV position to connect the PMOS driver.

2.1.2.4 JP5 (TS Pin)

The JP5 jumper is used to test the TS pin. By default, this jumper is set to the L position, which connects the TS pin with 10kΩ to GND to disable the TS pin monitoring function. Put this jumper in the H position to connect the TS pin to a potentiometer so that the TS pin resistance can be set and tested. Remove the jumper and connect the middle pin to the NTC network to use for temperature sense.

2.1.2.5 JP6 (Charger Enable)

The JP6 jumper is used to enable charger function. By default, this jumper is set to the H2 position, which uses the LDO on the EVM to pull up the EN_CHGR pin and enable the charger function. Put this jumper in the H1 position to use the USB2ANY adapter to pull up the EN_BST pin and enable charger function. Put this jumper in the L position to disable charger function.

2.1.2.6 JP7 (LDO Enable)

The JP1 jumper enables the LDO ,which can be used to supply EN pins of the device. By default, this jumper is set to the H position. Put this jumper in the L position to disable the LDO.

2.2 Test Procedure

The TPS61381-Q1 integrates charger, boost and SOH functions for back up power applications. Verify the device through these three functions.

2.2.1 Verifying Boost Function

1. Prepare 1 power supply, 1 battery simulator and an e-load.
2. Set the power supply current limit to 2A. Set the power supply to 12V. Turn off the power supply output, and connect the positive output of the power supply to J1 and connect the negative output to J2.
3. Set the battery simulator current limit to +10A, -5A. Set the battery voltage to 3V. Turn off the power supply output, and connect the positive output of the power supply to J3 and the negative output to J4.
4. Set the e-load to CC mode, set CC current to 1A, close the load, connect the positive output of the load to J5 and the negative output to J6.
5. Configure the jumpers as Figure 2-1.
6. Turn on the power supply first, connect the USB2ANY adapter J7 and connect the TPS61381Q GUI on your PC. Then open the battery simulator and the e-load.
7. Close the power supply output and verify if Vout voltage is approximately 6.2V when Vbat drops below 6.2V.

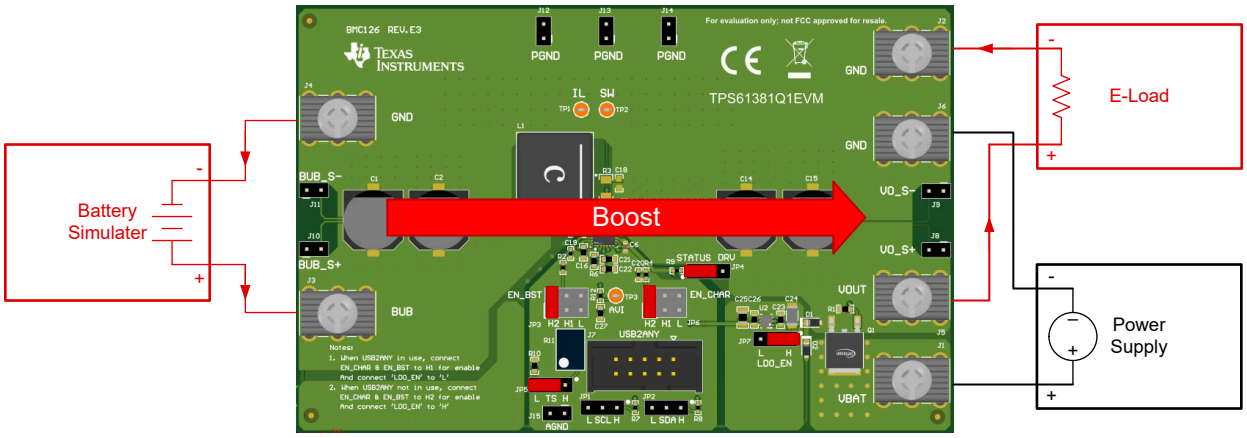


Figure 2-1. Verifying Boost Function

2.2.2 Verifying Charger Function

1. Keep the setup as similar to step 1-6 in Section 2.2.1.
2. Go to GUI *Charger Settings* page, select Li-ion in *Choose the Battery type* bar, set *Battery CV* as 4.20V and set *Charger, SOH* on the top bar as *Enable Charger*.
3. Verify if the battery simulator is charged by approximately 50mA
4. Close the power supply output. Verify if the battery simulator stops charging and starts outputting current when Vout drops below 6.2V . The Vout voltage need to be held at approximately 6.2V when Vout drops below 6.2V if the device is working normally.

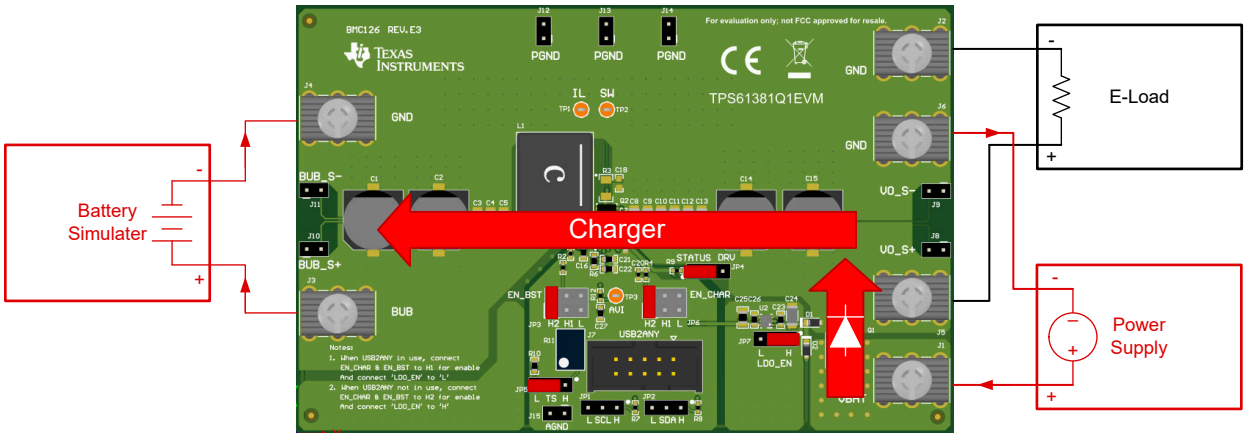


Figure 2-2. Verifying Charger Function

2.2.3 Verifying SOH Function

1. Keep the setup as similar to steps 1-6 in Section 2.2.1.
2. Go to GUI *SOH Settings* page, set *Enable AVI Pin Output* to *Battery voltage* and set *AVI Pin Ratio To The Backup Battery Voltage* as 1/2 with GUI.
3. Set *Charger, SOH* as *Enable SOH*. Check if the AVI pin voltage is approximately 1.5V.
4. Set *SOH Discharge Current* to 500mA with GUI and check if the battery simulator is discharged by approximately 500mA.
5. Set *Enable AVI Pin Output* to *Discharge Current* and check if the AVI pin voltage is approximately 0.5V.

