EVM User's Guide: TPD4SXQ1EVM

4-Channel USB PD SPR/EPR Port Protection EVM

Description

The TPD4SXQ1EVM is a three-part breakaway style evaluation module for the purpose of testing TPD4S480-Q1, TPD4S481-Q1, and TPD4S201-Q1 with existing automotive USB Type-C® systems. The pass-through design allows users to easily attach the EVM to their existing system and test for IEC61000-4-2 ESD and short-to-VBUS events while maintaining USB2.0 and USB Power Delivery (PD) capabilities. Status LEDs provide visual indication of fault events and a TUSB211A-Q1 USB2.0 redriver is added to enhance signal integrity.

Get Started

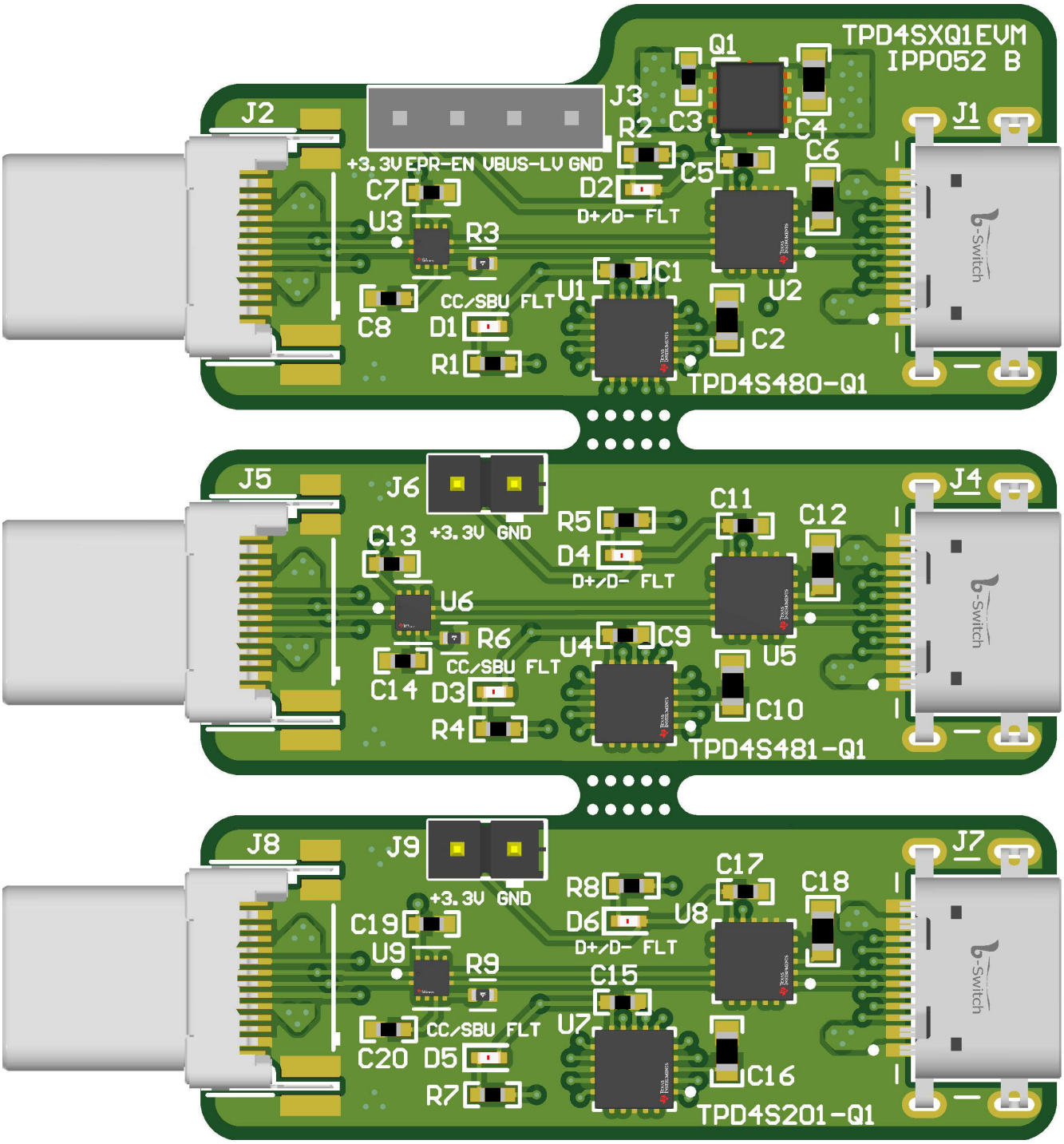
1. Order the EVM
2. Read the TPD4SXQ1EVM User's Guide (this document).
3. Refer to the appropriate device datasheet or E2E for questions and support.
   a. TPD4S480-Q1
   b. TPD4S481-Q1
   c. TPD4S201-Q1

Features

- TPD4S480-Q1
  - 4 Channel 48V Short-to-VBUS Protection
  - 4 Channel 8kV (contact)/15kV (air gap) IEC61000-4-2 ESD protection
  - CC dead battery resistors for handling dead battery use case
  - VBUS divider circuit with enable for dividing down Extended Power Range (EPR) level VBUS
  - FET driver for control of external EPR blocking FET
- TPD4S481-Q1
  - 4 Channel 48V Short-to-VBUS Protection
  - 4 Channel 8kV (contact)/15kV (air gap) IEC61000-4-2 ESD protection
  - CC dead battery resistors for handling dead battery use case
- TPD4S201-Q1
  - 4 Channel 20V Short-to-VBUS Protection
  - 4 Channel 8kV (contact)/15kV (air gap) IEC61000-4-2 ESD protection
  - CC dead battery resistors for handling dead battery use case

Applications

- Automotive USB charging
- Automotive media hub
- Automotive head unit
- Automotive rear seat entertainment



1 Evaluation Module Overview

1.1 Introduction

The TPD4SXQ1EVM is an evaluation module for the TPD4S480-Q1, TPD4S481-Q1, and TPD4S201-Q1 Type-C port protectors. Each panel breaks away for individual analysis dependent on the protected system's needs. USB PD Standard Power Range (SPR) systems are protected by TPD4S201-Q1, while Extended Power Range (EPR) systems require the TPD4S480-Q1 or TPD4S481-Q1. The evaluation module follows a Type-C pass through design to be plugged into an existing system's USB Type-C port. Once device power is provided to the board, the EVM serves as an extension of the existing system.

This User's Guide describes how to operate the TPD4SXQ1EVM and test ESD and overvoltage protection performance. USB 2.0 signals are passed through each panel to ensure functionality is not impaired. SS TX/RX signals are not passed through.

1.2 Kit Contents

The EVM kit contains the TPD4SXQ1EVM.

1.3 Specifications

The board specifications of the TPD4SXQ1EVM are shown in Table 1-1

Table 1-1. Board Specifications

Input voltage	2.7-4.5V
Maximum nominal system VBUS (TPD4S480-Q1, TPD4S481-Q1)	48V
Maximum nomininal system VBUS (TPD4S201-Q1)	20V
Maximum bus current	5A

1.4 Device Information

The TPD4S480-Q1, TPD4S481-Q1, and TPD4S201-Q1 are a series of 4-channel ESD and OVP protection devices for USB Type-C Power Delivery applications. Each device provides 8kV contact and 15kV air-gap IEC61000-4-2 ESD protection. The TPD4S480-Q1 and TPD4S481-Q1 protect against short-to-VBUS events up to 48V for USB PD EPR systems. TPD4S201-Q1 supports short-to-VBUS events up to 20V for USB PD SPR systems.

TPD4S480-Q1 integrates a VBUS divider circuit and FET driver, allowing PD controllers not rated for EPR operation to safely operate in EPR voltage ranges. When enabled by GPIO or automatically when VBUS exceeds 24V, the TPD4S480-Q1 disables the optional external blocking FET and enables the voltage divider. This action protects 20V rated PD controllers and allows the use of existing VBUS sense circuits.

2 Hardware

2.1 Setup

Each section of the EVM is designed to serve as an extension to the existing Type-C port that needs protection. The port retains its existing capabilities except for those requiring SSTX/SSRX signals, but with added ESD and short-to-VBUS protection.

