EVM User's Guide: TPD4SXQ1EVM

四通道 USB PD SPR/EPR 端口保护 EVM

说明

TPD4SXQ1EVM 是一款由三部分组成的分体式评估模块，旨在结合现有汽车 USB Type-C® 系统测试 TPD4S480-Q1、TPD4S481-Q1 和 TPD4S201-Q1。直通式设计使用户能够轻松地将 EVM 连接到其现有系统，并在保持 USB2.0 和 USB 电力传输 (PD) 功能的同时，测试 IEC61000-4-2 ESD 和 VBUS 短路事件。状态 LED 提供了故障事件的视觉指示，并增加了 TUSB211A-Q1 USB2.0 转接驱动器以增强信号完整性。

开始使用

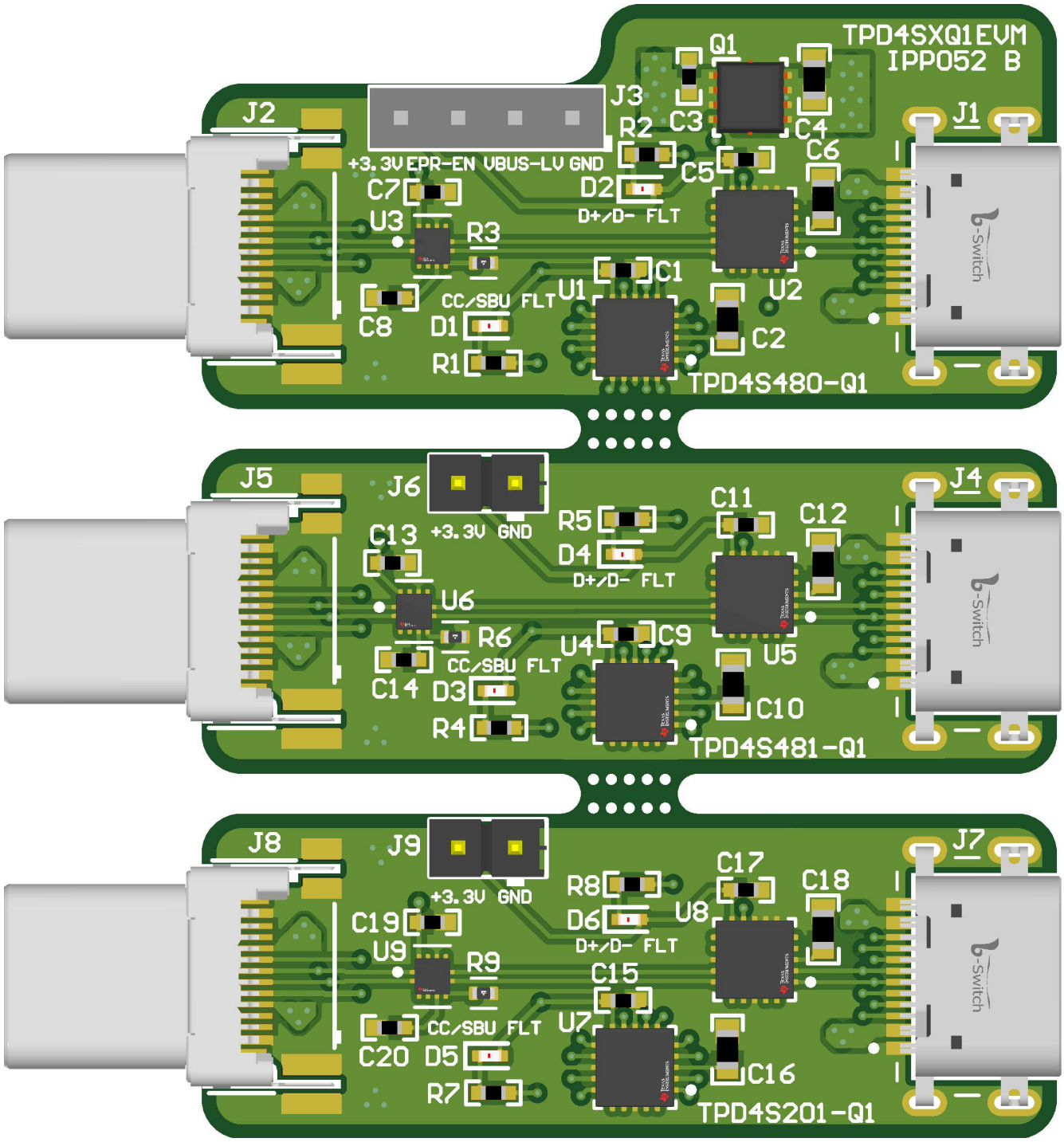
1. 订购 EVM
2. 阅读 TPD4SXQ1EVM 用户指南（本文档）。
3. 如有疑问或需要支持，请参阅相应的器件数据表或 E2E。
   a. TPD4S480-Q1
   b. TPD4S481-Q1
   c. TPD4S201-Q1

特性

- TPD4S480-Q1
  - 四通道 48V VBUS 短路保护
  - 四通道 8kV（接触）/15kV（空气间隙）IEC61000-4-2 ESD 保护
  - CC 无电电池电阻器，用于处理无电电池用例
  - 具有用于对扩展功率范围 (EPR) 电平 VBUS 进行分压的使能功能的 VBUS 分压器电路
  - 用于控制外部 EPR 阻断 FET 的 FET 驱动器
- TPD4S481-Q1
  - 四通道 48V VBUS 短路保护
  - 四通道 8kV（接触）/15kV（空气间隙）IEC61000-4-2 ESD 保护
  - CC 无电电池电阻器，用于处理无电电池用例
- TPD4S201-Q1
  - 四通道 20V VBUS 短路保护
  - 四通道 8kV（接触）/15kV（空气间隙）IEC61000-4-2 ESD 保护
  - CC 无电电池电阻器，用于处理无电电池用例

应用

- 汽车 USB 充电
- 汽车媒体中心
- 汽车音响主机
- 汽车后座娱乐系统



1 评估模块概述

1.1 简介

TPD4SXQ1EVM 是 TPD4S480-Q1、TPD4S481-Q1 和 TPD4S201-Q1 Type-C 端口保护器的评估模块。每个面板会分开，以便根据受保护系统的需求进行单独分析。USB PD 标准功率范围 (SPR) 系统受 TPD4S201-Q1 保护，而扩展功率范围 (EPR) 系统需要 TPD4S480-Q1 或 TPD4S481-Q1。该评估模块遵循 Type-C 直通设计，可插入现有系统的 USB Type-C 端口。向电路板提供器件电源后，EVM 将用作现有系统的扩展。

本用户指南介绍了如何操作 TPD4SXQ1EVM 并测试 ESD 和过压保护性能。USB 2.0 信号通过每个电池板传递，以确保功能不会受到影响。SS TX/RX 信号不会传递。

1.2 套件内容

EVM 套件包含 TPD4SXQ1EVM。

1.3 规格

表 1-1 显示了 TPD4SXQ1EVM 电路板规格

表 1-1. 评估板规格

输入电压	2.7V 至 4.5V
最大标称系统 VBUS（TPD4S480-Q1、TPD4S481-Q1）	48V
最大标称系统 VBUS (TPD4S201-Q1)	20V
最大总线电流	5A

1.4 器件信息

TPD4S480-Q1、TPD4S481-Q1 和 TPD4S201-Q1 是一系列适用于 USB Type-C 电力输送应用的 4 通道 ESD 和 OVP 保护器件。每个器件均提供 8kV 接触放电和 15kV 空气间隙 IEC61000-4-2 ESD 保护。TPD4S480-Q1 和 TPD4S481-Q1 可防止 USB PD EPR 系统发生高达 48V 的 VBUS 短路事件。TPD4S201-Q1 支持高达 20V 的 VBUS 短路事件，适用于 USB PD SPR 系统。

TPD4S480-Q1 集成 VBUS 分压器电路和 FET 驱动器，确保不符合 EPR 运行要求的 PD 控制器也能在 EPR 电压范围内安全运行。当由 GPIO 启用或在 VBUS 超过 24V 的情况下自动启用时， TPD4S480-Q1 会禁用可选的外部阻断 FET 并启用分压器。此举能保护额定电压为 20V 的 PD 控制器，并允许使用现有的 VBUS 检测电路。