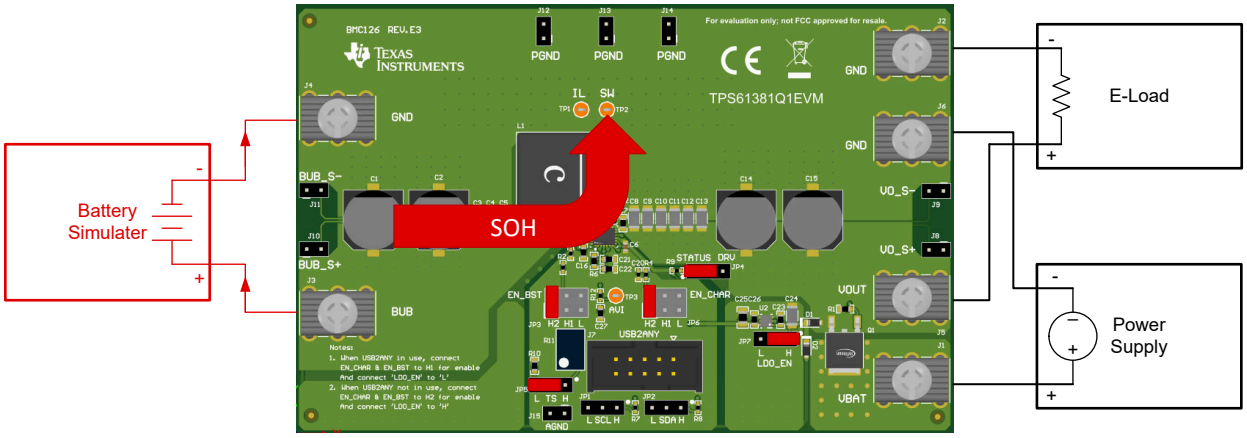


Figure 2-3. Verifying SOH Function

3 Software

3.1 Software User Interface

3.1.1 Install USB2ANY Explorer

Download and install the USB2ANY explorer from: http://www.ti.com/tool/USB2ANY. Upgrade the firmware version to 2.8.2.0.

3.1.2 GUI Installation

A graphical user interface (GUI) is available from on GUI. The GUI allows simple and convenient programming of the device through the TI USB2ANY device.

- Download the zip file for the desired platform.
- Extract the zip folder and install the GUI.
- Run through the installation steps. The installation wizard prompts for GUI Composer Runtime. This is done automatically.
- Open the GUI → TPS61381Q1.

3.1.3 Interface Hardware Setup

Connect the USB2ANY adapter to your PC using the supplied USB cable. Connect the TPS61381EVM connector J6 to the USB2ANY adapter using the supplied 10-pin ribbon cable. The connectors on the ribbon cable are keyed to prevent incorrect installation.

Figure 3-1 shows a quick connection overview.

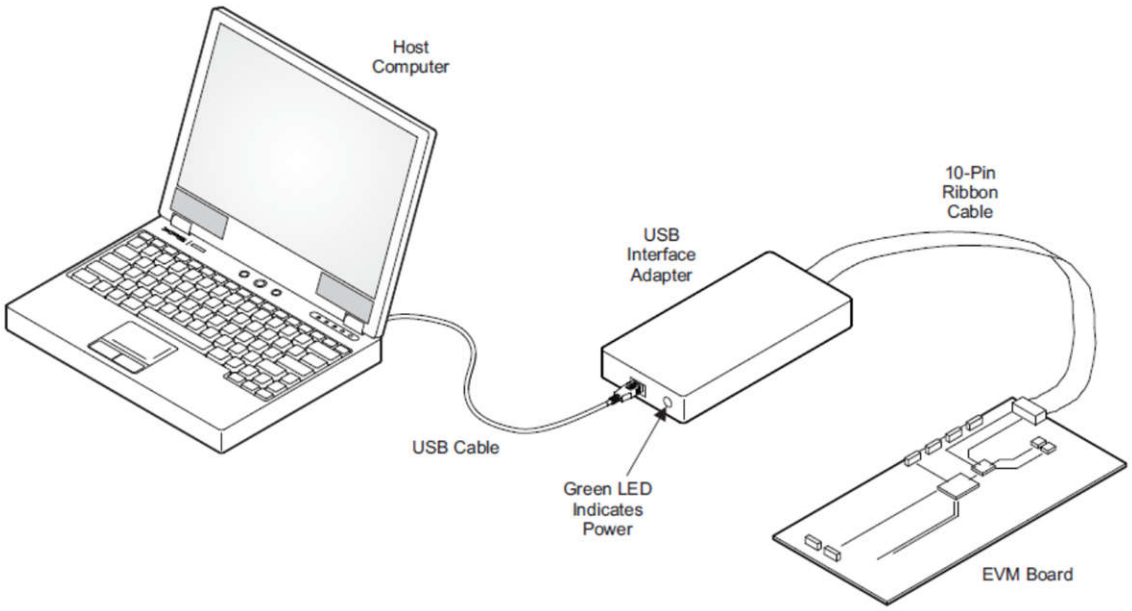


Figure 3-1. Quick Connection Overview

3.1.4 User Configuration Screen

The TPS61381QEVM board can be enabled by following the steps below:

1. Set the EVM hardware as described in step 1-6 in Section 2.2.1. Turn on the power supply.
2. Open the TPS61381QEVM GUI.
3. Click the connect button on the bottom bar, as shown in Figure 3-2. After the GUI and device are connected, the GUI reads all registers and shows a notification.