TPD4S201-Q1 and TPD4S481-Q1 setup is identical. Connect the Type-C plug to the existing system's Type-C receptacle. Conect a 3.3V power supply to the header pins at the top of the board. The EVM's Type-C receptacle now acts as the existing system's Type-C port. Evaluation of the system can resume as normal. It is advised to use a Type-C breakout board to aid in ESD and short-to-VBUS testing.

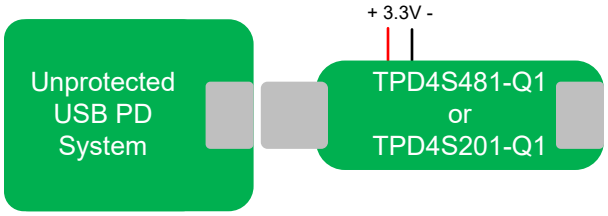


Figure 2-1. TPD4S481-Q1, TPD4S201-Q1 Setup

TPD4S480-Q1 is setup in a similar manner. Additional headers for EPR_EN and VBUS_LV signals are provided. EPR_EN may be connected to 0 or 3.3V and VBUS_LV may be monitored via a DMM or oscilloscope.

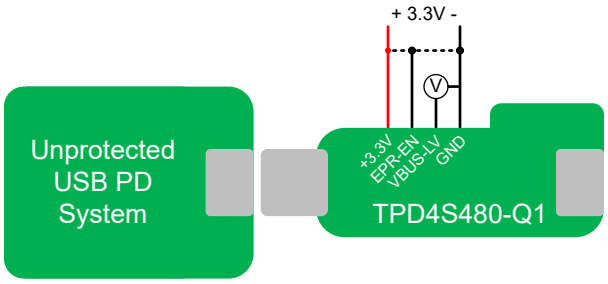


Figure 2-2. TPD4S480-Q1 Setup

All three sections contain net ties and 0402 solder pads on the reverse side. By default, the CC1/2 pins are not connected to the RPD_G1/2 pins for dead battery support. If dead battery support is required, cut the two net tie traces and create a solder bridge across the 0402 solder pads. Please refer to the Feature Description section of the device datasheet for additional details to support dead battery operation.