2 硬件

2.1 设置

EVM 的每个部分都旨在用作需要保护的现有 Type-C 端口的扩展。除需要 SSTX/SSRX 信号的功能外，该端口会保留其现有功能，同时增加 ESD 和 VBUS 短路保护。

TPD4S201-Q1 和 TPD4S481-Q1 设置相同。将 Type-C 插头连接到现有系统的 Type-C 插座。向电路板顶部的接头引脚选择 3.3V 电源。该 EVM 的 Type-C 插座现在可用作现有系统的 Type-C 端口。系统评估可恢复正常。建议使用 Type-C 分线板来协助进行 ESD 和 VBUS 短路测试。

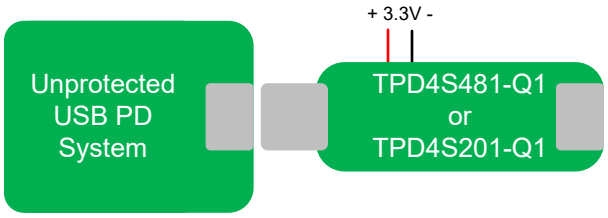


图 2-1. TPD4S481-Q1 和 TPD4S201-Q1 设置

TPD4S480-Q1 以类似的方式设置。为 EPR_EN 和 VBUS_LV 信号提供了附加接头。EPR_EN 可连接到 0V 或 3.3V，VBUS_LV 可通过 DMM 或示波器进行监控。

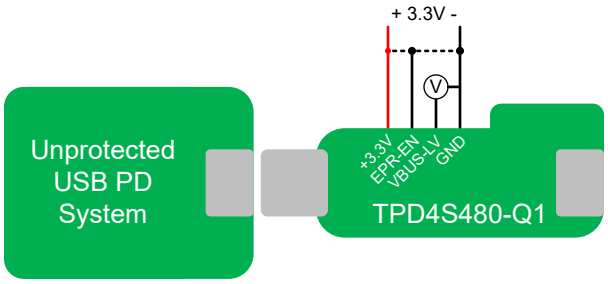


图 2-2. TPD4S480-Q1 设置

所有三个部分的背面都包含网带和 0402 焊盘。默认情况下，CC1/2 引脚未连接到 RPD_G1/2 引脚以支持电池无电状态。如果需要支持无电电池，请切断两条网带布线，并在 0402 焊盘上创建一个焊桥。有关支持电池无电运行的更多详细信息，请参阅器件数据表的特性说明部分。