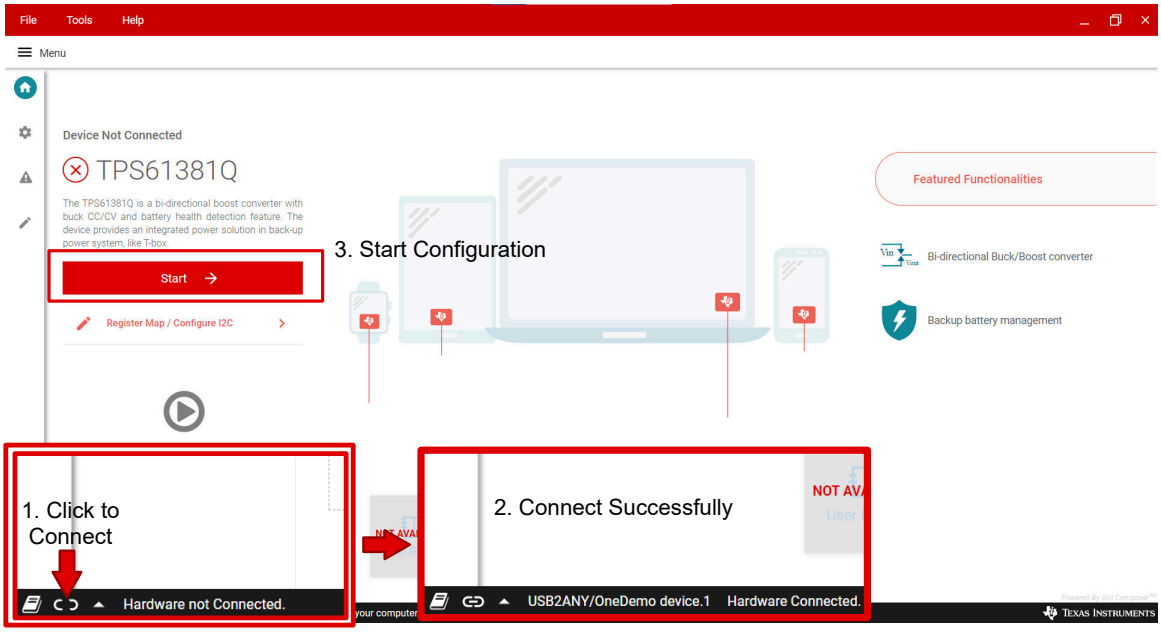


Figure 3-2. GUI Connect and Start

4. Click the *Start* button and the GUI automatically turns on to the Configuration Screen (see Figure 3-3). The TPS61381 is set to boost enable by default. The default output voltage is 6.2V. Set the boost mode output voltage, current limit point, and so forth according to the design target.

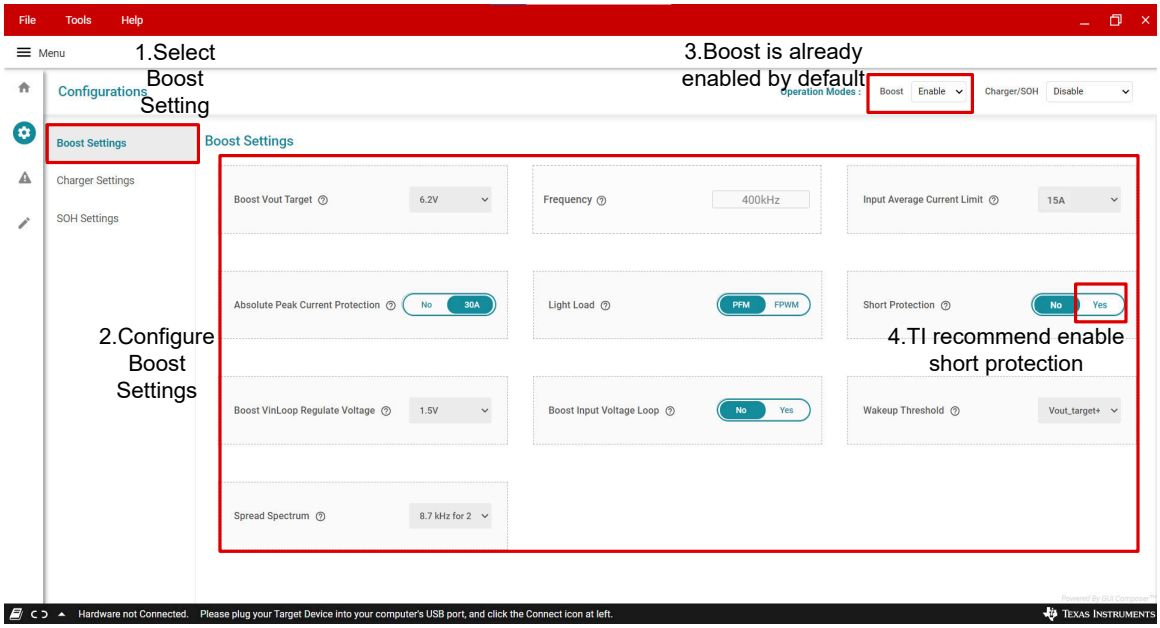


Figure 3-3. Boost Settings Sheet

5. Click the *Charger Settings* button and switch to Charger Settings Sheet (see Figure 3-4). The charger is set to Li-ion mode by default. Set the charger mode battery type, cell number, CC current, and so forth according to the design target.