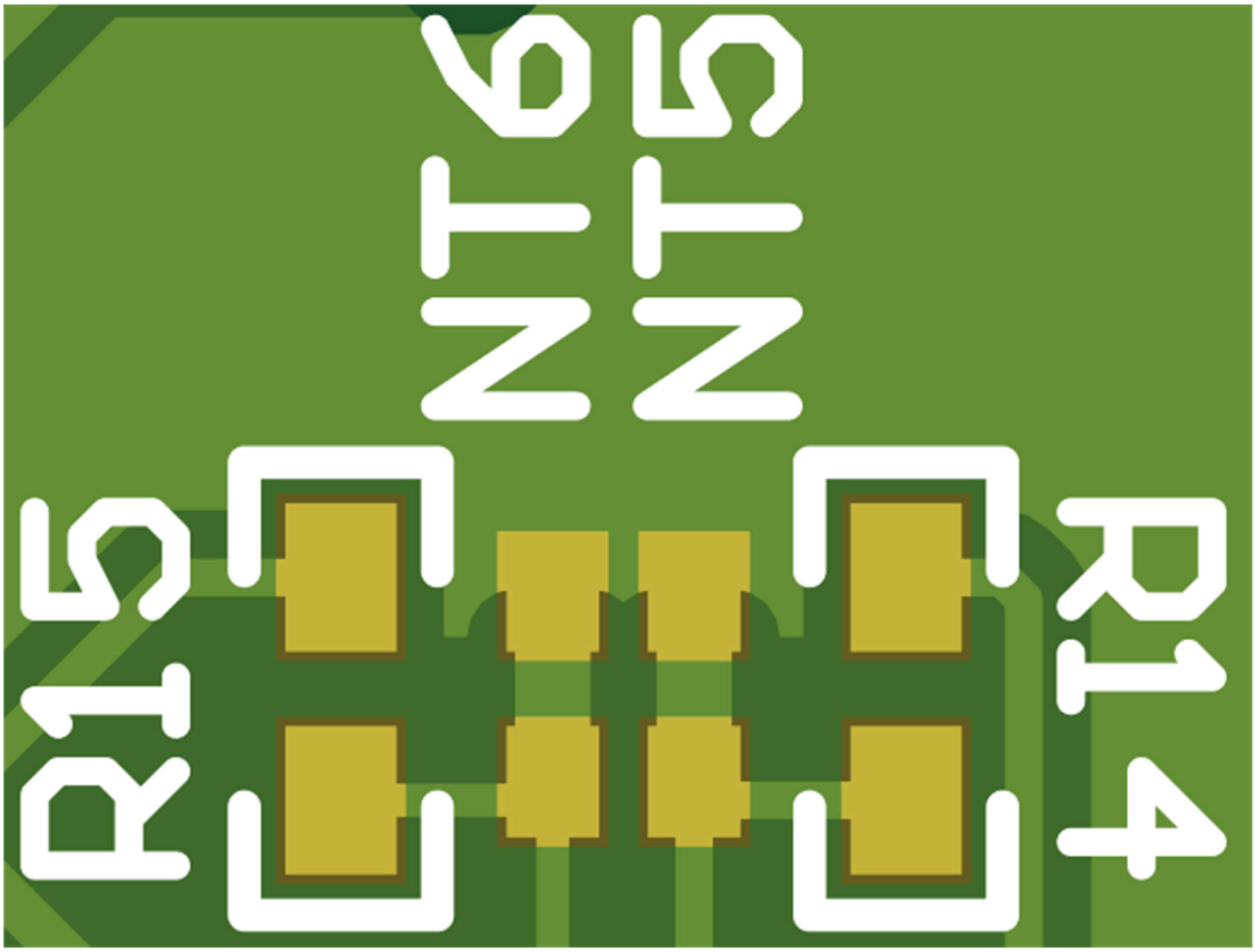


Figure 2-3. Dead Battery Support Disabled

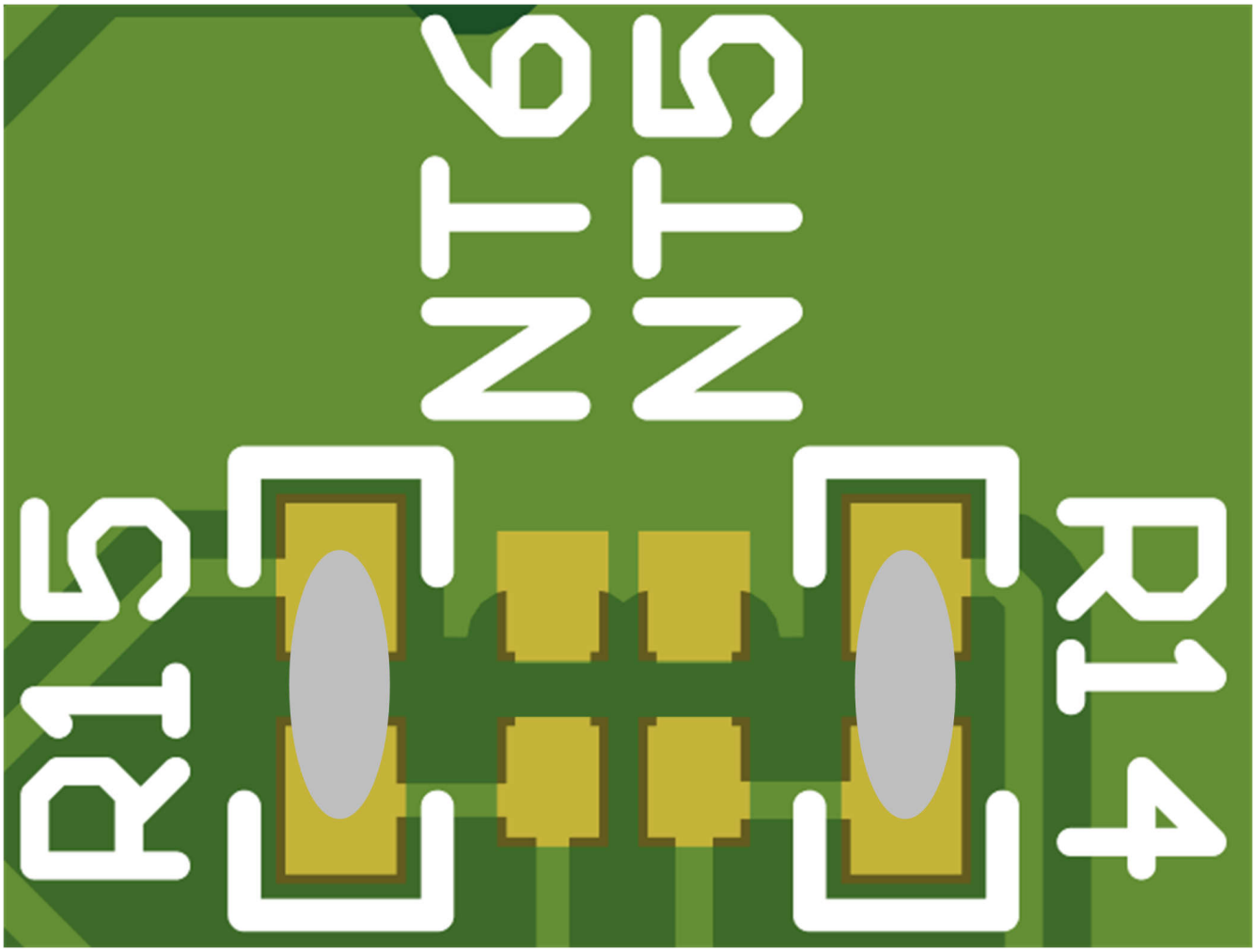


Figure 2-4. Dead Battery Support Enabled

2.2 Connector Information

Table 2-1 describes the external connectors associated with TPD4S480-Q1

Table 2-1. TPD4S480-Q1 External Connections

Reference	Pin (Label)	Description
J1	N/A	Type-C receptacle. ESD/OVP stresses are applied on this side of the EVM.
J2	N/A	Type-C plug. This is the protected side of the EVM and connects to the existing system's Type-C receptacle.
J3	1 (GND)	Ground. Connect to low side of external test equipment.
	2 (VBUS-LV)	Divided VBUS signal. When EPR_EN pin is asserted, VBUS_LV measures half of VBUS. Typically connects to PD controller VBUS input.
	3 (EPR-EN)	Digital input. When EPR_EN pin is asserted, VBUS_LV measures half of VBUS. Typically connects to PD controller digital output. Consider connecting via J3 header pin 1 (GND) or 4 (+3.3V).
	4 (+3.3V)	U1/U2 power. Connect to high side of external power supply.

Table 2-2 describes the headers associated with TPD4S481-Q1

Table 2-2. TPD4S481-Q1 External Connections

Reference	Pin (Label)	Description
J4	N/A	Type-C receptacle. ESD/OVP stresses are applied on this side of the EVM.
J5	N/A	Type-C plug. This is the protected side of the EVM and connects to the existing system's Type-C receptacle.
J6	1 (GND)	Ground. Connect to low side of external test equipment.
	2 (+3.3V)	U4/U5 power. Connect to high side of external power supply.

Table 2-3 describes the headers associated with TPD4S201-Q1

Table 2-3. TPD4S201-Q1 External Connections

Reference	Pin (Label)	Description
J7	N/A	Type-C receptacle. ESD/OVP stresses are applied on this side of the EVM.
J8	N/A	Type-C plug. This is the protected side of the EVM and connects to the existing system's Type-C receptacle.
J9	1 (GND)	Ground. Connect to low side of external test equipment.
	2 (+3.3V)	U7/U8 power. Connect to high side of external power supply.

2.3 Debug Information

If USB 2.0 data transfer is not functional after adding the EVM to the existing system, R3, R6, and R9 are provided to adjust the gain of the TUSB211A-Q1 USB2.0 redriver. The gain is set to the lowest setting by default.