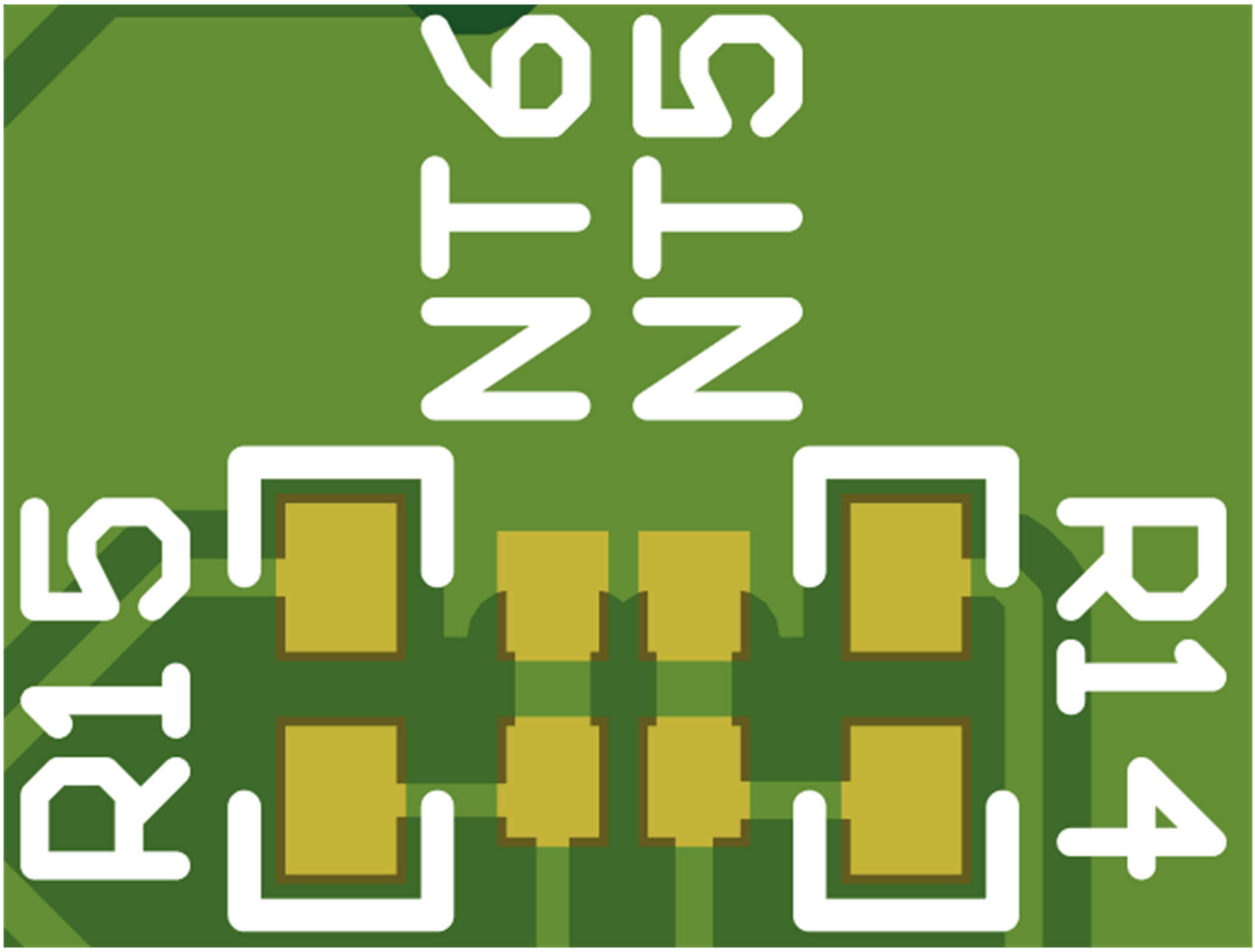


图 2-3. 禁用电池无电支持

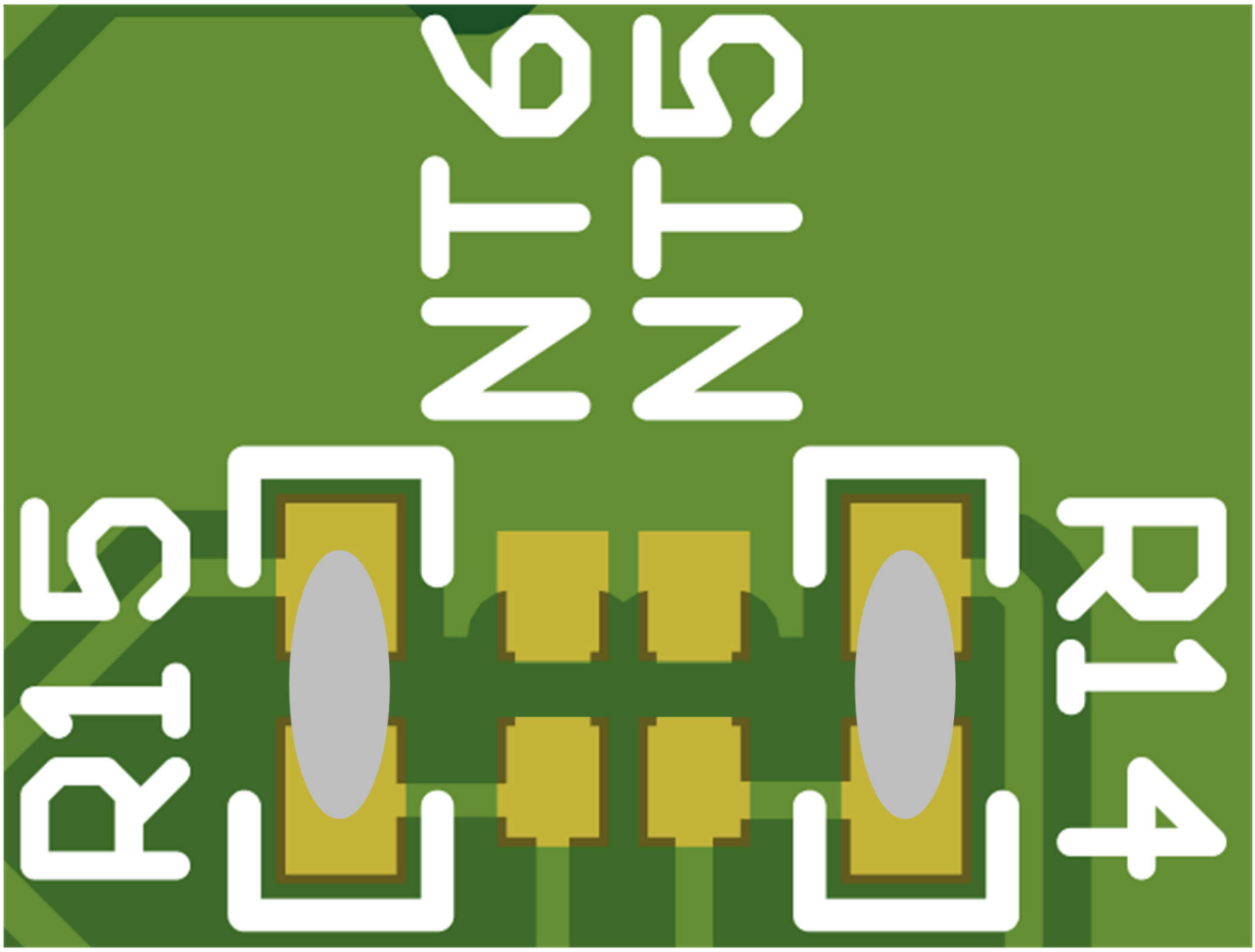


图 2-4. 启用电池无电支持

2.2 连接器信息

表 2-1 介绍了与 TPD4S480-Q1 相关的外部连接器

表 2-1. TPD4S480-Q1 外部连接接口

参考	引脚（标签）	说明
J1	不适用	Type-C 插座。在 EVM 的这一侧施加 ESD/OVP 应力。
J2	不适用	Type-C 插头。这是 EVM 的受保护侧，并连接到现有系统的 Type-C 插座。
J3	1 (GND)	接地。连接到外部测试设备的低侧。
	2 (VBUS-LV)	分压后的 VBUS 信号。当 EPR_EN 引脚被置为有效时，VBUS_LV 测量 VBUS 的一半。通常连接到 PD 控制器 VBUS 输入。
	3 (EPR-EN)	数字输入。当 EPR_EN 引脚被置为有效时，VBUS_LV 测量 VBUS 的一半。通常连接到 PD 控制器数字输出。 考虑通过 J3 接头引脚 1 (GND) 或 4 (+3.3V) 进行连接。
	4 (+3.3V)	U1/U2 电源。连接到外部电源的高侧。

表 2-2 介绍了与 TPD4S481-Q1 相关的接头

表 2-2. TPD4S481-Q1 外部连接接口

参考	引脚（标签）	说明
J4	不适用	Type-C 插座。在 EVM 的这一侧施加 ESD/OVP 应力。
J5	不适用	Type-C 插头。这是 EVM 的受保护侧，并连接到现有系统的 Type-C 插座。
J6	1 (GND)	接地。连接到外部测试设备的低侧。
	2 (+3.3V)	U4/U5 电源。连接到外部电源的高侧。

表 2-3 介绍了与 TPD4S201-Q1 相关的接头

表 2-3. TPD4S201-Q1 外部连接接口

参考	引脚（标签）	说明
J7	不适用	Type-C 插座。在 EVM 的这一侧施加 ESD/OVP 应力。
J8	不适用	Type-C 插头。这是 EVM 的受保护侧，并连接到现有系统的 Type-C 插座。
J9	1 (GND)	接地。连接到外部测试设备的低侧。
	2 (+3.3V)	U7/U8 电源。连接到外部电源的高侧。

2.3 调试信息

如果在将 EVM 添加到现有系统后 USB2.0 数据传输不起作用，则提供 R3、R6 和 R9 来调整 TUSB211A-Q1 USB2.0 转接驱动器的增益。默认情况下，增益设置为最低值。