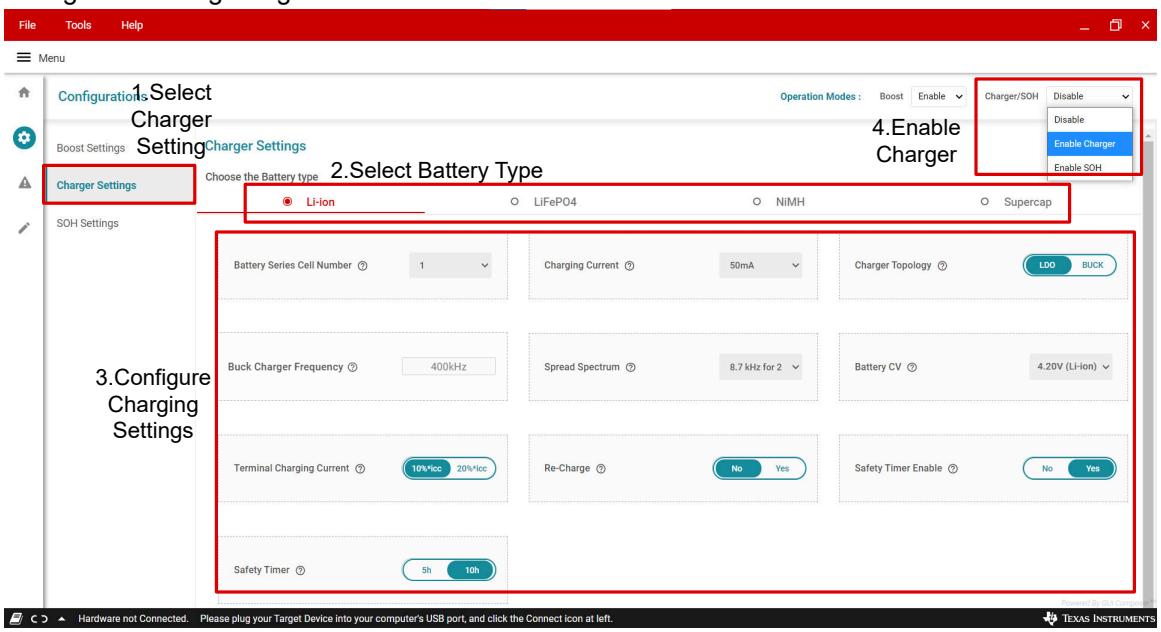


Figure 3-4. Charger Settings Sheet

6. Click the *SOH Settings* button and switch to the SOH Settings Sheet (see Figure 3-5). Set the SOH discharge current, AVI pin output ratio, AVI output, and so forth according to the design target.

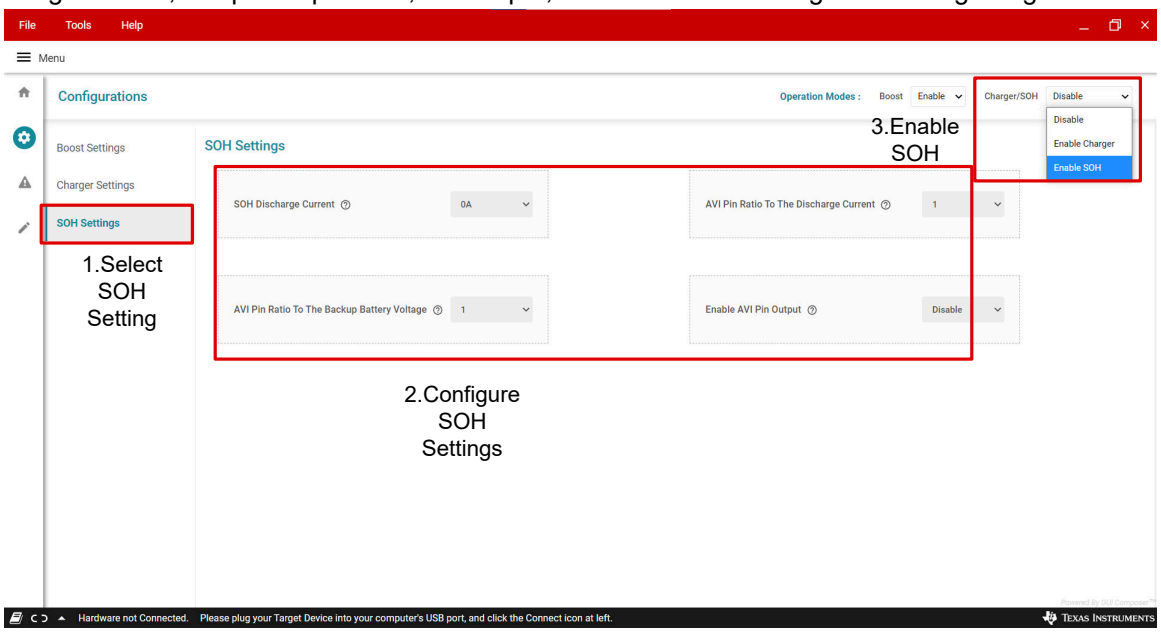


Figure 3-5. SOH Settings Sheet

3.1.5 Status and Fault Indications Screen

TPS61381-Q1 GUI offers multiple device status and fault indications function. Enter the Status and Fault Indications Screen (Figure 3-6) to check the device' status and fault condition.