3 Hardware Design Files

3.1 Schematics

Male / System Side

Female / Connector Side

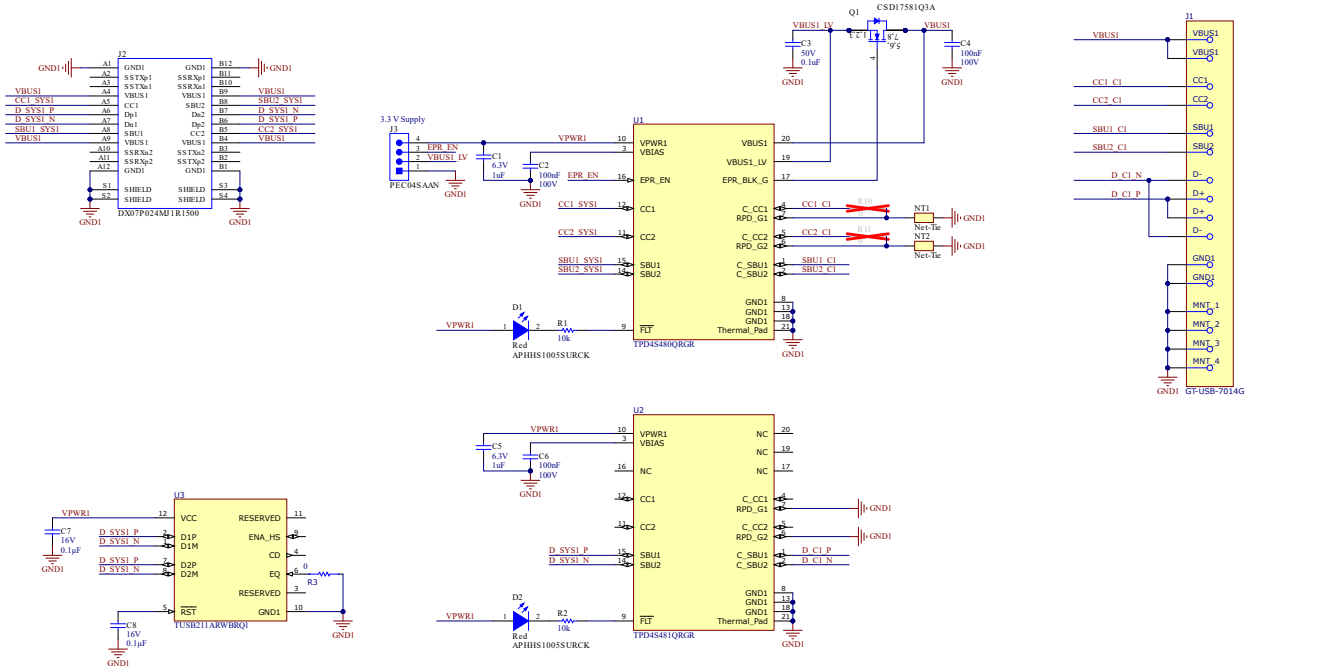


Figure 3-1. TPD4S480-Q1 Variant

Male / System Side

Female / Connector Side

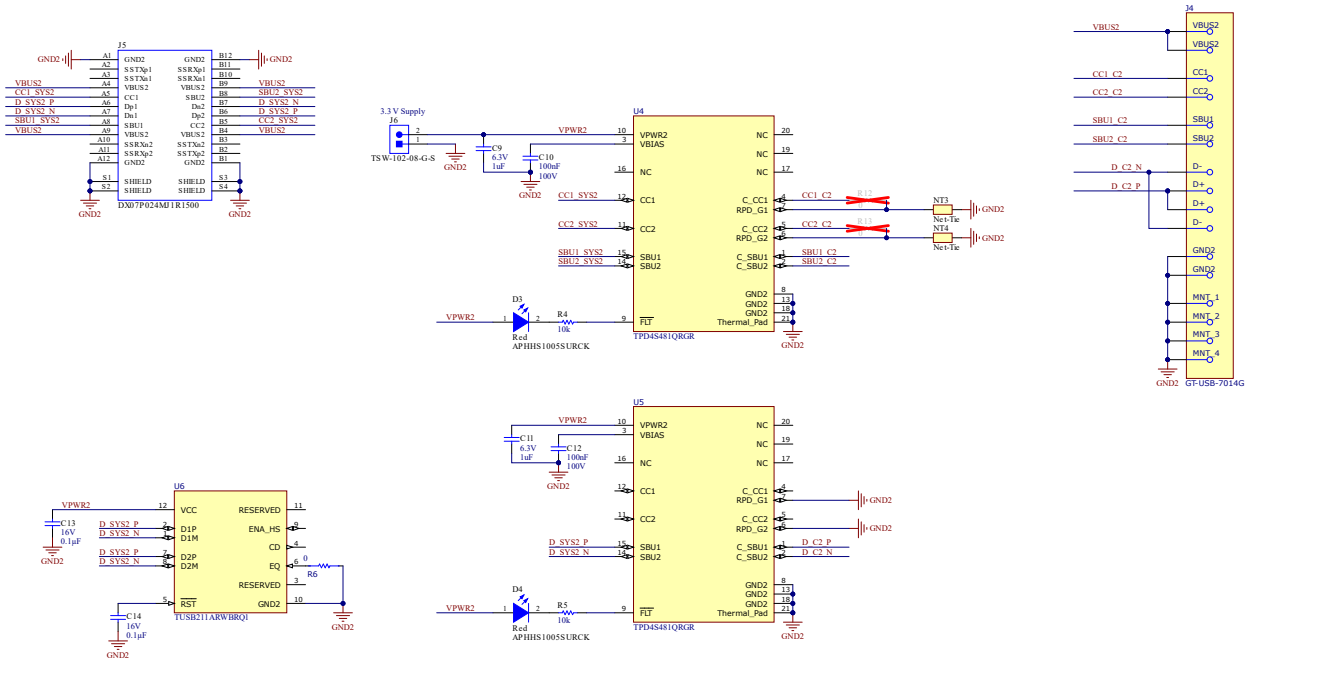


Figure 3-2. TPD4S481-Q1 Variant

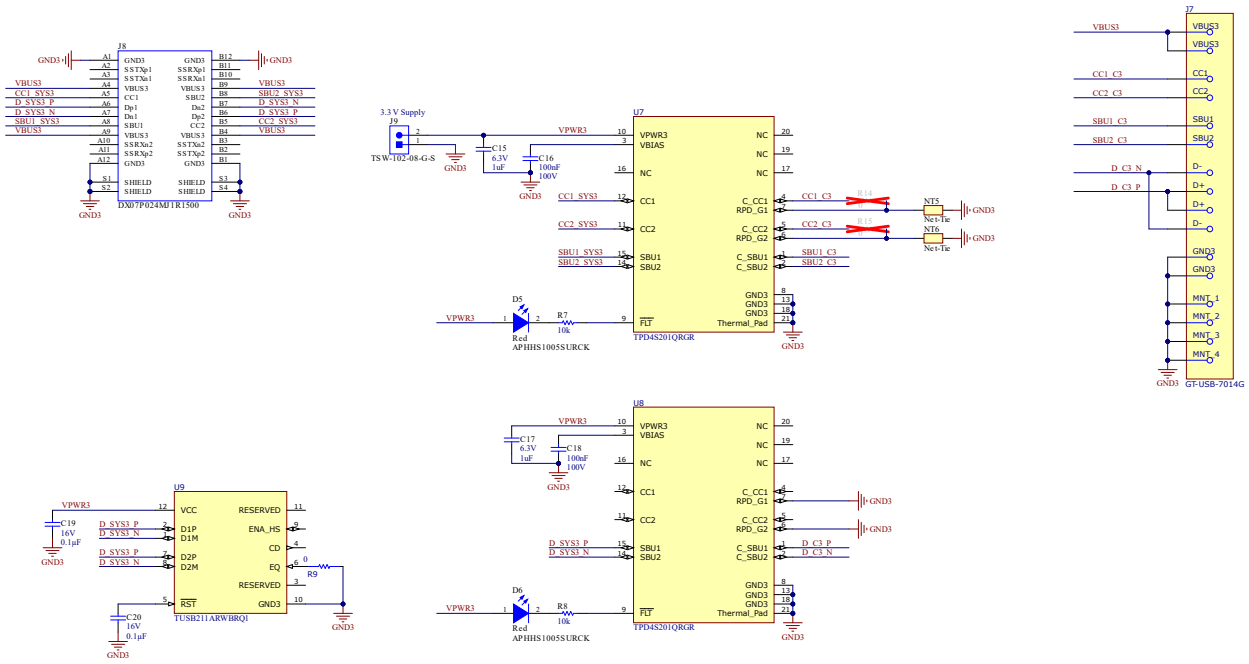


Figure 3-3. TPD4S201-Q1 Variant

3.2 PCB Layouts

Note

PCB silkscreen may vary to reflect hardware revision.