3 硬件设计文件

3.1 原理图

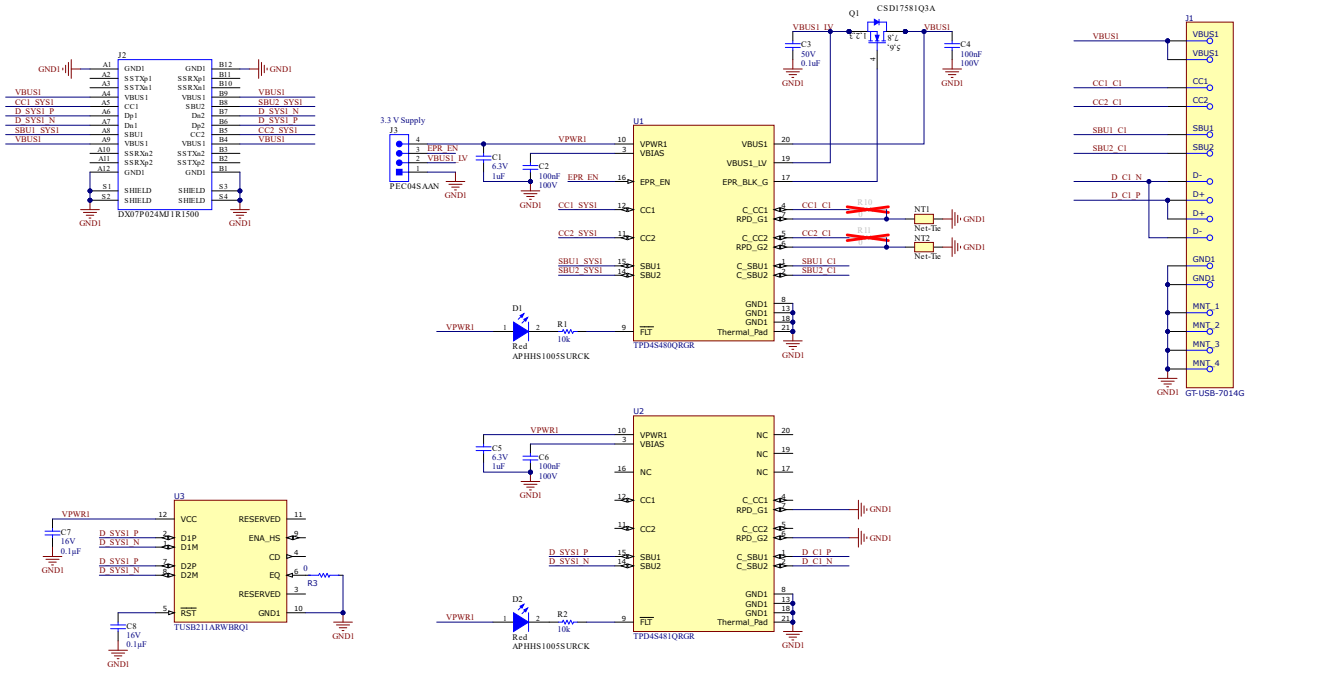


图 3-1. TPD4S480-Q1 变体

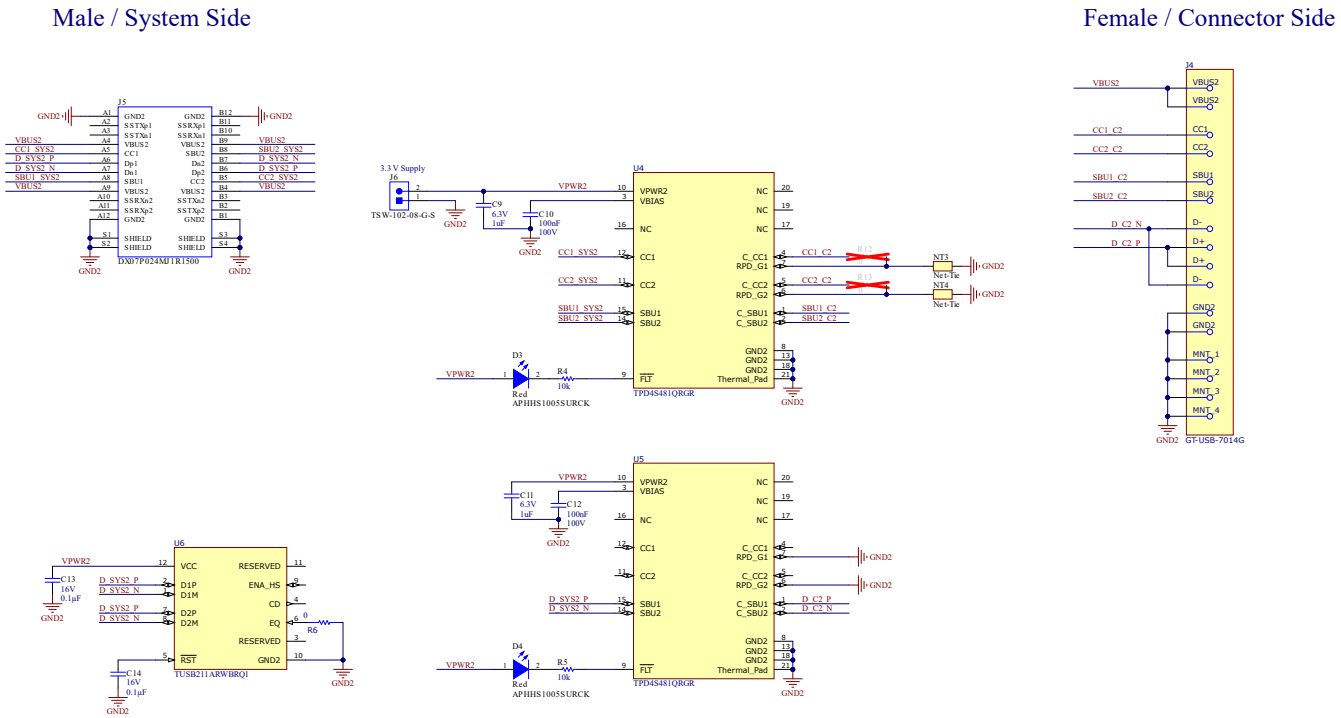


图 3-2. TPD4S481-Q1 变体

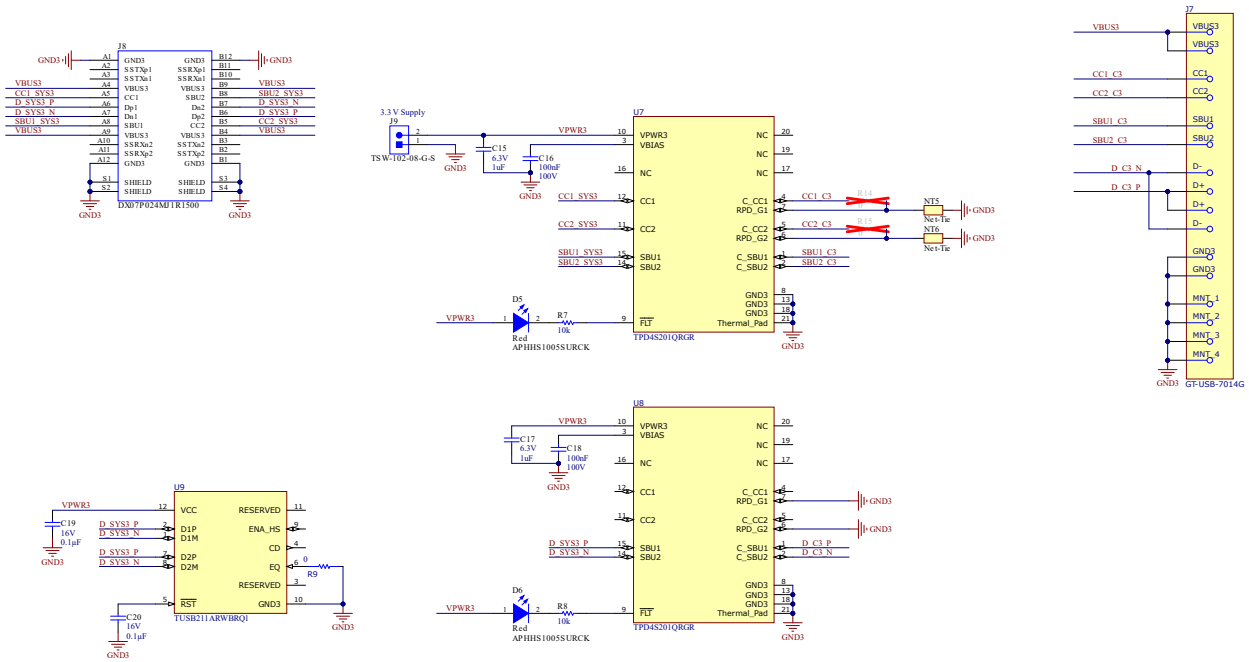


图 3-3. TPD4S201-Q1 变体

3.2 PCB 布局

备注

PCB 丝印可能会有所不同，以反映硬件版本。

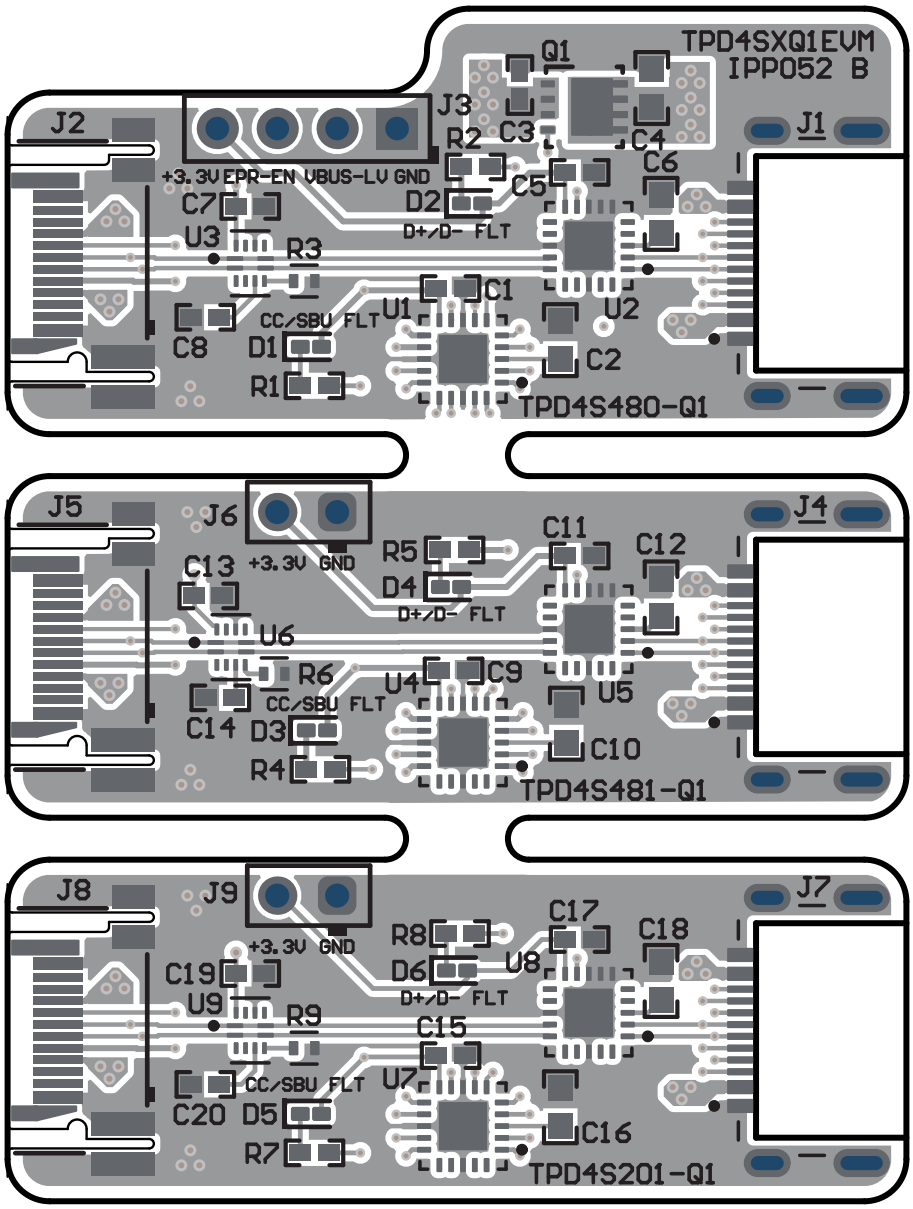


图 3-4. 顶部复合视图

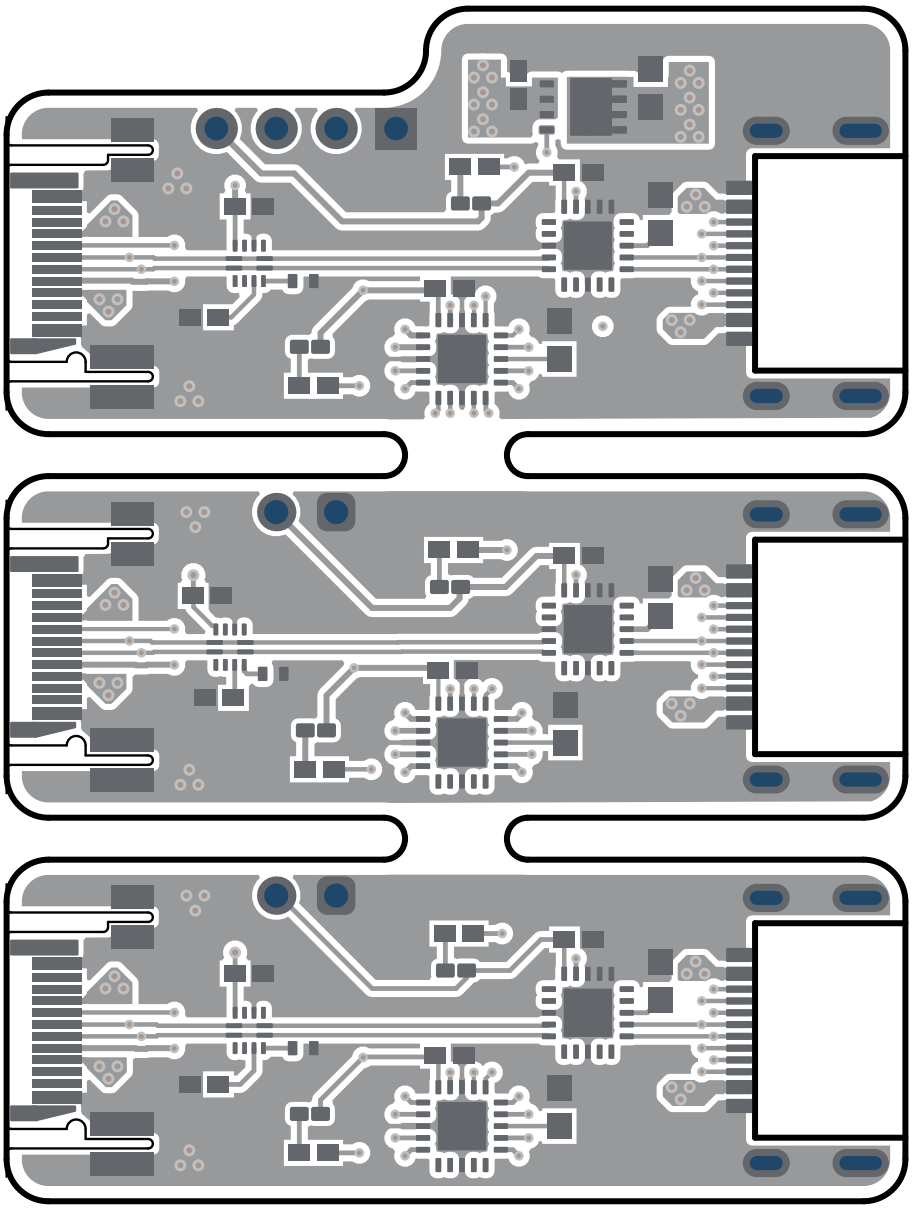


图 3-5. 顶层掩模

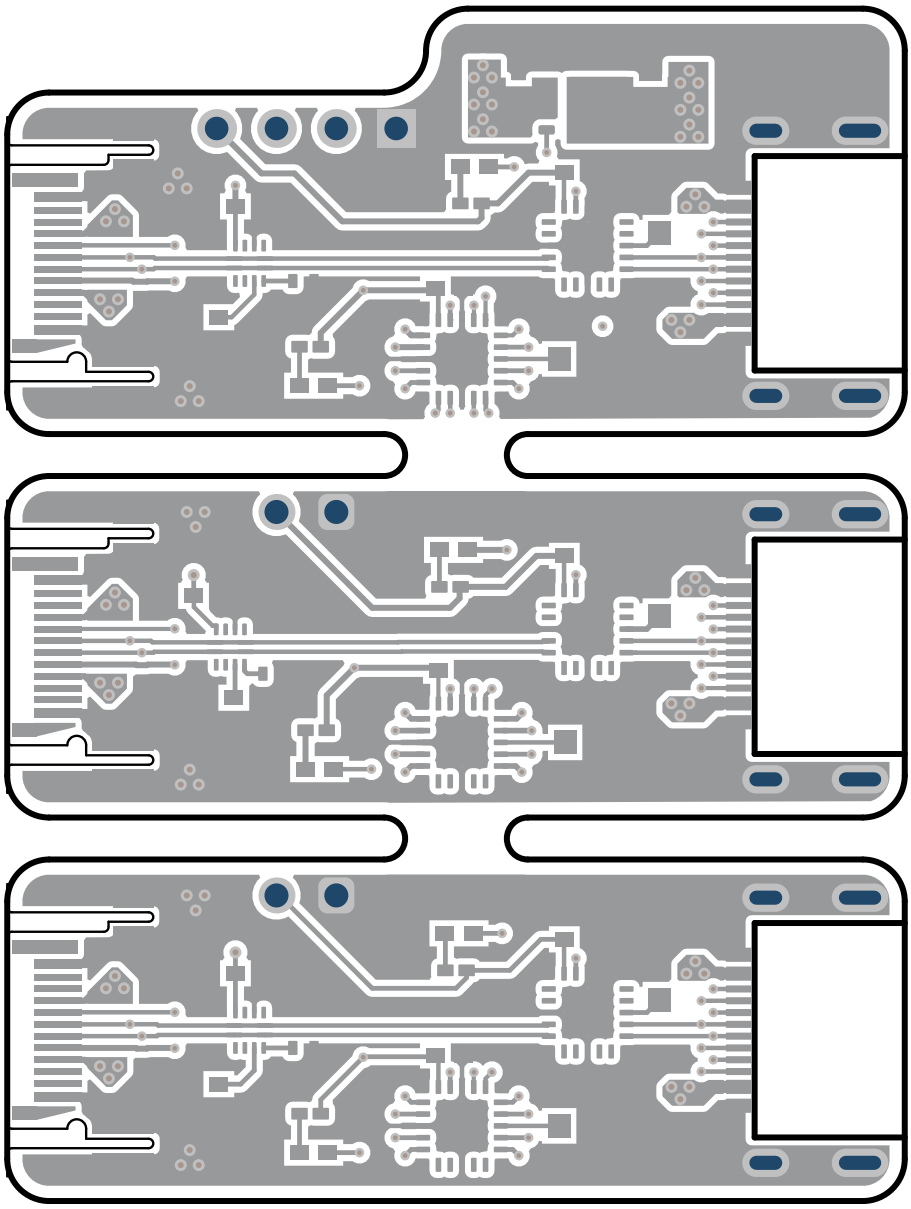


图 3-6. 顶层

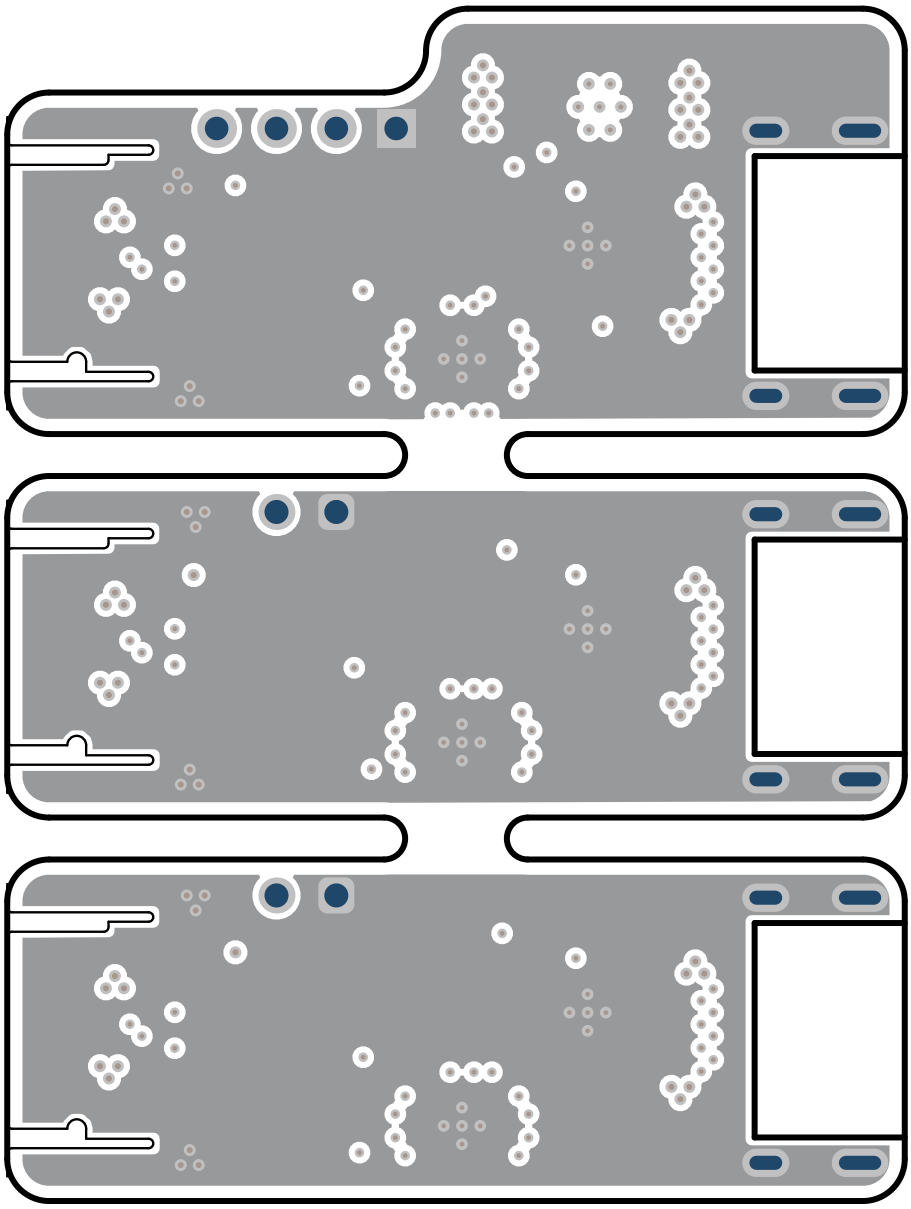


图 3-7. 第 2 层