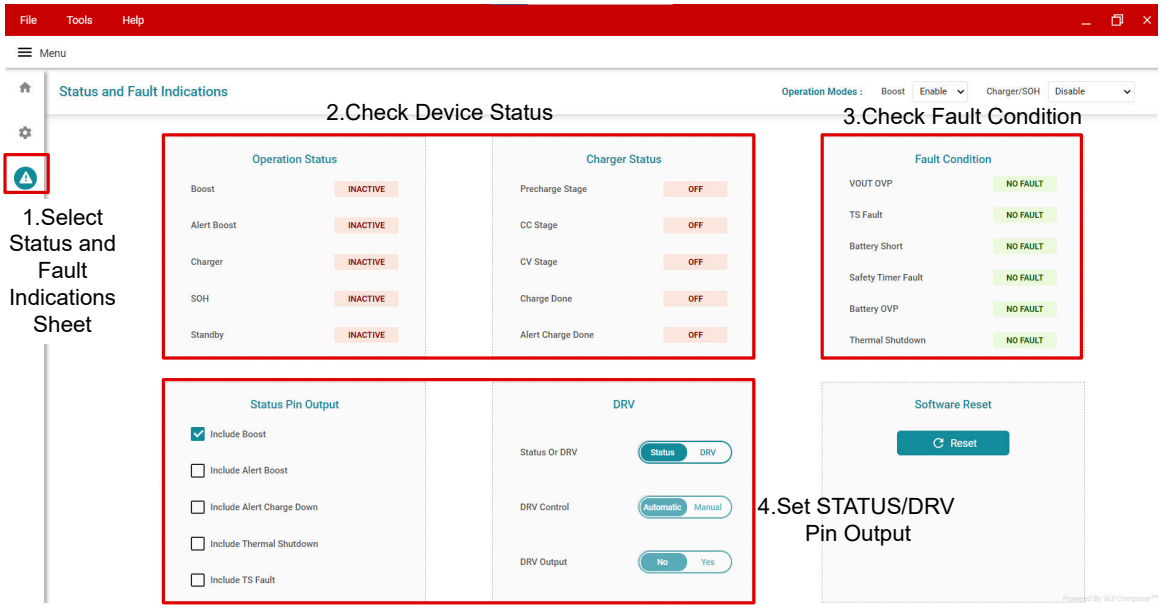


Figure 3-6. GUI Status and Fault Indications Screen

3.1.6 Register Map Screen

The Register Map Screen (see Section 3.1.6) shows a register-wise view of all parameters. A detailed description of each register bit can be found in this screen. Enter this screen to read and update the register bits to check.

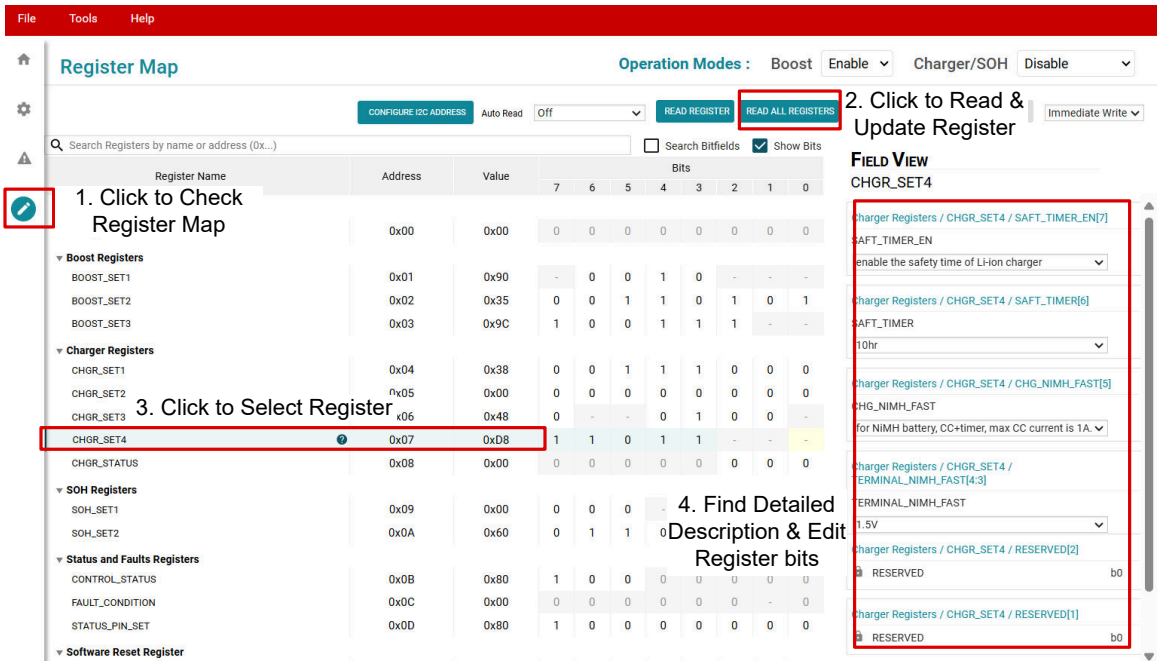


Figure 3-7. GUI Register Map Screen

3.2 Modification

This EVM requires an appropriate I²C interface, such as the TI USB2ANY, to configure the TPS61381-Q1.