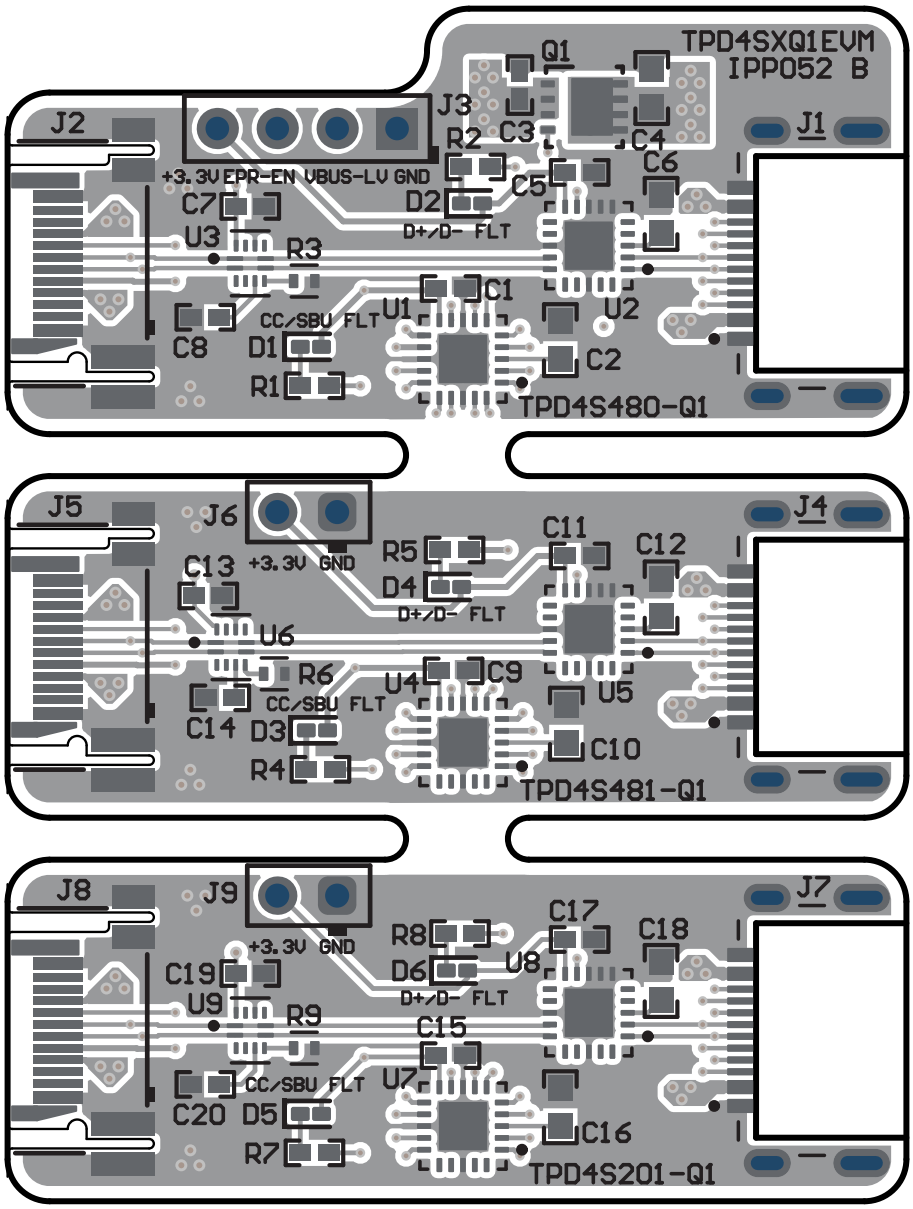


Figure 3-4. Top Composite View

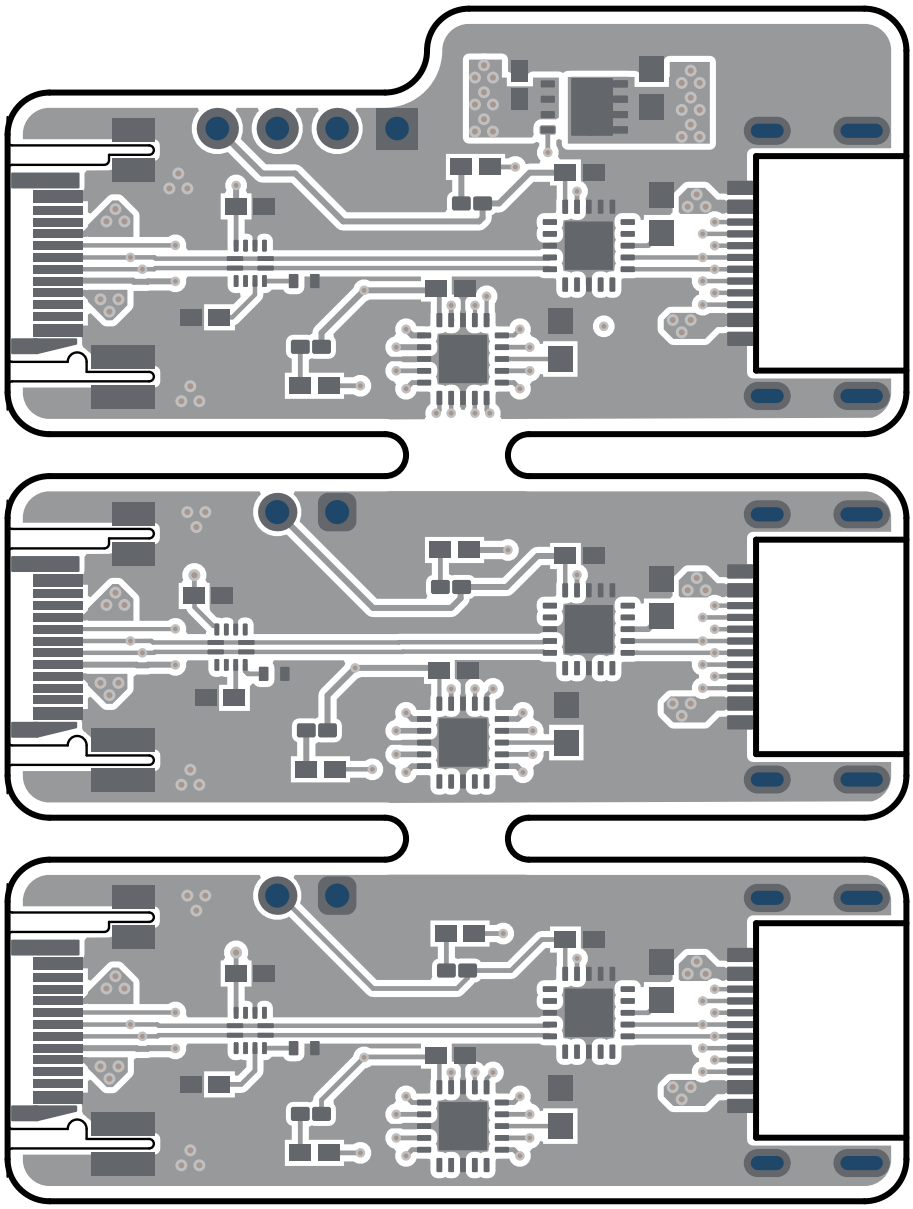


Figure 3-5. Top Layer Mask

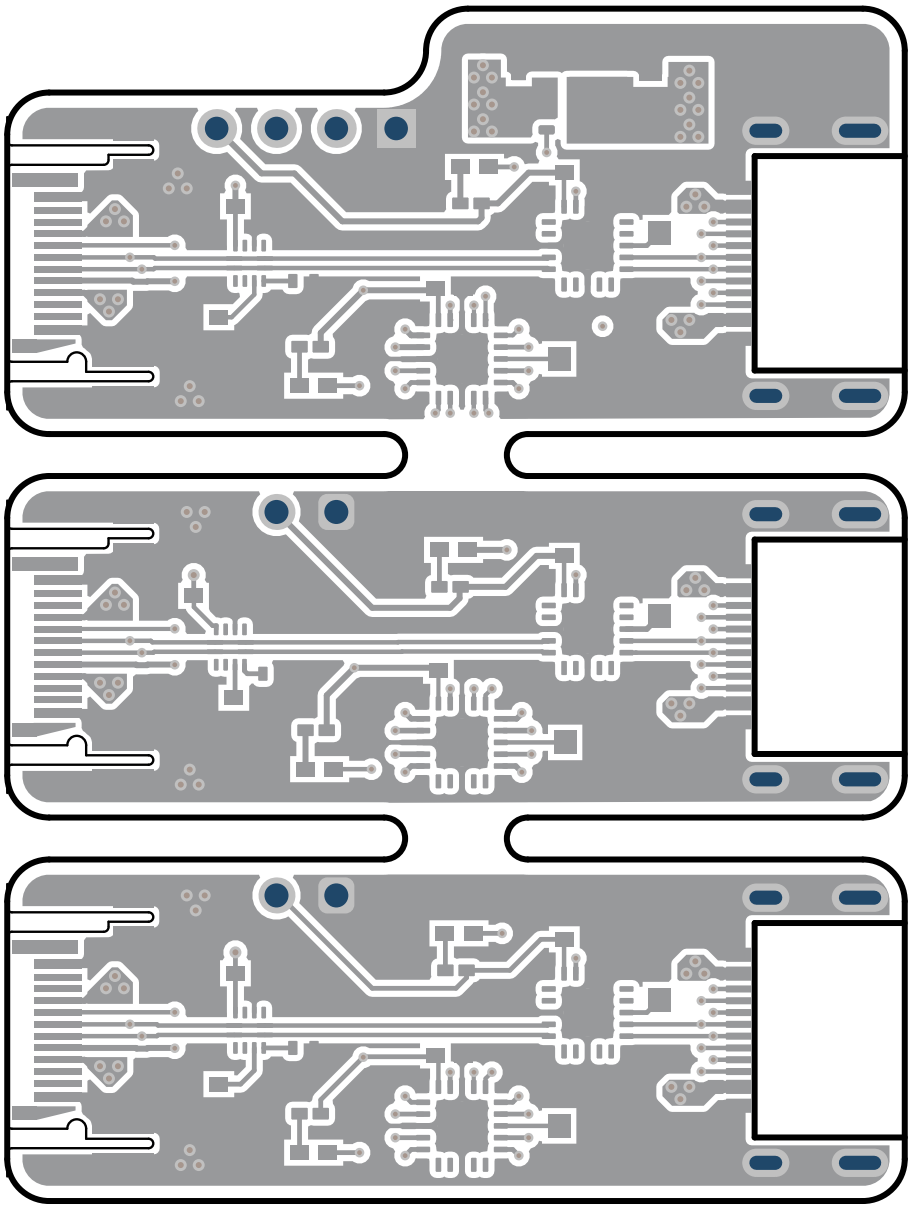


Figure 3-6. Top Layer

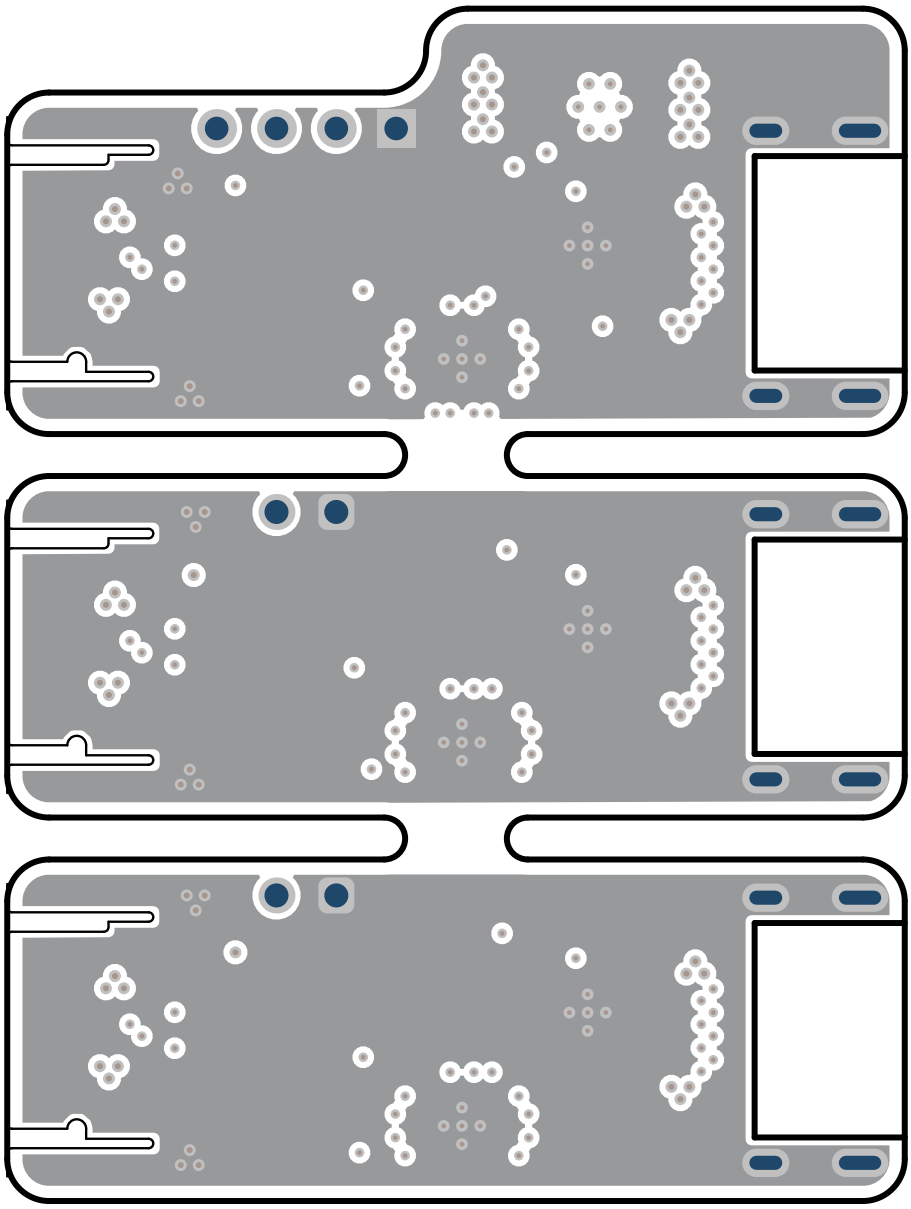


Figure 3-7. Layer 2

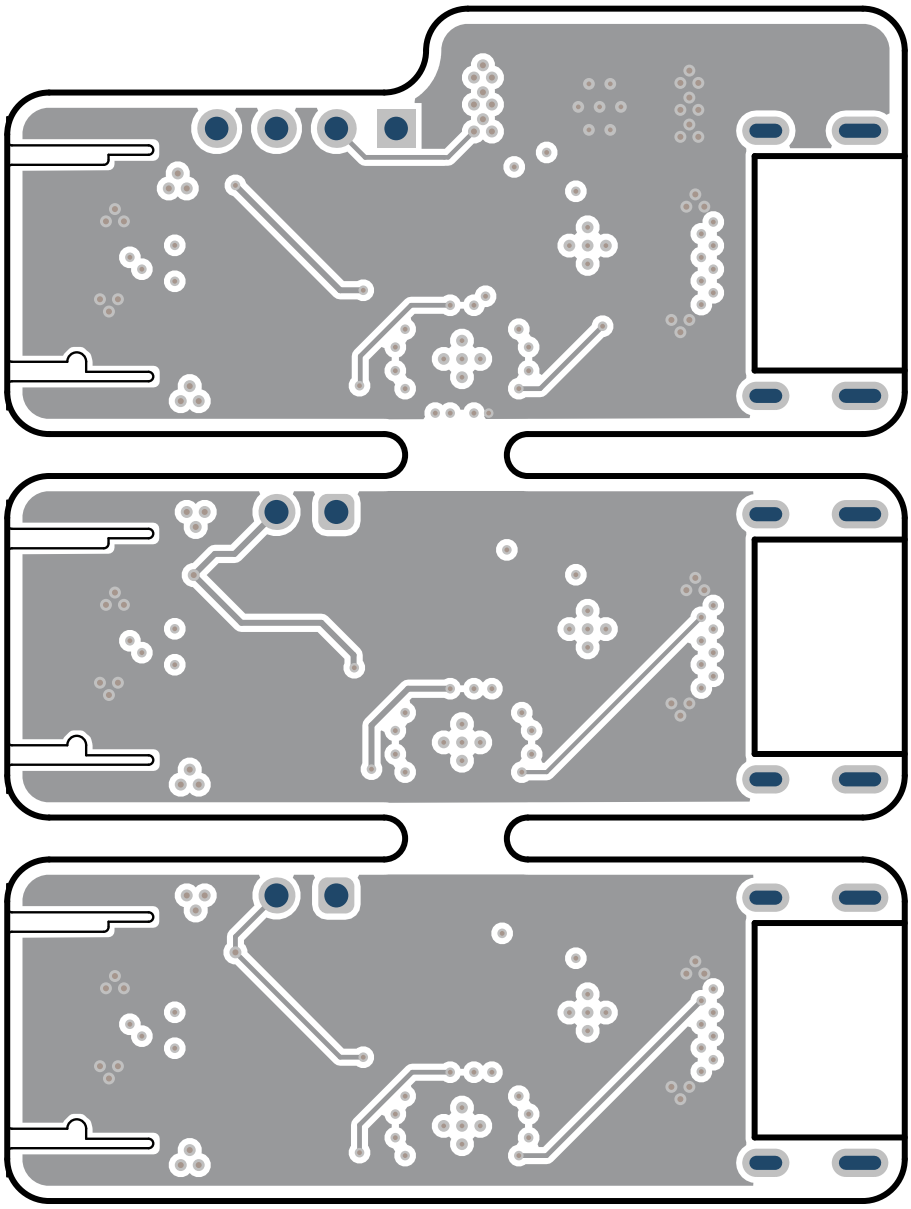


Figure 3-8. Layer 3

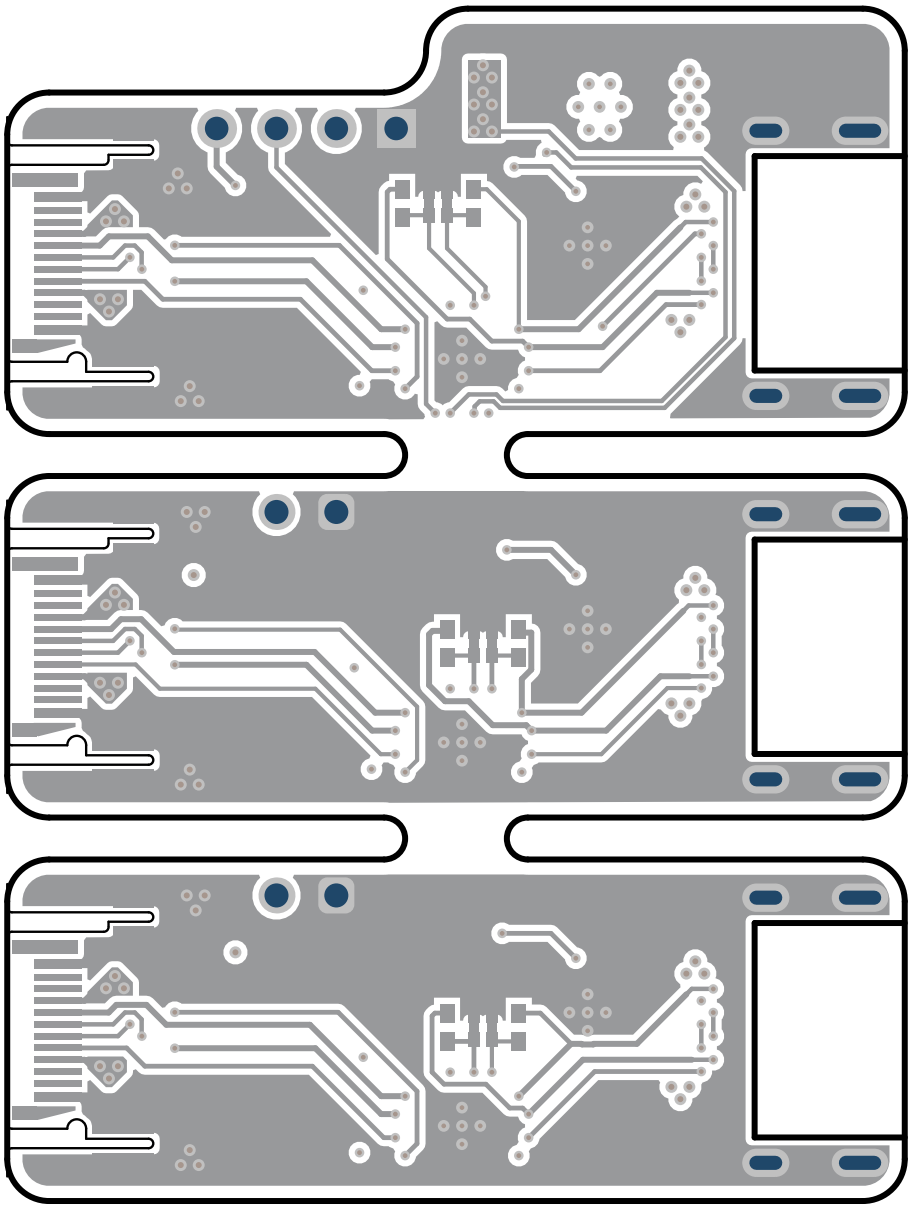


Figure 3-9. Bottom Layer

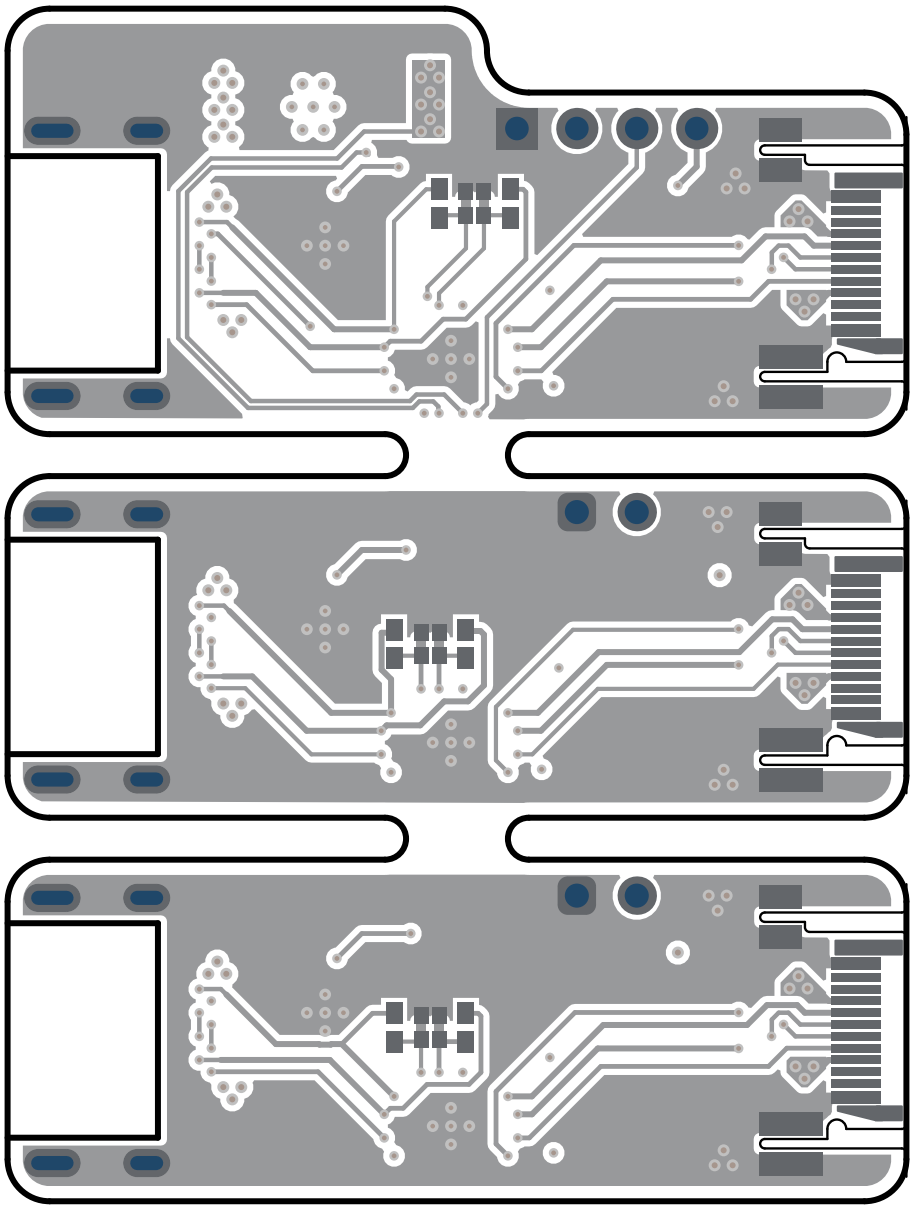


Figure 3-10. Bottom Layer Mask

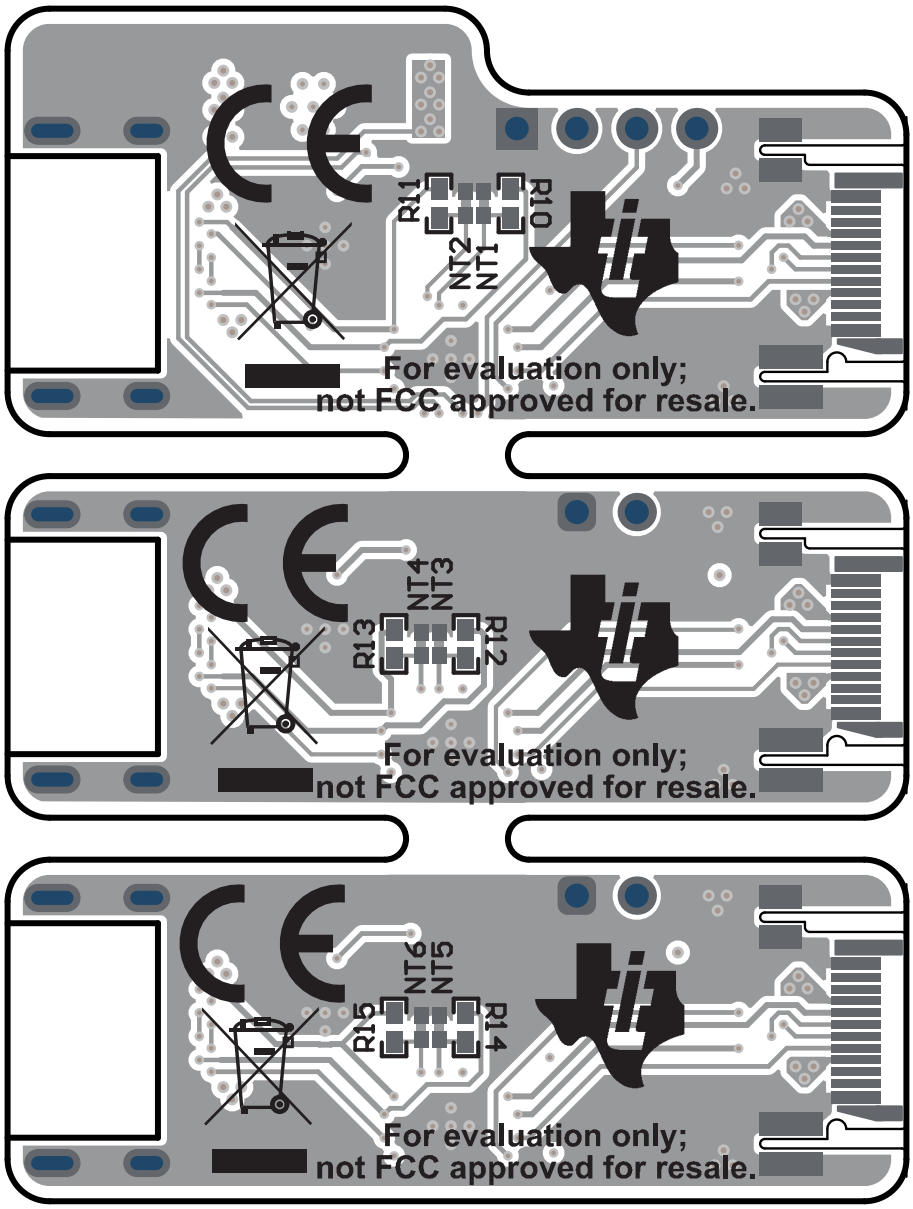


Figure 3-11. Bottom Composite View

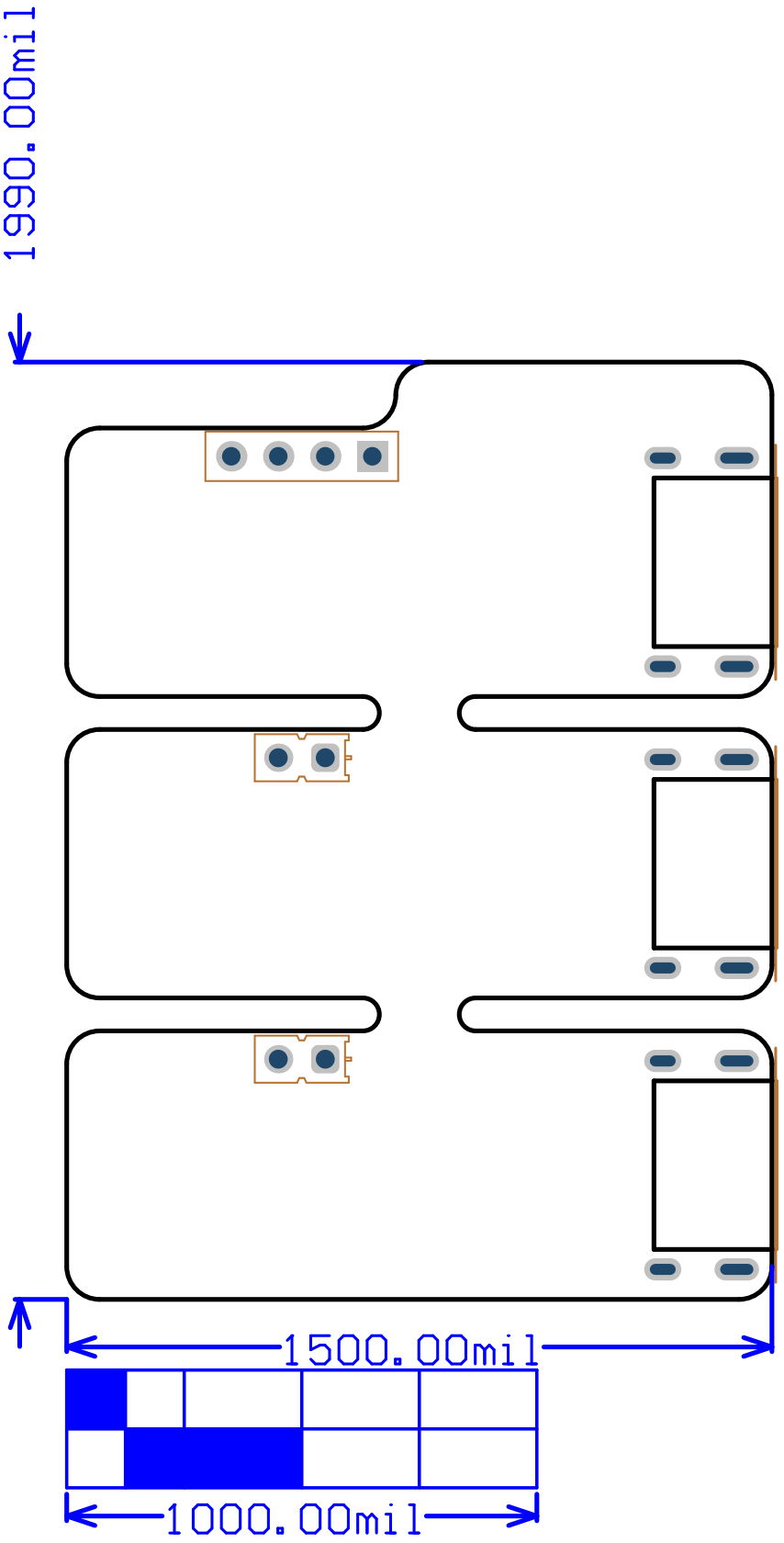


Figure 3-12. Board Dimensions

3.3 Bill of Materials (BOM)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
C1, C5, C9, C11, C15, C17	6	1uF	CAP, CERM, 1 uF, 6.3 V,+/- 10%, X7R, 0402	0402	GRM155R70J105 KA12D	MuRata
C2, C4, C6, C10, C12, C16, C18	7	0.1uF	CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, 0603	0603	GRM188R72A104 KA35D	MuRata
C3	1	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0402	0402	GCM155R71H104 KE02D	MuRata
C7, C8, C13, C14, C19, C20	6	0.1uF	CAP, CERM, 0.1 µF, 16 V,+/- 5%, X7R, AEC-Q200 Grade 1, 0402	0402	GCM155R71C104 JA55D	MuRata
D1, D2, D3, D4, D5, D6	6	Red	LED, Red, SMD	0402	APHHS1005SUR CK	Kingbright
J1, J4, J7	3		USB 2.0 5A 1 Sink board 16P Female -40℃~+85℃ Gold High Conductivity Copper Type-C SMD USB Connectors ROHS	CONN_USB	GT-USB-7014G	G-Switch Electronics
J2, J5, J8	3		Plug, USB3.1, TYPE-C, R/A, SMT	Plug, USB3.1, TYPE-C, R/A, SMT	DX07P024MJ1R1 500	JAE Electronics