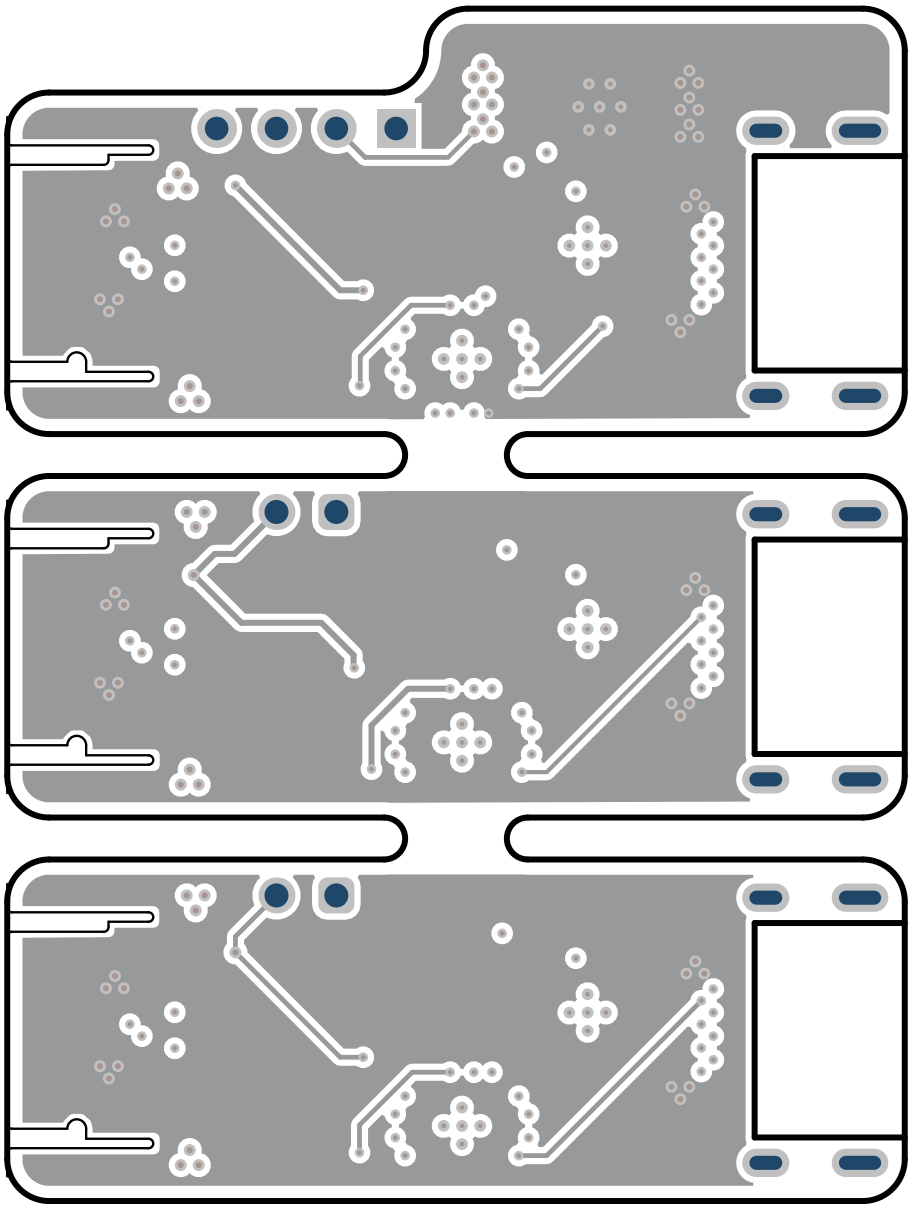


图 3-8. 第 3 层

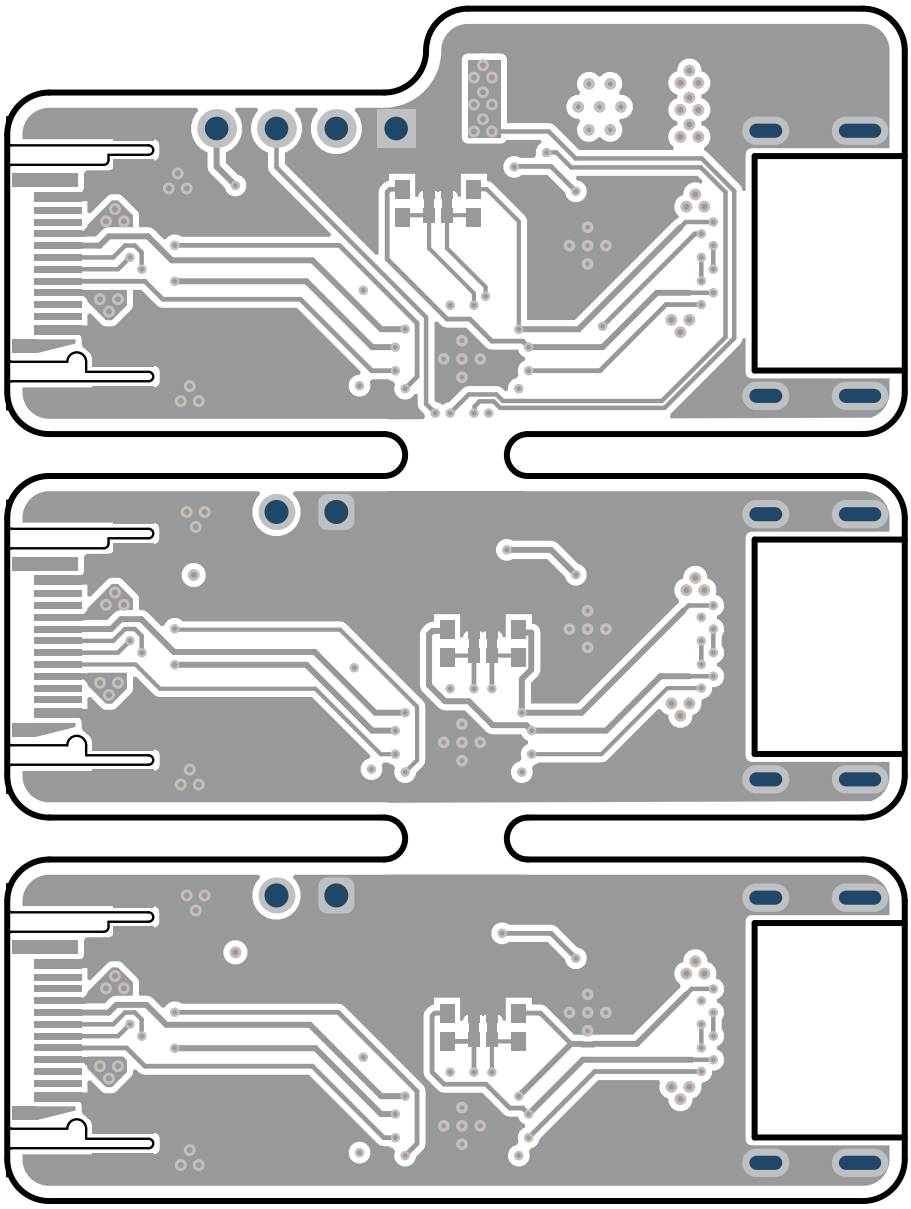


图 3-9. 底层

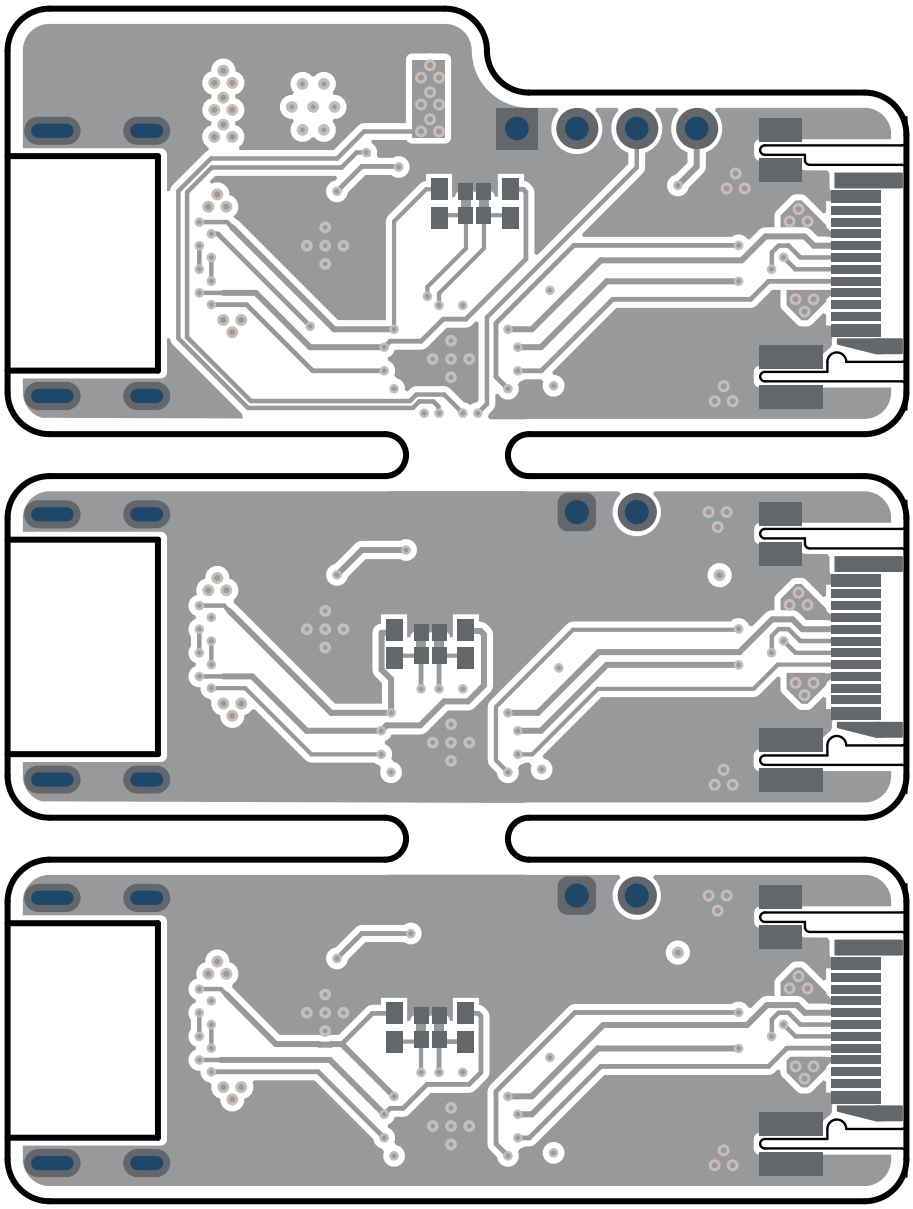


图 3-10. 底层掩模

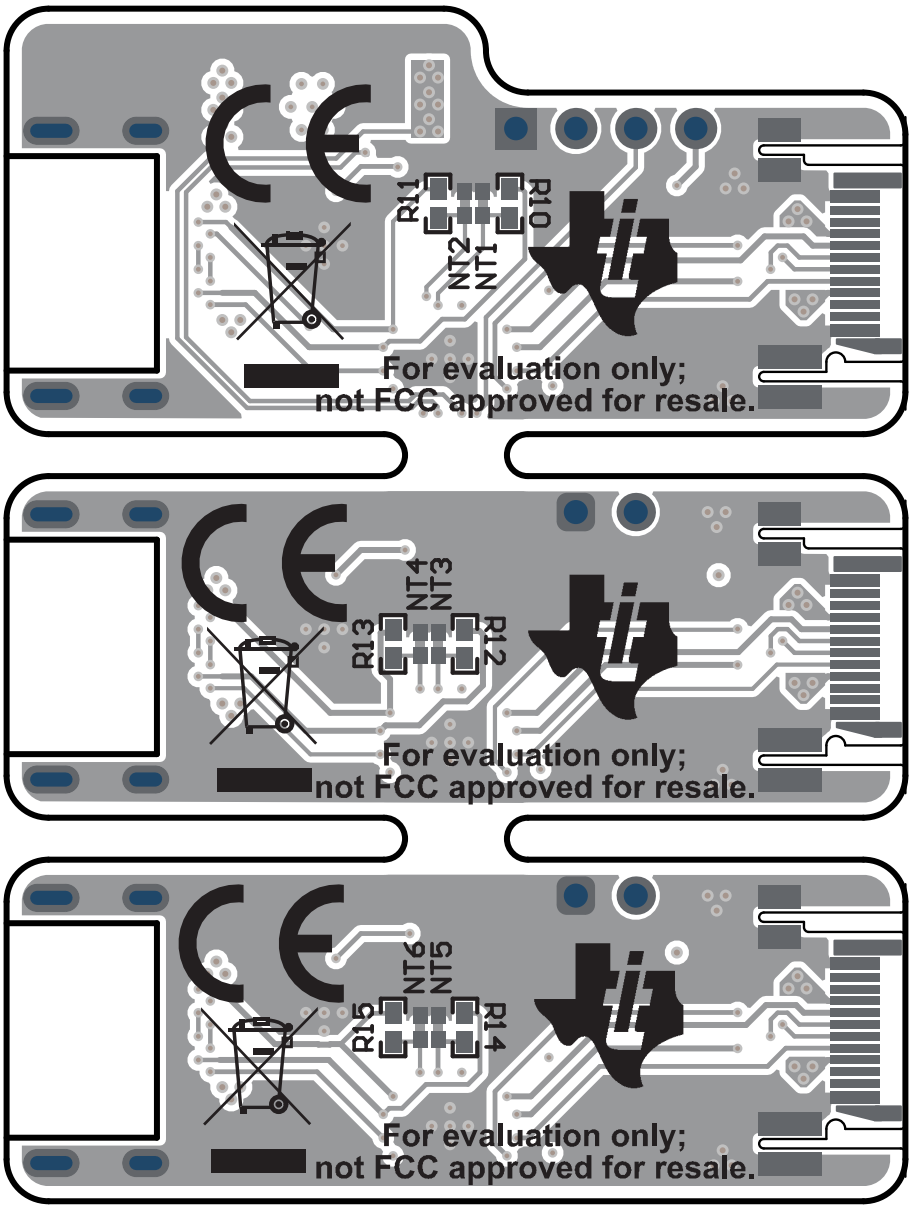


图 3-11. 底部复合视图

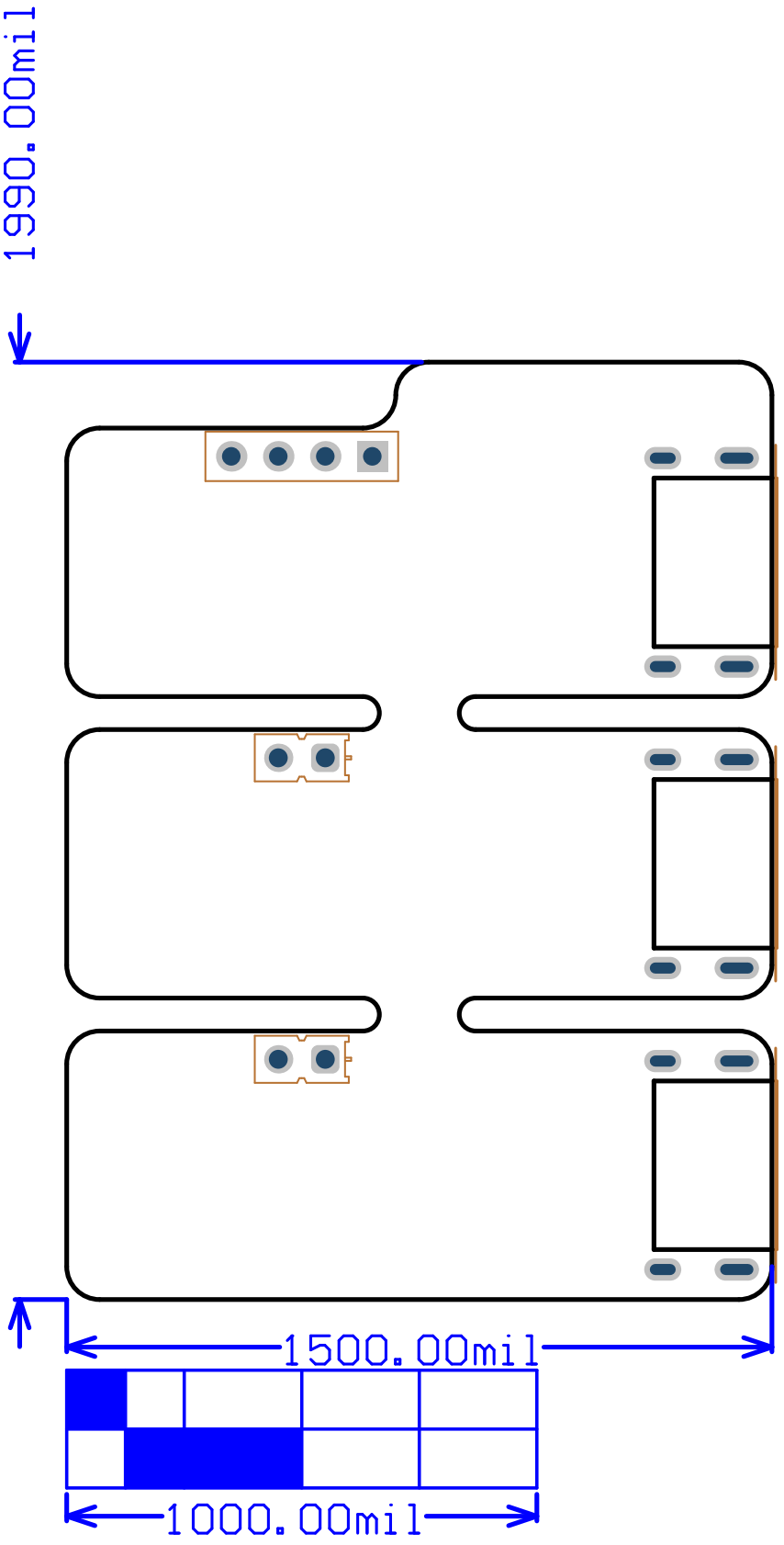


图 3-12. 电路板尺寸

3.3 物料清单 (BOM)

位号	数量	值	说明	封装参考	器件型号	制造商
C1、C5、C9、C11、C15、C17	6	1uF	电容，陶瓷，1 µF，6.3V，+/-10%，X7R，0402	0402	GRM155R70J105KA12D	MuRata
C2、C4、C6、C10、C12、C16、C18	7	0.1uF	电容，陶瓷，0.1µF，100V，+/-10%，X7R，0603	0603	GRM188R72A104KA35D	MuRata