4 Hardware Design Files

4.1 Schematic

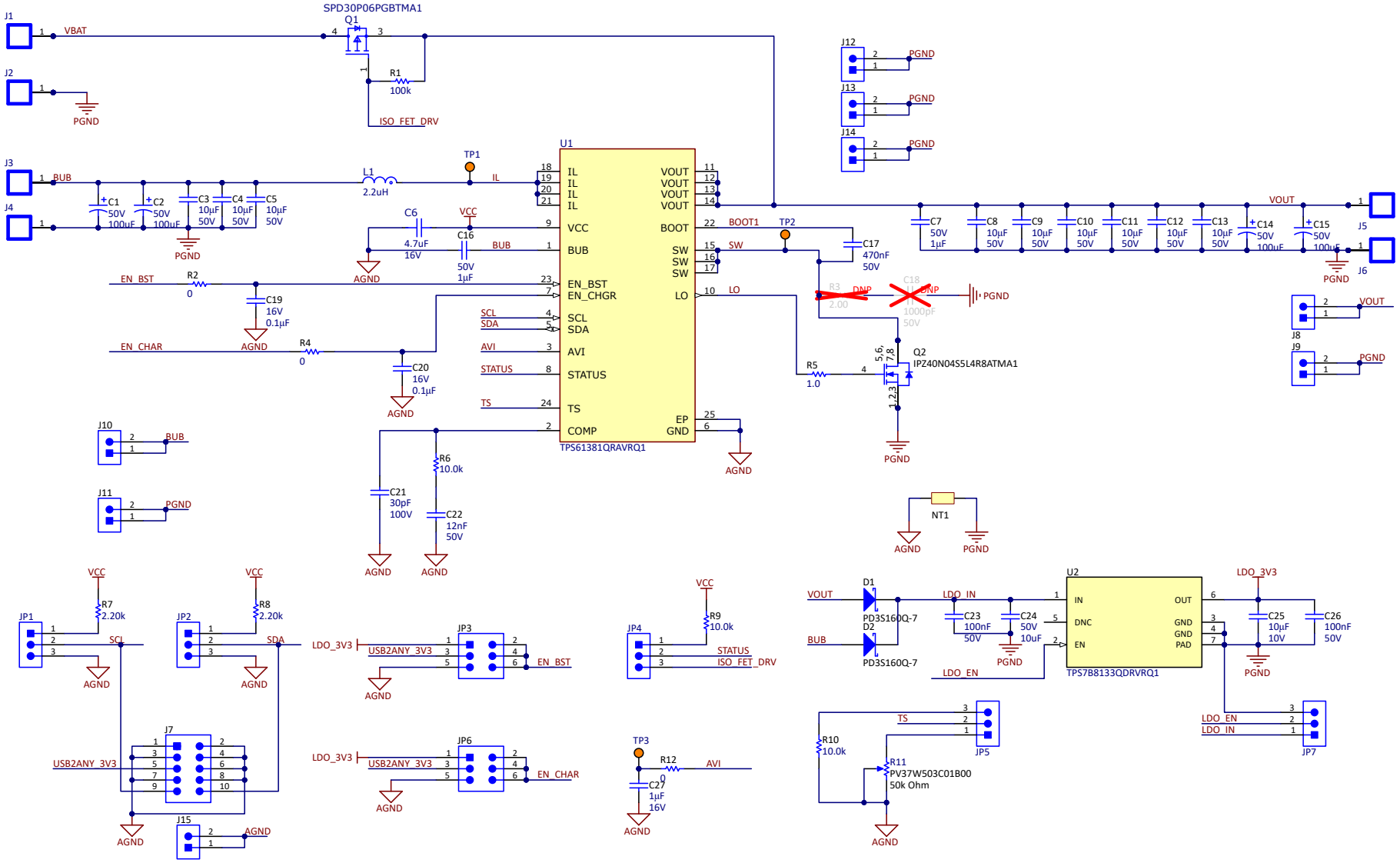


Figure 4-1. TPS61381-Q1 EVM Schematic

4.2 PCB Layout

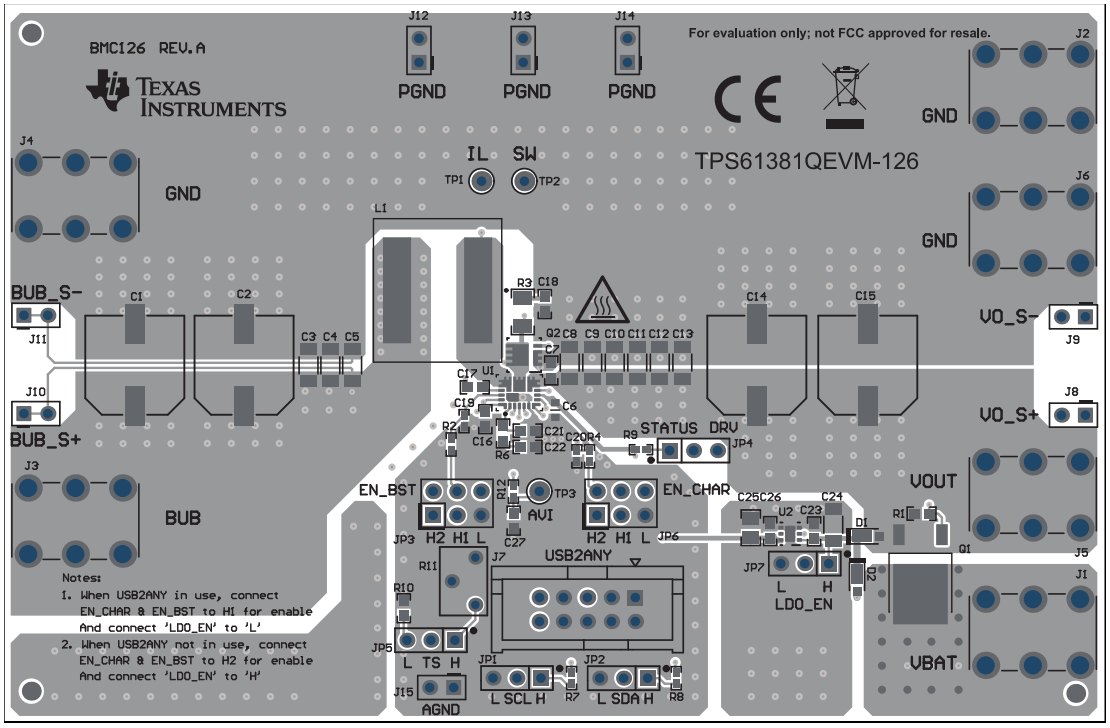


Figure 4-2. TPS61381-Q1 EVM Top-Side Layout

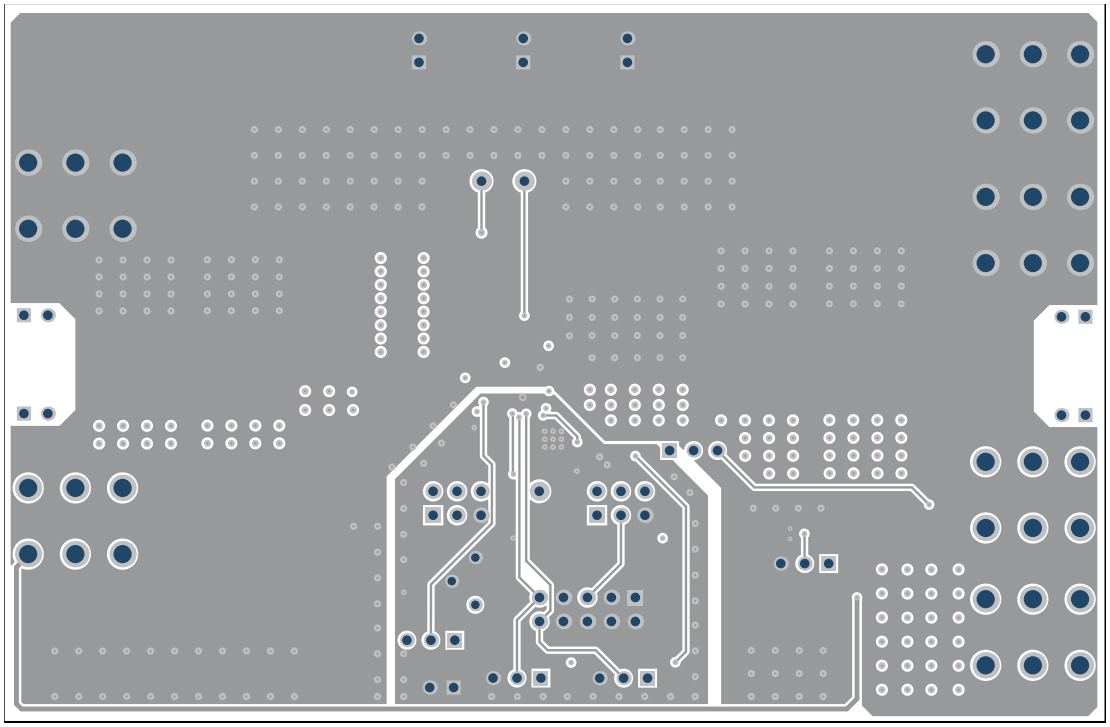


Figure 4-3. TPS61381-Q1 EVM Inner Layer1

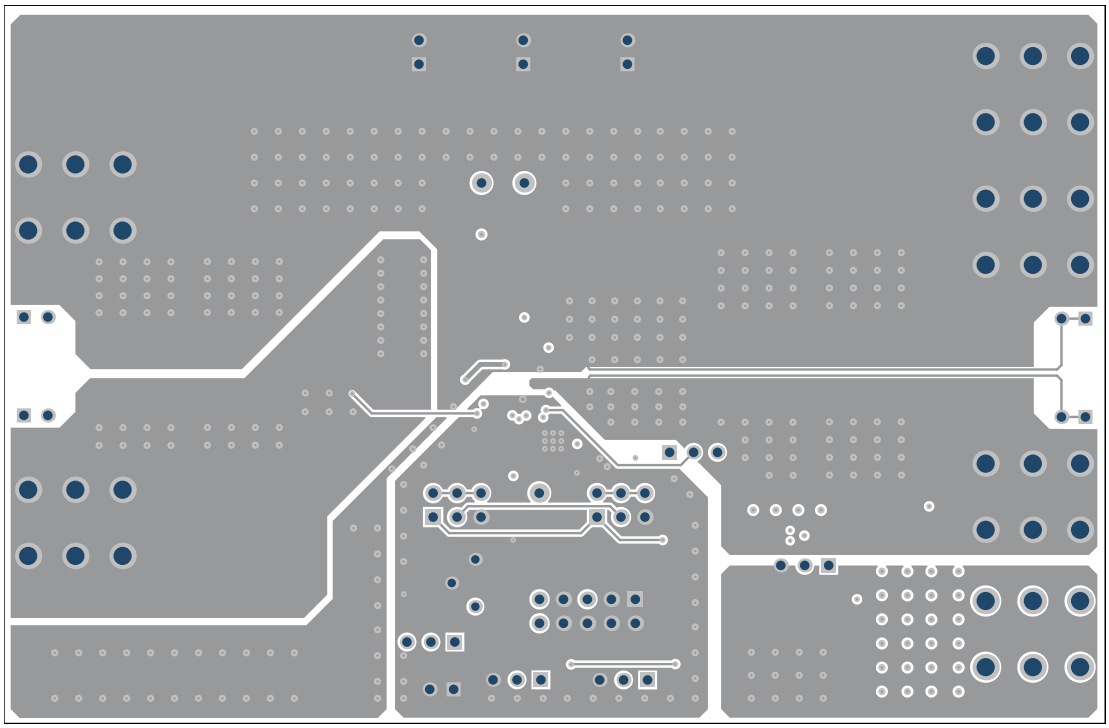


Figure 4-4. TPS61381-Q1 EVM Inner Layer2

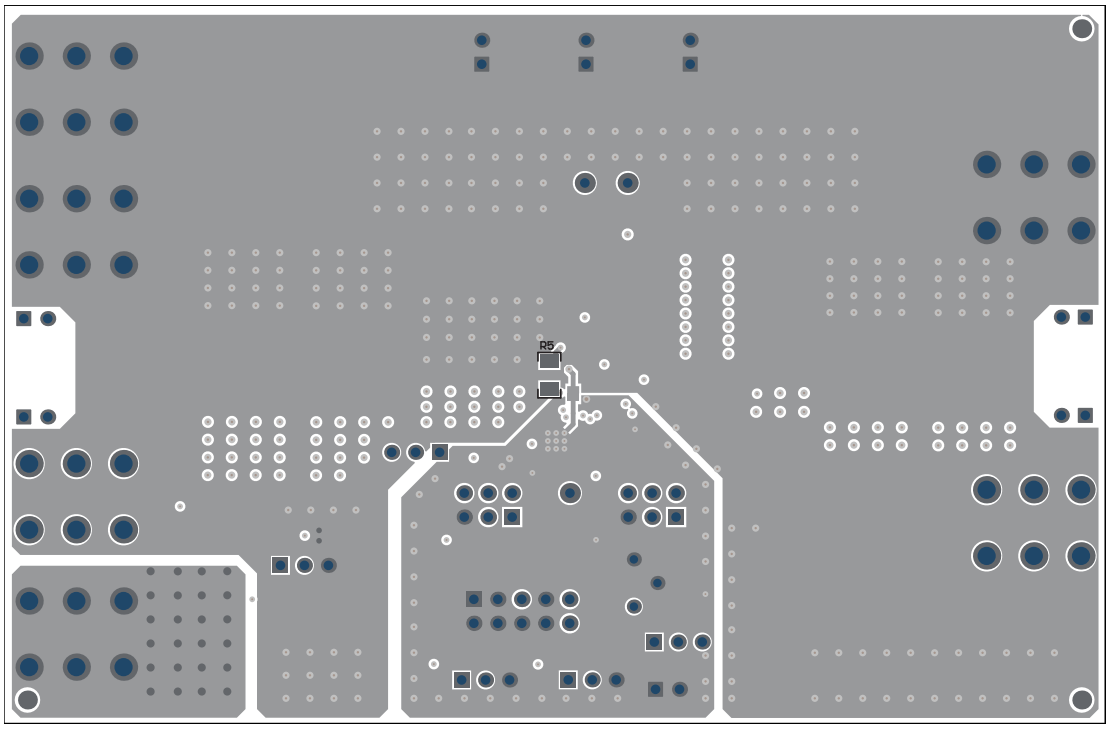


Figure 4-5. TPS61381-Q1 EVM Bottom-Side Layout

4.3 Bill of Materials

Table 4-1. Bill of Materials

Designator	Quantity	Value	Description	Package	Part Number	Manufacturer
C1, C2, C14, C15	4	100uF	CAP, Polymer Hybrid, 100uF, 50V,+/- 20%, 0.028 ohm, AEC-Q200 Grade 1, D10xL10.2mm SMD	Panasonic_G	EEH-ZC1H101P	Panasonic
C3, C4, C5, C8, C9, C10, C11, C12, C13	9	10uF	CAP, CERM, 10µF, 50V,+/- 10%, X7R, AEC-Q200 Grade 1, 1206	1206_190	CGA5L1X7R1H106K160AC	TDK
C6	1	4.7µF	AEC-Q200 Compliant Chip Multilayer Ceramic Capacitor for Infotainment 4.7uF ±10% 16V X7S SMD 0603	FP-GRT188C71C475KE13D_0603-MFG	GRT188C71C475KE13D	Murata
C7, C16	2	1uF	CAP, CERM, 1µF, 50V,+/- 20%, X5R, AEC-Q200 Grade 3, 0603	0603	GRT188R61H105ME13D	MuRata
C17	1	0.47uF	CAP, CERM, 0.47uF, 50V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E3X7R1H474K080AB	TDK
C19, C20	2	0.1uF	CAP, CERM, 0.1µF, 16V,+/- 5%, X7R, AEC-Q200 Grade 1, 0402	0402	GCM155R71C104JA55D	MuRata
C21	1	30pF	CAP, CERM, 30pF, 100V,+/- 1%, C0G/NP0, AEC-Q200 Grade 1, 0603	0603	GCM1885C2A300FA16D	MuRata
C22	1	0.012uF	CAP, CERM, 0.012µF, 50V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	C0603C123K5RACTU	Kemet
C23, C26	2	0.1uF	CAP, CERM, 0.1µF, 50V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	06035C104KAZ2A	AVX
C24	1	10uF	CAP, CERM, 10uF, 50V, +/- 10%, X5R, AEC-Q200 Grade 1, 1206	1206_180	GRT31CR61H106KE01L	MuRata
C25	1	10uF	CAP, CERM, 10µF, 10V,+/- 10%, X7R, AEC-Q200 Grade 1, 0805	0805_HV	GCJ21BR71A106KE01L	MuRata
C27	1	1uF	CAP, CERM, 1uF, 16V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	GCM188R71C105KA64D	MuRata