J3	1		Header, 100mil, 4x1, Tin, TH	Header, 4x1, 100mil, TH	PEC04SAAN	Sullins Connector Solutions
J6, J9	2		Header, 2.54mm, 2x1, Gold, TH	Header, 2.54mm, 2x1, TH	TSW-102-08-G-S	Samtec
Q1	1	30V	MOSFET, N-CH, 30 V, 60 A, DNH0008A (VSONP-8)	DNH0008A	CSD17581Q3A	Texas Instruments
R1, R2, R4, R5, R7, R8	6	10k	RES, 10 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040210K0J NED	Vishay-Dale
R3, R6, R9	3	0	Jumper 0.063W, 1/16W Chip Resistor 0402 (1005 Metric) - Thick Film	0402	CRCW04020000Z 0EDC	Vishay

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
U1	1		USB Type-C® 48V EPR Port Protector: Short-to-VBUS Overvoltage and IEC ESD Protection	VQFN20	TPD4S480QRGR	Texas Instruments
U2, U4, U5	3		USB Type-C® 48V EPR Port Protector: Short-to-VBUS Overvoltage and IEC ESD Protection	VQFN20	TPD4S481QRGR	Texas Instruments
U3, U6, U9	3		Automotive, USB 2.0 480Mbps high-speed signal conditioner 12-X2QFN -40 to 105	X2QFN12	TUSB211ARWBRQ1	Texas Instruments
U7, U8	2		USB Type-C® 20V EPR Port Protector: Short-to-VBUS Overvoltage and IEC ESD Protection	VQFN20	TPD4S201QRGR	Texas Instruments

4 Related Documentation

4.1 Supplemental Content

- TPD4S480-Q1 Device Datasheet
- TPD4S481-Q1 Device Datasheet
- TPD4S201-Q1 Device Datasheet
- TUSB211A-Q1 Device Datasheet

5 Trademarks

All trademarks are the property of their respective owners.

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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.

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2 *Limited Warranty and Related Remedies/Disclaimers*:

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

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

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

WARNING

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

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

NOTE:

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

3 *Regulatory Notices:*

3.1 *United States*

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

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

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

CAUTION

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

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

FCC Interference Statement for Class A EVM devices

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

FCC Interference Statement for Class B EVM devices

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

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

3.2 *Canada*

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

Concerning EVMs Including Radio Transmitters:

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

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

Concernant les EVMs avec appareils radio:

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

Concerning EVMs Including Detachable Antennas:

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

Concernant les EVMs avec antennes détachables

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

3.3 *Japan*

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

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

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

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

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

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

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

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

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社

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西新宿三井ビル

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

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

3.4 *European Union*

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

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

4 *EVM Use Restrictions and Warnings:*

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

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

4.3 *Safety-Related Warnings and Restrictions:*

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

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

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

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

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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