C3	1	0.1uF	电容，陶瓷，0.1 µF，50V，+/-10%，X7R，AEC-Q200 1 级，0402	0402	GCM155R71H104KE02D	MuRata
C7、C8、C13、C14、C19、C20	6	0.1uF	电容，陶瓷，0.1µF，16V，+/-5%，X7R，AEC-Q200 1 级，0402	0402	GCM155R71C104JA55D	MuRata
D1、D2、D3、D4、D5、D6	6	红色	LED，红色，SMD	0402	APHHS1005SURCK	KINGBRIGHT
J1、J4、J7	3		USB 2.0 5A 1 接收板 16P 母 -40℃~+85℃ 镀金 高导电铜 Type-C SMD USB 连接器 ROHS	CONN_USB	GT-USB-7014G	G 开关电子器件
J2、J5、J8	3		插头、USB3.1、TYPE-C、R/A、SMT	插头、USB3.1、TYPE-C、R/A、SMT	DX07P024MJ1R1500	JAE Electronics
J3	1		接头，100mil，4x1，锡，TH	接头，4x1，100mil，TH	PEC04SAAN	Sullins Connector Solutions
J6、J9	2		接头，2.54mm，2x1，金，TH	接头，2.54mm，2x1，TH	TSW-102-08-G-S	Samtec
Q1	1	30V	MOSFET，N 沟道，30V，60A，DNH0008A (VSONP-8)	DNH0008A	CSD17581Q3A	德州仪器 (TI)
R1、R2、R4、R5、R7、R8	6	10k	电阻，10k，5%，0.063W，AEC-Q200 0 级，0402	0402	CRCW040210K0JNED	Vishay-Dale
R3、R6、R9	3	0	跳线 0.063W，1/16W 片式电阻器 0402 (公制 1005) - 厚膜	0402	CRCW04020000Z0EDC	Vishay

位号	数量	值	说明	封装参考	器件型号	制造商
U1	1		USB Type-C® 48V EPR 端口保护器：VBUS 短路过压和 IEC ESD 保护	VQFN20	TPD4S480QRGR	德州仪器 (TI)
U2、U4、U5	3		USB Type-C® 48V EPR 端口保护器：VBUS 短路过压和 IEC ESD 保护	VQFN20	TPD4S481QRGR	德州仪器 (TI)
U3、U6、U9	3		汽车类 USB 2.0 480Mbps 高速信号调节器 12-X2QFN -40 至 105	X2QFN12	TUSB211ARWBRQ1	德州仪器 (TI)
U7、U8	2		USB Type-C® 20V EPR 端口保护器：VBUS 短路过压和 IEC ESD 保护	VQFN20	TPD4S201QRGR	德州仪器 (TI)

4 相关文档

4.1 补充内容

- TPD4S480-Q1 器件数据表
- TPD4S481-Q1 器件数据表
- TPD4S201-Q1 器件数据表
- TUSB211A-Q1 器件数据表

5 商标

所有商标均为其各自所有者的财产。

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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最后更新日期：2025 年 10 月