D1, D2	2	60V	Diode, Schottky, 60V, 1A, AEC-Q101, PowerDI323	PowerDI323	PD3S160Q-7	Diodes Inc.
FID1, FID2, FID3, FID4, FID5, FID6	6		Fiducial mark. There is nothing to buy or mount.	Fiducial10-20	N/A	N/A
J1, J2, J3, J4, J5, J6	6		TERMINAL SCREW PC 30AMP, TH	SCREW_TERMINAL_8199	8199	Keystone
J7	1		Header (shrouded), 100mil, 5x2, Gold, TH	CONN_5103308-1	5103308-1	TE Connectivity
J8, J9, J10, J11, J12, J13, J14, J15	8		Header, 100mil, 2x1, Tin, TH	CONN_PEC02SAAN	PEC02SAAN	Sullins Connector Solutions
JP1, JP2, JP4, JP5, JP7	5		Header, 100mil, 3x1, Tin, TH	CONN_PEC03SAAN	PEC03SAAN	Sullins Connector Solutions
JP3, JP6	2		Header, 100mil, 3x2, Tin, TH	SULLINS_PEC03DAAN	PEC03DAAN	Sullins Connector Solutions

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	Package	Part Number	Manufacturer
L1	1	2.2uH	Shielded Power Inductor 2.2uH 20% 28.5A 1.6mOhm DCRmax, AECQ200, 13.4x15.0x13.0mm SMT	FP-XGL1313-222MED_SMT_IND_13MM4_15MM0-MFG	XGL1313-222MED	Coilcraft
Q1	1		P-Channel 60V 30A (Tc) 125W (Tc) Surface Mount PG-TO252-3	FP-SPD30P06PGBTMA1_TO252-3-MFG	SPD30P06PGBTMA1	Infineon
Q2	1	40V	MOSFET, N-CH, 40V, 40A, AEC-Q101, SON-8	PG-TSDSON-8-32	IPZ40N04S5L4R8ATMA1	Infineon Technologies
R1	1	100k	RES, 100 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100KFKEA	Vishay-Dale
R2, R4, R12	3	0	RES, 0, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04020000Z0ED	Vishay-Dale
R5	1	1.0	RES, 1.0, 5%, 0.5 W, 1206	1206	CRM1206-JW-1R0ELF	Bourns
R6, R10	2	10.0k	RES, 10.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310K0FKEA	Vishay-Dale
R7, R8	2	2.20k	RES, 2.20 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04022K20FKED	Vishay-Dale
R9	1	10.0k	RES, 10.0 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040210K0FKED	Vishay-Dale
R11	1	50k Ohm	Trimmer Potentiometer, Lead Sealed Type Multiturn PV37 Series, TH	Bourns_PV37W	PV37W503C01B00	Bourns
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5	5		Shunt, 2.54mm, Gold, Black	Wurth_60900213421	60900213421	Wurth Elektronik
TP1, TP2, TP3	3		Test Point, Miniature, Orange, TH	Keystone5003	5003	Keystone Electronics
U1	1		Bi-directional Boost Converter with LDO CC/CV and Battery Health Detection	RAV0024A-MFG	TPS61381QRAVRQ1	Texas Instruments
U2	1		Automotive 150mA high-voltage ultra-low-IQ low-dropout (LDO) linear regulator, DRV0006A (WSON-6)	DRV0006A	TPS7B8133QDRVRQ1	Texas Instruments

5 Additional Information

5.1 Trademarks

All trademarks are the property of their respective owners.

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

3.1.1 *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

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

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

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

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

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

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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/lsds/ti_ja/general/eStore/notice_02.page

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

3.4 *European Union*

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

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

4 *EVM Use Restrictions and Warnings:*

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

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

4.3 *Safety-Related Warnings and Restrictions:*

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

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

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

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

6. *Disclaimers:*

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

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

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

8. *Limitations on Damages and Liability:*

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

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

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

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

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